UNIVERSITY OF BERGEN
Department of Earth Science

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Marine Geological Cruise Report

from

Ranafjorden-Sørfjorden

R/V "Johan Hjort"

UoB Cruise No. JH-13-184
IMR Cruise No. 2013213

19. - 25. November 2013

Department of Earth Science
University of Bergen, Norway
November 2013

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1. INTRODUCTION

1.1. Objective

The main objective of the marine geological cruise to Ranafjorden-Sørfjorden (Fig. 1) and the Vesterålen margin area is a scientific contribution to the Seabed IV project "*Assessing Offshore Geohazards: site surveying, sampling and comparison of shallow, submarine landslides in coastal and deepwater environments, Northern Norway"* (C-DOG), where the main aim is to decipher the signature of slide planes through a geological, geotechnical and geophysical programme. The cruise on the R/V Johan Hjort was to perform in situ CPTu tests on sites studied the last years both in terms of geological, geotechnical (long cores and short CPTu) and geophysical settings and processes. Especially the area in the Sørfjorden has been a field of multidisciplinary scientific campaigns.

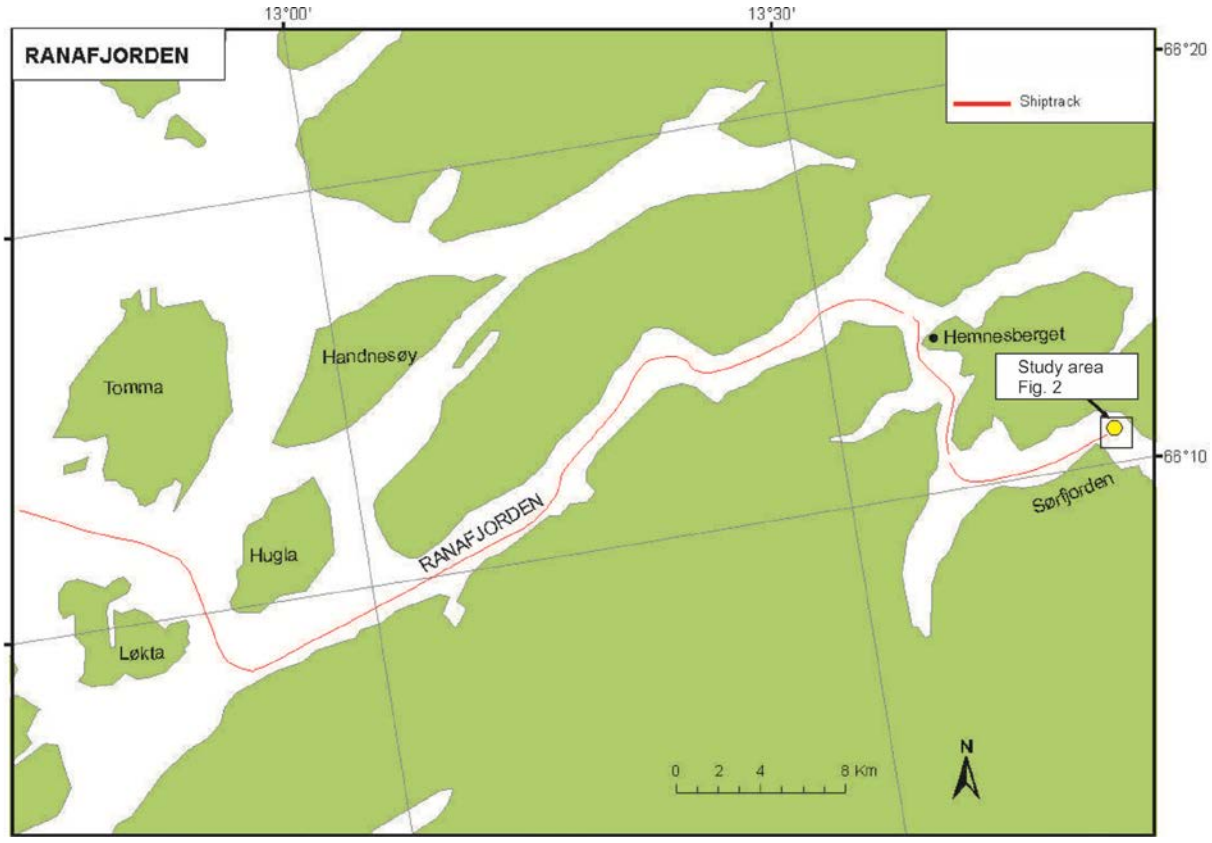

Fig. 1. Overview map of the Ranafjorden-Sørfjorden area.

The report will give a short description of the cruise performance. Figure 1 shows the survey area with ship track line, whereas the general survey log is provided in Table 1. In Figure 2 is a detailed overview over the bathymetry of the inner Sørfjorden basin and the location of the target sites and successful CPTu stations.

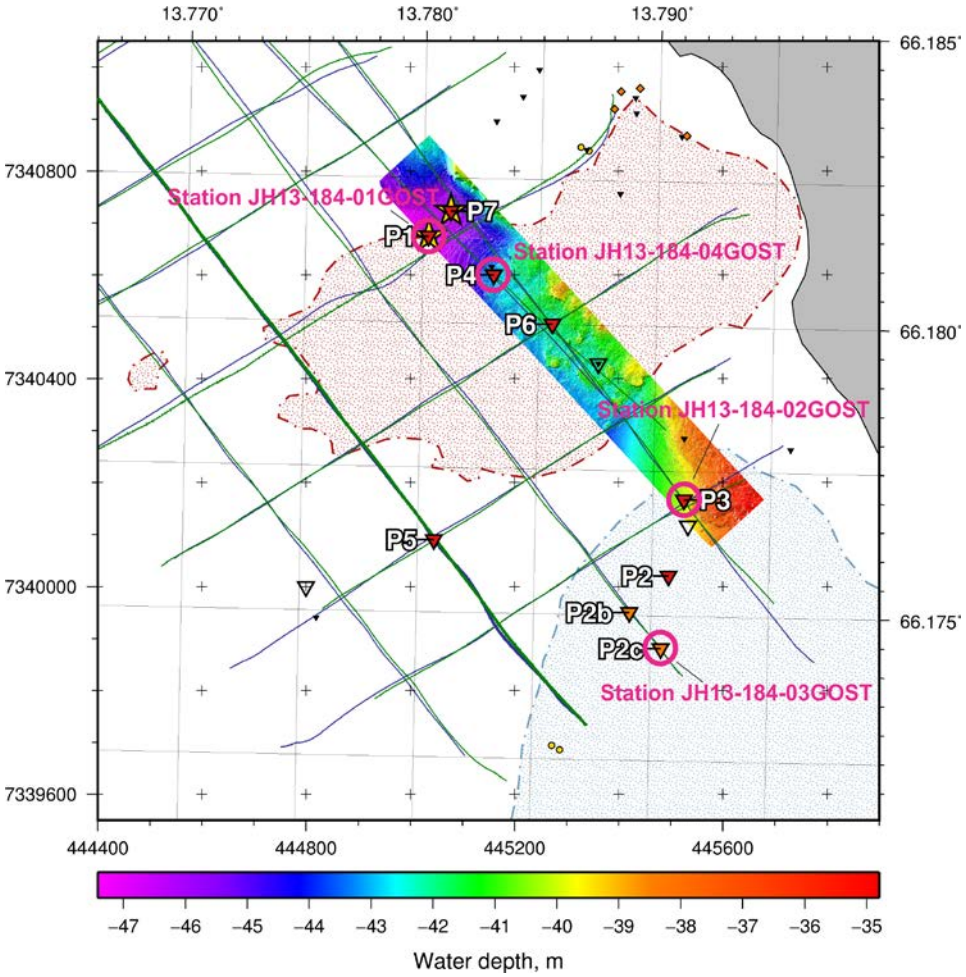

Fig. 2. GOST stations and proposed locations for CPTu tests in the Sørfjorden study area. Shown are seismic lines, extent and bathymetry of the 3D seismic block, extent of the 1996 land slide (red hatched) and the free gas zone (blue hatched). Location of proposed sites for CPTu tests are indicated with inverted triangles. Stations with successful CPTu test are marked with open magenta circles.

1.2. Scientific Party

Jo Brendryen	UoB	Cruise leader, Scientist
Halfidi Haflidason*	UoB	Scientist
Tobias Mörz	MARUM	Scientist
Wolfgang Schunn	MARUM	Scientist
Johannes Brock	MARUM	Scientist

* could not participate on board during the cruise

UoB: University of Bergen, Dept. of Earth Science, Allegt. 41, 5007 Bergen, Norway
MARUM: MARUM – Center for Marine Environmental Sciences and Faculty of Geosciences, 2
8359 Bremen, Germany

1. METHODS

2.1. Research vessel

R/V Johan Hjort has a length of 64.4 m, beam of 13.0 m and a displacement of 1950 tonnes, and is owned by the Institute of Marine Research. R/V Johan Hjort is outfitted with diesel motors with a power of 2400 kw. The main duties are research operations within the areas of fishery, acoustic and environment. To accommodate these tasks the vessel is arranged with A-frame, heavy duty cranes and one CTD davit crane in a hangar. The vessel has a DP-positioning system.

R/V Johan Hjort has room for 34 persons in 24 single berth cabins and 5 double berth cabins and it has a crew of 15. We thank the captain John Gerard Aasen and the crew on R/V Johan Hjort for their help during the cruise.

2.2. Geotechnical Offshore Seabed Tool (GOST)

GOST is an innovative geotechnical tool to characterize the subsoil by means of "push-in tools", i.e. cone penetration testing along with pore pressure measurements, known as CPTu (Fig. 3). The primary focus of GOST is offshore site investigation but due to its modular layout, the system also works onshore, for instance mounted on a truck. Thus, GOST can be operated from almost any platform which can handle around 9 tons of weight. GOST is mainly designed to operate from the seafloor. It is powered and controlled via a standard single wire coaxial cable. During continuous offshore surveys, the tool is only slightly lifted from the seafloor and hanging within the water column during site-transit – called "dangling operation". GOST stays under water without the need of full recovery until all sites are penetrated. This leads to a large number of tests in considerable less valuable vessel time than any other top-pressed CPT tool would be capable of. GOST can handle straight and coiled rod setups of many diameters. So far, we use a 'digital subtraction cone' of 5 cm^2 in conjunction with a differential pore pressure system on a rod of 2 cm in diameter.

Cone Parameters measured:

I. Standard:

- Cone Resistance,
- Sleeve Friction,

- Diff. Pore-Pressure,
- Cone Inclination,
- Temperature

II. Optional: Heat Flow (not included on the cruise)

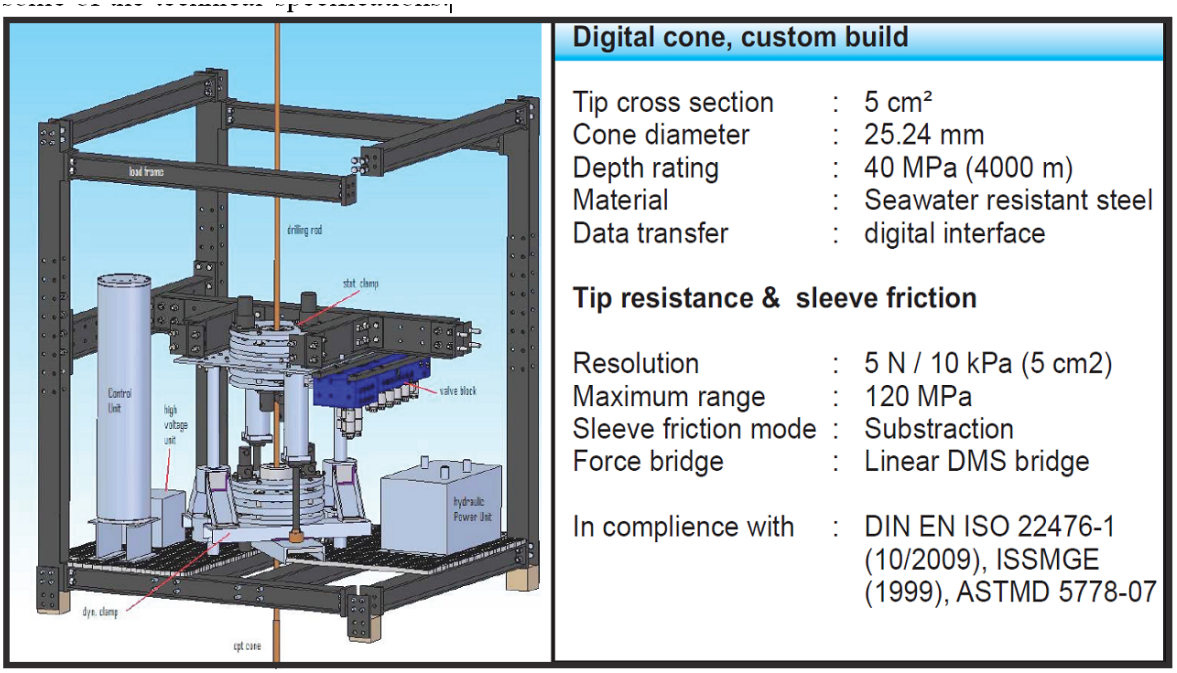

Fig. 3. To the left is the GOST unit as used in the straight rod mode. To the right it is listed some of the technical specifications.

3. FIELD OPERATIONS

A summary of ship-board operations is provided in Table 1 and the field site overview is in Table II.

3.1. Weather and sea state conditions

The weather conditions during the cruise period were good, calm sea and little to no wind. Sub-zero temperatures prevailed during most of the operations.

3.2. Summary of general cruise performance

1. Loading the GOST system and associated equipment took place in Bergen before the cruise. Removing of the divider and spooling of the main steel rope on the note-winch also took place in Bergen.

2. **18th Nov.** Ship and scientific crew arrived in Bodø in the afternoon/evening 18th Nov.

3. **19th Nov.** Mobilization and testing of launching/deployment and electronics of the GOST system took place in Bodø harbor the 19th Nov. as well as during the transit to Sørfjorden in the evening. It was necessary to modify the frame for fastening the tension winch to the deck and to weld mounting brackets for the out-board gangway on the working deck. The tension winch is used to support the 30 m log rod during deployment, operation and recovery of the GOST system. This work was done at Rapp Hydema in Bodø Harbour.

4. During testing it was revealed problems with the tension winch that is used to support the 30 m log rod during deployment, operation and recovery of the GOST system. The winch was found to lose power during operation, which if it had happened during a real launch of the GOST system it would have caused the steel rod to break. It was revealed that the dimensions of the hydraulic pipes of the winch were too small in order to handle the oil flow from the powerful hydraulic pump at Johan Hjort. The pump overheated and shut down accordingly. The problem was fixed by reducing the oil pressure delivered from the hydraulic pump to 140 Bar. Afterwards the tension winch worked perfectly.

5. The prioritized locality for this cruise was Vesterålen. The weather conditions during late November in Vesterålen are, however, generally not optimal for launching complicated seabed operations. The weather forecast indicated that the wind speed the 20th and 21th Nov. would be between 7-12 m/s something that isolated could have allowed launching the GOST system. However a forecasted wave height of 4 m on 20th Nov. would have precluded deployment of the GOST. Both wind and wave conditions were forecasted to degrade from late the 21. Nov. As the combined deployment and recovery of the GOST system to ~600 meter water depth will take in the order of 8 hours, the possible weather window of one day would have been too short. It was therefore decided to go for plan B which was Ranafjorden-Sørfjorden.

6. The weather conditions in Sørfjorden were excellent throughout the cruise with calm sea and no wind. Subzero temperatures did however pose some problems as fresh water used for pressure compensation of the rod froze within the steel rods used in the GOST system.

7. **20th Nov.** Arrived at station JH13-184-01GOST in Sørfjorden at about 07:00 20th Nov. Starting preparing for launching GOST (see above photo). GOST launched at 09:53 and deployed on sea-floor at 12:05. Static mode CPTu test meter (JH13-184-01GOST-static) started and data was recorded continuous down to 17. At 17 meter the probe hit a hard layer that from the seismic imagery looked like a mass transport

deposit. This resulted in loss of the probe and the full recovery of the GOST on deck. It is likely that the probe hit a rock embedded in sand or gravel that prevented the rock from rotating and deflecting the probe. When embedded in fine-grained and cohesive material, a rock when hit by the probe, will usually rotate and deflect the probe. The missing probe was replaced and the GOST system was prepared for a new deployment. Due to the risk of losing more equipment and time it was decided to abandon JH13-184-01GOST and deploy the GOST at station JH13-184-02GOST instead.

8. **21th Nov.** GOST launched for deployment on Station 2 at 09:45, deployed at sea-floor at 10:50, starting static mode CPTu test (JH13-184-02GOST-static) immediately. Data recorded continuously down to 20.25 meter where the test was stopped due to high rod inclination that increased the risk of breaking and losing the rod and probe. The rod was pulled up and prepared for vibrator mode test. At 12:30 the GOST frame was lifted up and lowered on the sea-floor again in order to have an undisturbed hole for the vibrator mode CPTu test (JH13-184-02GOST-vibro). During the vibration mode test data were recorded continuously down to 15 meter before the rod was pulled up and the GOST was lifted 8 meters from the sea floor as preparation for transit to the next station. Transit to station JH13-184-03GOST was performed while the GOST was hanging 30 meter under the ship. When at DP on station (14:40) the GOST was deployed at sea floor and static mode CPTu test (JH13-184-03GOST-static) started. After 20 meter of data recording the test was stopped at 15:20 due to high rod inclination. The rod was pulled up and GOST was lifted at 16:05 and prepared for transit to Station JH13-184-04GOST while hanging. The ship was on DP at the station at 17:30, the GOST was deployed on sea-floor and static CPTu test started. At 17:54 the tip resistance and sleeve friction sensors were found to be malfunctioning likely due to salt-water intrusion. The GOST had to be recovered on deck and the probe replaced. At 19:41 the GOST was recovered on deck and preparations for a new deployment started.

9. **22th Nov.** At 05:30 preparations for new deployment at station JH13-184-04GOST started and the GOST was launched at 09:03. However, the connection with the probe was lost during deployment and it had to be recovered on deck. The reason for the loss of contact was likely that saltwater had leaked in to the data cable within the rod and short circuited the connector in the probe unit. At 11:00 the GOST was on deck and preparations for a new deployment started. At 13:00 the GOST was launched and at 14:37 it was successfully deployed on sea-floor. The GOST had to be operated manually due to a malfunction of a hydraulic valve on the GOST unit. CPTu data from test JH13-184-04GOST-static was recorded continuously down to 30.25 meter before the test stopped at 16:00 and the rod was pulled up. At 19:30 (after dinner), the GOST was recovered on deck and preparations for departure from Sørfjorden continued. Operations in Sørfjorden ended at ~21:00, departure from Sørfjorden to Bergen.

10. **24th Nov.** Arrival Bergen, Nykirkekaien at ~20:00.

11. 25th Nov. Demobilization.

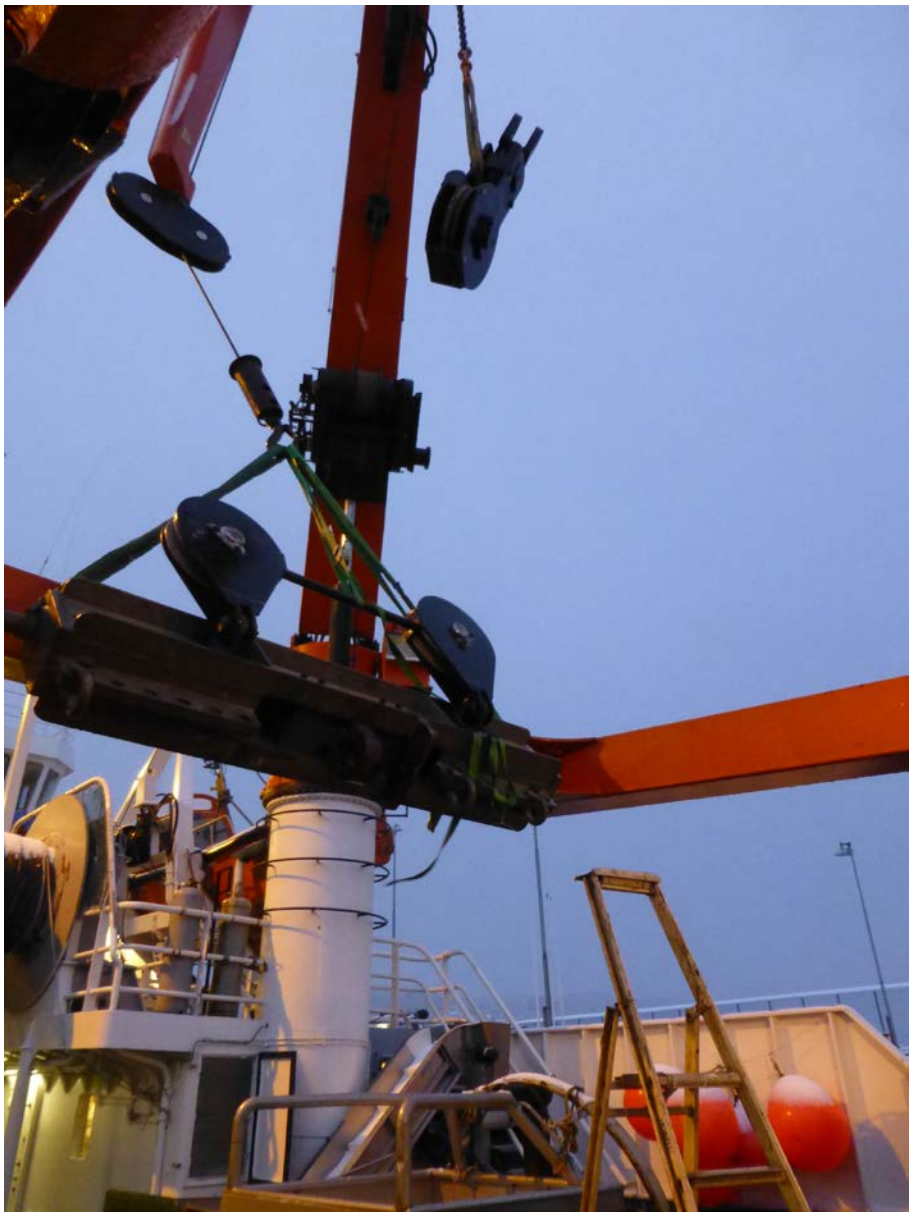

Fig. 4. Mobilisation on R/V Johan Hjort. Mounting the traverse in the A-frame. The traverse with 3 blocks is spesially desgined for the John Hjort.

Fig. 5. GOST frame is being mounted on the weights

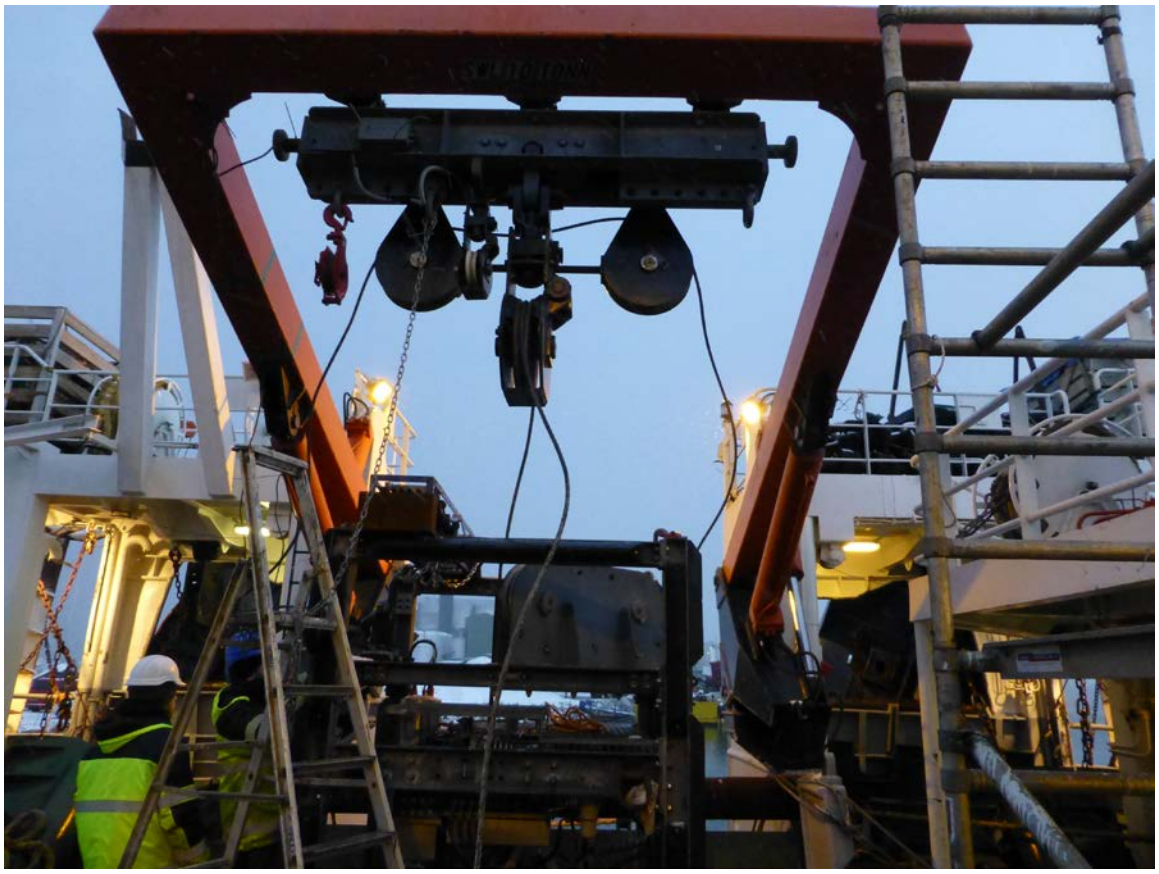

Fig. 6. Steel rope in the blocks.

Fig. 7. Testing the deployment and winches

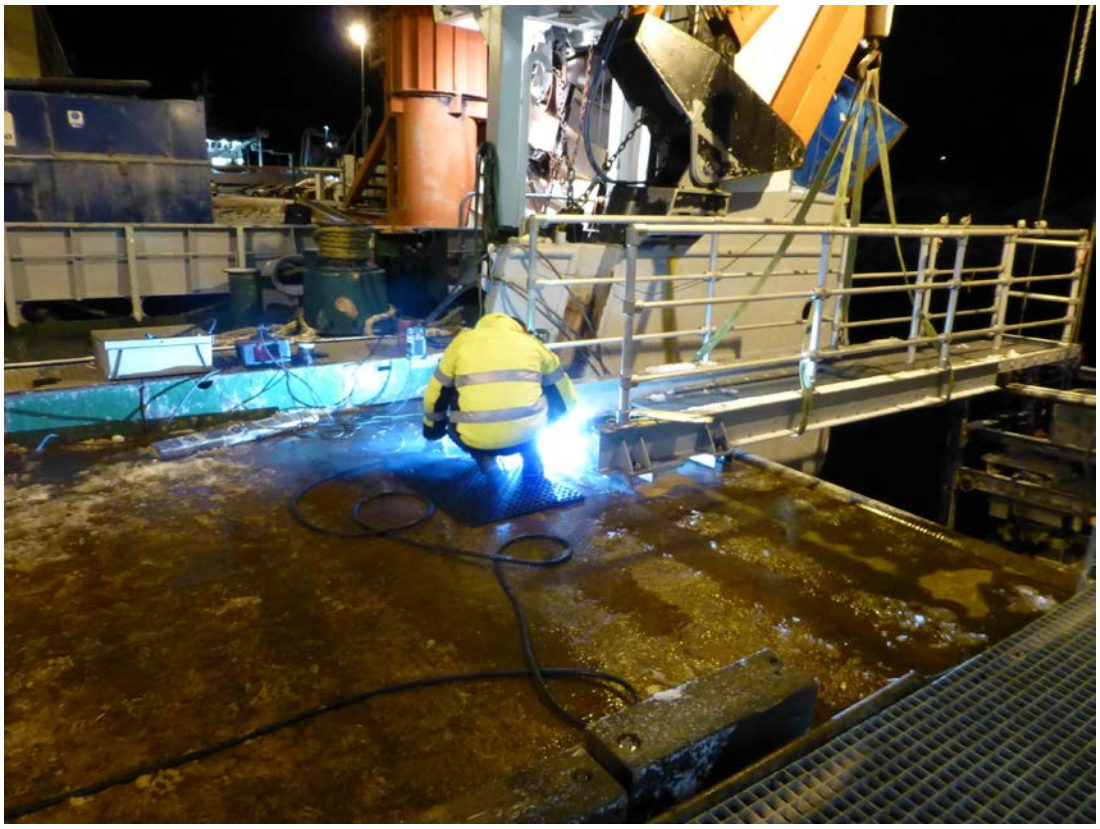

Fig. 8. Welding the outboard gangway to the working deck.

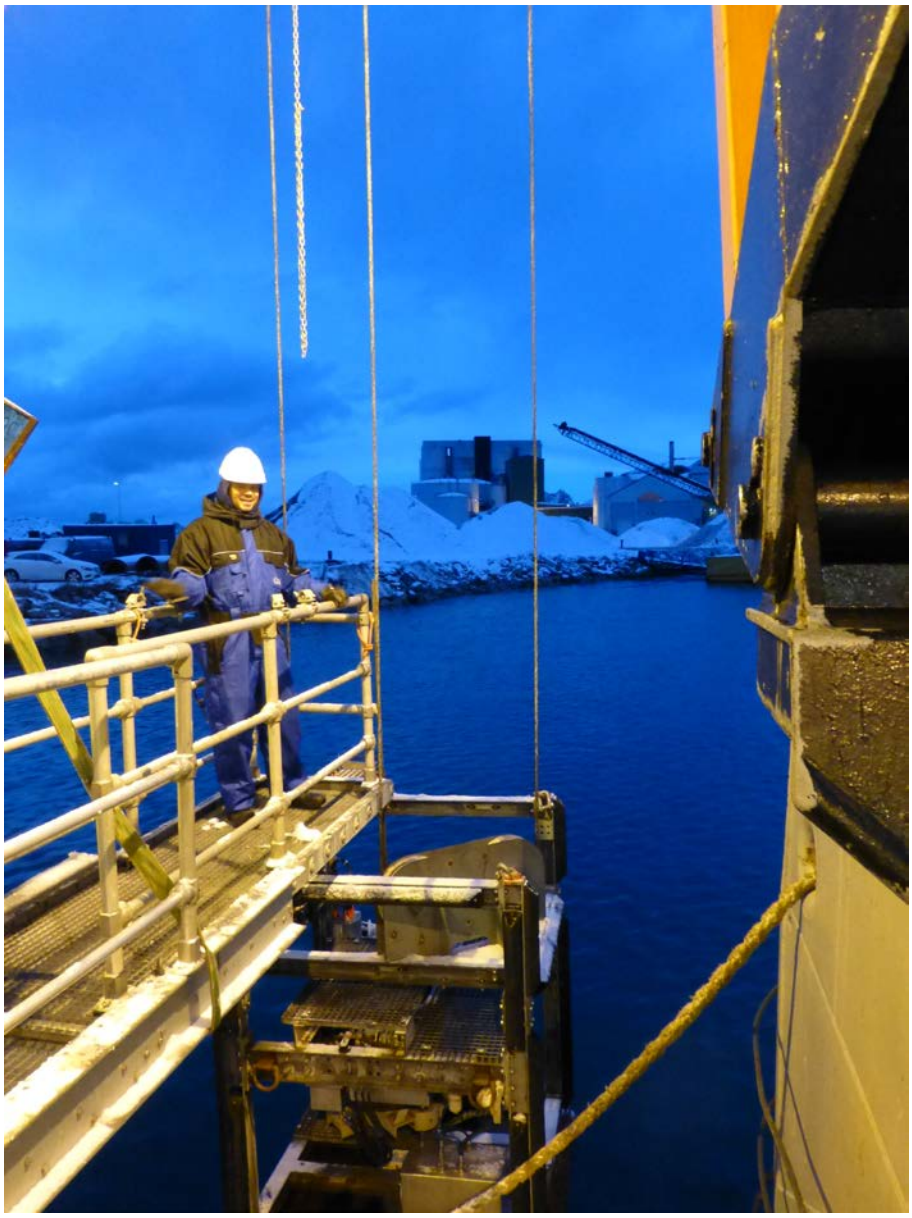

Fig. 9. Testing the welding of the gangway.

Fig. 10. Mounting the coaxial power cable drum.

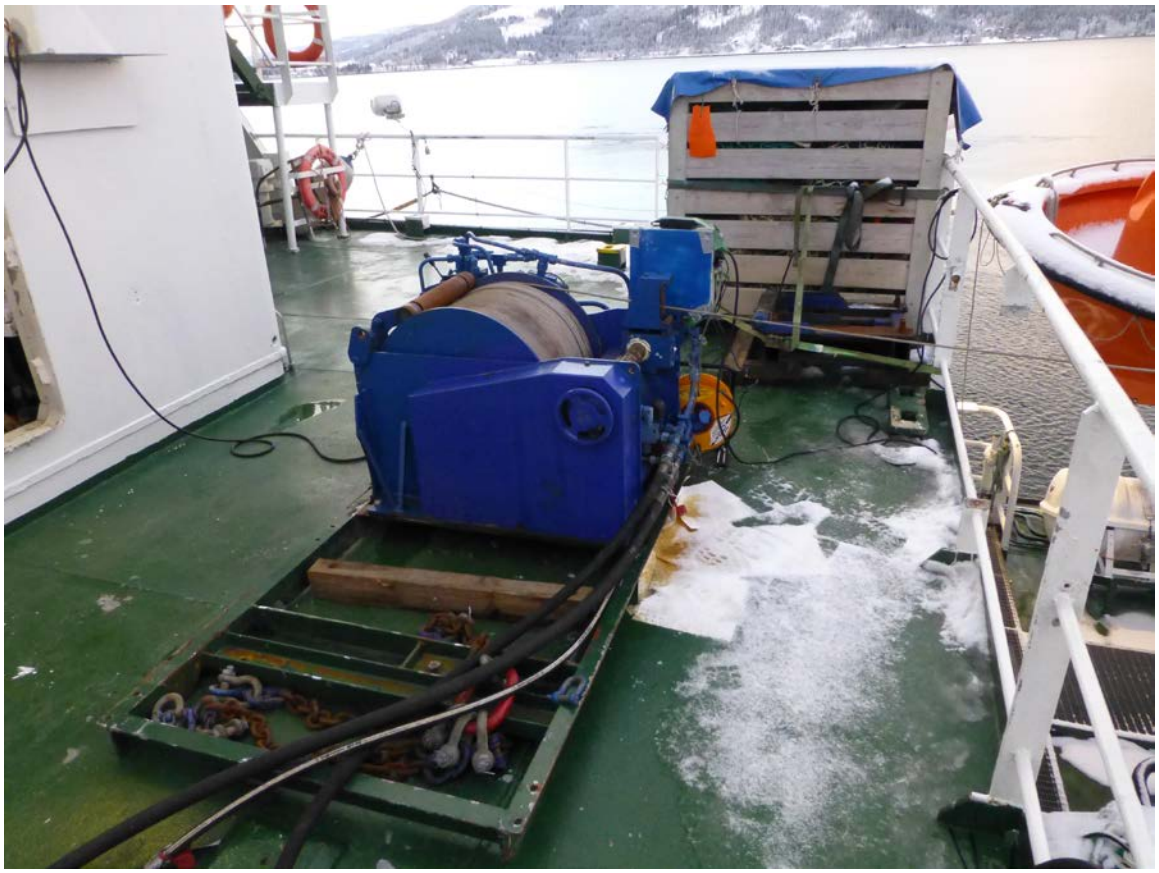

Fig. 11. The tension winch mounted on deck.

Fig. 12. Launching the GOST at Station JH13-184-01GOST.

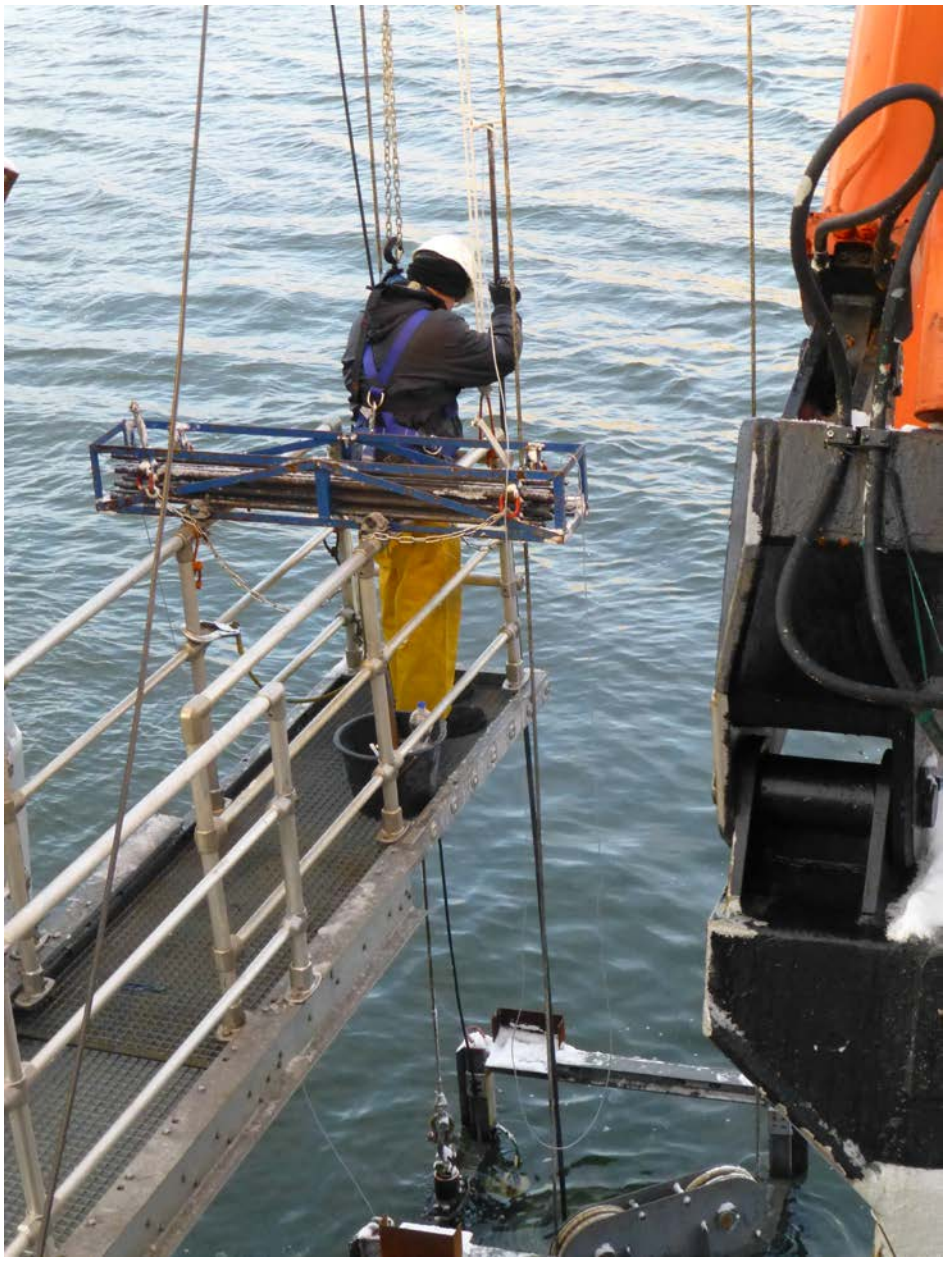

Fig. 13. Building the 30m long rod.

Fig. 14. Incoming data at Station JH13-184-01GOST.

Fig. 15. Recovery of the GOST on station JH13-184-01GOST after loosing probe. Dismantling of the 30m long rod.

Fig. 16. Good weather conditions prevailed during the cruise

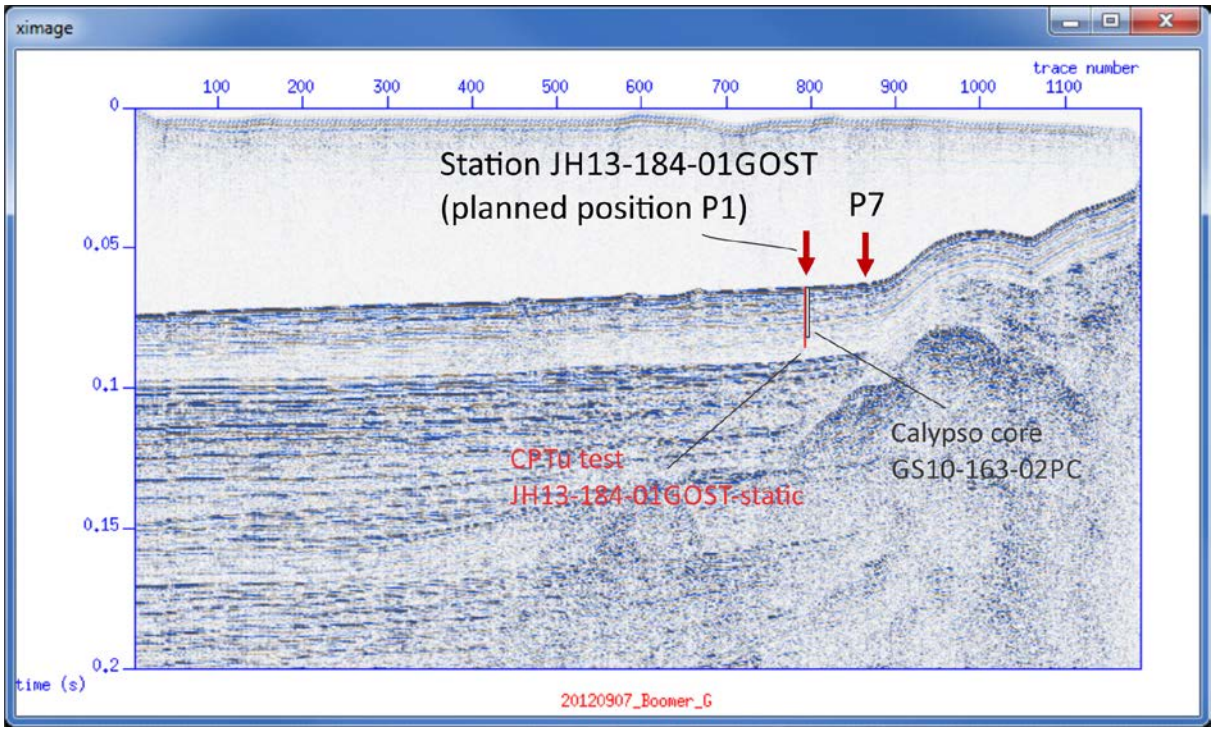

Fig. 17. Boomer profile from Sørfjorden where position of station JH13-184-01GOST and penetration depth (17m) of CPTu test JH13-184-01GOST-static (red) and calypso core GS10-163-02PC (white box) are projected assuming a sound velocity of 1600 m/s. Planned position P7 is also indicated.

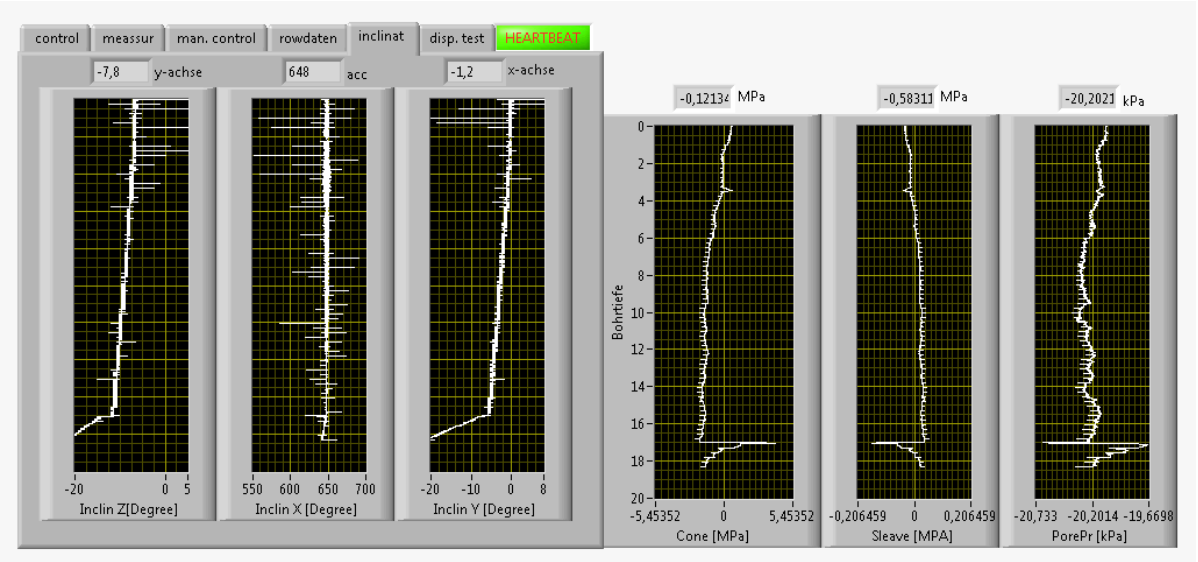

Fig. 18. Screenshot of unprocessed data from CPTu test JH13-01GOST-static as displayed on the control panel. Note the large excursion at ~17 m depth. This is where the probe broke.

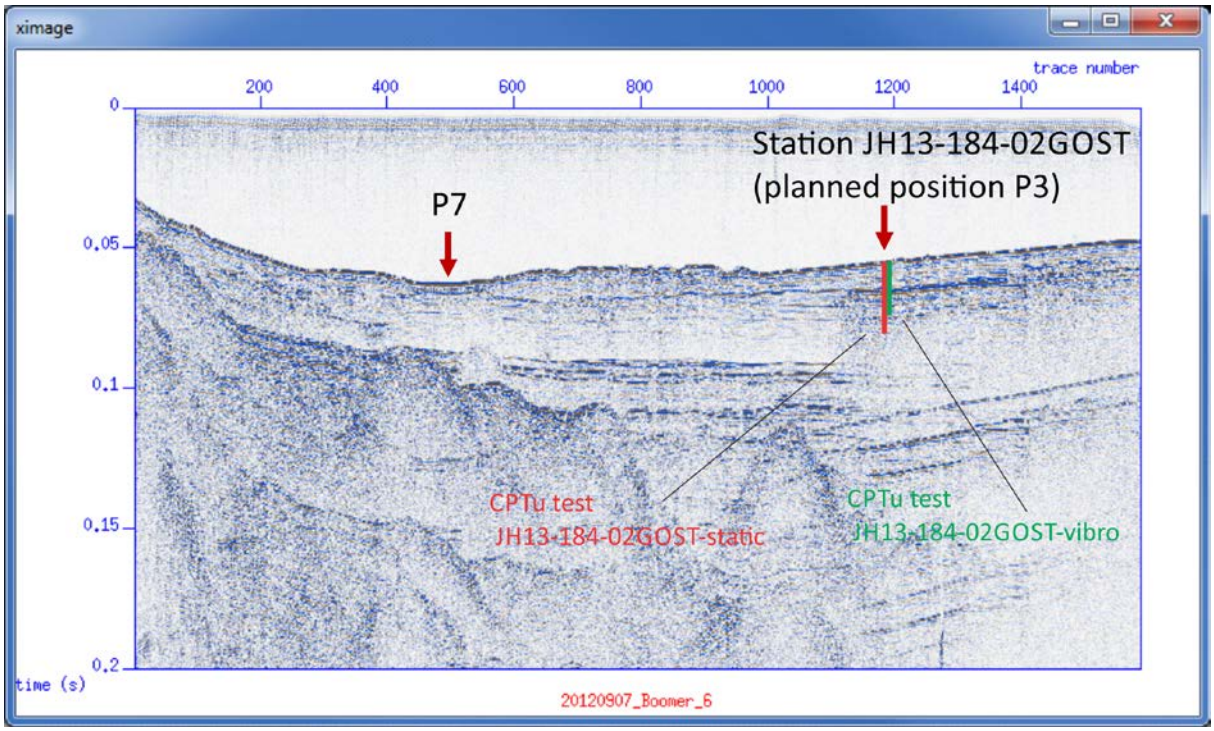

Fig. 19. Boomer profile from Sørfjorden where location of station JH13-184-02GOST is indicated together with the penetration depths of CPTu tests JH13-184-02GOST-static (red)(20.25m) and JH13-184-02GOST-vibro (green)(15m), assuming a sound velocity of 1600 m/s. Planned position P7 is also marked.

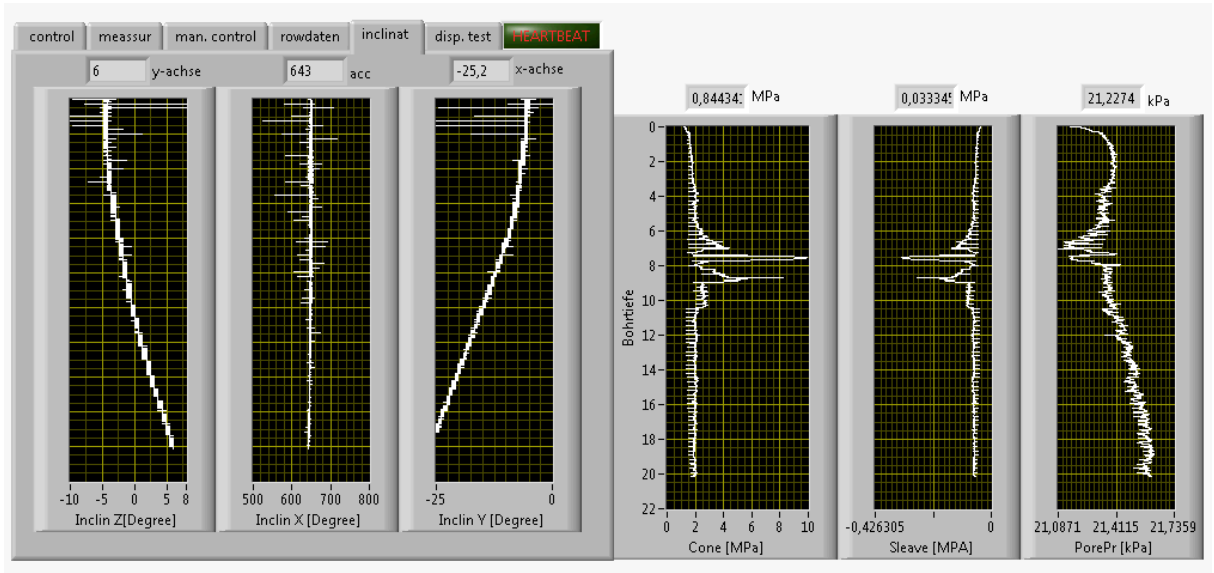

Fig. 20. Screenshot of unprocessed data from CPTu test JH13-184-02GOST-static as displayed on the control panel.

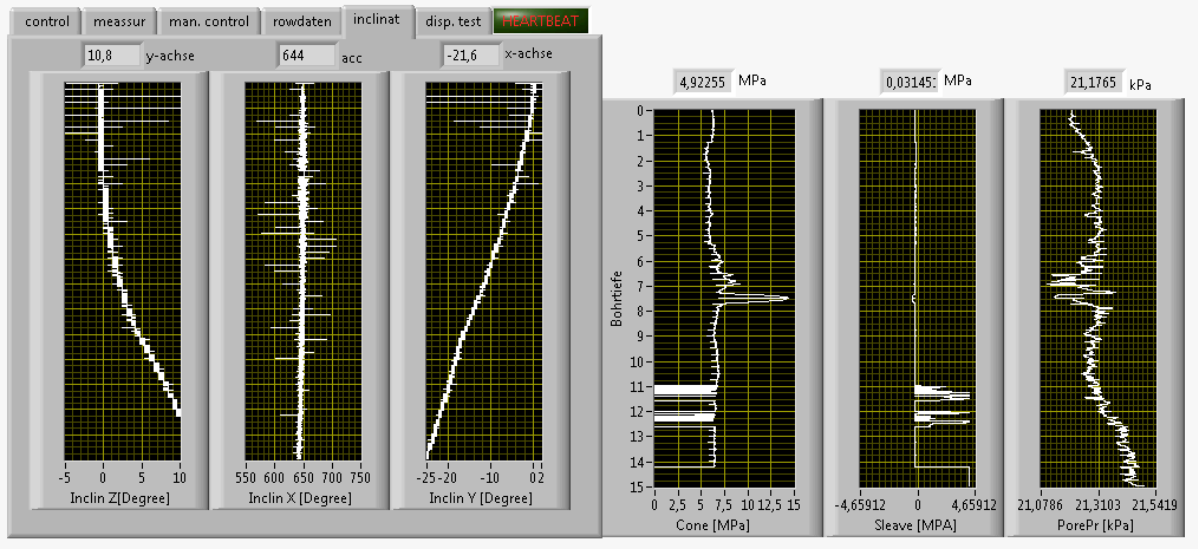

Fig. 21. Screenshot of unprocessed data from CPTu test JH13-184-02GOST-vibro as displayed on the control panel

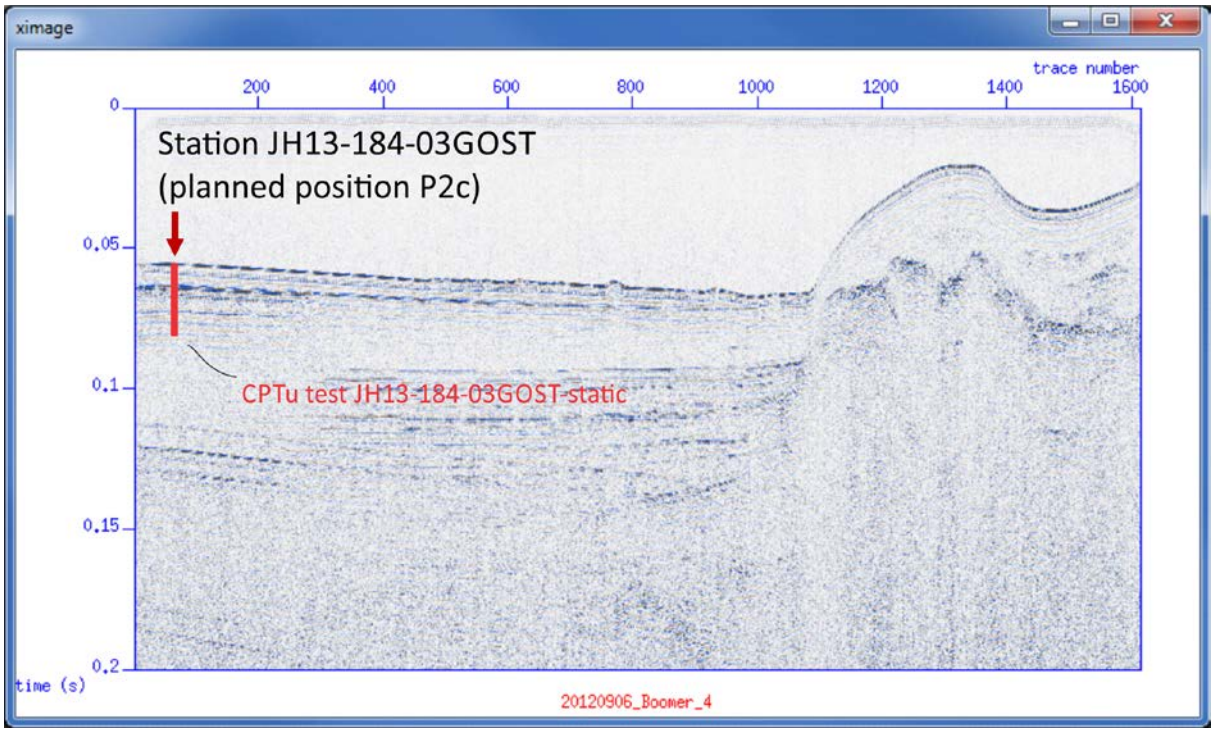

Fig. 22. Boomer profile from Sørfjorden where location of station JH13-184-03GOST is together with the penetration depth (20m) of CPTu test JH13-184-03GOST-static (red) assuming a sound velocity of 1600 m/s.

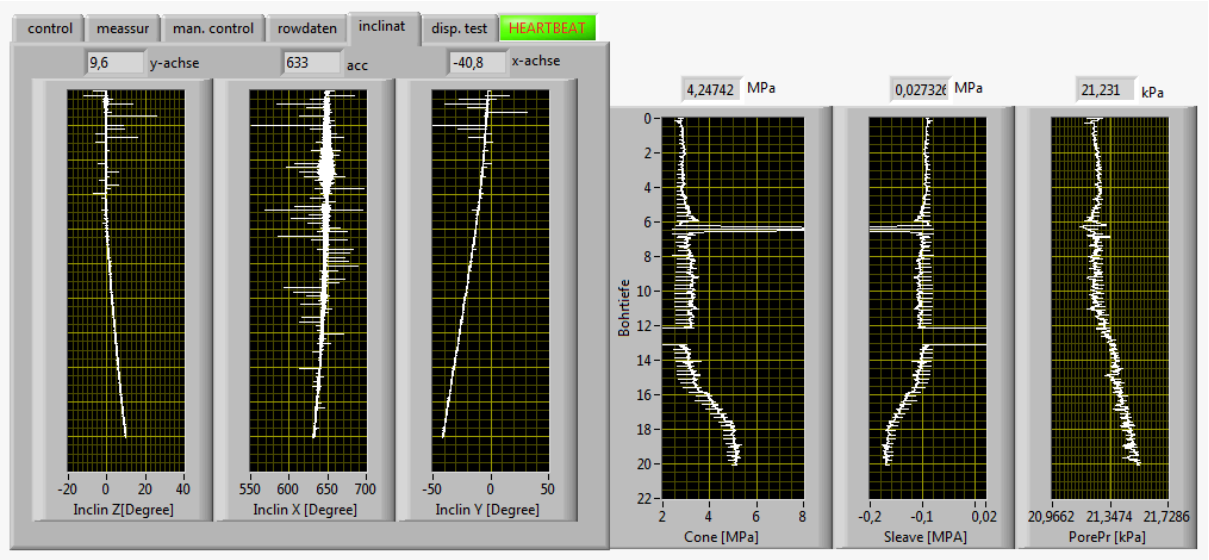

Fig. 23. Screenshot of unprocessed data from CPTu test JH13-184-03GOST-static as displayed on the control panel

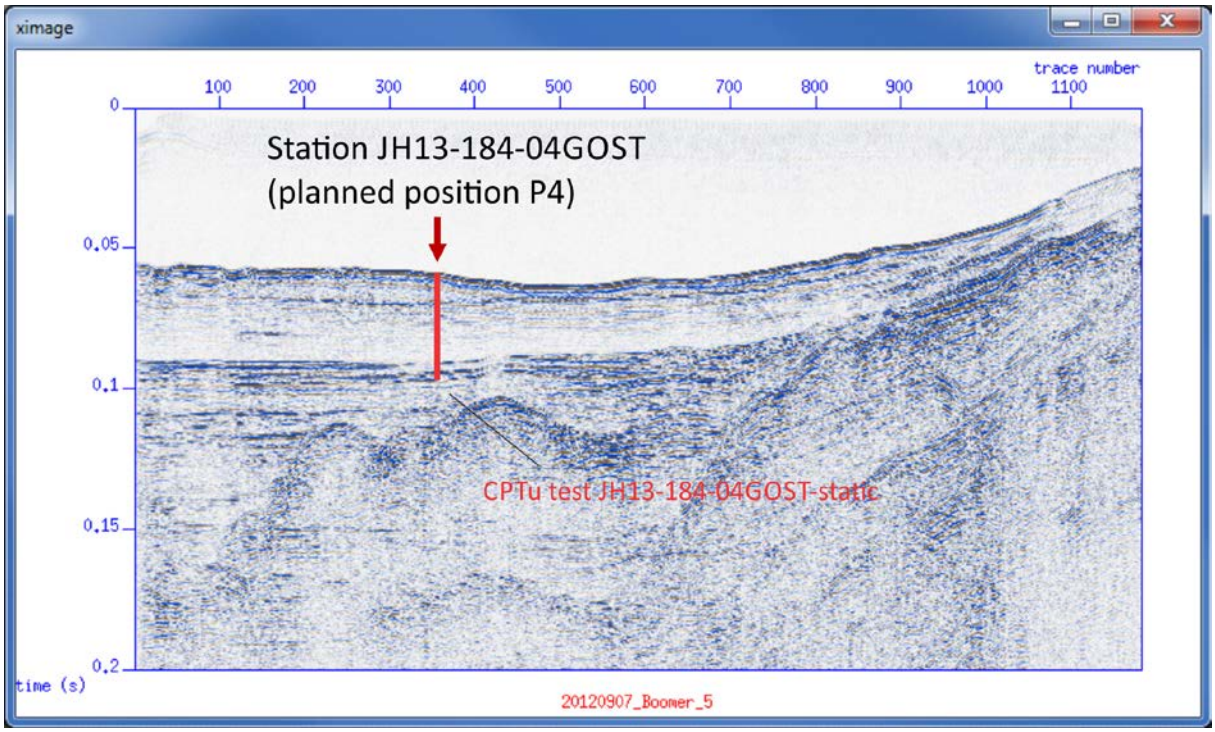

Fig. 24. Boomer profile from Sørfjorden where location of station JH13-184-04GOST is indicated together with the penetration depth (30.25m) of CPTu test JH13-184-04GOST-static (red) assuming a sound velocity of 1600 m/s.

Table I	General Survey log Cruise JH-13-184	
Date	**Time/Julian Day UTC**	**Subject**
19.11.2013	07:00/323	Start mobilisation, Bodø
19.11.2013	07:00/323	Meeting with the captain and crew for discussing the details in the operation
19.11.2013	08:45/323	Moving ship to Rapp Hydema for welding of tension winch and outboard gangway
19.11.2013	19:57/323	End Mobilisation
19.11.2013	19:57/323	Departure Bodø
20.11.2013	06:00/324	Arrival Sørfjorden, at Station JH13-184-01GOST, Testing and preparing for launching
20.11.2013	08:53/324	Launching the GOST
20.11.2013	11:05/324	GOST deployed at seafloor, Start static mode CPTu test (JH13-184-01GOST-static)
20.11.2013	11:54/324	End test at Station JH13-184-01GOST (17 m penetration), probe lost in hard layer
20.11.2013	11:54/324	Start pulling up rod and recovering the GOST
20.11.2013	14:24/324	GOST recovered on deck
20.11.2013	14:24/324	Repairing equipment and preparing for transit to station JH13-184-02GOST
21.11.2013	08:25/325	Launching the GOST at station JH13-184-02GOST
21.11.2013	09:50/325	GOST deployed at seafloor, Start static mode test (JH13-184-02GOST-static)
21.11.2013	10:45/325	End static mode test at Station JH13-184-02GOST (20,25 m penetration), pulling rod up
21.11.2013	11:30/325	Probe at sediment surface, lifting and lowering the GOST, preparing for vibro test
21.11.2013	11:30/325	Starting vibro mode test, stop at 15 m, pulling up rod.
21.11.2013	12:42/325	Probe at sediment surface, lifting GOST 8 m, preparing for transit to new station
21.11.2013	13:40/325	On position, deployment at Station JH13-184-03GOST, static mode CPTu test starts
21.11.2013	14:20/325	End test at Station JH13-184-03GOST (20 m penetration), pulling up rod
21.11.2013	15:05/325	Probe at sediment surface, lifting GOST, preparing for transit to new station
21.11.2013	15:22/325	Leaving station, transit to next station
21.11.2013	16:30/325	In position at station JH13-184-04GOST, deploying GOST to sea-floor
21.11.2013	16:49/325	GOST deployed on seafloor, static CPTu test starts
21.11.2013	16:54/325	Malfunction of tip and sleeve sensors, test stopped, pulling up rod
21.11.2013	17:16/325	Probe at sediment surface, restart of probe unsuccesful, GOST has to be recovered
21.11.2013	18:41/325	GOST recovered on deck, repair of system
22.11.2013	04:00/326	Start preparing GOST for deployment
22.11.2013	08:03/326	Launching GOST, lost contact with probe during deloyment, had to be recovered
22.11.2013	10:00/326	GOST recovered on deck, repair of system
22.11.2013	12:00/326	Launching GOST
22.11.2013	13:37/326	GOST deployed on seafloor, static CPTu test starts
22.11.2013	15:00/326	Static test stops at 30,25 m penetration, pulling up rod.
22.11.2013	18:30/326	GOST recovered on deck, preparing for departure Sørfjorden
22.11.2013	20:00/326	Departure Sørfjorden - transit to Bergen
24.11.2013	19:00/328	Arrival Bergen
25.11.2013	07:00/329	Starting demobilisation
25.11.2013	11:00/329	Demobilisation completed

Table II	**Sampling Stations Log** **Cruise JH-13-184**				
Date	Time/ Julian Day UTC	Subject	Water depth m	Geographical coordinates (WGS 84; Zone 33) Latitude **(N)**	 Longitude **(E)**
20.11.2013	08:53/324	Launching the GOST at Station JH13-184-01GOST	46	66° 10.889	13° 46.813
20.11.2013	11:05/324	GOST deployed at seafloor, Start static mode CPTu test (JH13-184-01GOST-static)			
20.11.2013	11:54/324	End test at Station JH13-184-01GOST (17 m penetration), probe lost			
20.11.2013	11:54/324	Start pulling up rod and recovering the GOST			
20.11.2013	14:24/324	GOST recovered on deck			
21.11.2013	08:25/325	Launching the GOST at station JH13-184-02GOST	39	66° 10.627	13° 47.478
21.11.2013	09:50/325	GOST deployed at seafloor, Start static mode CPTu test (JH13-184-02GOST-static)			
21.11.2013	10:45/325	End static mode test (20,25 m penetration), pulling rod up			
21.11.2013	11:30/325	Probe at sediment surface, lifting and lowering the GOST, preparing for vibro test			
21.11.2013	11:30/325	Starting vibro mode CPTu test at station JH13-184-02GOST (JH13-184-02GOST-vibro), stop at 15 m, pulling up rod.	39	66° 10.627	13° 47.478
21.11.2013	12:42/325	Probe at sediment surface, lifting GOST 8 m, preparing for transit to new station			
21.11.2013	13:40/325	On position, deployment at Station JH13-184-03GOST, static mode test CPTu starts (JH13-184-03GOST-static)	39	66° 10.466	13° 47.426
21.11.2013	14:20/325	End test at Station JH13-184-03GOST (20 m penetration), pulling up rod			
21.11.2013	15:05/325	Probe at sediment surface, lifting GOST, preparing for transit to new station			
22.11.2013	12:00/326	Launching GOST at station JH13-184-04GOST	43	66° 10.858	13° 46.976
22.11.2013	13:37/326	GOST deployed on seafloor, static CPTu test starts (JH13-184-04GOST-static)			
22.11.2013	15:00/326	Static test stops at 30,25 m penetration, pulling up rod.			
22.11.2013	18:30/326	GOST recovered on deck			