

CRUISE REPORT

CAGE-CO2 Cruise and GEO3144 Teaching Cruise to the western Svalbard margin and the Barents Sea

Vestnesa Ridge, West Svalbard slope, Storfjorden Trough, Storfjorden and the Barents Sea

on R/V Helmer Hanssen, July 21st – July 29th 2014

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1. Summary

From the afternoon of July 21st to the morning of July 29th 2014, CAGE at the Department of Geology Uit, the Arctic University of Norway, arranged a scientific cruise with teaching (GEO3144/8144- Arctic Marine Geology and Geophysics Cruise) aimed at investigating and teaching students about the western Svalbard margin, methane seep sites at Vestnesa and Storfjorden Trough and the Barents Sea on R/V “Helmer Hanssen”. Investigated areas were (in order of visiting sites on the cruise): Vestnesa Ridge, the west Svalbard slope, Storfjorden Trough, Storfjorden and western Barents Sea (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.

A total of 11 gravity cores, 7 box-cores (with a total of 18 sub-samples retrieved), 9 plankton net casts and 16 CTD (conductivity-temperature-depth) casts were performed at Vestnesa Ridge, Storfjorden Fan, Storfjorden Trough, Storfjorden and the western Barents Sea, respectively. All gravity cores were logged onboard by magnetic susceptibility loop sensor for stratigraphical purposes and educational purposes.

Chirp profiles and multibeam echo sounder lines were acquired during transits and during surveys of Storfjorden and several pockmarks at the Vestnesa Ridge. A total of 129 lines were collected during transits and during surveys. A total of six seismic lines were performed with the airgun.

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 projects (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 during 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. For these projects we aim to collect piston-, gravity and multicores and plankton net samples and CTD records at several sites: the Vestnesa, the west Svalbard slope, Storfjorden Trough, Storfjorden and the western Barents Sea

3. Objectives

The objectives of the cruise were:

- To collect piston*-cores in high-resolution, undisturbed sediments of Vestnesa for reference (sediments containing millennial-scale variability).
- To retrieve piston*-, gravity- and multi-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 release flares of CH₄ and the nature of surface sediments (gas bubbles, dolomite encrustations, bacterial mats etc.) by chirp and echo-sounding on Vestnesa and the shelf in Storfjorden Trough.
- To study the deglaciation and ice age history and paleoceanography of the Svalbard-Barents Sea ice sheet using sites from Storfjorden Trough and Storfjorden - part of ongoing projects since 2002.
- To collect plankton samples and sediment-surface 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.
- 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.

* Upon arriving at the ship we learned that the piston corer would not be working because of problems with the crane's hydraulic system

** Before the cruise we learned that the multicorer would be on Lance (the NP-ship) and would be replaced by the boxcorer.

4. Participants

Crew RV Helmer Hanssen:

Captain: John K. Almestad
 Vice captain: Inge Berg
 Chief engineer: Hjörtur Poulsen
 Second engineer: Kristian Kristiansen
 Boatswain: Oddmund Kopperstad
 Boatswain: Stein Einar Hansen
 Able seaman: Oskar Torgersen
 Able seaman: Geir Bjarne Nygård
 Able seaman: Geir Sørensen
 Stewart: Svend Krøyserth
 Galley assistant: Steven Andresen
 Vice Captain student: Sander Ludvigsen

Scientific crew:

Name	Affiliation
Rasmussen, Tine Lander (Professor; chief scientist)	UiT
Nielsen, Tove (Senior researcher; co-chief scientist)	GEUS
Iversen, Steinar (Engineer)	UiT
Katarzyna Zamelczyk (post doc)	UiT

Sztybor, Kamila (PhD. student)	UiT
Joanna Przytarska (post doc)	IO
Malgorzata Nowak (phd student)	IO
Anna Siliakova (Post doc)	UiT
Björg Jónsdóttir (master student)	UiT
Students GEO3144/8144:	
Erna Ósk Arnardóttir (master student)	UiT
Karoline Myrvang (master student)	UiT

UiT = Uit, the Arctic University of Norway
 GEUS = Geological Survey of Denmark and Greenland
 IO = Institute of Oceanology, Polish Academy of Sciences

5. Equipment

Acoustic 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)

Sediment sampling

- Gravity corer (total weight 1900 kg; 6 m steel barrel; inner diameter of steel barrel: 11 cm)
- 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- and/or box cores were retrieved from Vestnesa, Storfjorden Trough and Storfjorden, south of Spitsbergenbanken, Bjørnøy Trough and north of Troms. 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. A box core of 50x50x50 cm was used to obtain undisturbed surface sediments. Two cm thick mud was scooped off part of the core and plastic liners were pushed into the sediment to retrieve longer core samples. The surface samples were preserved in Rosa Bengal stained alcohol.

Piston coring was the main purpose on Vestnesa and in Storfjorden, but had to be abandoned because of problems with the crane operating the core.

Plankton sampling

Plankton nets were cast at multi-core 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 almost 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 Vestnesa and in Storfjorden for nutrient analyses back 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 north of the Vestnesa Ridge and in Storfjorden and the Barents Sea, 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, soft starts of the Chirp system were performed, 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.

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 used to detect gas bubbles rising from seep sites at the seafloor through the water column. 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. Surveys have been undertaken over Vestnesa and in Storfjorden outer Trough.

7. Preliminary results and outcome of the cruise

Scientific goals:

In general, for the work on the Vestnesa Ridge, because of no piston core we stayed shorter than planned and took only a few gravity cores for master projects and reference. A short acoustic survey of a previously sampled pockmark gave good new information of the core sites. Plankton net samples did not exactly take place above flares because of drifting. Good weather allowed that practically all planned material was collected in Storfjorden area (CTD's, plankton samples, surface samples from box cores and acoustic mapping and profiling). All gravity cores were logged onboard with the magnetic susceptibility loop sensor for educational purposes to be able to evaluate the stratigraphy and if the purpose of sampling each particular core site was fulfilled (see e.g., Rasmussen et al., 1996, 2007; Jessen et al., 2010).

CAGE projects:

8.1 Paleo-CIRCUS and OA-Ocean Acidification

In essence, all the originally planned data concerning Vestnesa, Storfjorden Fan, Storfjorden Trough, Storfjorden and the western Barents Sea were successfully collected for the Paleo-CIRCUS and OA project. 16 CTD casts were performed, 9 plankton net tows, 1e gravity cores were retrieved in total for the projects. In addition, 7 box cores were collected to retrieve undisturbed coretop sediment for planktic and benthic foraminifera analyses and macrofauna. The gravity cores in Storfjorden Trough and Storfjorden was meant to reach into deglacial deposits and glacial marine sediments to reconstruct the history of ice retreat in Storfjorden and Storfjorden Trough. The magnetic susceptibility measurements show that deglacial sediments were reached.

A total of 9 stations of plankton net with two casts at each station were performed. The content were sieved onboard and preserved in alcohol with Rosa Bengal and buffered with Disodium Hydrogen Phosphate and Sodium Hydrogen Phosphate.

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

The surveying of active gas seep sites at Vestnesa (two active pockmarks (1 and 2) sampled in 2012) was successful. A chirp and multibeam survey (mapping) of the active pockmarks 1 and 2 was performed going over all previous sampling stations. Both pockmarks showed strong flares on the echo-sounder, and the 3.5 kHz captured several flare sites with transparent sediments interrupting otherwise nicely stratified sediments. The pockmark 2 was sampled around 1200 m water depth in a Pogonophor-worm field. On entering the area several pockmarks slightly shallower was recorded and one pockmark (supposedly with low activity) at c. 1180 m water depth was sampled.

In total one CTD was taken, two gravity cores and one plankton net tow were taken in pockmark 1, which we forgot to do in 2012. The material will be analysed by a master student and a post doc at the Department of Geology, Uit as part of ongoing research within CAGE.

Educational goals:

The two students participated in all aspects of the scientific program; the planning and retrieval of gravity-, and box-cores, plankton net sampling, sampling program for living benthic and planktic foraminifera from surface samples (box-core samples) as well as in the planning of bathymetric and sub-bottom profiling programs. The students experienced logging of whole cores, sieving of plankton samples 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 problematic and how to study the acidification processes; they learned about the extremely complicated sedimentology and morphology of the methane seep sites. They experienced deep sea – shelf- and fjord environments (both arctic and boreal).