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CRUISE REPORT

GEO8144/3144 – Marine Geology and Geophysics Cruise 2015 Greenhouse Gases in the Ocean

on R/V Helmer Hanssen, July 23rd – August 3rd 2015

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Bjørn Runar Olsen contributed with data processing and handling of all equipment connected with this cruise. The captain and the crew and all cruise participants contributed to the collection of the data. They are all warmly thanked for their great effort to make this cruise a great success.

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1. Summary

From the late afternoon of July 23rd to the morning of August 3rd, 2015, the Department of Geology Uit, the Arctic University of Norway, arranged a scientific teaching cruise aimed at investigating the western and northern Svalbard margin, the Fram Strait to east Greenland, methane seep sites at Vestnesa, Prins Karls Forland and Storfjorden Trough and the Barents Sea on R/V “Helmer Hanssen”. Investigated areas were (in order of visiting sites on the cruise): west of Prins Karls Forland, Vestnesa Ridge Storfjorden Fan, the northwest Svalbard slope to north of Schmeerenburgfjorden. On the track towards Tromsø we sampled in Storfjorden Trough (Figs. 1 and 2). The scientific sampling was done within the framework of several ongoing projects at the Department of Geology, University of Tromsø: “CAGE - Centre for Arctic Gashydrate, Environment and Climate”, in which the sub-projects “Paleo-CIRCUS”, “OA-Ocean Acidification” is included. The courses GEO8144/GEO3144 are under the regie of AMGG (the Research School of Arctic Marine geology and Geophysics, this year’s course responsible is Prof. T.L. Rasmussen.

A total of 2 gravity cores, 8 plankton net casts and 22 CTD (conductivity-temperature-depth) casts were performed along the route to Northern Svalbard at the western Barents Sea slope. Data were also collected in Storfjorden Trough and the mouth of Storfjorden. In addition, CTD’s and a small chirp and multibeam survey was performed off Schmeerenburgfjorden, north of fjorden and in its northernmost part.

Chirp profiles and multibeam lines were acquired during transits and during the survey of outer Schmeerenburgfjorden. The recording started from c. 71 N on the western Barents Sea slope and ended at 70.00 N.

2. Background

During the cruise, data were collected for the following projects:

- **1) “CAGE – Centre of Arctic Gashydrate, Environment and Climate”, 2) “CO₂ and the ocean circulation system: Natural variations in CO₂ and climate during the last interglacial-glacial cycle” (Paleo-CIRCUS), and 3) “Ocean Acidification; Effects of ocean chemistry changes on planktic foraminifera in the Fram Strait: ocean acidification from natural to anthropogenic changes” (OA).** The overall purpose of project (1) is to study and reconstruct the emission of methane through time in relation to past climate change. The purpose of project (2) is to study the exchange of Atlantic surface water and polar water along the Svalbard margin compared to natural variations in CO₂ and climate in the past. The purpose of (3) is to study the preservation of calcareous planktic foraminifera in relation to acidification of the water column, sediment surface in the present in relation to anthropogenic influence and in the past under natural climate variability. We aim to collect gravity and boxcores and plankton net samples and CTD records and water samples at various locations: western Barents Sea margin, Vestnesa Ridge, northwest and northern Svalbard, Storfjorden Trough, and the western Barents Sea.

3. Objectives

The objectives of the cruise were:

- To collect plankton samples and CTD and water samples from the entire planned study areas with the purpose of studying the content of living and subrecent planktic foraminifera and the conditions of their shells in order to elucidate the effect of CaCO₃ preservation (ocean acidification) on the living and recently dead planktic foraminifera. Water samples and CTD for water properties and chemistry. In Storfjorden also brine overflow will be studied by CTD and water sampling.
- To collect gravity cores in high-resolution, undisturbed sediments containing millennial-scale variability and sediments from the Last Glacial Maximum.
- To retrieve gravity-cores from active pockmarks of methane gas seepage on the crest of the Vestnesa Ridge in order to investigate foraminifera-fauna assemblages in past and present environments affected by release of methane and reconstruct variations in activity of methane seeping in relation to climate and oceanographic change.
- To observe and record variability in the release flares of CH₄ and the nature of surface sediments (gas bubbles, dolomite encrustations, bacterial mats etc.) by chirp and echosounding at Vestnesa. In addition, plankton net sampling above flares on the shelf in Storfjorden Trough to record effects of seeping on planktic foraminifera and their shells.
- To study the deglaciation and ice age history and paleoceanography of the Svalbard-Barents Sea ice sheet using sites from Storfjorden Trough - part of ongoing projects since 2002.
- To acquire swath-bathymetry and chirp data, as well as to retrieve sediment cores in order to investigate sedimentary processes and reconstruct the glacial retreat history in Storfjorden in combination with core studies.

4. Participants

Scientific crew:

Name	Affiliation
Rasmussen, Tine Lander (Professor; chief scientist)	UiT
Nielsen, Tove (senior researcher, co-chief scientist)	GEUS
Antoon Kuijpers (emiritus, co-chief scientist)	GEUS
Bjørn Runar Olsen (Engineer)	UiT
Sztybor, Kamila (PhD. student)	UiT
Mohamed Ezat (PhD. student)	UiT
Jessen, Simon P. (Post Doc)	UiT
Dijkstra, Noortje (Post Doc)	UiT

Students:

Lisbeth Jensen (master student)	UiT
Eira Triguera Enguinados (master student)	UiT
Håkan Karlsen (master student)	UiT
Lasse Aase Tønnesen (master student)	UiT
Ida Kristin Danielsen (master student)	UiT
Lea Canzler (master student)	UiT
Christine Joanne Lockwood (master student)	UiT
Gert Vidar Høgseth (master student)	UiT
Carina Nilsen (master student)	UiT
Monica Hulthin (master student)	UiT
Kärt Üpraus (PhD student)	UiT/NGU

Amando Lasebuda (PhD student)	UiT
Daniel Hesjedal Wiberg (PhD student)	UiT

UiT = UiT, the Arctic University of Norway
 GEUS = Geological Survey of Denmark and Greenland
 NGU = Geological Survey of Norway

5. Equipment

Acoustic and seismic equipment

- Kongsberg Maritime EM 300 multibeam echo sounder
- EdgeTech 3300-HM hull-mounted sub-bottom profiler ("Chirp"); 4*4 arrays
- Kongsberg Maritime EK60 splitbeam echosounder (18, 38 and 120 kHz)
- Mini-air-gun (*Sercel* GI)

Sediment sampling

- Gravity corer (total weight 1900 kg; 6 m steel barrel; inner diameter of steel barrel: 11 cm)
- Piston corer ((total weight >2000 kg, 12m steel barrel, inner diameter 11 cm)
- Multi corer (MC) KC model 72.000 with 6 core liners (1 m length each)
- Giant box corer (50*50*50 cm³)

Water properties:

- CTD (*Seabird 911 Plus*) with compact rosette with water samplers

Plankton net:

- Type WP-2 net from *HydroBios*

6. Methods

Sediment sampling

Gravity- cores were retrieved from Vestnesa Ridge Storfjorden Trough. Piston cores were retrieved just north of Vestnesa and in a pockmark at Vestnesa, Plastic liners with an outer diameter of 11 cm (inner diameter: 10 cm) were put into the steel barrel. After retrieval, the plastic liners were cut into sections of up to 100 cm length. They were covered with plastic caps, taped, labelled and stored at +4°C.

Plankton sampling

Plankton nets were cast at previous multi-core stations and CTD-stations for capture of planktic foraminifera for investigations of ocean acidification and for fauna studies. Mesh size were 90 micron. Samples were preserved in 96% alcohol with Rosa Bengal and buffered with Disodium Hydrogen Phosphate and Sodium Hydrogen Phosphate.

Water properties

The water properties – temperature, salinity – were measured at every sampling station and at regular intervals using a *Seabird 911 Plus* CTD. Data collection was performed during downcasts at a speed of approx. 1.0 m/s. The data of selected CTD stations were used for records of modern water mass properties records for the paleo-studies and studies of living planktic and

benthic foraminifera and to calculate sound-velocity profiles for calibrating the multibeam echo sounder system. Water samples were taken on a regular basis for water chemistry analyses in Uit labs.

Acoustic investigations

Seafloor mapping:

Swath-bathymetry surveys were carried out using a *Kongsberg Maritime EM 300 multibeam echo sounder*. Sound-velocity profiles of the water column for calibrating the equipment were recorded from CTD casts where necessary. Swath-bathymetry data was also collected during the transits between working areas and stations. The equipment worked well during the acquisition and the data are of good quality. Some preliminary data cleaning was performed using the software programme *Neptune* version 6.6.

Seismic profiling:

High-resolution seismic profiles (Chirp), using an *EdgeTech 3300-HM* hull-mounted sub-bottom profiler, were collected along the ship tracks during the swath-bathymetry data acquisition from Isfjorden Trough and onwards. A small survey was performed in Storfjorden and StrofjordenTrough as well as during transits. Pulse mode and shot rate were varied, depending on the water depth. The equipment worked well and the data are generally of good quality. After the departures from Longyearbyen and well out over deep water over Isfjorden Trough, the chirp was started by soft start, starting with 1% of the total effect, followed by a doubling of the effect every minute. During the data collection, the sea surface was constantly monitored from the bridge. The chirp was turned off whenever passing through protected areas such as Smeerenburgfjorden, Hinlopen....

Air-gun seismic data were collected with a *Sercel* GI gun attached to a metal array. Data was collected in Storfjorden. The reflected signal was received with a single channel *Fjord Instruments* streamer containing a 10 m long dummy section and a 6 m long active section with 20 hydrophones. The air gun and streamer were towed 65 and 60 m behind the vessel, respectively. The equipment worked excellent, and data are of good quality. All acoustic data were store digitally together with the navigation information.

Echo-sounder flare observation

The echo-sounder installed on RV Helmer Hanssen was planned to be used to detect gas bubbles rising from seep sites at the seafloor off Prins Karls Forland, Vestnesa Ridge and in Storfjorden Trough. The gas bubbles, due to their high impedance difference, give very strong backscattering signals, which can be used to detect active seep sites and quantify the amount of gas being released.

7. Preliminary results and outcome of the cruise

Scientific goals:

In general, because of poor weather conditions and longer times at stations than anticipated the surveys at Vestnesa were abandoned. Also the program north of Svalbard had to be cut shorter. Instead, we did a small survey of outer Schmeerenburgfjorden for a master project. In Storfjorden the program was also reduced to lack of time and sea ice.

CAGE projects:

8.1 Paleo-CIRCUS and OA-Ocean Acidification

In essence, all the originally planned data concerning plankton sampling and CTD and water sampling (except north of Svalbard, on Vestnesa and over flares in Storfjorden Trough) was fulfilled. Stations along the western Barents Sea slope to northwest Svalbard were successfully collected for the Paleo-CIRCUS and OA project. 22 CTD casts were performed, 8 plankton net tows, and 2 gravity cores were retrieved in total for the projects. The gravity core in Storfjorden Trough was meant to reach into deglacial deposits and glacial marine sediments to reconstruct the history of ice retreat in Storfjorden and Storfjorden Trough. The gravity core on Bjørnøya Fan is meant to collect sediments from the Last Glacial maximum and the deglaciation. CTD and water samples were taken to analyse water properties and chemistry at plankton stations and gravity core stations for the OA- and Paleo-CIRCUS projects. Plankton samples were taken to study the impact of ocean acidification on the shells of the specimens and to study seasonal changes in species distribution and depth habitats.

The collected material will be analysed at the Department of Geology, UiT, the Arctic University of Norway, as part of ongoing research (seniors and Post docs) and also form a basis for future master, PhD and post doc studies a.o. The Paleo-CIRCUS project is financed by the Mohn Foundation and UiT, while the OA project is financed by the Norwegian Research Council. Both projects also receive funding from CAGE, also via the Norwegian Research Council and UiT.

8.2 Methane release and past climate change, Vestnesa and Storfjorden Trough

This part had to be given up due to bad weather and lack of time. The sites will be visited and sampled during the summer cruise 23 July to 3rd of August 2015, instead. The coordinates of the planned survey in Vestnesa was (and to be done in summer): 79.00.680N, 006.52.890E to 79.03.653N, 006.34.529E. Flare site in Storfjorden Trough will be visited again in the summer for plankton net and CTD.

8.3. Educational outcome

The students were divided into two groups and all students participated in all aspects of the scientific program; the planning and retrieval of piston-, gravity-cores, plankton net sampling, sampling program for living planktic foraminifera from surface samples plankton net samples) as well as in the planning of bathymetric and sub-bottom profiling programs. Each group reported to each other during all shift changes of what had been done and what was planned for the next 6 hours. The students performed logging of whole cores, logging and descriptions of split cores, sampling for check of sediment ages, sieving of plankton samples with living foraminifera and sediment samples for foraminifera-studies and overall procedures for handling of cores and samples. They also participated in the stratigraphical assessment of cores and correlations of cores and correlations into a wider framework determined by the sub-bottom and bathymetric charts. Because of the very varied nature of the scientific program the students got first-hand experience with ocean acidification and how to study the acidification processes; they learned about the extremely complicated sedimentology and morphology of slope and shelf methane seep sites and complications of obtaining a reliable stratigraphy on records disturbed by methane release compared to 'normal records'. They experienced deep sea-, shelf- and fjord environments in the Arctic and collected water samples from methane seep sites and brine from Storfjorden

and Storfjorden Trough. They participated in sampling for deglaciation studies over moraine ridges and basal till in Smeerenburgfjorden, Hinlopen, Storfjorden, Storfjorden Trough and Leirdjupet. Several cores were taken solely for teaching purposes, while others for both teaching, master projects and purposes of ongoing projects at UiT.