CRUISE REPORT

MARINE GEOLOGICAL CRUISE TO THE ANDØYA CANYON AND
LYNGENFJORDEN, NORTHERN NORWAY

(UITo-EUROSTRAFORM-04/1)

RV Jan Mayen 21.-28.11. 2004

by
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1. Introduction and scientific objectives

The cruise was organized into two parts separated by a change of ship crew in Tromsø (25.11). Part I (21. - 24.11) went to the Andøya Canyon, part II (25. – 28.11) focused on Lyngenfjorden. During part I we acquired multibeam bathymetry data from the Andøya Canyon and did the final testing of the Kongsberg Simrad EM 300 Multibeam Echo sounder. This work is part of the University of Tromsø activities within the EU-funded EUROSTRATAFORM project (http://www.soc.soton.ac.uk/CHD/EUROSTRATAFORM). The fundamental concept of EUROSTRATAFORM (EUROpean STRATA FORMation) is to follow the fate of sediment particles and how they form the strata on ocean margins. On the Norwegian continental margin the study area is the Andøya Canyon and the attached deep-sea channel, the Lofoten Basin Channel. In more detail our work will focus on: 1) sediment transport processes through the canyon and their temporal and spatial variability, and 2) seabed instability within the canyon.

The data collected during the second part of the cruise will be analysed within the Norwegian Research Council-funded SPONCOM project (http://www.ig.uib.no/sponcom/index.htm). SPONCOM (Sedimentary Processes and Palaeo-environment on Northern Continental Margins) is a strategic University project at the University of Tromsø. The multibeam bathymetry data from Lyngenfjorden together with previously acquired high-resolution seismic data will be analysed in order to shed more light on: 1) the chronology and dynamics of the last glaciation - deglaciation in the Lyngen area, and 2) the processes and fluxes of the fjord sedimentation.
2. Cruise participants

In addition to the regular crew of the University of Tromsø research vessel *Jan Mayen* (http://www.nfh.uit.no/hmenyvis.aspx?id=194) the cruise participants were:

**Part I: 21.-24.11:**
Jan Sverre Laberg, Research Scientist, Department of Geology, University of Tromsø (cruise leader)
Stéphanie Guidard, Research Assistant, Department of Geology, University of Tromsø
Steinar Iversen, Science Engineer, Department of Geology, University of Tromsø
Gaute Salomonsen, Research Scientist, Department of Geology, University of Tromsø
Maarten Vanneste, Post. Doc., Department of Geology, University of Tromsø
Kyrre Lydersen, Norwegian College of Fisheries, University of Tromsø
Ulf Norman, Norwegian College of Fisheries, University of Tromsø
Kjetil Aasekjaer, Kongsberg Maritime AS
Erik Grong, Kongsberg Maritime AS
Berit Horvei, Kongsberg Maritime AS

**Part II: 25.-28.11:**
Jan Sverre Laberg, Research Scientist, Department of Geology, University of Tromsø (cruise leader)
Stéphanie Guidard, Research Assistant, Department of Geology, University of Tromsø
Steinar Iversen, Science Engineer, Department of Geology, University of Tromsø
Ole Andreas Jenssen, Master student, Department of Geology, University of Tromsø
3. Cruise narrative

Sunday 21.11. Some snow, breeze and calm sea. Departure from Tromsø at 12.00 (local time) heading for Andnesbassenget in inner Malangen. We reached a box corer station at about 13.00 where we did a CTD/water sample cast before sampling the sea floor sediments using the large box corer. We got a nice quality sample. Then we sailed for Finnsnes where Gaute Salomonsen left the ship.

Leaving Finnsnes we sailed for Harstad where 3 persons from Kongsberg Maritime joined us. They were responsible for the final testing of the Simrad EM 300 multibeam system. The testing was done in the Andøya Canyon which we reached around midnight.

Monday 22.11. Breeze, partly cloudy, calm sea – a very nice day. We started calibration and testing of the EM 300 system during the night and did CTD-station 601. From the morning this was combined with surveying in the outer part of the Andøya Canyon with good quality results. The surveying continued throughout the afternoon and evening.

Tuesday 23.11. A windy day with northerly breeze increasing to gale. We continued with testing of the level of noise during the night, and then we completed surveying in the outer area and sailed to the southern, upper part of the canyon area. Here we did CTD 602 in order to get the correct sound velocity profile. The wind was increasing and we had to change survey direction from N – S to E – W. The multibeam data was still of very good quality.

Wednesday 24.11. The wind speed was still increasing, wind direction is now from southwest. We continued surveying throughout the night with good results despite the weather conditions. From the morning we focused on “holes” in the data set which were filled at about 11.00. Then we started sailing for Tromsø where we docked at 18.00 and were staying for 24 hours for a crew change.
Thursday 25.11. Cloudy, northerly gail. Ship crew change in Tromsø. Departure at about 16.30 sailing for Lyngen. Arrived at the first CTD-station (603) in the outermost part of the fjord at about 20.00. Then we took one more station in the outer part of the fjord (outside the Spåkenes moraine) (604) and one inside the morainal bank (605) before we started surveying the inner part of the fjord.

Friday 26.11. We continued the inner fjord survey running lines from the Spåkenes moraine to the innermost part of Storfjorden. Lines in the middle of the fjord were run at 11 knots speed, along the fjord sides we had to reduce the speed to about 6 knots due to a very irregular sea bottom relief. From the evening we started surveying the submarine part of the Spåkenes moraine. The weather is very good, southerly breeze and no clouds.

Saturday 27.11. Still very good weather, southerly breeze and no clouds. We finished the Spåkenes moraine at about 08.00 and then we sailed further into the fjord along the eastern side to complete our survey in this area, fill in some small data gaps and to do the area close to the Skibotn delta.

The Skibotn area survey, including the lower Skibotn delta front was completed at about 14.00, and then we sailed north along the western part of the fjord towards the Spåkenes to fill remaining data gaps which resulted in a very nice data set from the inner part of Lyngen. The next area to be surveyed was the outer part of Lyngenfjorden (the area between the Spåkenes moraine and Lyngstuva). We ran a number of profiles along the fjord at 11 knots speed.

Sunday 28.11. Good weather conditions, cloudy and southerly breeze. The outer part of Lyngen was surveyed during the night and morning. Data of very good quality was collected. The survey ended at about 13.00 and we started sailing for Tromsø where we docked at 16.30 and started unloading the ship.
4. The EM 300 multibeam system

A Kongsberg Simrad EM 300 multibeam echo sounder has been installed in the hull of R/V Jan Mayen. The EM300 multibeam system is designed to map the sea floor morphology and its acoustic backscatter from depths as shallow as 10 m, across the continental margin to beyond the continental rise, down to about 5000 m water depths. The system is a complete one, in the sense that all necessary sensor interfaces (e.g. positioning system, attitude, heading, clock, synchronisation), data displays for quality control and sensor calibration, seabed visualisation and data logging are a standard part of the system, as well as integrated seabed acoustical imaging capability.

The system runs with a nominal sonar frequency of 30 kHz, in order to obtain an optimal balance between small dimensions, narrow beams and good range capability. This results in an angular coverage of up to 150 degrees and 135 beams (which are always within the active swath) per ping as narrow as 1 degree. The beam spacing is normally equidistant, with equiangular available. The transmit fan is split in several individual sectors, with independent active steering according to vessel roll, pitch and yaw to place all soundings on a best-fit to a line perpendicular to the survey line, thus ensuring a uniform sampling of the bottom and 100% coverage. Pulse length and range sampling are variable with water depths, to obtain best resolution. The swath width, dependent on seabed sediments, in shallow waters (< 500 m) is typically 5 times the water depth. Down to 2000 m, a swath width is 4-5 km is common.

The system runs on a high performance PC (dual 2.8 GHz, 2 GB RAM), displaying the data collected and logging them to hard disk. As a standard, the following parameters are logged: depth, seabed imaging, vessel position, vessel attitude, and sound speed. The operator station converts range and angle data to xyz triplets, applying all corrections required by varying vessel attitude and sound speed. Sound speeds were loaded from external data source, being CTD sound velocity through the water column, after appropriate filtering and editing. A graphical user interface provides control on the data quality and parameters used. Note that,
because of the protection housing installed around the hardware to avoid damage of ice contact, the amplitudes recorded are slightly attenuated (~6 dB).

A complete data processing system is available as well, consisting of NEPTUNE, POSEIDON, TRITON, and CFLOOR:

NEPTUNE: used for post-processing of bathymetric data collected from single beam or multibeam echo sounders, consisting of cleaning and filtering of positioning data, analysis and correction of depth data, tidal height adjustments, automated data cleaning based on statistical rules or manual editing, controlled data thinning, and export of final soundings for further data processing.

POSEIDON: used for post-processing of seabed image data (in dB) into acoustic, imagery mosaic maps and overlays. This included merging of the data from different surveys, filtering and interpolation.

TRITON: used for seabed sediment classification. It extracts signal features from the seabed image data, and feeds them to a statistical classification procedure to obtain the best estimate for seabed sediment type and segmentation as a function of position in the form of a map overlay.

CFLOOR (third-party software, ROXAR): used for digital terrain modelling and plot generation. This consists of establishing a digital terrain model from an interpolation of the sounding data. From this, the program produces contour maps, 3D plots, depth profiles along specified routes, fair sheets, volumetric calculations, etc. Results from POSEIDON and TRITON can be combined in CFLOOR.

**Some technical specifications/system performance data:**

- **Main operational frequency:** 30 kHz
- **Maximum ping rate:** 10 Hz
- **Number of beams for each ping:** 135
- **Beam widths:** 1x1, 1x2, 2x2 or 2x4 degrees
- **Beam spacing:** equidistant or equiangular
- **Coverage sector:** up to 150 degrees
Transmit beam steering: Stabilized for roll, pitch and yaw

Depth resolution: 1 to 16 cm

Pulse lengths: 0.7, 2, 5, and 15 ms

Range sampling rate: 4.5 kHz (37 cm)


5. Previous multibeam surveys of the Andøya Canyon

The Andøya Canyon data set as presented in Figures 1-3 also includes contributions from the University of Bergen (Fig. 1). This part was collected using the Kongsberg Simrad EM300 and EM 1002 of RV G.O. Sars in September 2004.

6. Preliminary results

6.1 The Andøya Canyon

Located on the steepest part of the Norwegian continental slope the Andøya Canyon (Laberg et al. 2000) represents a 30 km long, up to 20 km wide and 1100 m deep V-formed incision (Figs. 1-3). The headwall is about 7 km long and has an up to 20° gradient. It forms the present shelf break at about 200 m water depth and is located only 10 km from the coastline. The thalweg is up to 1 km wide and its gradient is 5° or less. A tributary valley joins the canyon where the thalweg reaches 1100 m water depth. The uppermost part of the canyon has an incised axial channel formed by turbidity currents originating close to the shelf break. The eastern sidewall is the steepest and has a gradient of up to 20°. It is dominated by a number of straight and shallow, parallel to subparallel gullies up to 100 m in width. The gullies are erosional features probably formed by turbidity currents that originate at or near the shelf break. The gullies can be followed to the base of the canyon where some of the them have adjusted to thalweg base level, others terminate on top of an up to 150 m high escarpment
Figure 1: Shaded-relief map of the Andøya Canyon. Gullies, slides, the location of CTD-stations 601-602 (Figures 4-5) and the outline of the University of Bergen part of the data set (box) are indicated.
Figure 2: Bathymetric map of the Andøya Canyon. The contour interval is 20 meter.
Figure 3: Slope dip map (degree) of the Andøya Canyon area.
Figure 4: Results from CTD-station 601 in the lower part of the Andøya Canyon. See Figure 1 for location.
Figure 5: Results from CTD-station 602 in the upper part of the Andøya Canyon. For location, see Figure 1.
defining the eastern boundary of the thalweg. A number of deeper and wider incisions
displaying a spectrum of forms characterise the western sidewall. The largest is a 2.5 km
wide, amphitheatre formed slide scar. Within the slide scar small, elongated highs probably
represents sediment ridges that moved for some distance and then stopped. On the lower part
of the continental slope the western sidewall is dominated by a large slide scar, up to 8 km
wide and 400 m deep that feed into the canyon. In this area the eastern sidewall is
characterised by a 10 km wide incision also indicating a large sediment failure. In summary,
the canyon shows a very complex morphology probably related to a variety of gravity driven
processes responsible for the canyon growth. The timing, frequency and origin of events
within this canyon are presently not known.

6.2 Lyngenfjorden
Following the late Weichselian glacial maximum when the Fennoscandian Ice Sheet front
was situated at or near the shelf break the main part of Lyngenfjorden was deglaciated
between Older Dryas and Early Preboreal (~12 – 9.5 $^{14}$C ka BP). During this period the ice
retreat was interrupted by several episodes of ice halt or readvances, both climatically
induced and topographically controlled episodes have been identified (Corner, 1980). In the
outer part of Lyngenfjorden a prominent bank is seen across the fjord from Spåkenes to
Koppangen (Fig. 6). According to Mellem (1991) the bank comprises both the Skarpnes
(Older Dryas) and the Tromsø-Lyngen (Younger Dryas) moraine. The morainal bank across
the fjord at Ørnes (Fig. 6) was probably deposited during a glacier readvance at (9900 – 9800
$^{14}$C years BP) and at 9600 – 9500 $^{14}$C years BP the ice front had retreated to an onland
position at Skibotn and Otern (Corner, 1980).

7. Acknowledgement

Thanks to Maarten Vanneste for his help in producing Figure 6.
Figure 6: Bathymetric map of Lyngenfjorden. The contour interval is 5 meter. CTD stations 603-605 are indicated (Figures 7-9).
Figure 7: Results from CTD-station 603 in the outermost part of Lyngenfjorden. For location, see Fig. 6.
**Figure 8:** Results from CTD-station 604 in the outer part of Lyngenfjorden. See Fig. 6 for location.
Figure 9: Results from CTD-station 605 in the outer part of Lyngenfjorden. For location, see Fig. 6.
8. References


