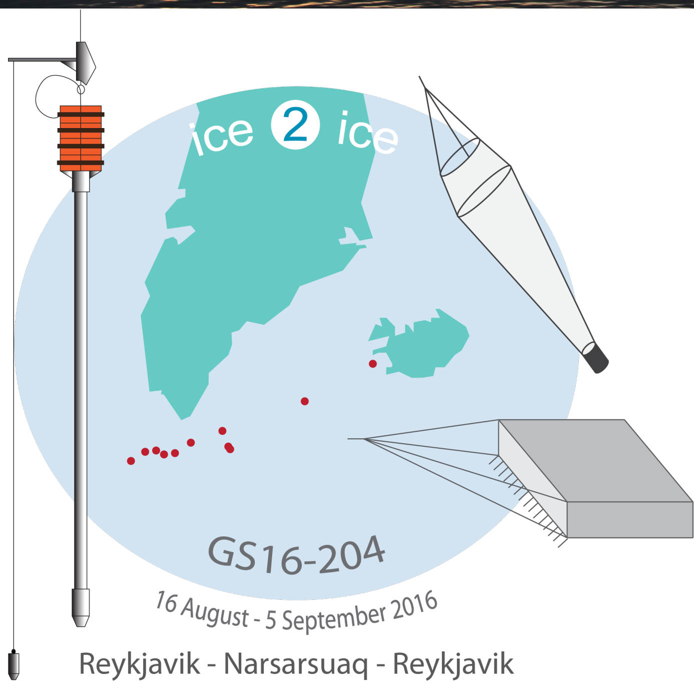
Ice2Ice Cruise GS16-204

16. Aug. to 5. Sept. 2016

Cruise report



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1. List of participants

Scientific crew

Berben, Sarah	Scientist	Belgian	University of Bergen, Norway
Blindheim, Dag-Inge	Technician	Norwegian	UNI Research Climate, Norway
Cook, Eliza	Scientist	British	University of Copenhagen, Denmark
DeFleurian, Basile	Scientist	French	University of Bergen, Norway
Dokken, Trond	Cruise leader	Norwegian	UNI Research Climate, Norway
Geng, Marilena	Student	German	Danish Meteorological Institute
Gkinis, Vasileios	Scientist	Greek	University of Copenhagen, Denmark
Griem, Lisa	PhD student	German	University of Bergen, Norway
Loose, Nora	PhD student	German	University of Bergen, Norway
Melvik, Vilde	Student	Norwegian	University of Bergen, Norway
Monsen, Stig	Technician	Norwegian	University of Bergen, Norway
Olsen, Ida Synnøve	Scientist	Norwegian	University of Bergen, Norway
Sadatzki, Henrik	PhD student	German	University of Bergen, Norway
Simon, Margit	Scientist	German	UNI Research Climate, Norway
Strømsøe, Jørund	Co-cruise leader	Norwegian	UNI Research Climate, Norway
Tisserand, Amandine	Scientist	French	UNI Research Climate, Norway
Vallelonga, Paul	Scientist	Australian	University of Copenhagen, Denmark
Vinther, Bo	Scientist	Danish	University of Copenhagen, Denmark

Kley France

Albert, Charly	Technician	French	Kley France, France
Aubry, Remy	Technician	French	Kley France, France
Le Clainche, Remy	Technician	French	Kley France, France

IMR Instrument technicians

Steinsland, Asgeir	Technician	Norwegian	Institute of Marine Research, Norway
Sudmann, Åse Nina	Technician	Norwegian	Institute of Marine Research, Norway

IMR Ship Crew

Aasen, Marius	Trainee	Norwegian	Institute of Marine Research, Norway
Brattholmen, Karl Tore	Catering assistant	Norwegian	Institute of Marine Research, Norway
Dahl, Helge Olav	Netman	Norwegian	Institute of Marine Research, Norway
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Grønnevik, Sigmund	1. Engineer	Norwegian	Institute of Marine Research, Norway
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Midttveit, Gunnleiv	1. Officer	Norwegian	Institute of Marine Research, Norway
Møvik, Terje	Electrician	Norwegian	Institute of Marine Research, Norway
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Nordbø Henriksen, Julie K.	Catering assistant	Norwegian	Institute of Marine Research, Norway
Olsen, Roy Helge	Netman	Norwegian	Institute of Marine Research, Norway
Simonsen, Svein Are	Trawlmaster	Norwegian	Institute of Marine Research, Norway
Strømmen, Odd Idar	A.B.	Norwegian	Institute of Marine Research, Norway
Troland, Hans Sangolt	Chief officer	Norwegian	Institute of Marine Research, Norway
Tysnes, Hans-Petter	Steward	Norwegian	Institute of Marine Research, Norway
Veivåg, Kjetil	A.B.	Norwegian	Institute of Marine Research, Norway
Vindenes, Preben	Captain	Norwegian	Institute of Marine Research, Norway

Picture of the science crew onboard- left to right: Nora Loose, Vasileios Gkinis, Trond Dokken, Margit Simon, Basile deFleurian, Amandine Tisserand, Ida Synnøve Olsen, Sarah Berben, Marilena Geng, Lisa Griem, Eliza Cook, Vilde Melik, Jørund Strømsøe, Henrik Sadatzki, Stig Monsen, Dag-Inge Blindheim. Front raw left-right: Bo Vinther, Paul Vallelonga.

Acknowledgements:

We are very grateful for the help and service given by Captain Preben Vindenes and the crew on the ship. The technicians, Åse Sudmann and Asgeir Steinsland from the Institute of Marine Research, provided help on the coring system and the acoustics, respectively. Big thanks to both for their flexibility and insight, which were absolutely crucial for the success of our operations. Thanks to ERC for funding the Ice2Ice project which enable the whole operation.

Reykjavik, 04.09.16
Trond Dokken and Jørund Raukleiv Strømsøe

2. Ice2Ice project overview

The cryosphere is in fast transition. The possibility that the ongoing rapid demise of Arctic sea ice may instigate abrupt changes on the Greenland Ice Sheet (GIS) is, however, not tackled by current research. Ice cores from the GIS show clear evidence of past abrupt warm events with up to 15 degrees warming in less than a decade, most likely triggered by rapid disappearance of Nordic Seas sea ice. Is the dramatic decline in Arctic Sea Ice heralding a new phase of abrupt change, similar to those recorded in ocean sediments and ice cores? Such changes would have major consequences for the GIS mass balance and global climate, including accelerated sea level rise.
Ice2Ice will is the first concerted effort to tackle question of the cause and future implications of past abrupt climate change in Greenland, the main hypothesis being that Arctic and sub-Arctic sea ice cover exerts important controls on past and future Greenland temperature and ice sheet variations.

In Ice2Ice this will be done by:
- describing the nature, timing and extent of abrupt events across climate archives,
- resolving mechanisms behind the sudden demise of sea ice cover,
- identifying the risk that the ongoing rapid diminution of Arctic sea ice cover could give abrupt GIS changes in the future
- determining the impacts of such changes for the GIS and Arctic and global climate

The cruise tackles the first of these objectives, and aims to provide material for detailed investigations of past rapid changes in sea ice cover and ocean circulation from areas off southern Greenland (Fig.1; 2).

3. Background

The Eirik Ridge, situated off Cape Farewell, the southern tip of Greenland [*Hunter et al.*, 2007] is an elongate, mounded sediment drift with a length to width ratio of 2:1. Sediment accumulates rapidly in this area as a result of the influx of sediments eroded from the Denmark Strait and eastern Greenland margin suspended in Denmark Strait Overflow Water (DSOW) and transported by the deep-water flow of the Deep Western Boundary Current (DWBC). It is suggested that during the Mid-Miocene [*Hunter et al.*, 2007] the flow of deep water into the North Atlantic was established as a result of basin formation and rifting of the Labrador and North Atlantic Basins as well as the subsidence of the Greenland –Scotland Ridge.
South of Greenland, when DWBC reaches Cape Farewell, the Coriolis force causes the current to reverse its direction to predominantly flow north into the Labrador Sea along the West Greenland Margin. The loss of velocity associated with the reversal of the bottom current direction results in deposition of the suspended sediment and hence the formation of the Eirik Drift [*McCave and & Tucholke*, 1986].

The Eirik drift area is a key location for monitoring past changes in some of the crucial Atlantic Meridional Overturning Circulation (AMOC) water masses. At depth, the sites lay in the pathway of the DWBC with a dominating signal of DSOW, the Nordic Overflow that flows west of Iceland [*Holliday et al.*, 2009]. Hence North

Atlantic Deep Water /DWBC flow variability can be studied over time (Fig. 2). The surface and intermediate depths are bathed by the Subpolar Mode Waters and Labrador Sea Water with incursions of the Irminger Current and East Greenland Current which allows to monitor the rates of Arctic freshwater export carried in the East Greenland Current (EGC) and the East Greenland Coastal Current. Moreover, being located in the northern Subpolar Gyre (SPG) the location is ideal monitoring surface water variability in the latter one in conjunction with changes observed in the Nordic Sea inflow.

4. Cruise objectives and activities

4.1. Objectives of coring operations

In order to investigate the history of the DWBC and the SPG dynamics during Dansgaard–Oeschger events (D/O) within Marine Isotope Stage 3 in the northern North Atlantic, the G.O. Sars visited sites at the Eirik Drift during this expedition. The recovered sediment archives aim to document changes in ocean circulation and sea ice cover at times of abrupt changes.
Surface waters reaching the southern tip of Greenland constitute the western branch of the SPG. Changes in its strength influence the properties, structure and volume transport of the surface circulation in the North Atlantic [*Hátún et al.*, 2005] and hence the NAC inflow behaviour in the Nordic Seas. Material collected in the western Nordic Seas during the Ice2Ice cruise 2015 was aiming to document sea-ice variability and ocean-circulation changes during D/O events in relation to changes in the GIS temperatures. In combination with material collected this year we aim to understand when deep-water formation re-occurred in comparison to the observed sea-ice cover decline/ subsurface water masses changes in the Nordic Seas during D/O events. Moreover, these sites will additionally give insights about when and how the northern North Atlantic was influenced by freshwater discharges coming of the GIS after abrupt warming during D/O interstadials. Freshening of surface water masses within the SPG will have had consequences, among others, for Labrador Sea deep-water formation.

4.2 Objectives of shell dredging at Flaxaflói and Jökulbanki

The aim of the dredging was to collect live-collected and dead, sub-fossil, specimens of bivalves that can be used for chronology building. The primary target for the dredging was the long-lived species *Arctica islandica* (L.). Until recently, the species *A. islandica* has been a commercially interesting species fished for export around Iceland. Today, commercial fishing of this species is only done on the north-eastern shelf of Iceland.

4.3 Cruise activities

The ship left Reykjavik harbour on Tuesday August 17th at 5pm (UCT) after bringing on-board the coring systems and the associated supplies. The departure was delayed by one day due to the installation procedure of the refurbished Calypso™ piston corer winch system.

After leaving the port, scientific operations started approximately 45 min thereafter on the Faxafloi area northwest of Reykjavik where an extensive 12 hour program of dredging was performed. Known stations from the previous Ice2Ice cruise in 2015 (GS15-198) were revisited as well new stations in the area were performed (**station 1-14**) (Fig. 2).

The dredging started in a relatively shallow area (40-45 meters water depth) of Flaxaflói where both living and sub-fossil specimens were collected from this shallow location. A deeper location was re-dredged, an area which in 2015 also proved to be inhabited by the *A. islandica.* These stations were all located at approximately 100 meters' depth. Live-collected and sub-fossil specimens were retrieved from these deeper areas as well, and these will supplement those specimens dredged in the same area during GS15-198. There appears to be a gap in the distribution through time (i.e. geological age) at the deepest locations compared to the shallower locations. Dredging was also performed at deeper water depths (145-170 meters) of Jökulbanki, aiming to locate specimens even further into North Atlantic waters. No specimens, either live-collected or sub-fossil, where found at these depths. Thereafter the vessel started the transit to the first proposed coring station on the 18th of August.

The first **C**onductivity, **T**emperature, and **D**epth measurement (CTD) (Number (NB): 566; **station 15**) was taken for calibration purposes on the 19th of August at a water depth of 131 m off southwest Island at 64°24,72 N/22°32,80 W. One water sample from the ocean bottom was taken. A full CTD (NB: 567; **station 16**) was taken on the same day at 62°26,09 N/32°14,87 W at 2970 m water depth with ten depth intervals sampled for stable oxygen (O) and three for stable carbon isotopes (C). Testing of the winch system continued throughout all stations. On the 20th of August at **station 17**; southeast Greenland margin; another CTD (NB: 568) was taken with a water depth of 2785 m at 59°42,92 N/39°30,28 W with eleven water samples for O and three for C isotopes. Topas surveying was started on the 20th of August in order to evaluate the sediment properties on the sea floor for coring purposes (Fig.1).

On the 21st of August 2016 at 2220 m water depth operation started at **station 18** at 60°01,84 N/40°33,45 W with taking a set of two multicores which failed. Thereafter a gravity core (GC) was lowered and a total recovery of 228 cm of sediment was made. A CTD (NB: 569) was taken with a total of twelve samples for O and four C isotopes. A calypso core (CC) was taken at this station with a full recovery of 1861 cm.
Same day **station 19 at** 59°48,86 N/39°47,92 W and 2675 m water depth a full set of four multicores were taken with a recovery up to 36 cm. Thereafter a GC was taken with a recovery of 316.5 cm (3 sections). A CTD (NB: 570) with eleven O and three C samples was taken. A CC followed these operations with a full recovery of 2008,5cm.

On 23rd of August **station 20** was reached at 58° 57,02 N/44° 33,36 W with 2004 m water depth. A CTD (NB:571) was taken with eleven samples for O and two C isotopes. A GC was lowered and only had 33.5 cm recovery due to a opened core catcher loosing the remaining sediment. A CC was taken and only revealed 925 cm of sediment as a big dropstone was hit and blocked the tube.

On the 24th of August transit to Narsarsuaq, SW Greeland, was made to drop off parts of the Kley France crew. Thereafter the vessel moved towards the Eirik Ridge area. Due to a storm in the area the arrival was delayed. Topas recording was started on the 25th of August at and continued throughout the night.
Operation on **station 21** at 57° 42, 70 N/ 48° 00,69 W started the 26th of August 2016 at 3335 m water depth with taking a CTD (NB: 572) with twelve samples for O and three samples for C isotopes. Two GCs were taken, however returned on the surface broken and hence without sediment recovery. Thereafter a CC was successfully taken with a recovery of 1964 cm. Operations continued with the recovery of 4 multicores of a length between 30- 31 cm. At the end of the day into the morning of the 27th of August 2016 a plankton net was taken at 400, 200, 100 and 50 m water depth.

The transit continued on the 27th of August 2016 recording Topas on selected lines (Fig. 2). However strong winds in the area prevented from any coring operations on that day. On the 28th of August **station 22** at 58° 02,83 N/47° 02,36 W with 3160 m water depth was reached and operations started with a CTD (NB:573) where 11 samples were taken for O and three for C isotope analysis. Two CCs with 1974 cm and 1955,5 cm recovery respectively were taken. One GC core recovered 332,5 cm of sediment at this station and operations ended with a complete set of multicores up to 42 cm recovery. Topas operations were started after completion of the coring and continued into the morning of the 29th of August.
The vessel arrived at **station 23** at 58° 76.13 N/ 45° 41.87 W at 2270 m water depth and coring operation started with a CC on the 29th of August 2016. Two GCs with 318 and 320 cm recovery respectively were taken at that station and one multicore. Operations ended with CTD (NB:574) operations taking twelve O and three C isotope samples.
The night to the 30th of August 2016 was used for Topas operations. **Station 24** was reached in the morning of the 30th of August at 58° 36,21 N/ 46° 22,77 W and 2540 m water depth. Operations started with taking a complete set of multicores between 35.5 and 37.5 cm length. A GC, 338,5 cm recovery and CC, 2042 cm recovery, were taken thereafter. Operations on that station ended with taking CTD (NB:575) with eleven samples taken for O and three samples taken for C isotope analysis. From that station the vessel continued on surveying Topas throughout the night.
On the 31st of August the vessel reached **station 25** at 58° 13, 29 N/ 45° 31,56 W with a water depth of 2274 m. A GC, 315 cm recovery and a CC, 1970,5 cm recovery were taken. The vessel started the transit back to Island when operations finished in the evening. On the 1st of September 2016 a plankton net was taken at **station 26** at 59° 13,95 N/ 43° 02.87 W. The upper water column was samples for plankton samples at 400, 200, 100 and 50 m water depth.
The vessel continued thereafter with the transit back to Island with arrival in Reykjavik the 4th of September 2016.

5. Area of operation

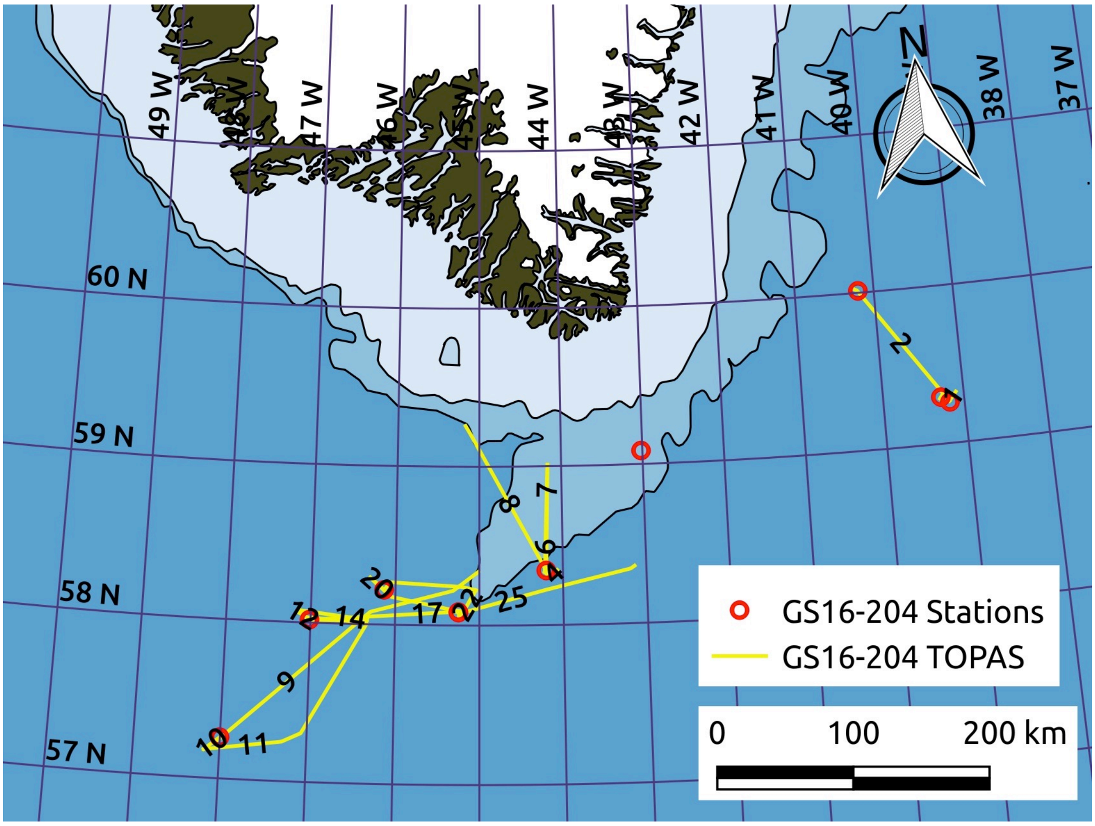


Figure 1: *Map showing Topas transits acquired during the cruise. GS16-204 core stations are indicated as red open circles.*

5.1 Topas lines

Survey log										
See map	File name	Date	Time (UTC)		Area	Start of line		End of line		Direction
Line #			Start of line	End of line		Latitude (N)	Longitude (W)	Latitude (N)	Longitude (W)	
1	20160820173204	20-Aug-16	17:32	18:40	SE Greenland	59° 53,14	39° 16,39	59° 44,11	39° 31,16	SW/220°
2	20160820202858_000	20-Aug-16	20:28	01:58 (21.08)	SE Greenland	59° 44,02	39° 31,34	60° 02,32	40° 35,31	NW/310°
	20160821020000_001	21-Aug-16	02:00	02:48	SE Greenland	60° 02,36	40° 35,47	60° 04,81	40° 44,86	NW/310°
3	20160821230402	21-Aug-16	23:04	23:43	Eirik Drift	59° 50,87	39° 45,08	59° 47,39	39° 50,10	SW/220°
4	20160823052410	23-Aug-16	05:24	06:43	Eirik Drift	58° 57,30	44° 11,53	58° 50,17	44° 26,54	SW/231°
5	20160823064311	23-Aug-16	06:43	07:37	Eirik Drift	58° 50,20	44° 26,59	58° 55,34	44° 36,44	NNW/315°
6	20160823073841	23-Aug-16	07:38	09:00	Eirik Drift	58° 55,51	44° 36,42	59° 01,36	44° 28,11	NE/49°
7	20160823090030	23-Aug-16	09:00	11:15	Eirik Drift	59° 01,33	44° 28,17	58° 57,01	44° 33,36	SW/230°
8	20160823201628_000	23-Aug-16	20:16	23:44	Toward Narsasuaq	58° 57,78	44° 34,12	59° 32,69	45° 16,91	NW/330°
	20160823234415_001	23-Aug-16	23:44	00:43 (24.08)	Toward Narsasuaq	59° 32,75	45° 16,98	59° 42,64	45° 28,49	NW/330°
9	20160825134453_000	25-Aug-16	13:44	18:16	Eirik Drift	58° 56,15	45° 01,89	58° 36,10	45° 52,25	SW/212°
	20160825181650_001	25-Aug-16	18:16	23:06	Eirik Drift	58° 36,05	45° 52,38	58° 12,91	46° 49,28	SW/212°
	20160825230601_002	25-Aug-16	23:06	05:35 (26.08)	Eirik Drift	58° 12,83	46° 49,48	57° 39,59	48° 07,83	SW/212°
	20160826053531_003	26-Aug-16	05:35	05:58	Eirik Drift	57° 39,58	48° 07,84	57° 37,65	48° 12,21	SW/212°
10	20160827021617	27-Aug-16	02:16	04:55	Eirik Drift	57° 41,81	48° 02,31	57° 29,49	48° 30,10	SW/230°
11	20160827045544_000	27-Aug-16	04:55	09:15	Eirik Drift	57° 29,50	48° 30,07	57° 40,98	47° 48,23	NE/65°
	20160827091524_001	27-Aug-16	09:15	13:35	Eirik Drift	57° 40,99	47° 48,23	57° 50,50	47° 11,75	NE/65°
	20160827133504_002	27-Aug-16	13:35	17:45	Eirik Drift	57° 50,50	47° 11,75	58° 01,43	46° 54,87	NE/65°
	20160827174556_003	27-Aug-16	17:45	19:22	Eirik Drift	58° 01,43	46° 54,88	58° 05,20	47° 07,74	NE/65°
12	20160827200125	27-Aug-16	20:01	22:02	Eirik Drift	58° 05,31	47° 08,17	58° 10,37	47° 24,97	NW/290°
13	20160827220238	27-Aug-16	22:02	22:45	Eirik Drift	58° 10,39	47° 24,95	58° 12,40	47° 21,89	NE/41°
14	20160827224602	27-Aug-16	22:46	02:31 (28.08)	Eirik Drift	58° 12,39	47° 21,87	58° 04,35	46° 55,46	SE/104°
15	20160828023301	28-Aug-16	02:33	03:10	Eirik Drift	58° 04,30	46° 55,44	58° 02,35	47° 00,68	SW/229°
16	20160828031156	28-Aug-16	03:11	04:51	Eirik Drift	58° 02,38	47° 00,95	58° 04,97	47° 07,98	NW/308°

Survey log

See map	File name	Date	Time (UTC)		Area	Start of line		End of line		Direction
Line #			Start of line	End of line		Latitude (N)	Longitude (W)	Latitude (N)	Longitude (W)	
17	20160829023717_000	29-Aug-16	02:37	06:30	Eirik Drift	58° 03,01	47° 00,02	58° 09,34	46° 13,67	NE/72°
	20160829063055_001	29-Aug-16	06:30	09:31	Eirik Drift	58° 09,34	46° 13,67	58° 14,35	45° 37,95	NE/72°
18	20160829225849	29-Aug-16	22:58	23:08	Eirik Drift	58° 13,96	45° 40,47	58° 14,33	45° 38,84	NE/74°
19	20160829230840_000	29-Aug-16	23:08	02:10 (30.08)	Eirik Drift	58° 14,34	45° 38,85	58° 28,98	46° 08,43	NW/315°
	20160830021027_001	30-Aug-16	02:10	05:12	Eirik Drift	58° 28,98	46° 08,44	58° 42,77	46° 38,35	NW/315°
	20160830051213_002	30-Aug-16	05:12	06:34	Eirik Drift	58° 42,78	46° 38,36	58° 48,56	46° 50,86	NW/315°
20	20160830063947	30-Aug-16	06:39	09:00	Eirik Drift	58° 48,86	46° 50,77	58° 36,21	46° 22,76	SE/108°
21	20160830200945_000	30-Aug-16	20:09	23:11	Eirik Drift	58° 36,25	46° 22,75	58° 44,29	46° 10,35	NW/329°
	20160830231131_001	30-Aug-16	23:11	02:13 (31.08)	Eirik Drift	58° 44,29	46° 10,35	58° 40,19	45° 34,65	NW/329°
	20160831021317_002	31-Aug-16	02:13	04:37	Eirik Drift	58° 40,19	45° 34,64	58° 36,77	45° 07,36	NW/329°
22	20160831043736_000	31-Aug-16	04:37	08:57	Eirik Drift	58° 36,74	45° 07,35	58° 16,68	45° 29,14	SSW/200°
	20160831085716_001	31-Aug-16	08:57	11:21	Eirik Drift	58° 16,67	45° 29,14	58° 06,03	45° 40,04	SSW/200°
23	20160831112652	31-Aug-16	11:26	12:32	Eirik Drift	58° 06,55	45° 40,17	58° 15,00	45° 41,60	NW/355°
24	20160831123332	31-Aug-16	12:33	13:15	Eirik Drift	58° 14,98	45° 41,45	58° 13,32	45° 32,40	SE/112°
25	20160831202932_000	31-Aug-16	20:29	00:49 (01.09)	Eirik Drift	58° 13,28	45° 32,42	58° 36,93	44° 33,14	NE/53°
	20160901004912_001	01-Sep-16	00:49	04:41	Eirik Drift	58° 36,93	44° 33,13	58° 57,12	43° 31,63	NE/53°
	20160901044151_002	01-Sep-16	04:41	05:12	Eirik Drift	58° 57,13	43° 31,63	58° 59,91	43° 23,63	NE/53°

5.2 Station list

GS16-204- Ice2ice		Station report							
Station	Area	Date	Time (UTC)	Water depth (m)	Latitude (N)	Longitude (W)	Device	Recovered length (cm)	Remarks
1	SW Iceland	17/08/16	18:26	44	64° 12,78	22° 49,90	Dredge		Collecting *A. islandica*
2	SW Iceland	17/08/16	19:12	44	64° 12,90	22° 49,31	Dredge		Collecting *A. islandica*
3	SW Iceland	17/08/16	19:39	44	64° 12,95	22° 49,12	Dredge		Collecting *A. islandica*
4	SW Iceland	17/08/16	22:44	102	64° 21,95	22° 54,25	Dredge		Collecting *A. islandica*
5	SW Iceland	18/08/16	23:14	100	64° 21,98	22° 51,87	Dredge		Collecting *A. islandica*
6	SW Iceland	18/08/16	00:14	100	64° 22,00	22° 51,86	Dredge		Collecting *A. islandica*
7	SW Iceland	18/08/16	01:11	102	64° 21,95	22° 54,24	Dredge		Collecting *A. islandica*
8	SW Iceland	18/08/16	01:44	101	64° 21,97	22° 52,69	Dredge		Collecting *A. islandica*
9	SW Iceland	18/08/16	02:20	98	64° 21,40	22° 52,00	Dredge		Collecting *A. islandica*
10	SW Iceland	18/08/16	02:52	101	64° 21,91	22° 52,66	Dredge		Collecting *A. islandica*
11	SW Iceland	18/08/16	06:42	168	64° 29,28	22° 39,16	Dredge		Collecting *A. islandica*
12	SW Iceland	18/08/16	07:03	148	64° 29,01	22° 38,38	Dredge		Collecting *A. islandica*
13	SW Iceland	18/08/16	07:20	149	64° 28,56	22° 38,70	Dredge		Collecting *A. islandica*
14	SW Iceland	18/08/16	08:10	146	64° 25,62	22° 33,53	Dredge		Collecting *A. islandica*
15	SW Iceland	18/08/16	08:38	131	64° 24,72	22° 32,80	CTD		CTD 566
16	Irminger basin	19/08/16	09:53	2970	62° 26,09	32° 14,87	CTD		CTD 567
17	SE Greenland margin	20/08/16	18:44	2785	59° 42,92	39° 30,28	CTD		CTD 568
18	SE Greenland margin	21/08/16	02:45	2220	60° 01,84	40° 33,45	MC	0.0	No sediment i Multicorer (two times)
							CTD		CTD 569
							GC	228.0	Penetration till c. 2,5m - good recovery
							CC	1861.0	Full penetration, corer head full of sediment
19	SE Greenland margin	22/08/16	11:00	2675	59° 48,86	39° 47,92	MC	36.0	A: 36cm, B: 36cm, C: 36cm, D: 35,5cm
							GC	316.5	3,5 m barrel, 3 sections
							CC	2008.5	14 sections
							CTD		CTD 570
20	Eirik Drift	23/08/16	13:30	2004	58° 57,02	44° 33,36	CTD		CTD 571
							GC	33.5	Short section, slid out
							CC	925.0	Stone filling the barrel
21	Eirik Drift	26/08/16	05:30	3335	57° 42,70	48° 00,69	CTD		CTD 572
							GC	0.0	4,5 m core barrel broken
							CC	1964.0	14 sections
							GC	0.0	3,5 m barrel intact, corecatcher lost (nails cut off).
							PN		Plankton net: 400m, 200m, 100m, 50m
							MC	31.0	A: 31cm, B: 30cm, C: 30,5cm, D: 30cm
22	Eirik Drift	28/08/16	06:06	3160	58° 02,83	47° 02,36	CTD		CTD 573
							CC-A	1974.0	14 sections
							GC	332.5	3,5 m barrel, 3 sections
							CC-B	1955.5	Core for DNA analysis
							MC	42.0	A: 41cm, B: 42cm, C: 42cm, D: 42cm
23	Eirik Drift	29/08/16	10:00	2270	58° 13,76	45° 41,87	CC	1943.0	14 sections
							GC-A	318.0	3,5 m barrel, 3 sections
							GC-B	320.0	for Earth-lab, U. of Bergen, Dept. Of Earth Sci., not splitted.
							MC	33.0	A: 33cm, B: 32cm, C: 32cm, D: 32cm
							CTD		CTD 574
24	Eirik Drift	30/08/16	08:15	2540	58° 36,21	46° 22,77	MC	37.5	A: 37,5cm, B: 37,5cm, C: 37,5cm, D: 36,5cm
							CC	2042.0	14 sections
							GC	338.5	3,5 m barrel, 3 sections
							CTD		CTD 575
25	Eirik Drift	31/08/16	12:30	2274	58° 13,29	45° 31,56	GC	315.0	3,5 m barrel, 3 sections
							CC	1970.5	14 sections
26	Eirik Drift	01/09/16	12:30	n.a	59° 13,95	43° 02,87	PN		Plankton net: 400m, 200m, 100m, 50m

6. Station description

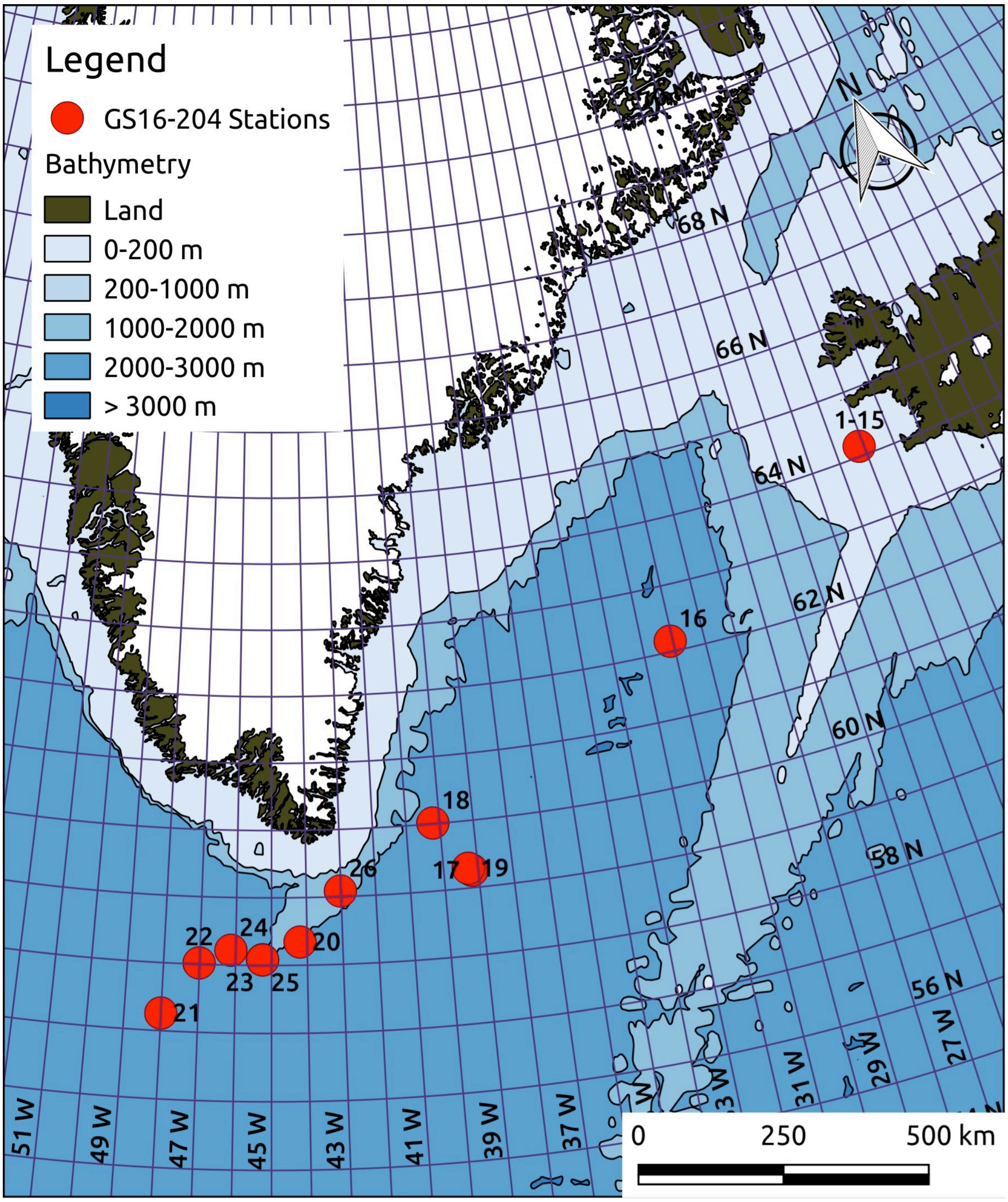


Figure 2: *Map showing the geographical positions of coring stations described beneath.*

Station: GS16-204-1 to 3

Longitude	Latitude	Water depth	Date	Start time
64° 12,78	22° 49,90	44 m	17.08.16	18:26

Device	Remarks
Dredge	Collecting bivalve *Arctica Islandica*

Station: GS16-204-4 to 11

Longitude	Latitude	Water depth	Date	Start time
64° 21,95	22° 54,25	100-102 m	17.08.16	22:44

Device	Remarks
Dredge	Collecting bivalve *Arctica Islandica*

Station: GS16-204-11 to 14

Longitude	Latitude	Water depth	Date	Start time
64° 29,28	22° 39,16	146-168 m	18.08.16	06:42

Device	Remarks
Dredge	Collecting bivalve *Arctica Islandica*

Station: GS16-204-15

Longitude	Latitude	Water depth	Date	Start time
64° 24,72	22° 32,80	131 m	18.08.16	08:38

Device	Remarks
CTD	Water sample taken at bottom. CTD 566.

Station: GS16-204-16

Longitude	Latitude	Water depth	Date	Start time
62° 26,09	32° 14,87	2970m	19.08.16	09:55

Device	Remarks
CTD	Water samples taken (see report below). CTD 567

CTD (Temperature, Salinity, Oxygen, Density profile)

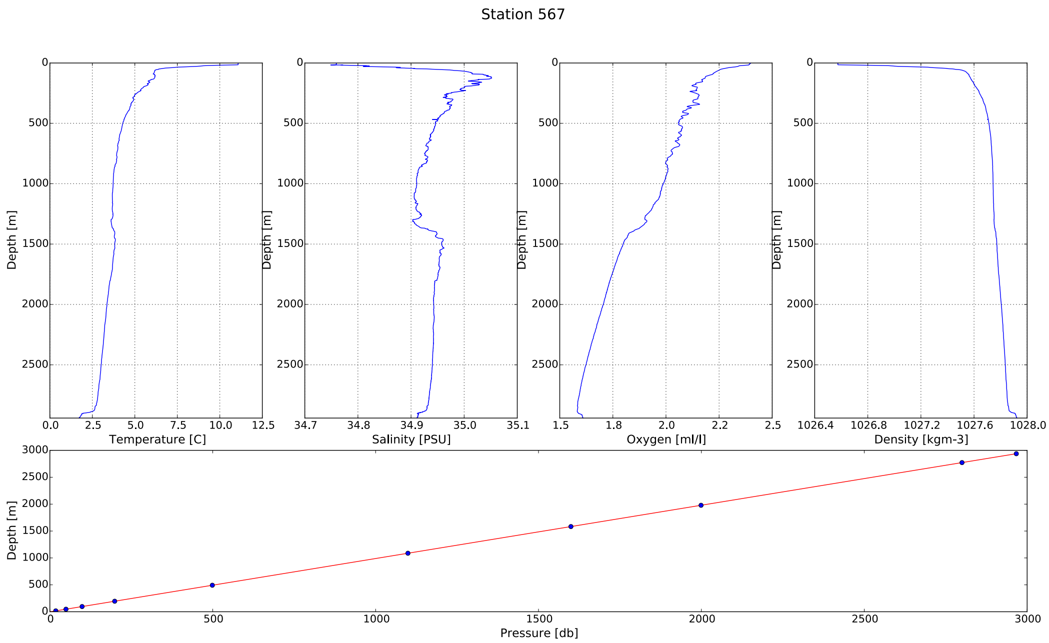


Figure 3: *CTD Profile 567- Station 16: Water samples taken for $\delta^{18}O$ analysis at 20; 50; 100; 200; 500; 1100; 1600; 2000; 2800 ($\delta^{13}C$); 2966 ($\delta^{13}C$) m water depth. Samples taken for $\delta^{13}C$ are indicated respectively.*

Station: GS16-204-17

Longitude	Latitude	Water depth	Date	Start time
59° 42,92	39° 30,28	2785m	20.08.16	18:45

Device	Remarks
CTD	Water samples taken (see report below). CTD 568

CTD (Temperature, Salinity, Oxygen, Density profile)

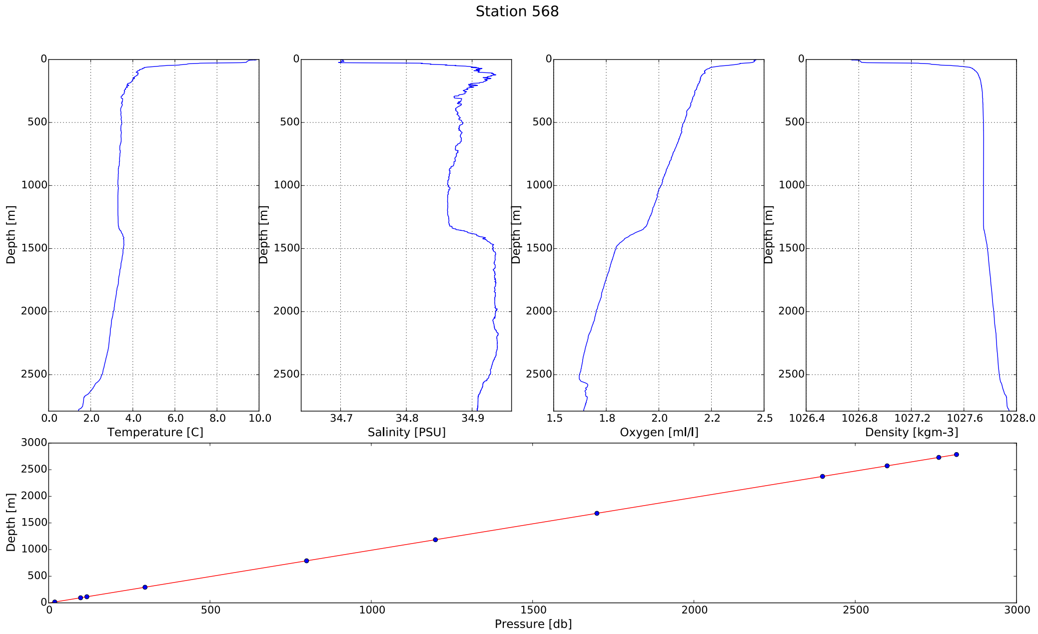


Figure 4: *CTD Profile 568- Station 17: Water samples taken for $\delta^{18}O$ analysis at 20; 100; 120; 300; 800 ($\delta^{13}C$); 1200; 1700 ($\delta^{13}C$); 2400; 2600; 2760; 2813($\delta^{13}C$) m water depth. Samples taken for $\delta^{3}C$ are indicated respectively.*

Station: GS16-204-18

Longitude	Latitude	Water depth	Date	Start time
60° 01,84	40° 33,45	2220m	21.08.16	02:45

Coring Devices	Remarks
Multicore	No sediment in multicore (Failed two times)
CTD	Water samples taken (see report below). CTD 569
Gravity core (GC)	226,5cm
Calypso core (CC)	1861cm

CTD (Temperature, Salinity, Oxygen, Density profile)

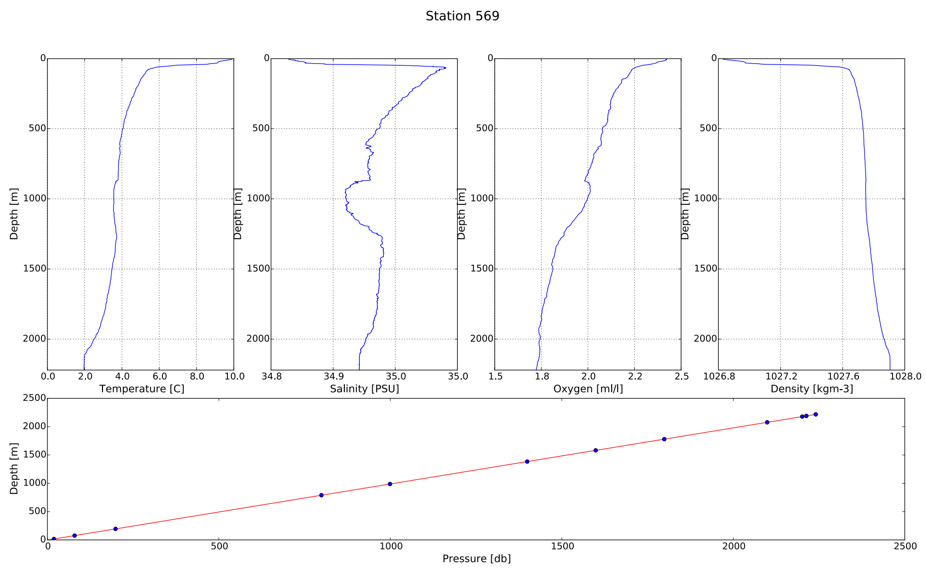
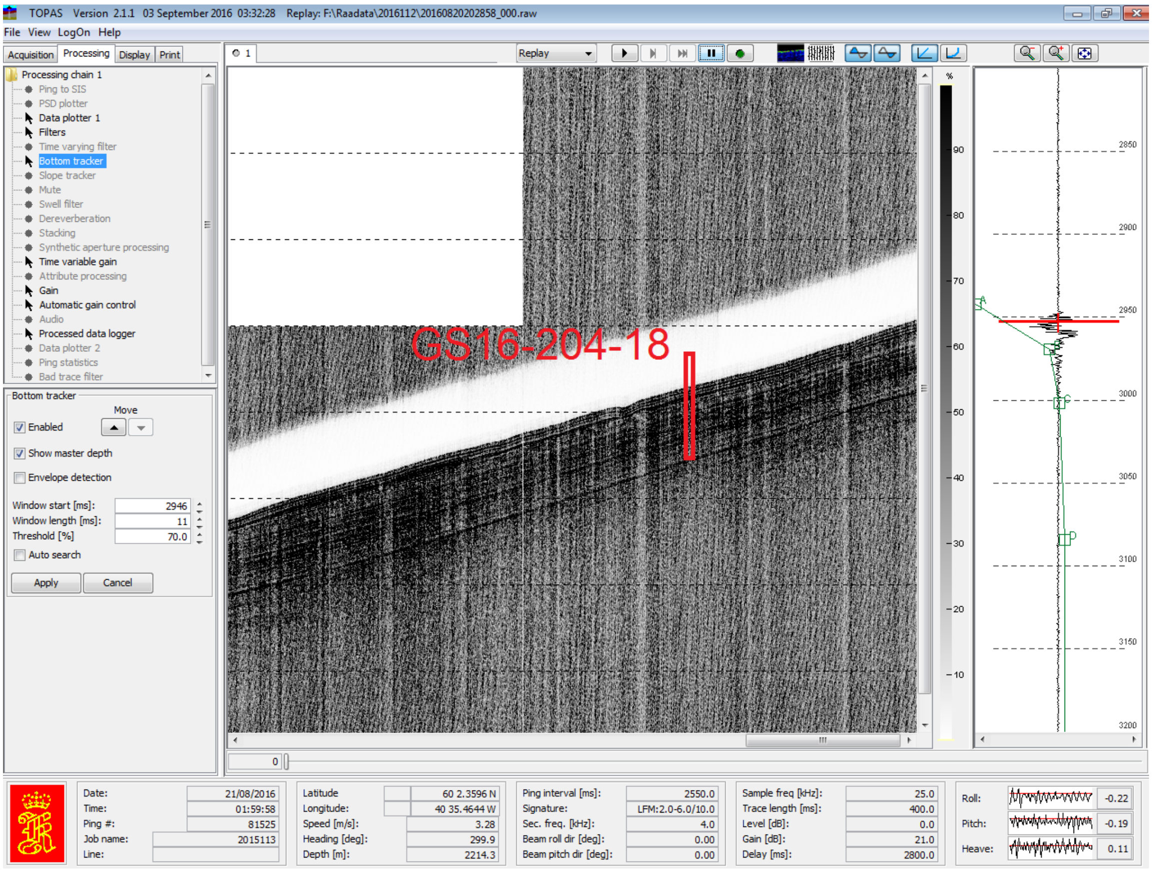


Figure 5:*CTD Profile 569- Station 18: Water samples taken for $\delta^{18}O$ analysis at 20; 80; 200 ($\delta^{13}C$); 800 ($\delta^{13}C$); 1000; 1400; 1600 ($\delta^{13}C$), 1800; 2100; 2200($\delta^{13}C$); 2212; 2240 m water depth. Samples taken for $\delta^{13}C$ are indicated respectively.*

Topas profile at coring station

Topas file name: 20160820202858



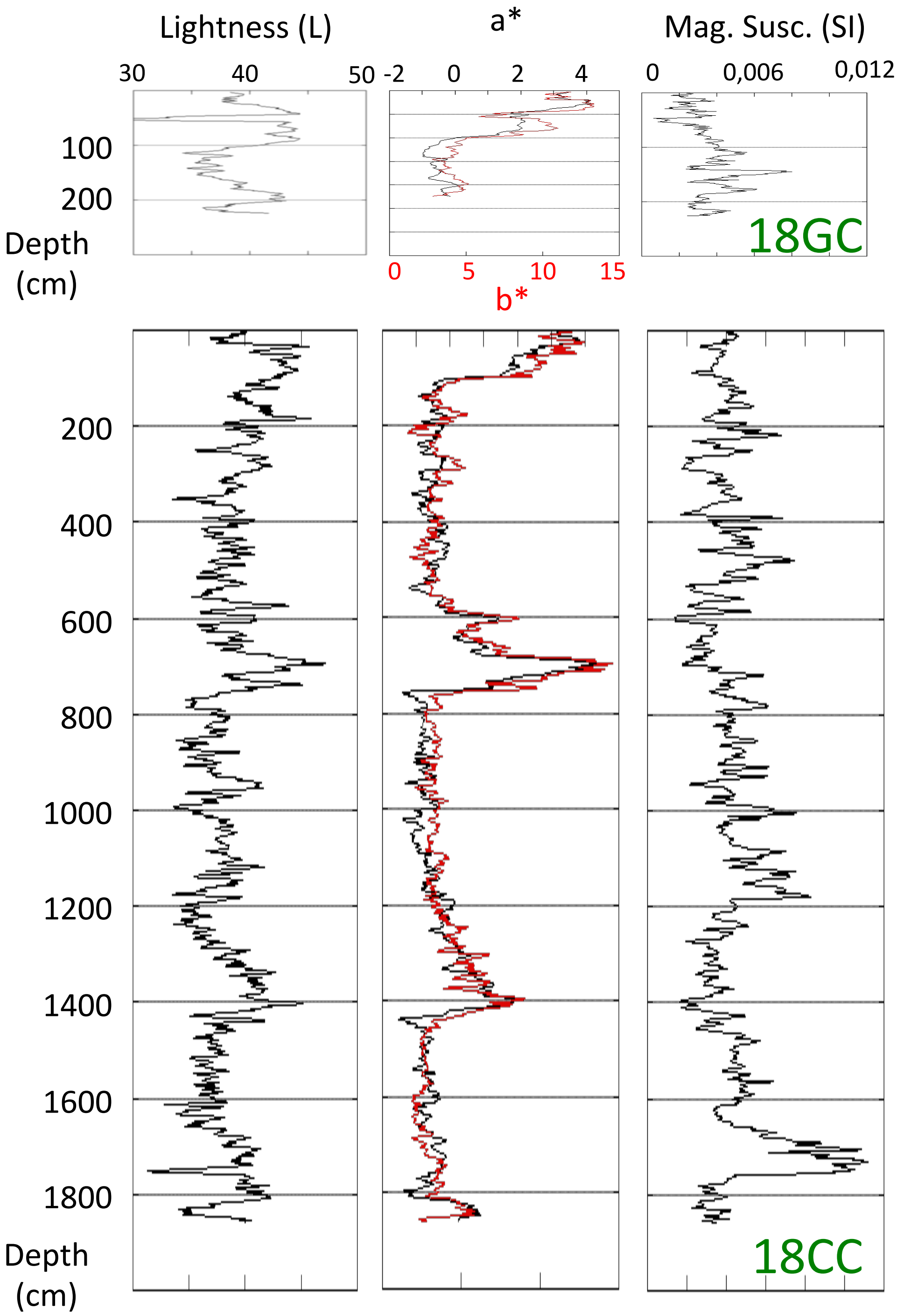
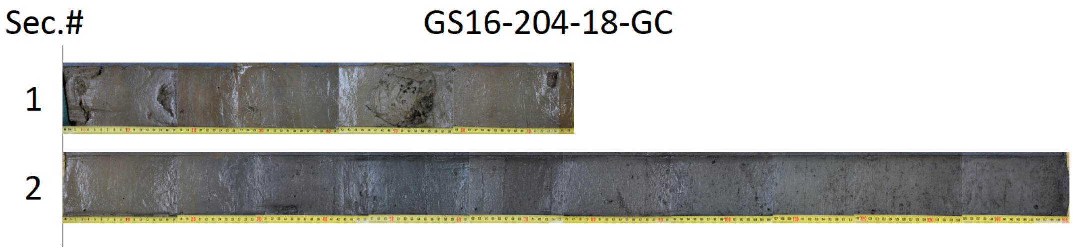
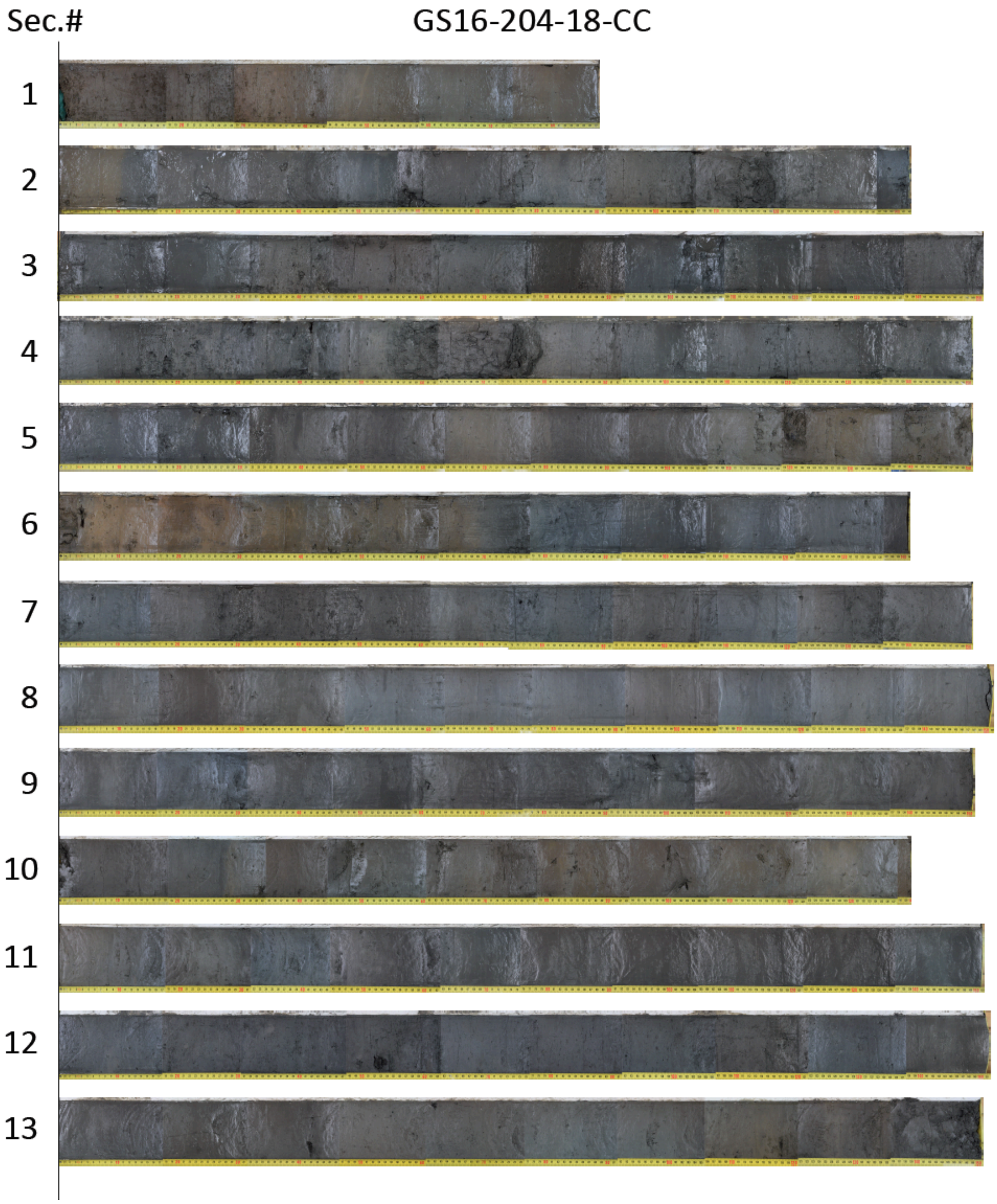


Figure 6: *Graphical correlation of sediment colour reflectance (L*; a*; b*) profiles for cores GS16-204-18 Gravity Core (GC); (top left& middle panel) and Calypso Core (CC); (left& middle panel). Graphical correlation of magnetic susceptibility (SI) profiles for cores GS16-204-18 GC (top right panel) and CC (lower right panel). All records are displayed on their individual depth scales in cm.*

Section pictures

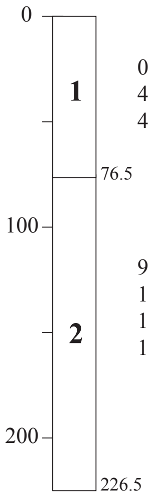




Lithology

Core: GS16-204-18 GC

Depth (cm) | Section | Lithology



0–76.5 cm: Brownish, no sharp boundaries
4 cm: IRD Φ 1.5 cm
48-56 cm: IRD/consolidated sediment

96.5 cm: Sharp boundary from brownish to grey
143.5-149 cm: Dark grey horizon
160-162 cm: Dark grey spots
123.5-126 cm: IRD

Core: GS16-204-18 CC

Section	Depth (cm)	Lithology
1	0–87.5	0-13: Brown, silt, IRD Φ <1 cm 13-21: Brown, clay, maybe some organic material 21-35.5: Brown, coarser (same as first layer) 35.5-87.5: Brown, clay, higher water content, clay-silt
2	87.5–230	87.5-97.5: Sharp boundary, brown to grey 97.5-230: Grey, gradually increasing size fraction, different water content 195-208: Large IRD/consolidated material 208-230: Increasing water content
3	230–380.5	230-259: Grey 259-320: Grey-brown 320-380.5: Grey 321-327: Grey/brown, soupy with small stones 353-355: Brown layer
4	380.5–531	380.5-387: Grey, sharp boundary to black until 394 cm 394-427: Grey with brown spots, some coarse grains, bioturbation? 423-431: Dark grey, smooth 431-460: Brown grey, with consolidated material 460-531: Grey with some brown and dark coarse/consolidated layers ca. 7 cm thick
5	531–681	531-611.5: Silty, gradually changing from dark grey to light grey to brownish, ending in sharp boundary, Small stones in brown area 611.5: Sharp boundary from brown to dark grey 611.5-681: Silty, dark grey with brown spots. Dropstone? Increasing amount of stones downwards
6	681–822	681-686: Brownish grey, sandy silt 686-750: Light brown to darker brown 750: Boundary from brownish to dark grey 750-822: Dark grey
7	822–972	822-972: Grey, silt, homogenous 885-922: Some bioturbation structures
8	972–1122	972-1013: Grey, silt, some bioturbation 1013-1122: Grey, silt, homogenous

Core: GS16-204-18 CC

Depth (cm)	Section	Lithology
1122–1271.5	9	1122-1271.5: Grey silt, some lighter grey spots 1145-1156: Dropstone Φ 2-4cm, probably more than one 1210-1222: Dropstone Φ 2-3cm
1271.5–1411	10	1271.5-1299.5: Silt, dark grey, homogenous 1299.5: Sharp boundary from dark grey to brown 1299.5-1386: Sandy silt, brown, dropstones Φ <4cm 1386-1411: Lighter brown, some bioturbation, sandy silt, small stones
1411–1561	11	1411-1431.5: Brownish grey, dens silt, some bioturbation 1431.5-1461: Silty clay, grey with small areas of light grey silt 1461-1561: Dark grey, sandy silt, high water content (from 1538 cm and downwards there are some light grey stripes)
1561–1711	12	1561-1567.5: Dark grey, homogenous silt 1567.5-1662: Grey with slightly lighter grey spots. Sandy silt, small stones 1662-1711: Light grey, sandy silt, small stones

Depth (cm)	Section	Lithology
1711–1861	13	1711-1756.5: Dark grey silt, small stones 1756.5: Sharp boundary from dark grey to light grey 1756.5-1813: Light grey, sandy silt, small dropstones? 1813: Brown boundary 1813-1861: Coarse, brown, sandy silt, decreasing density downwards, large dropstone at 1856-1861 cm (Φ 7 cm)

Station: GS16-204-19

Longitude	Latitude	Water depth	Date	Start time
59° 48,86	39° 47,92	2675m	22.08.16	14:35

Coring Devices	Remarks
Multicore	A: 36cm, B: 36cm, C: 36cm, D: 35,5cm
CTD	Water samples taken (see report below). CTD 570
Gravity core (GC)	316,5 cm
Calypso core (CC)	2008,5 cm

CTD (Temperature, Salinity, Oxygen, Density profile)

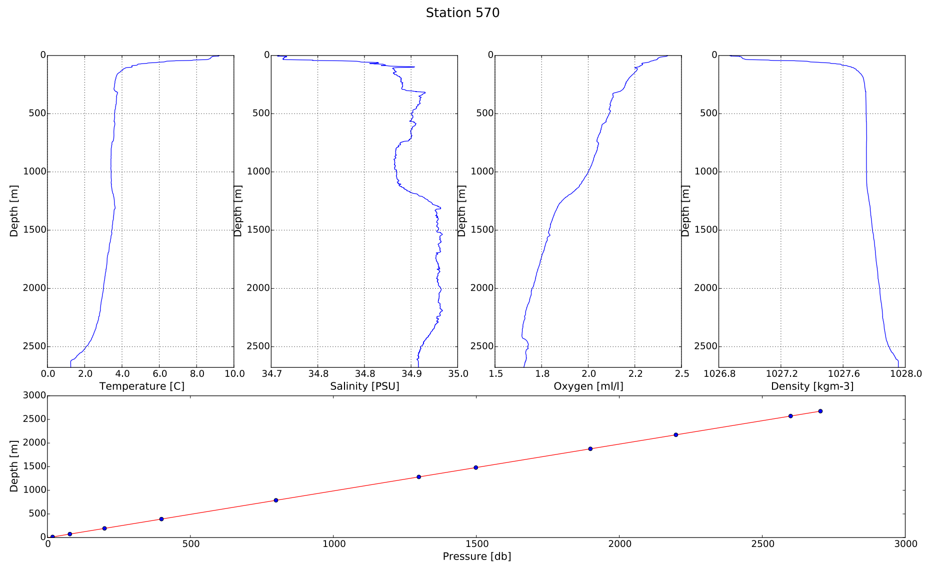
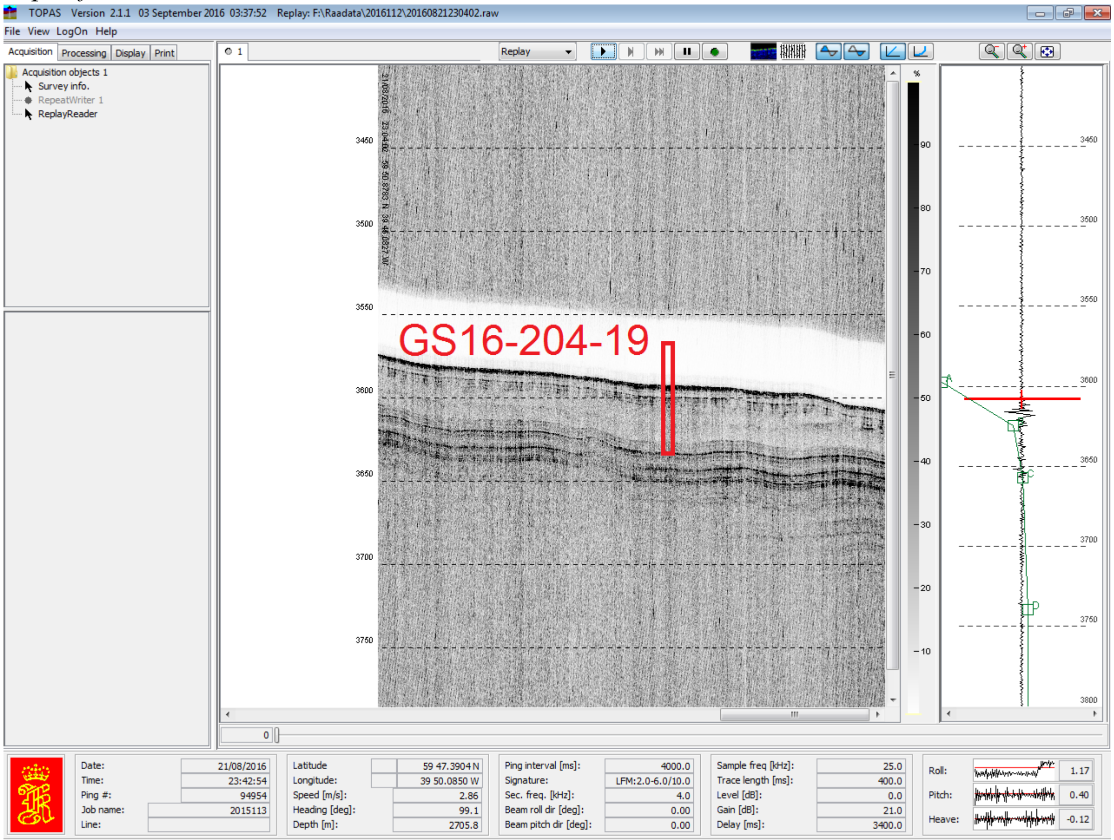


Figure 7: *CTD Profile 570- Station 19: Water samples taken for $\delta^{18}O$ analysis at 20; 80; 200; 400; 800($\delta^{13}C$); 1300; 1500; 1900 ($\delta^{13}C$); 2200; 2600; 2704 ($\delta^{13}C$) m water depth. Samples taken for $\delta^{13}C$ are indicated respectively.*

Topas profile at coring station

Topas file name: 20160821230402



Spectrophotometer (colour) and magnetic susceptibility

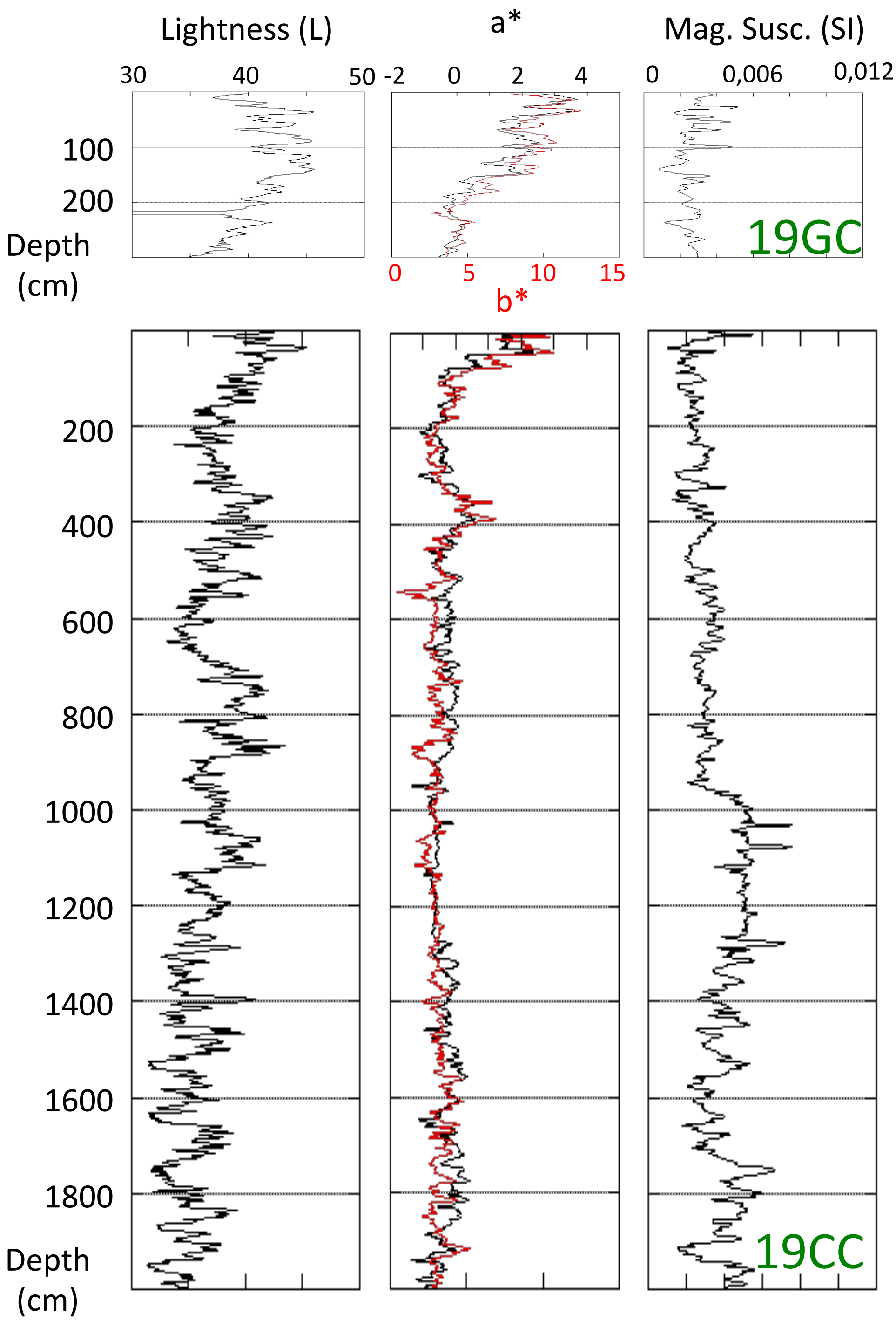
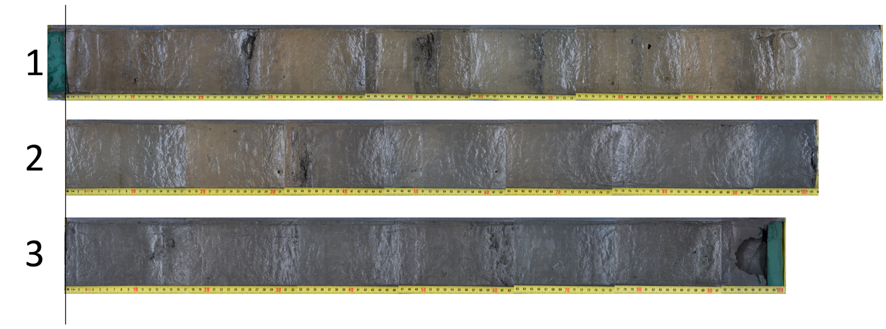


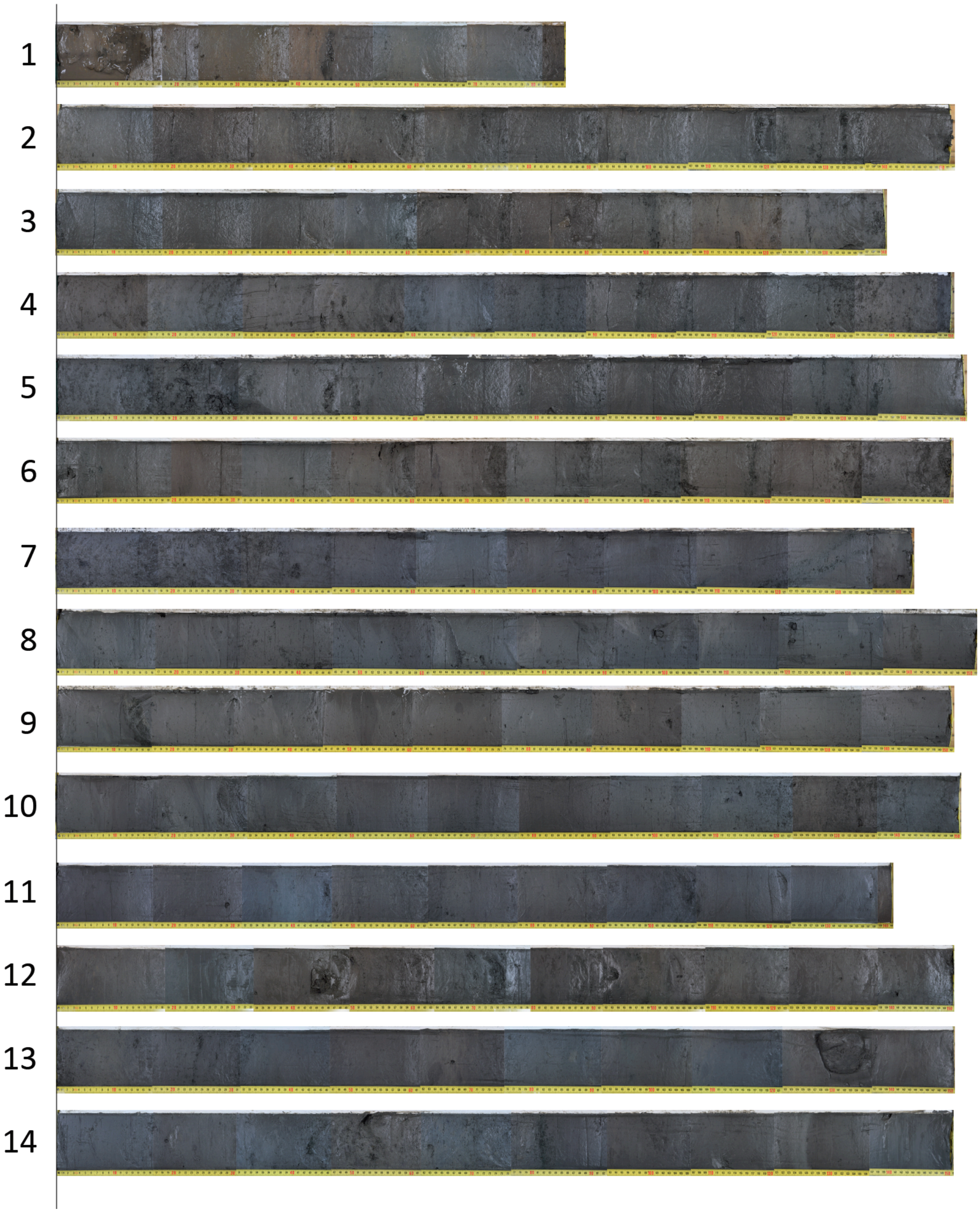
Figure 8: *Graphical correlation of sediment colour reflectance (L*; a*; b*) profiles for cores GS16-204-19 GC (top left& middle panel) and CC (lower left& middle panel). Graphical correlation of magnetic susceptibility (SI) profiles for cores GS16-204-19 GC (top right panel) and CC (lower right panel). All records are displayed on their individual depth scales in cm.*

Section pictures

Sec.# GS16-204-19-GC



Sec.# GS16-204-19-CC



Lithology

Core: GS16-204-19 CC

Depth (cm)	Section	Lithology
0–85	1	0-14: Extremely soupy, 1high water content, sediments disturbed 14-33: Grey-brown, homogenous silty clay 33-44: Brown, homogenous clay, forams 44-45: Very dark grey, silt, sharp boundaries, vel. Horizontal base (ash?), only clastic grains, no microfossils 45-71: Grey with irregular brown intervals, silty clay 71-85 : Darker grey, homogenous silty clay, forams
85–235.5	2	85-109.5: Dark grey, homogenous silty clay 109.5-135: Lighter grey, homogenous, silty clay, lighter grey spots, perhaps bioturbation 135-158: Dark grey, homogeneous silty clay 158-163: Two uneven brown layers at 94 cm and 97 cm, ~0.5 cm thick 163-235: Dark grey, homogenous silty clay, with few mm-sized gravels (IRD) at 120 cm
235.5–375	3	235.5-335: Dark grey, homogenous silly clay, few intervals og lighter grey at 278 cm 1cm-sized dropstone, hole at 321 cm 335-337: Very dark grey, clay, less wet, sharp boundaries 337-375: Light grey, partly brownish sandy silt, dropstone at 375 cm
375–524.5	4	375-439: Light grey, brownish interval at 387-393 cm; silty clay 439-444: Lighter grey with darker grey inclusions, silty clay 444-497: Dark grey, homogenous silty clay, black layers (ash?) at 456, 472 and 489 cm 497-524.5: Dark grey, sandy silty clay with gravel (IRD) at 505 and 510 cm
524.5–675	5	524.5-559: Grey, low water content, forams, consolidated with black color and holes (449 – 550 cm) 537-539: Dropstone Ø 1.5 cm 559-675: Dark grey and smooth with a hole at 588-593 cm, containing 5 layers of coarse material (dark in color) at 571, 575.5, 652, 657 and 660-663cm
675–825.5	6	675-810: Dark grey with dropstone at 730 (Φ 15 cm), hole at 731-733cm, black at 740, coarse at 781.5 and 792.5 cm 810-825.5: Very dark, consolidated, low water content
825.5–967.5	7	825.5-860: Consolidated, grey, microfossils (shells) 860-967.5: Grey, silt, dropstone cm-sized at 885, 901.5, 911 and 845-955 cm dark grey, generally coarser
967.5–1118	8	967-1118: Grey with lenses formed like ripples (change in color to light grey or even reddish); some with change in size fraction (at 1031 cm), some with bioturbation (at 1040-1046 cm); Dropstones at 1047.5 and 1063.5 cm

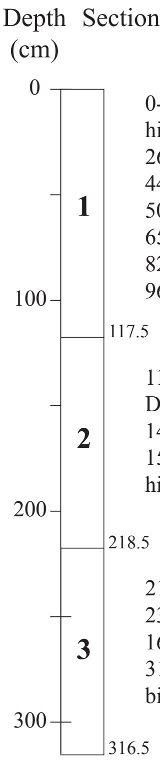
Core: GS16-204-19 CC

Depth (cm)	Section	Lithology
1118–1268	9	1118-1268: Dark grey, silty clay, some lenses of brown or dark grey down to 1187 cm 1129-1133 and 1212-1215: Coarser; dropstones at 1162, 1202, 1237 and 1235 cm (Φ 0.5 cm)
1268–1418	10	1268-1333: Grey with darker or brownish layers, microfossils and some shells, consolidated interval at 1295 – 1312 cm 1333-1417.5: Darker grey and slightly coarser, black inclusion at 1371 and 1379 cm; change from light grey to dark grey at 1390-1396 cm
1418–1558	11	1418-1554.5: Dark grey, silty clay, some slightly lighter grey intervals (e.g. 1454.5 – 1460 cm), some gravel 1554.4-1558: Brown, sandy silt
1558–1708	12	1558-1567: Dark grey, sandy silt, brown spots, small dropstones 1598-1634: Coarser, dark grey, sandy silt 1634-1708: Dark grey, some lighter grey intervals, sandy silt, some gravel
1708–1858.5	13	1708-1858.5: Consistent texture throughout core section, sandy silt, homogenous dark grey, some brownish spots 1836.5-1844: Large dropstone removed (Φ 12 cm), in separate bag
1858.5–2008.5	14	1904-1922: Brownish grey, course sandy silt, some gravel 1969-1973: Dropstone (Φ 2 cm) 1943-2008.5: Homogenous dark grey silt 1997-1999: Hole, Φ ca. 2 cm 1982-1985: Light grey silt, no sharp boundary

Shear strength (kPa) measured at the bottom of each section

Sec. #01	0
Sec. #02	0
Sec. #03	205.94
Sec. #04	98.07
Sec. #05	9.81
Sec. #06	117.68
Sec. #07	49.03
Sec. #08	98.07
Sec. #09	127.49
Sec. #10	29.42
Sec. #11	88.26
Sec. #12	235.36
Sec. #13	156.91
Sec. #14	17.68

Core: GS16-204-19 GC



Lithology

0-26: Light brown, homogenous silt,
high water content
26-27.5: Dark brown, sharp boundary at 27.5 cm
44.5-46.5: Dark brown, sharp boundary at 46.5 cm
50.5-55: Dark brown, silty clay
65-69.5: Dark brown, sharp boundary at 69.5, silty clay
82-83.5: Dark brown, not as sharp boundary as previous
96-102: Dark brown lines, silty clay

117.5-149.5: Light brown silt, high water content.
Dark brown area at 125-125.5, 146-147 and
149.5-152 cm (silty clay)
152-218.5: Grey, sandy silt with brown spots,
high water content

218.5-265: Grey silt with brown spots
232-234: Dropstone
165-311: Grey silt, no sharp boundary
311-316.5: Light grey, fine silt, homogenous,
big part missing (dropstone?)

Station: GS16-204-20

Longitude	Latitude	Water depth	Date	Start time
58° 57,02	44° 33,36	2004m	23.08.16	13:30

Coring Devices	Remarks
Multicore	No Multicore taken
CTD	Water samples taken (see report below). CTD 571
Gravity core (GC)	33,5 cm
Calypso core (CC)	925 cm

CTD (Temperature, Salinity, Oxygen, Density profile)

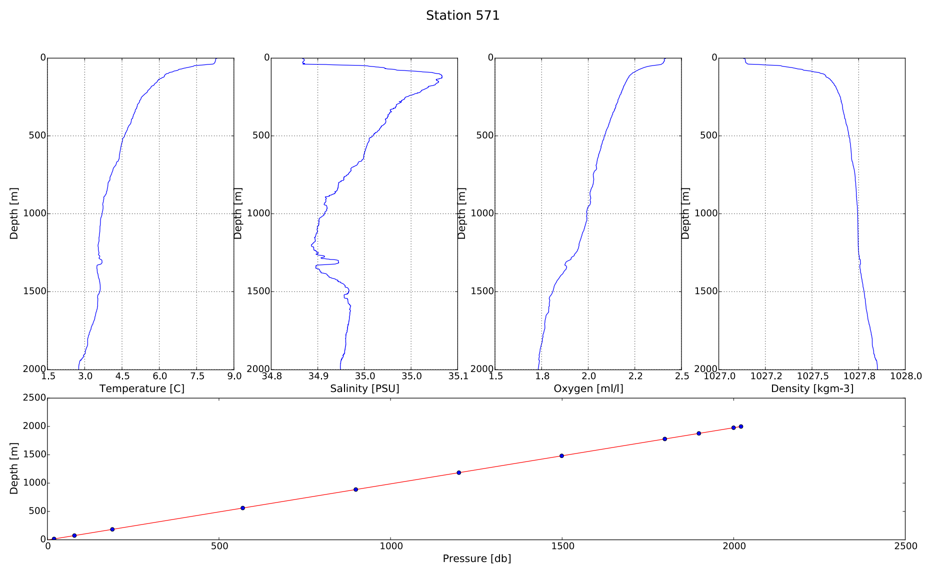
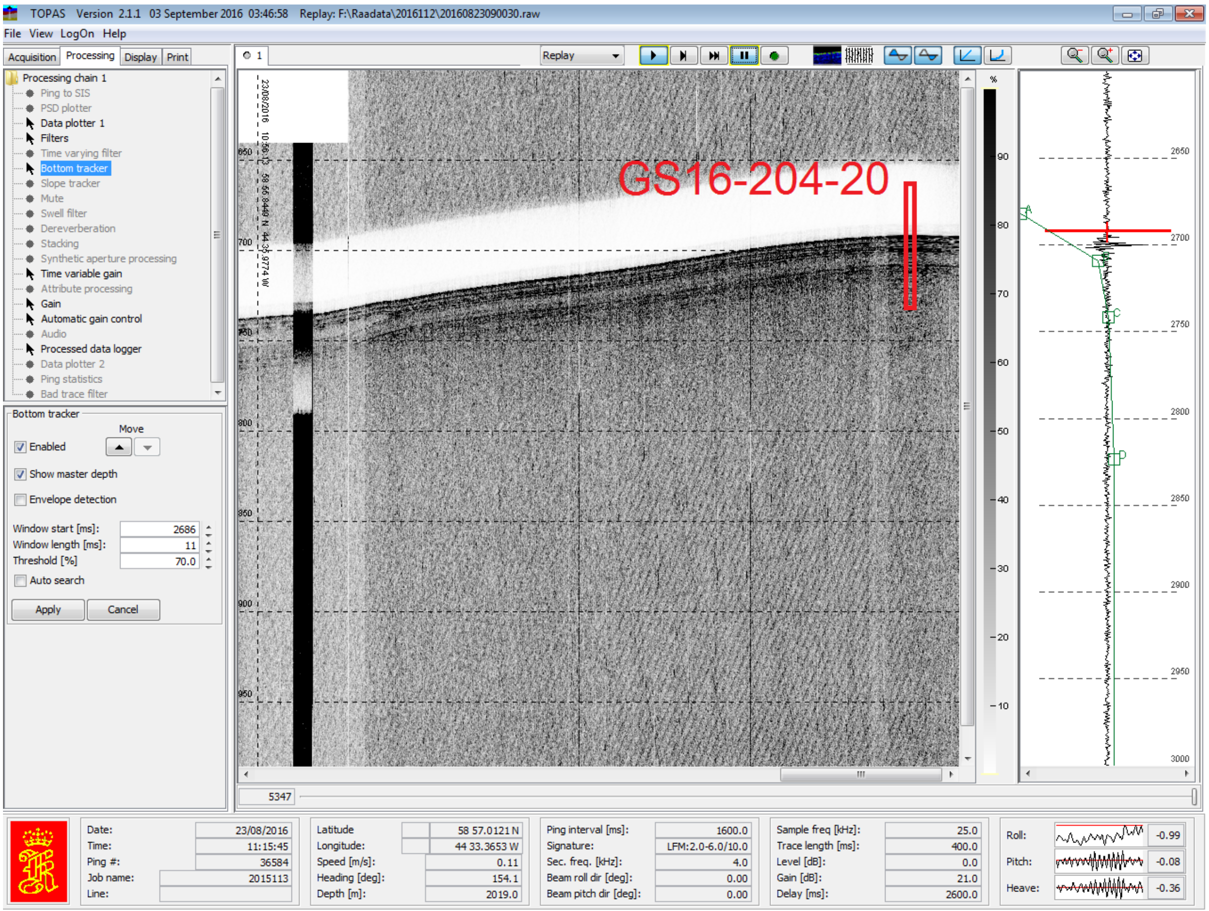


Figure 9: *CTD Profile 571- Station 20: Water samples taken for $\delta^{18}O$ analysis at 20; 80; 190; 570; 900; 1200; 1500; 1800 ($\delta^{13}C$); 1900; 2000 ($\delta^{13}C$); 2021 m water depth. Samples taken for $\delta^{13}C$ are indicated respectively.*

Topas profile at coring station

Topas file name: 20160823090030



Spectrophotometer (colour) and magnetic susceptibility

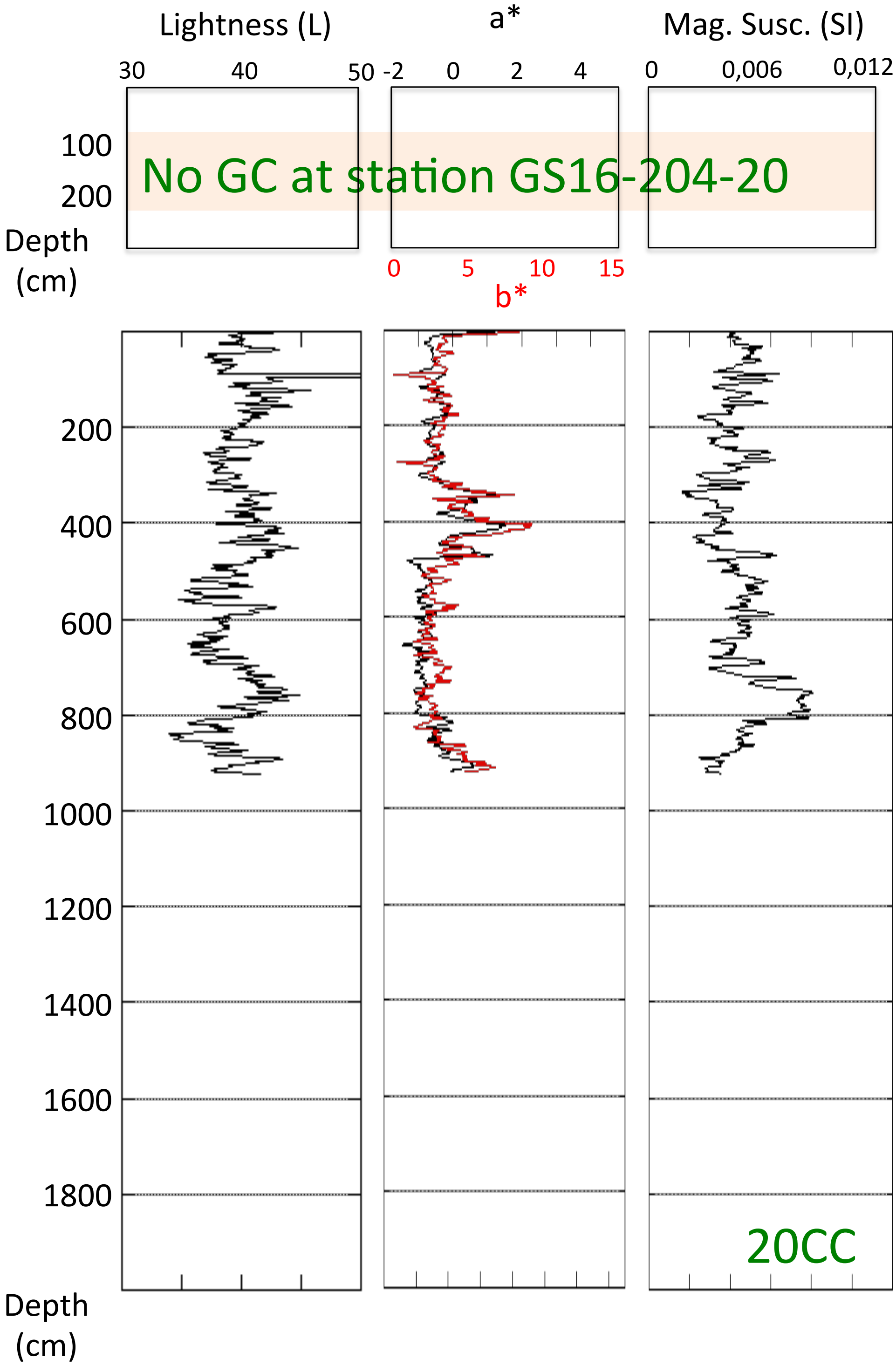
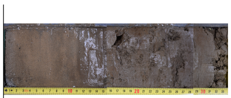


Figure 10: *Graphical correlation of sediment colour reflectance (L*; a*; b*) profiles for cores GS16-204-20 CC (left& middle panel). Graphical correlation of magnetic susceptibility (SI) profile for core GS16-204-20 CC (right panel). All records are displayed on their individual depth scales in cm.*

Section pictures

Sec.# GS16-204-20-GC

1



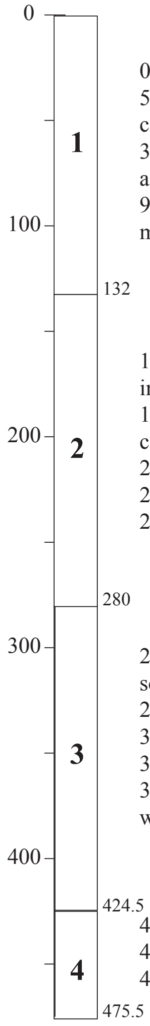
Sec.# GS16-204-20-CC

1
2
3
4
5
6
7

Lithology

Core: GS16-204-20 CC

Depth (cm) | Section | Lithology



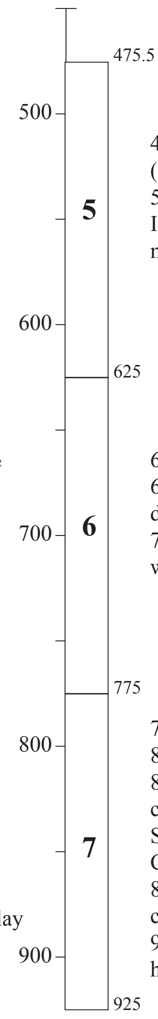
0-5: Brown, homogenous, silty clay
5-33: Grey mud, extremely high water content (not in-situ material)
33-98: Grey, homogenous silty clay, a little more compacted
98-132: Grey, slightly lighter, homogenous, more compacted silty clay

132-280: Grey silty clay; at 150-169 cm increased water content
171: Darker sandy layer/lens of condensed clay
202-211: Extremely high water content, hole
221-280: Big pieces of condensed clay
274-280: 6 cm-sized dropstone

280-332: Grey homogenous silty clay, some IRD at 283 and 329 cm
290-319: Disturbed, high water content
332-349: Brown homogenous silty clay
349-398: Brown-grey, silty to sandy clay
398-424.5: Brown-grey silty clay, high water content (softer), disturbed surface

424.5-450: Grey, homogenous, silty sandy clay
450-454: Light grey, sandy silt
454-475.5: Grey with brown layers/lenses, silty clay, condensed, IRD at 475 cm

Depth (cm) | Section | Lithology



475.5-504: Grey, silty clay with IRD (i.e. at 486-490 cm, 500 cm), rough surface
504 - 625: Grey, silty clay, homogenous, IRD at 578-581 cm, smooth surface, microfossils

625-692: Dark grey, sandy silt, dropstones
692-760: Coarser, rough surface, sandy silt, dark grey
760-775: Dark grey silty clay, higher water content

775-817: Dark grey, sandy silt
809.5-811: Lighter grey interval, sandy silt
817-919: Dark grey, coarse, sandy silt, consolidated relative to previous layers.
Several medium sized to large dropstones
Convex layering
881-882.5: Brown sandy silt, dropstones, coarse
919-925: Less consolidated, grey, homogenous, sandy silt

Shear strength (kPa) measured at the bottom of each section

Sec. #01	-
Sec. #02	39.23
Sec. #03	-
Sec. #04	-
Sec. #05	33.34
Sec. #06	58.84
Sec. #07	-

Station: GS16-204-21

Longitude	Latitude	Water depth	Date	Start time
57° 42,70	48° 00,69	3335 m	26.08.16	05:30

Coring Devices	Remarks
Multicore	A: 31cm, B: 30cm, C: 30,5cm, D: 30cm
CTD	Water samples taken (see report below). CTD 572
Gravity core (GC)	No gravity core. Two attempts, broken barrel and core-catcher lost
Calypso core (CC)	1964 cm

CTD (Temperature, Salinity, Oxygen, Density profile)

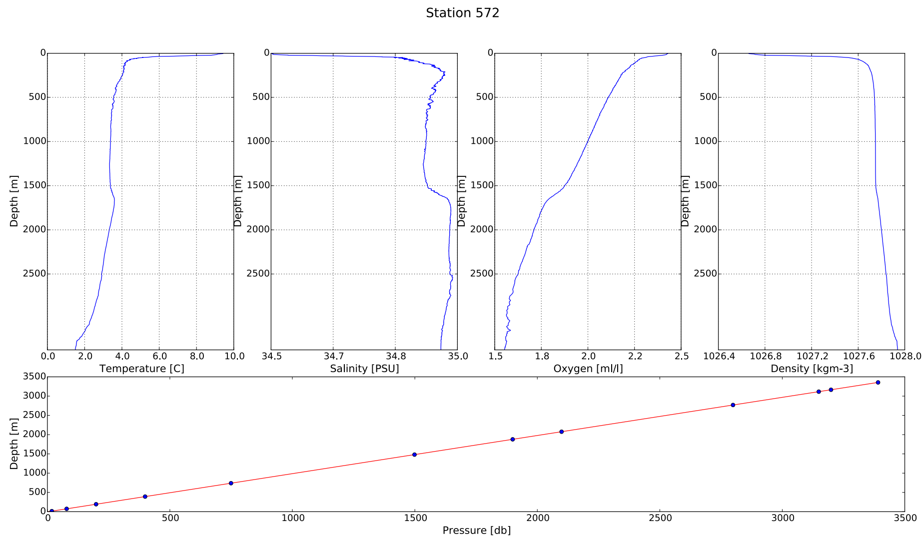
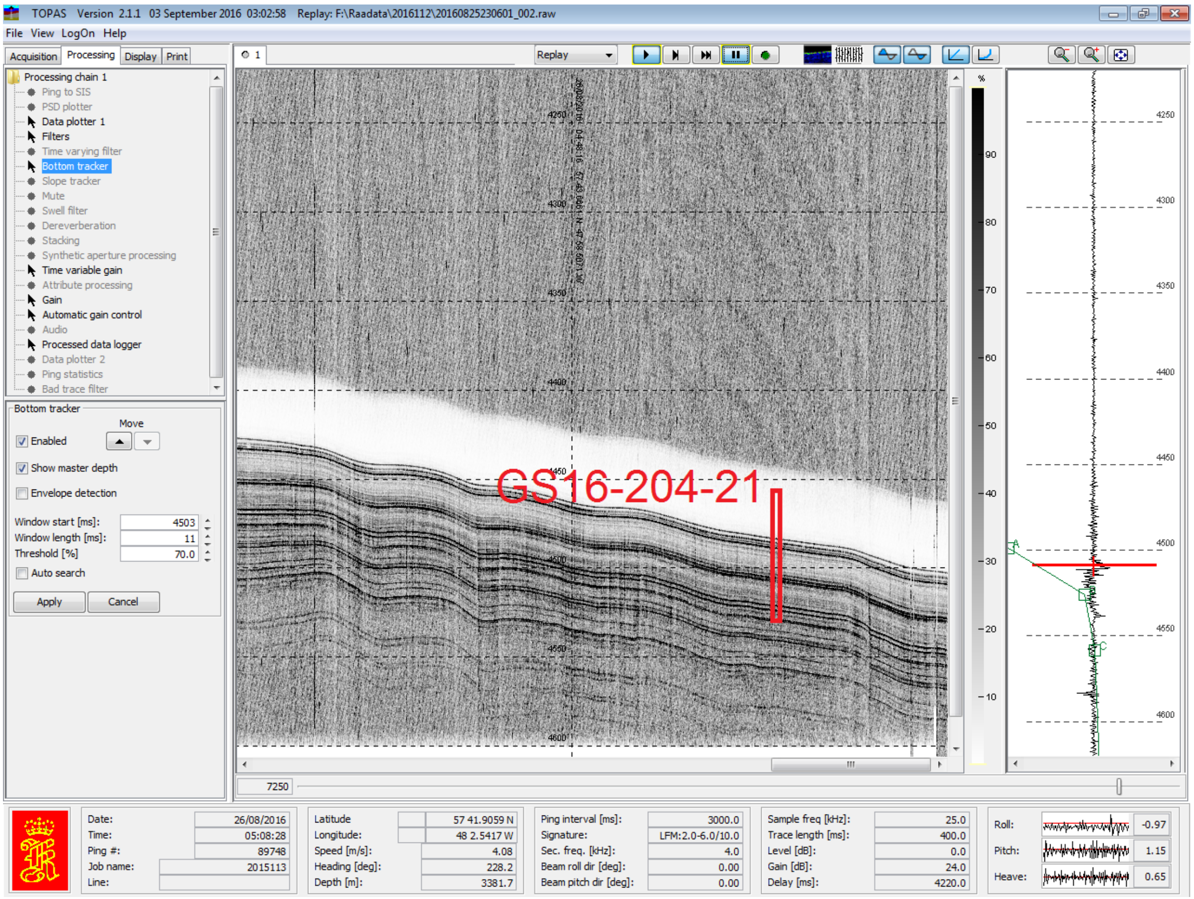


Figure 11: *CTD Profile 572- Station 21: Water samples taken for $\delta^{18}O$ analysis at 20; 80; 200; 400; 750 ($\delta^{13}C$); 1500; 1900; 2100 ($\delta^{13}C$); 2800; 3150; 3200, 3390($\delta^{13}C$) m water depth. Samples taken for $\delta^{13}C$ are indicated respectively.*

Topas profile at coring station

Topas file name: 20160825230601_002



Spectrophotometer (colour) and magnetic susceptibility

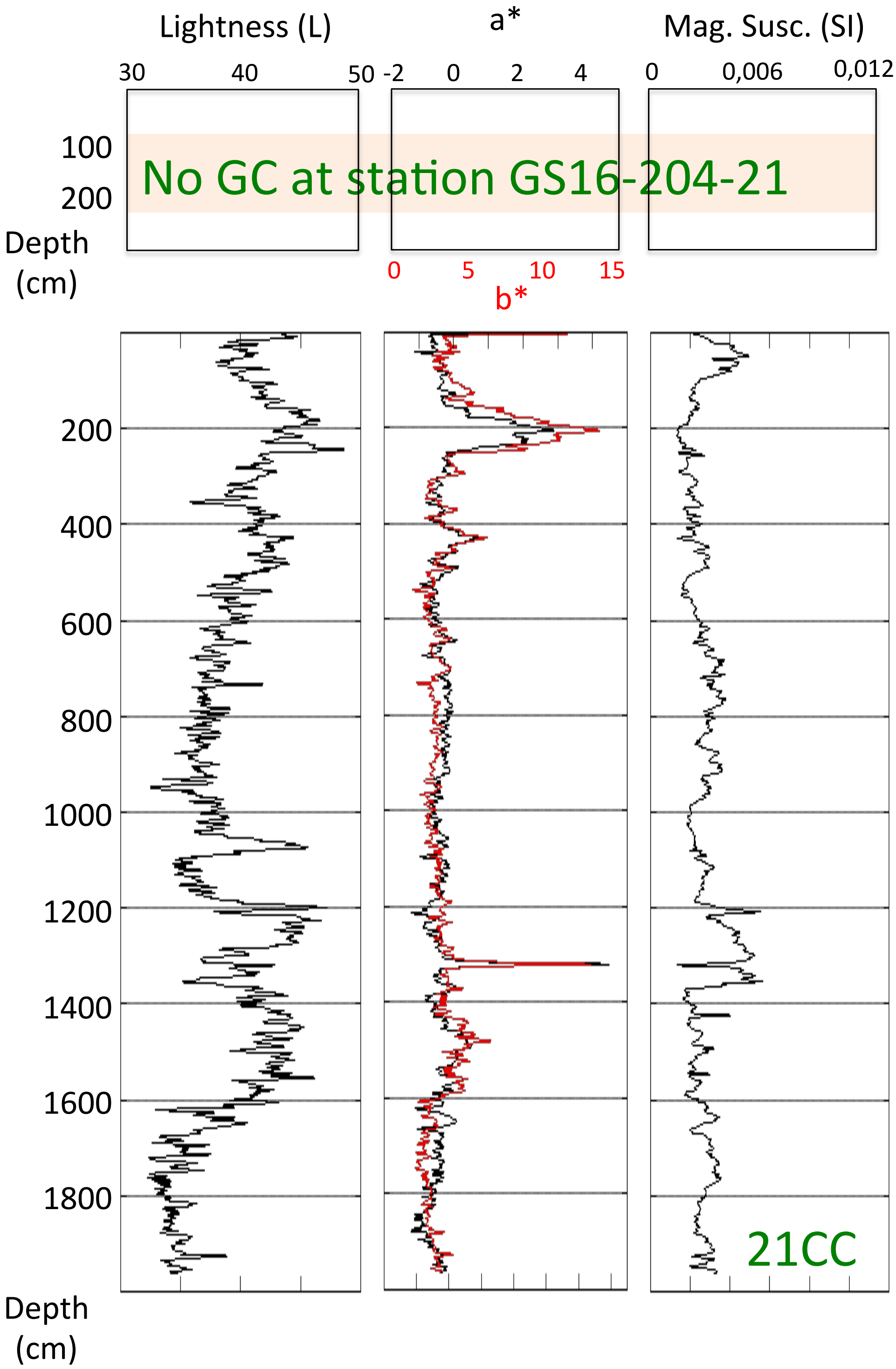
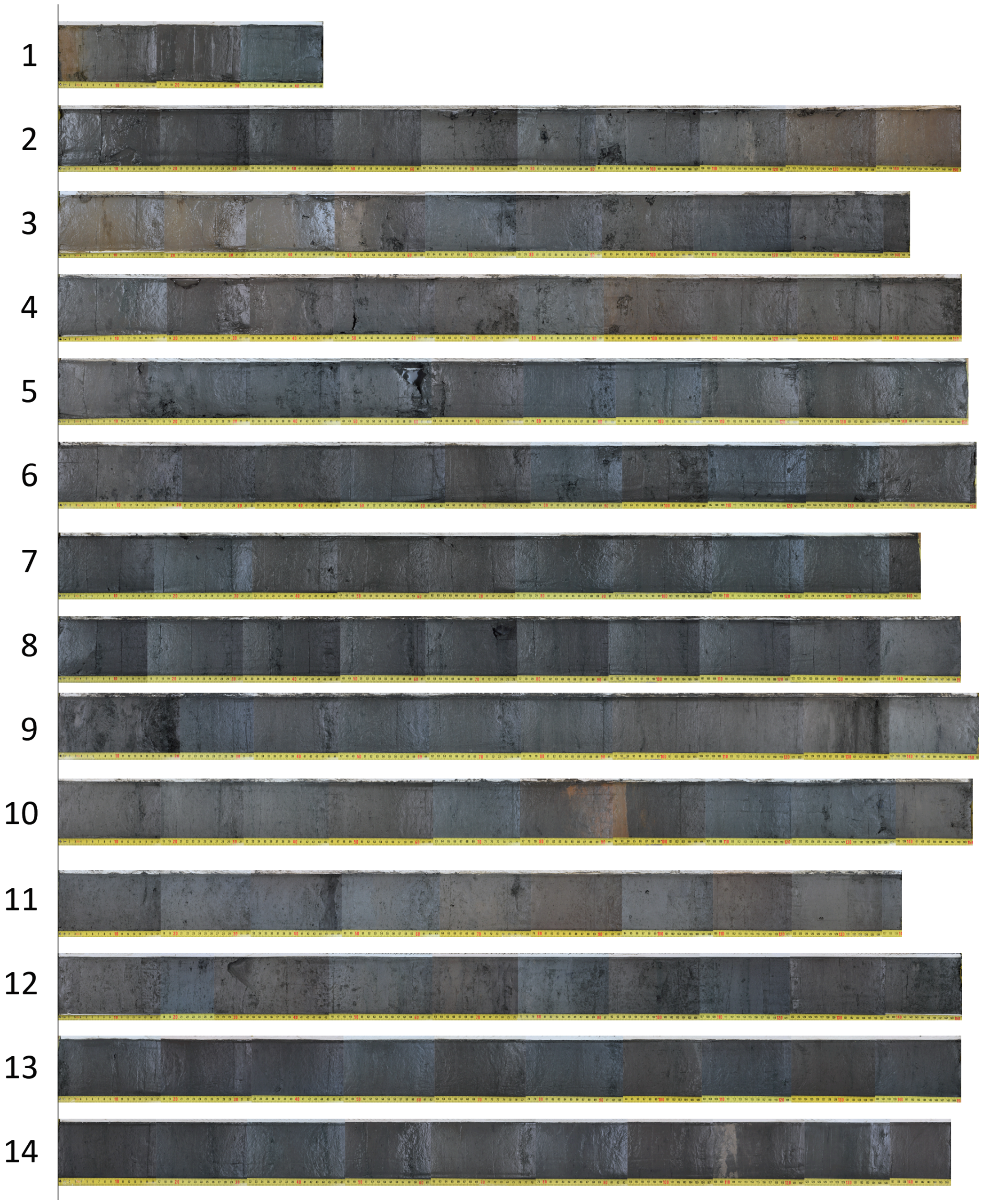


Figure 12*: Graphical correlation of sediment colour reflectance (L*; a*; b*) profiles for cores GS16-204-21 CC (left& middle panel). Graphical correlation of magnetic susceptibility (SI) profile for core GS16-204-21 CC (right panel). All records are displayed on their individual depth scales in cm.*

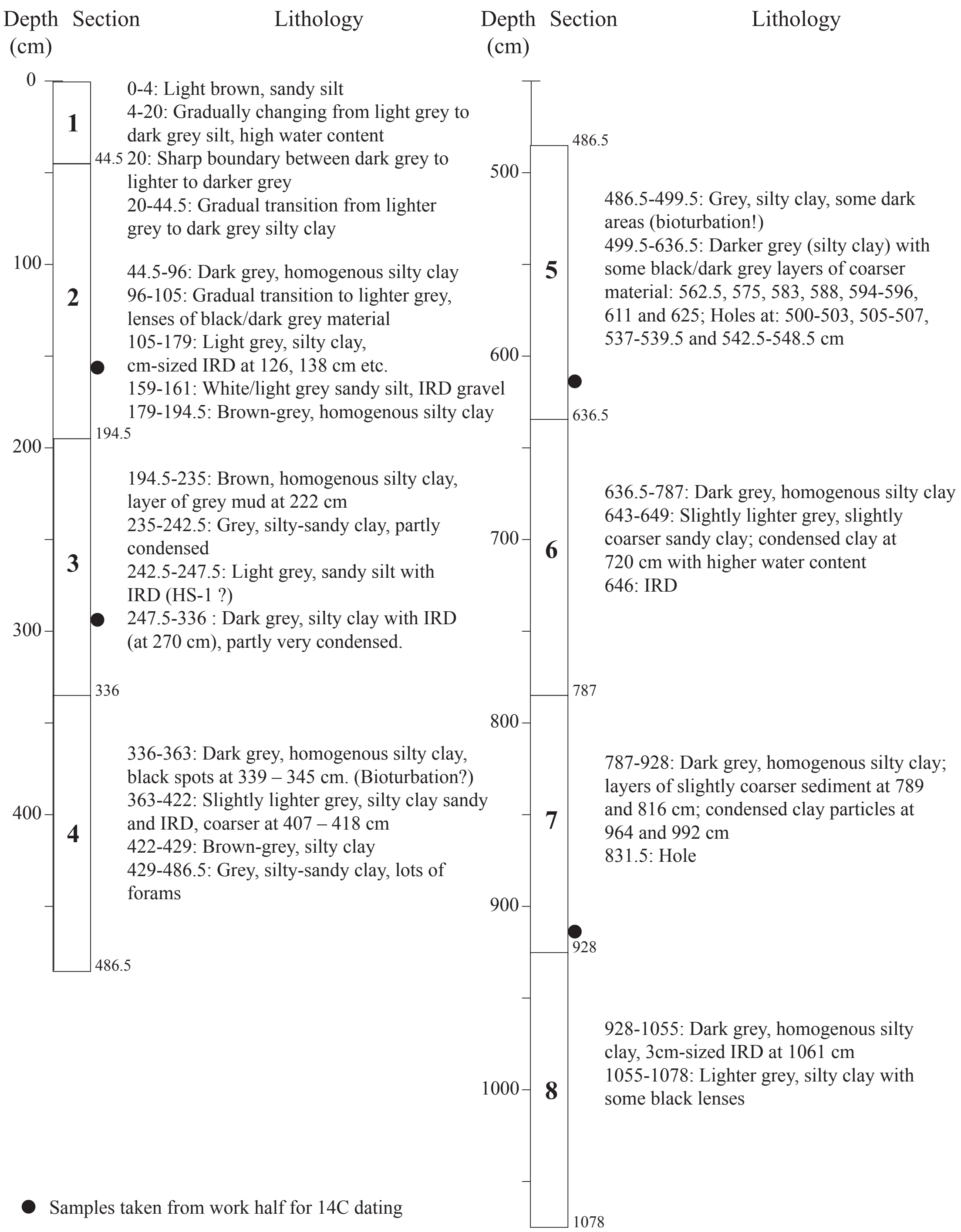
Section pictures

Sec.# GS16-204-21-CCA



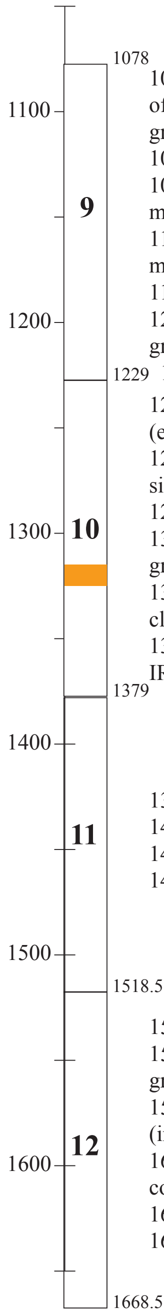
Lithology

Core: GS16-204-21 CC-A



Core: GS16-204-21 CC

Depth (cm) | Section | Lithology



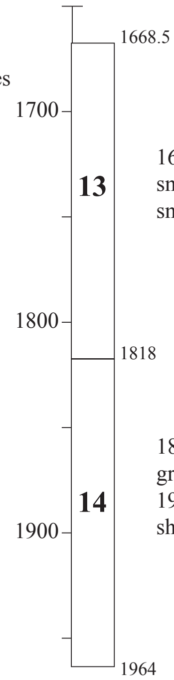
1078 – 1092: Lighter grey with darker lenses of condensed material, silty clay, rather gradual or rough transition
1092 – 1191: Dark grey, silty clay;
1095-1098cm: darker grey, very condensed material. At 1109 cm: Shell (macrofossil?)
1122 – 1123: Slightly coarser + condensed material
1191 – 1229: Light grey, coarser, sandy silt
1203 – 1213.5: Four ca. 1cm thick dark grey layers
1222: Ca. 0.7 cm thick sandy layer (HS?)

1229 – 1240.5: Light grey, silt with forams, (e.g. Pyrgo)
1240.5 – 1247: Slightly darker grey, finer, silty clay, sharp boundary at bottom
1247 – 1313: Light grey, coarser, silt
1313 – 1323: Orange layer, very fine, gradual transition at top, sharp at bottom
1323 – 1361: Dark grey homogenous silty clay, condensed material at 1355 cm
1361 – 1379: Lighter grey, silty clay, IRD at 1364.5 cm

1379 – 1424: Grey, silty clay, homogenous
1424 – 1426: Dark grey interval, silty clay
1426 – 1518.5: Grey sandy silt
1454.5 – 1556: Dark grey spot

1518.5 – 1583.5: Grey silty clay, rough surface
1583.5 – 1595: Same as above, with some grey-brownish intervals
1545.4 – 1550: Dropstone ф 4,5 cm (in separate bag)
1614 – 1619.5: Impression after consolidated clay (removed from working half)
1604 – 1668: Dark grey, silty clay, homogenous
1629 – 1631: Small dropstone

Depth (cm) | Section | Lithology



1668.5 – 1818: Dark grey silty clay, smooth, homogenous, firm sediment, small stone at 1704-1705 cm

1818 – 1964: Fine homogenous, silty clay, grey, a few dark grey spots, firm sediment
1925.5 – 1929.5: Light brown silty clay, sharp contrast to surrounding sediment

Shear strength (kPa) measured at the bottom of each section

Sec. #01	26.54
Sec. #02	15.69
Sec. #03	26.48
Sec. #04	47.07
Sec. #05	11.77
Sec. #06	9.81
Sec. #07	35.30
Sec. #08	49.03
Sec. #09	31.38
Sec. #10	32.36
Sec. #11	98.07
Sec. #12	54.92
Sec. #13	61.78
Sec. #14	-

Station: GS16-204-22

Longitude	Latitude	Water depth	Date	Start time
58° 02,83	47° 02,36	3160 m	28.08.16	06:06

Coring Devices	Remarks
Multicore	A: 41cm, B: 42cm, C: 42cm, D: 42cm
CTD	Water samples taken (see report below). CTD 573
Gravity core (GC)	332,5 cm
Calypso core (CC)	CC-A - 1964 cm CC-B – 1955,5cm (For DNA analysis, frozen on board)

CTD (Temperature, Salinity, Oxygen, Density profile)

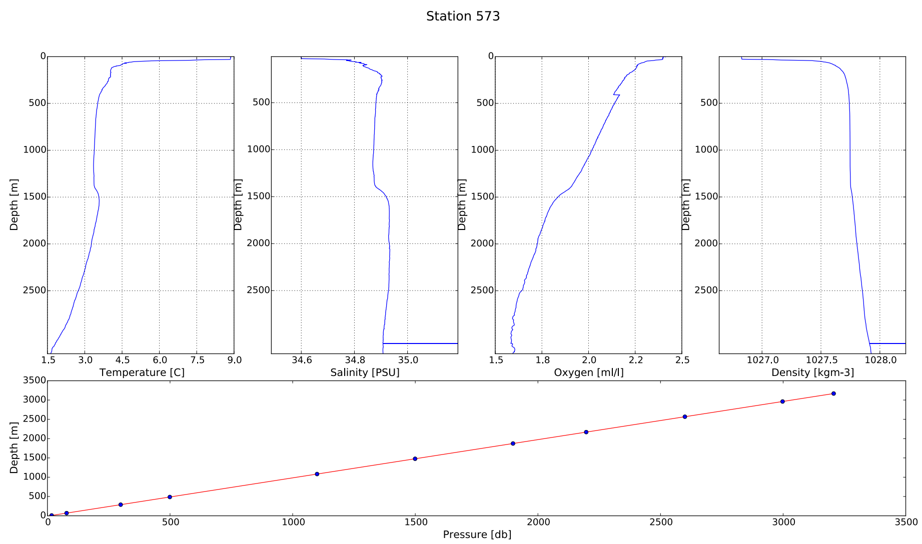
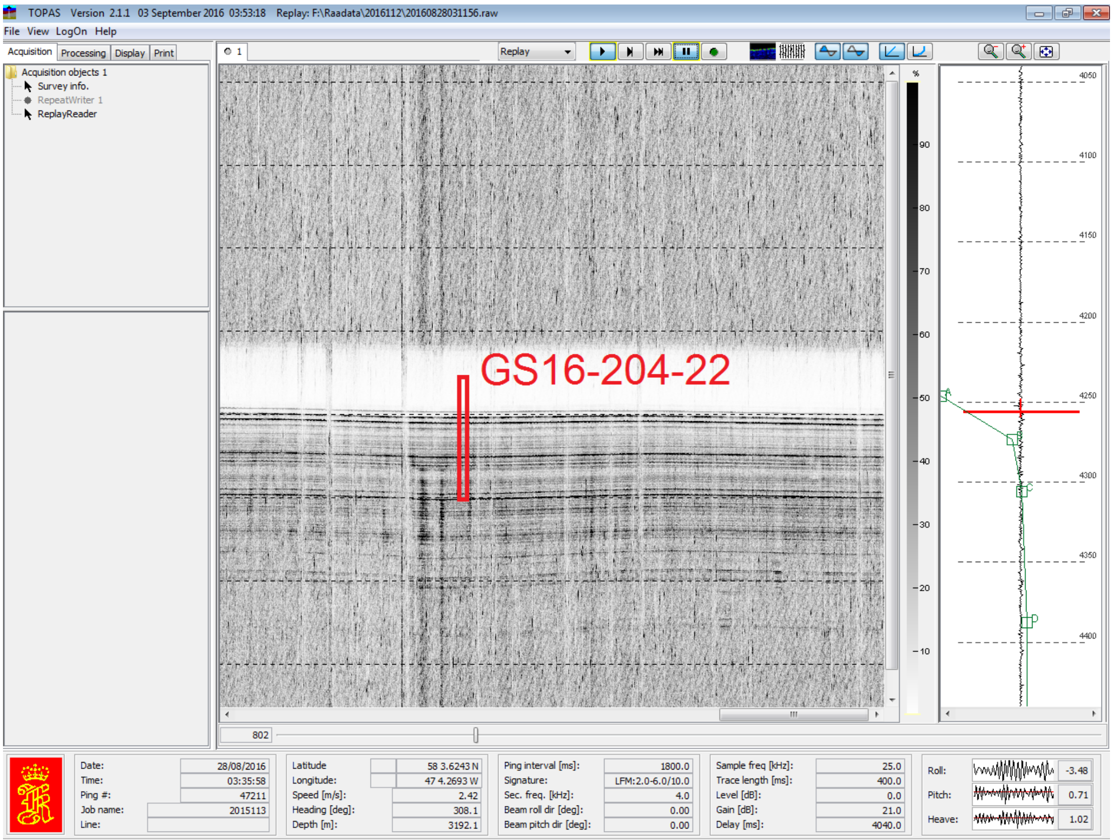


Figure 13: *CTD Profile 573- Station 22: Water samples taken for $\delta^{18}O$ analysis at 20; 80; 300; 500; 1100($\delta^{13}C$); 1500; 1900; 2200($\delta^{13}C$); 2600; 3000; 3206 ($\delta^{13}C$) m water depth. Samples taken for $\delta^{13}C$ are indicated respectively.*

Topas profile at coring station

Topas file name: 20160828031156



Spectrophotometer (colour) and magnetic susceptibility

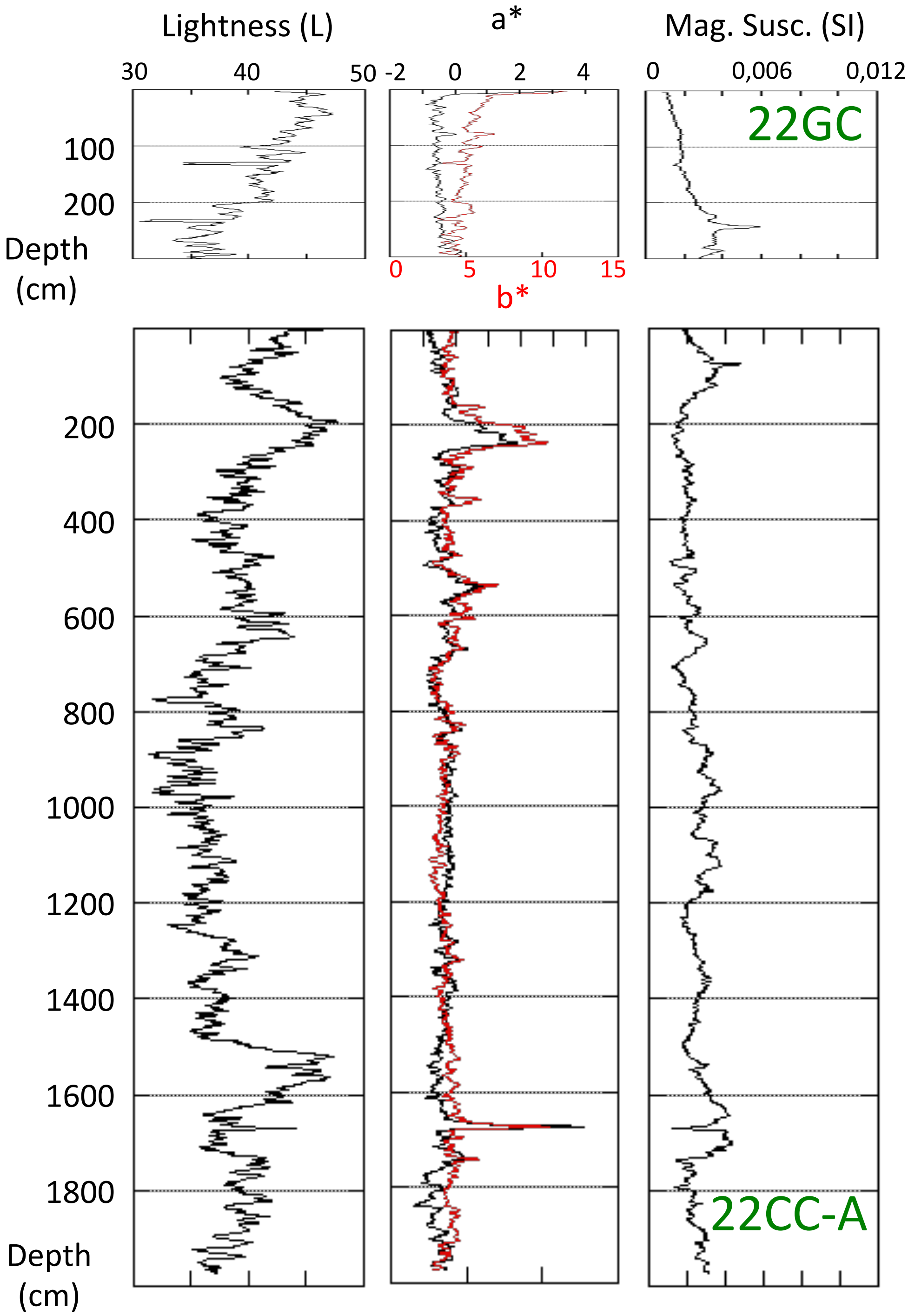


Figure 14: *Graphical correlation of sediment colour reflectance (L*; a*; b*) profiles for cores GS16-204-22 GC-A (top left& middle panel) and CC-A (lower left& middle panel). Graphical correlation of magnetic susceptibility (SI) profiles for cores GS16-204-22 GC-A (top right panel) and CC-A (lower right panel). All records are displayed on their individual depth scales in cm.*

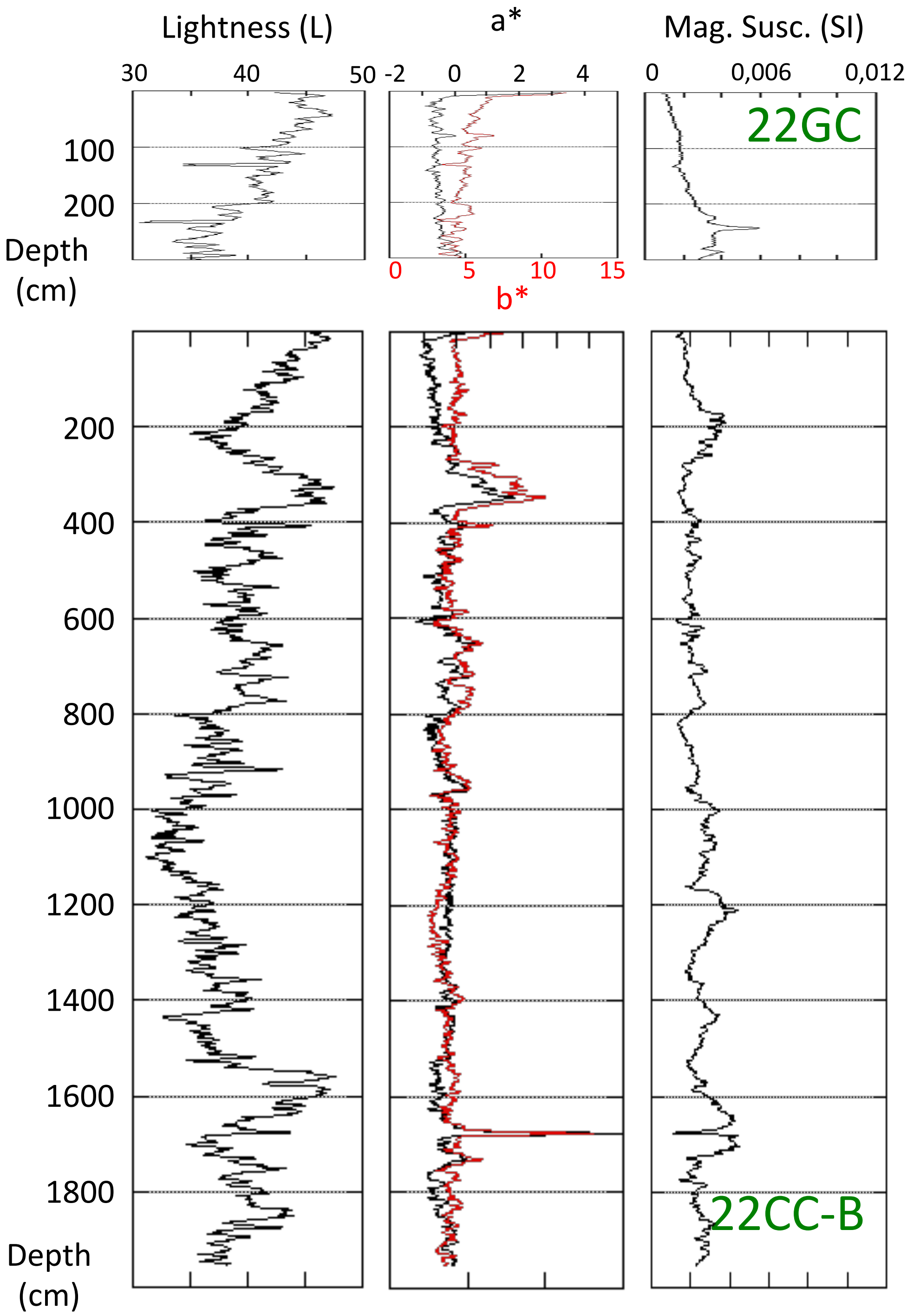


Figure 15: *Graphical correlation of sediment colour reflectance (L*; a*; b*) profiles for cores GS16-204-22 GC-A (top left& middle panel) and CC-B (lower left& middle panel). Graphical correlation of magnetic susceptibility (SI) profiles for cores GS16-204-22 GC-A (top right panel) and CC-B (lower right panel). All records are displayed on their individual depth scales in cm.*

Section pictures

Sec.# GS16-204-22-GC

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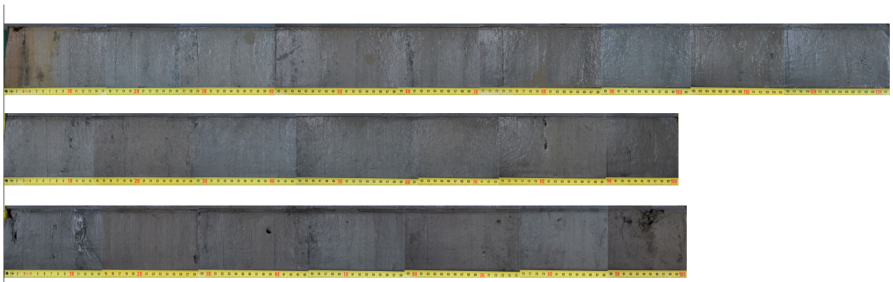

Sec.# GS16-204-22CCA

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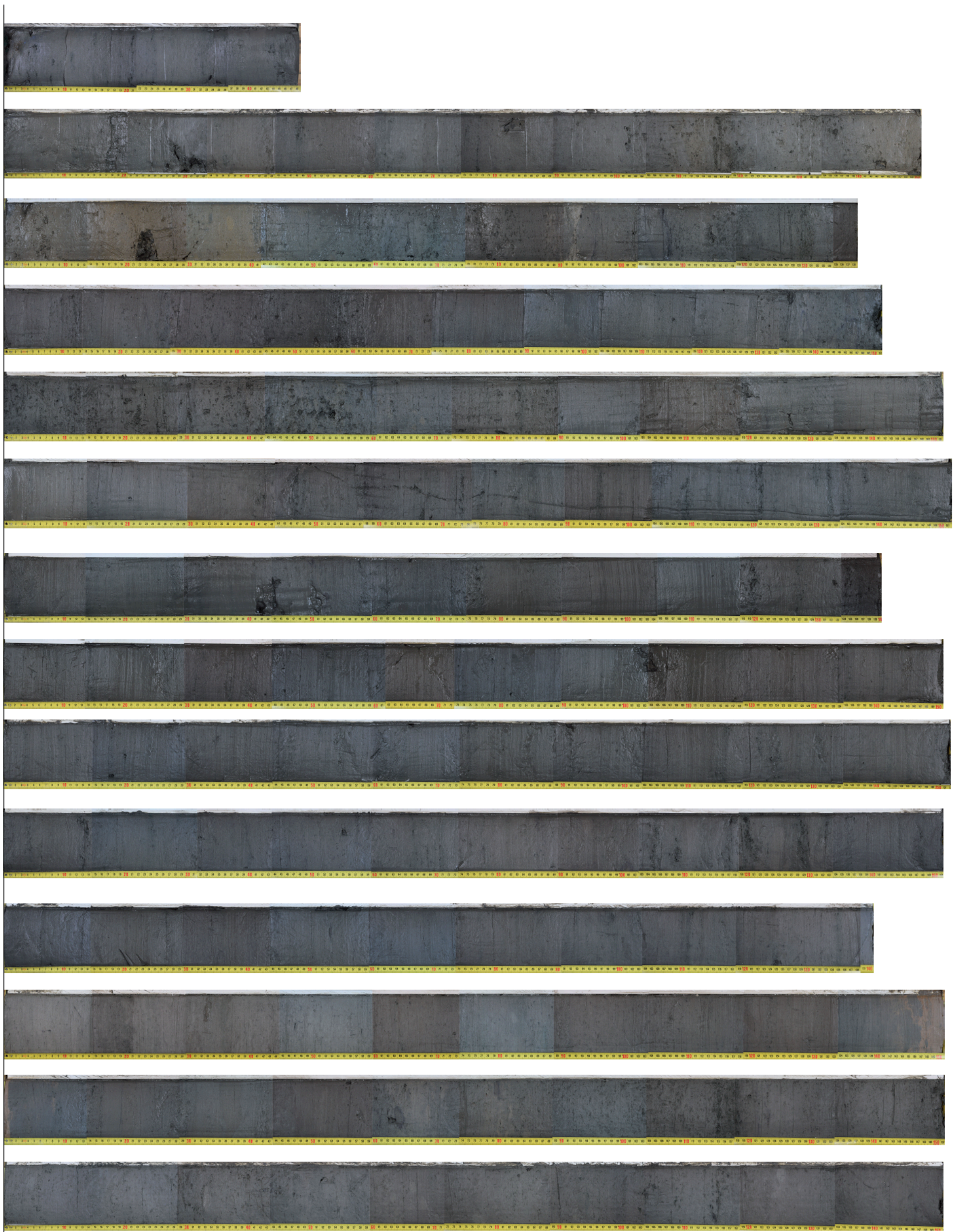

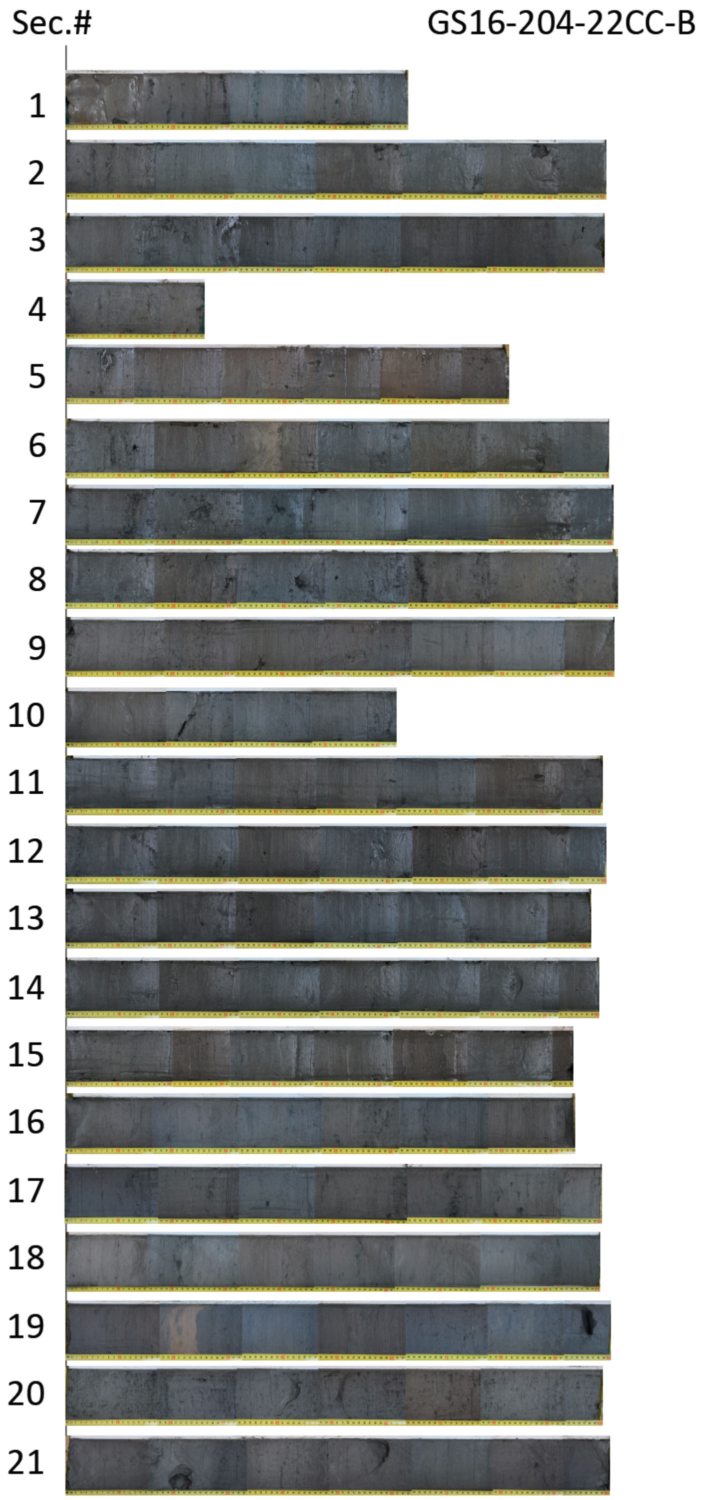
Sec.#
GS16-204-22CC-B
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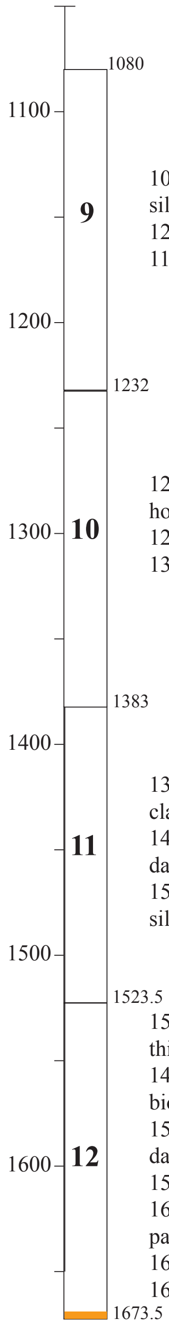
Lithology

Core: GS16-204-22 CC-A

Depth (cm)	Section	Lithology
0 – 48.5	1	0 – 3: Grey, partly brown, silty clay, very soft/high water content 3 – 48.5: Grey, silty clay, homogenous with several dark grey layers 42-48.5 cm slightly softer
48.5 – 199	2	48.5 – 136: Grey, homogenous silty clay, 51-72 cm partly condensed material 78 - 80: Hole with water, bioturbation 130 - 133: cm-sized IRD 136 – 195: Slightly lighter grey, partly brownish, silty-sandy clay, coarser, with IRD, perhaps bioturbation 195 – 199: Brown-grey, silty clay, homogenous, forams
199 – 338	3	199- 246: Brownish grey, gradual transition to lighter brown, sandy silt, bioturbation at 236 cm 222 – 225.5: Dark grey, sandy silt, IRD 246 – 338: Brownish grey silty sand, gradual transition to dark grey, silty clay with higher water content, muddy 291.5 – 293: Light grey layer, sandy silt 307 – 308: Dark grey line
338 – 489	4	338 – 433: Dark grey, sandy silt, bioturbation 399: Dropstone 433 – 489: Bioturbation, dark grey sandy silt
489 – 640	5	489 – 640: Grey silty clay, dark grey patches 533 – 557: Area with brown patches, sandy silt 599 – 603: Hole, silty clay, muddy 610: Bioturbation, some gravel
640 – 791	6	640 – 791: Grey-brownish sandy silt 570 – 690: Bioturbation 742: IRD, small dropstone ф 1.5 cm; Darker grey lines (less dense) at 736, 750, 756, 761 and 772 cm
791 – 930	7	791 – 930: Dark grey, sandy silt, homogenous 832 – 843: Muddy, high water content, holes/depressions 913 – 916: Bioturbation
930 – 1080	8	930 – 1080: Dark grey, wet, silty clay, homogenous; Dark layers at 944.5, 957, 983, 990, 1023, 1033, 1065 and 1071 cm 1050: Stone

● Samples taken from archive half for 14C dating at 150-151, 500-501 and 1000-1001 cm

Core: GS16-204-22 CC-A



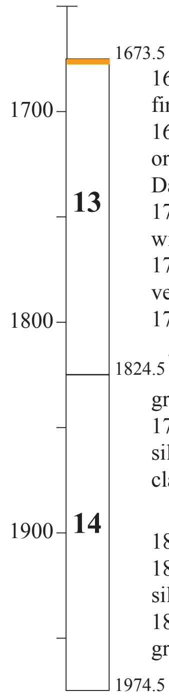
Lithology

1080 – 1232: Dark grey, homogenous silty clay, few black spots at 1114, 1201 and 1230 cm
1170: Hole filled with water

1232 – 1383: Dark grey, silty clay, homogenous; Dark layers at 1236, 1245.5, 1337.5, 1340, 1352 and 1360 cm
1318: Stone ɸ 0.5 cm

1383 – 1473: Dark grey, homogenous silty clay with some darker spots, IRD at 145.5 cm
1473 – 1508: Slightly lighter grey, silty clay, darker layers at 1482, 1493.5 and 1502 cm
1508 – 1523.5: Light grey with black spots, silty to sandy clay

1523.5 – 1539: Light grey with black spots, thin silty clay, greenish-grey layers at 1526.5 and 1528 cm
1439 – 1544.5: Dark grey mixed with light grey, silty clay, bioturbation
1544.5 – 1621: Light grey with black spots, silty clay, darker layers with slightly condensed material at 1558-1560, 1594-1597, 1605-1607 and 1610-1614.5 cm
1621 – 1665: Darker grey, homogenous silty clay, partly compacted material
1665 – 1670.5: Dark grey mixed with orange parts, diffuse transition
1670.5 – 1673.5: Orange, extremely fine clay



Lithology

1673.5 – 1674.5: Orange, extremely fine clay, sharp boundary at bottom
1674.5 – 1712: Dark grey, silty clay, orange lese at 1681.5 cm.
Darker layers at 1689 and 1693 cm
1712 – 1731: Slightly lighter grey, with black spots, silty clay
1731 – 1758: Light grey, 1736-1741 cm very light grey with dark lenses 1733 and 1737 cm. diffuse transition with darker grey at 1740-1745 cm (bioturbation?).
1751-1758 cm: light grey lenses in darker grey (bioturbation?)
1758 – 1824.5: Dark grey, homogenous silty clay, darker layer of compacted clay and IRD at 1788.5-1791.5 cm

1824.5 – 1841: Dark grey, silty clay
1841 – 1889: Slightly lighter grey, silty/sandy clay with IRD, sough surface
1889 – 1905: Dark grey with lenses of light grey at top and bottom (bioturbation)
1905 – 1911.5: Lighter grey, coarser, silty clay
1911.5 – 1974.5: Dark grey, homogenous, silty clay, 1927-1940 cm spots of compacted material + coarser (sandy) grains

Shear strength (kPa) measured at the bottom of each section

Sec. #01	11.77
Sec. #02	31.38
Sec. #03	45.11
Sec. #04	72.57
Sec. #05	68.65
Sec. #06	74.53
Sec. #07	84.34
Sec. #08	96.11
Sec. #09	96.11
Sec. #10	164.75
Sec. #11	149.06
Sec. #12	98.07
Sec. #13	162.79
Sec. #14	98.07

Core: GS16-204-22 CC-B

Depth (cm)	Section	Lithology
0 – 63	1	0 – 4: Boundary between upper soupy layer to firm sediment 0 – 63: Grey, silt, some darker grey lines in between (e.g. 33-34cm) 33 – 34: Less dense, line of dark grey silt
63 – 163.5	2	63 – 163.5: Grey silt, some dark grey spots 68: Layer of darker grey silt
163.5 – 263.5	3	163.5 – 263.5: Grey sandy silt, homogenous 195 – 198: Soft, lower density, grey silt 227 – 232: Some lighter grey patches
263.5 – 288	4	263.5 – 288: Grey, sandy silt, transition to more brownish colour. Bioturbation? 282 – 288: Some gravel
288 – 369	5	288 – 296: Grey sandy silt, some gravel 296 – 355: Brownish, silt, bioturbation 355 – 369: Grey silt
369 – 468.5	6	369 – 404: Grey silt 404 – 409.5: Light grey, sandy silt 410 – 468.5: Bioturbation, grey silt
468.5 – 568.5	7	468.5 – 482.5: Brownish-grey, sandy silt 482.5 – 519.5: Grey, homogenous silt 519.5 – Brownish-grey, sandy silt, bioturbation 551 – 560: Soft, lower density, muddy
568.5 – 669.5	8	568.5 – 669.5: Brownish-grey, bioturbation, sandy silt 631.5 – 633: Line of dark grey sandy silt 610: Some gravel
669.5 – 770	9	669.5 – 770: Grey, sandy silt 730: Bioturbation 715.5 – 726: Brownish grey
770 – 863	10	770 – 787: Brownish grey, sandy silt, some gravel 792 – 798: Crack in the sediment 790 – 801: Bioturbation 781 – 863: Dark grey, sandy silt
863 – 964	11	863 – 907: Grey, homogenous, sandy silt, some darker grey lines in between (e.g. 938) 907: Boundary, transition to darker shade of grey silt 960 – 963: Bioturbation
964 – 1064	12	963 – 1064: Dark grey, sandy silt, homogenous 970 – 974: Bioturbation
1064 – 1165.5	13	1064 – 1165.5: Dark grey, homognous, silty clay 1093.5 – 1034.5: Line of darker grey silt, higher porosity 1122: Line of darker grey silt

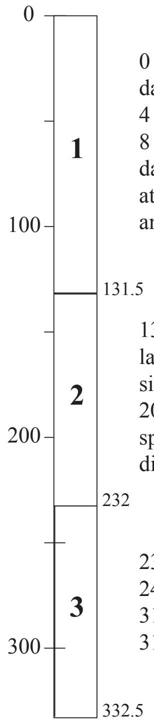
Core: GS16-204-22 CC-B

Depth (cm)	Section	Lithology
1165.5 – 1265.5	14	1116.5 – 1265.5: Dark grey, sandy silt, homogenous, wet 1248.5 – 1251: Dropstone ф 2.5 cm
1265.5 – 1362	15	1265.5 – 1362: Dark grey, sandy silt, homogenous
1362 – 1455	16	1362 – 1369: Soft, dark grey, silty clay 1369: Gradual transition from grey to darker shade of grey 1369 – 1397: Bioturbation
1455 – 1555	17	1455 – 1530: Dark grey, silt, homogenous, darker grey spots 1530 – 1547: Boundary, lighter grey 1547 – Boundary, even lighter grey, softer
1555 – 1655	18	1555 – 1609: Light grey, sandy silt, interrupted by a darker shaded grey interval at 1572 – 1577 cm 1609 – 1655: Gradual transition to darker shades of grey. Some darker grey intervals at 1614-1616 and 1622 – 1625 cm
1655 – 1755	19	1655 – 1670: Brownish-grey, silt 1670 – 1679: Transition to orange coloured layer, silt, sharp boundary at 1697. 1679 – 1755: Brownish grey, silt 1728 – 1742: Brown spots, bioturbation 1749 – 1752: Depression, dropstone (in separate bag)

Depth (cm)	Section	Lithology
1755 – 1855	20	1755 – 1774: Dark grey, clay with some coarser grains 1774 – 1855: Grey clay wish some black areas (randomly) and some coarser grains
1855 – 1955.5	21	1855 – 1955: Grey, smooth clay, no major color changes, some light lenses between 1 855-1862 cm (ф 1cm) Dropstones at 1875-1878 and 1910-1914 cm 1798: Dropstone ф 2 cm

Core: GS16-204-22 GC

Depth (cm) | Section | Lithology



0 – 4: Brown, soft, wet, silty clay, dark layer at 3-3.5 cm
4 – 8: Grey-brown transitional zone
8 – 131.5: Dark grey, silty clay, dark layers of condensed material at 21, 25.5, 34.5, 42.5, 60, 85.5 and 112.5 cm

131.5 – 209: Dark grey with darker layers at 141.5, 148 and 160 cm, silty clay wit spots of condensed material
209 – 232: Slightly lighter grey, with black spots, silty clay (coarser than above), diffuse transitions at 206-209cm

232 – 314: Dark grey, silty clay, homogenous. 244-245 cm darker layer; IRD at 305.5cm
314 – 332.5: Lighter grey, silty clay with sand, 311-314cm: black lenses/bioturbation

Station: GS16-204-23

Longitude	Latitude	Water depth	Date	Start time
58° 13,76	45° 41,87	2270 m	29.08.16	10:10

Coring Devices	Remarks
Multicore	A: 33cm, B: 32cm, C: 32cm, D: 32cm
CTD	Water samples taken (see report below). CTD 574
Gravity core (GC)	GC-A - 318 cm GC-B – 320 cm
Calypso core (CC)	1943 cm

CTD (Temperature, Salinity, Oxygen, Density profile)

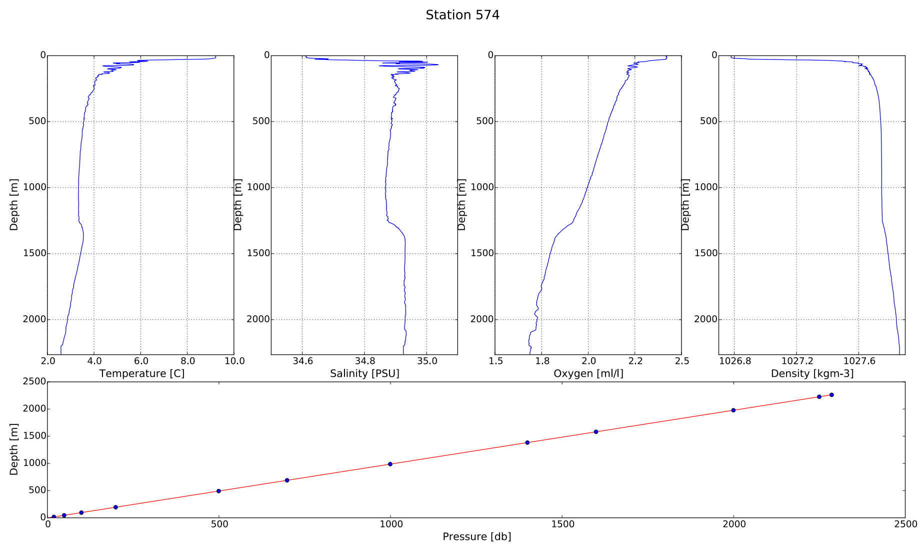
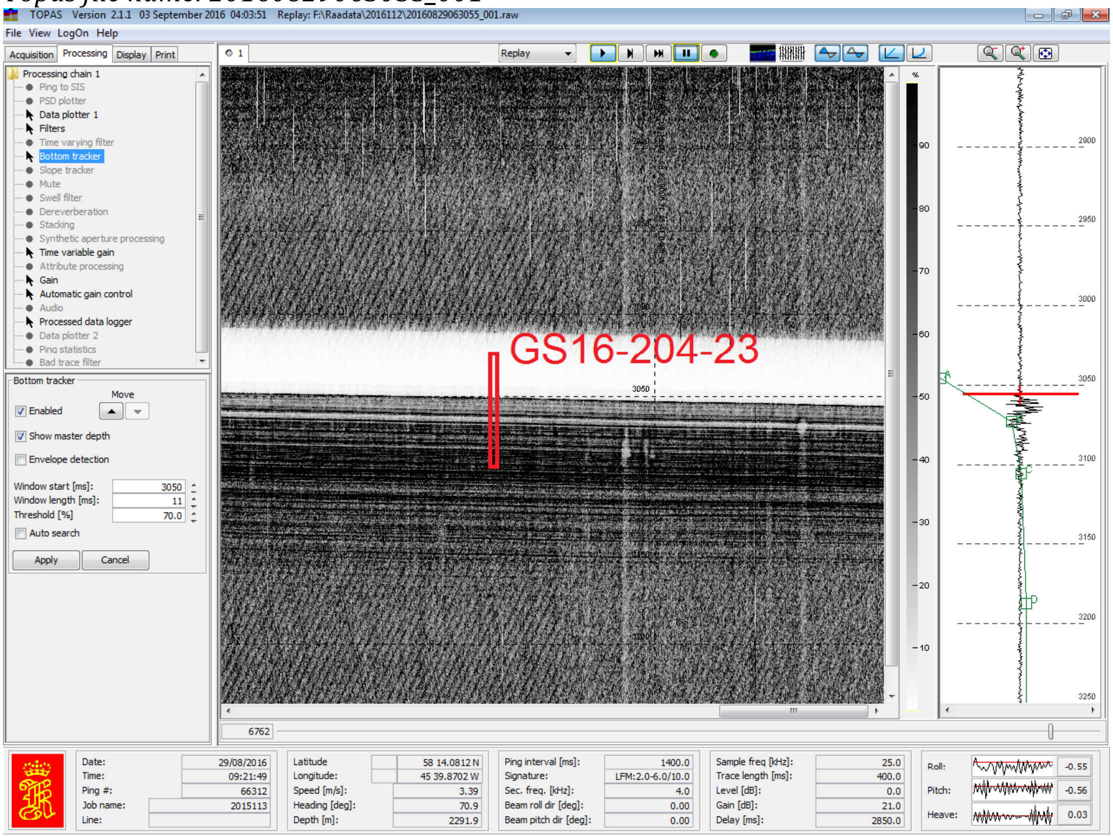


Figure 16: *CTD Profile 574- Station 23: Water samples taken for $\delta^{18}O$ analysis at 20; 50; 100; 200; 500; 700; 1000 ($\delta^{13}C$); 1400; 1600 ($\delta^{13}C$); 2000; 2250; 2285 ($\delta^{13}C$) m water depth. Samples taken for $\delta^{13}C$ are indicated respectively.*

Topas profile at coring station

Topas file name: 20160829063055_001



Spectrophotometer (colour) and magnetic susceptibility

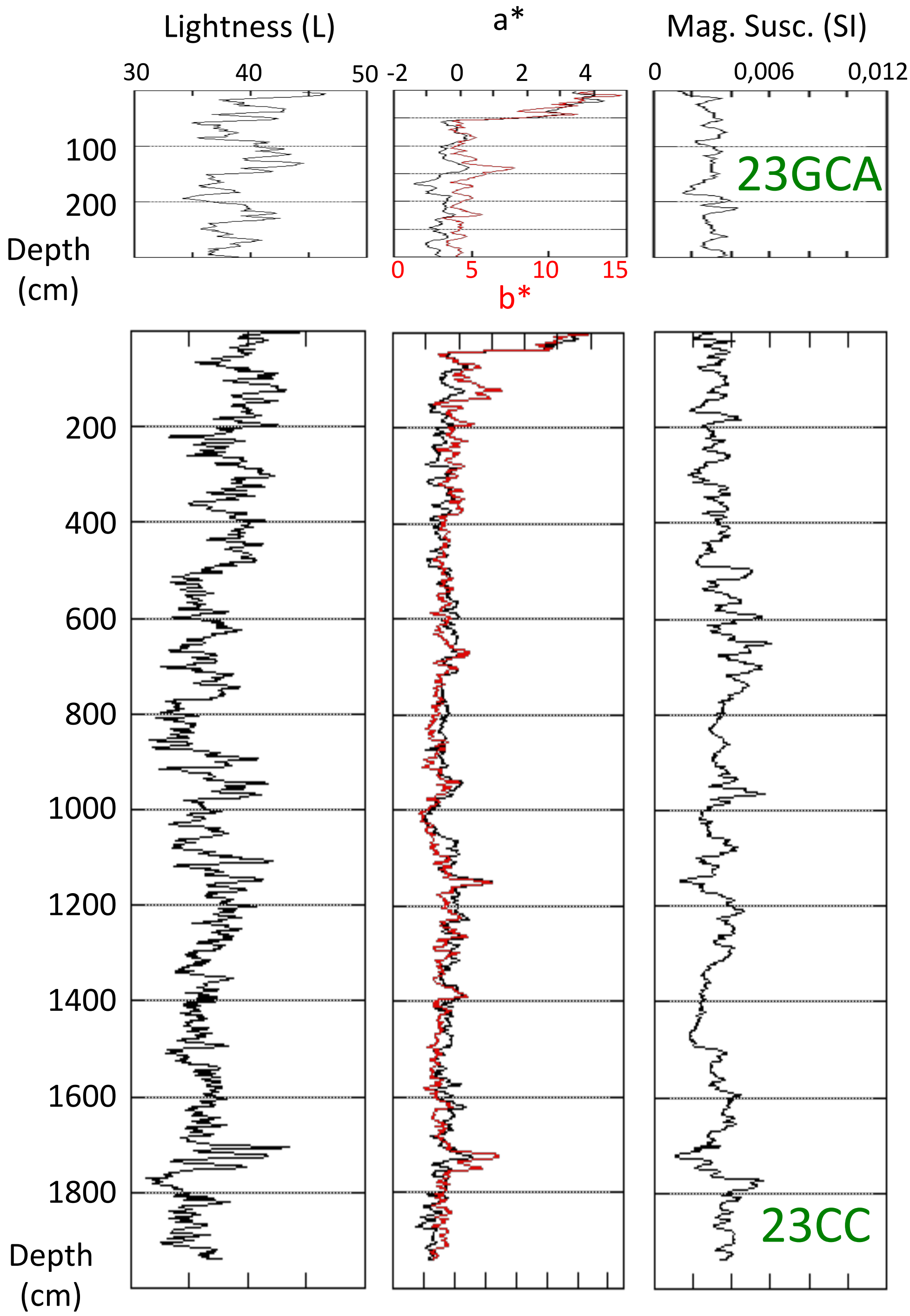


Figure 17: *Graphical correlation of sediment colour reflectance (L*; a*; b*) profiles for cores GS16-204-23 GC-A (top left& middle panel) and CC (lower left& middle panel). Graphical correlation of magnetic susceptibility (SI) profiles for cores GS16-204-23 GC-A (top right panel) and CC (lower right panel). All records are displayed on their individual depth scales in cm.*

Section pictures

Sec.# GS16-204-23GC-A

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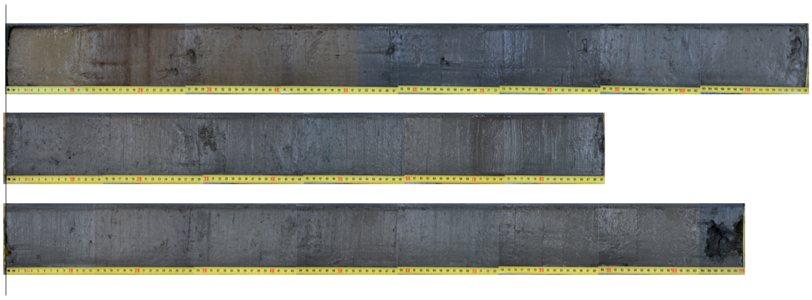

Sec.# GS16-204-23CC

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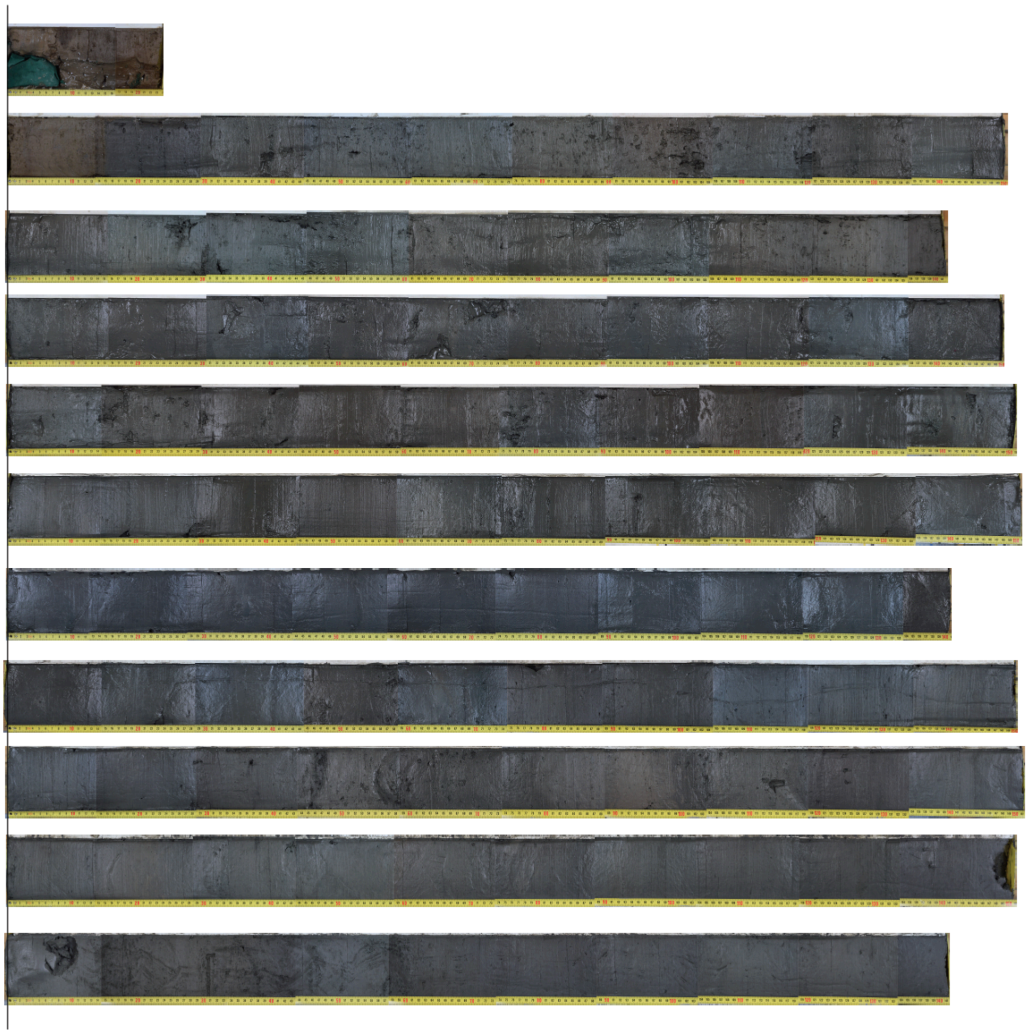
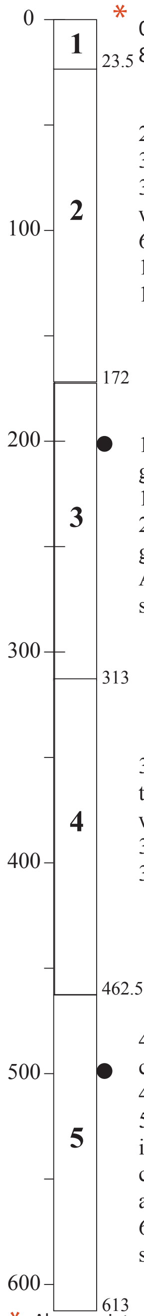


Lithology

Core: GS16-204-23 CC

Depth (cm)	Section	Lithology



* 0 – 8: Soft, brownish, sandy silt, muddy
8 – 23.5: Darker brown silt, bioturbation

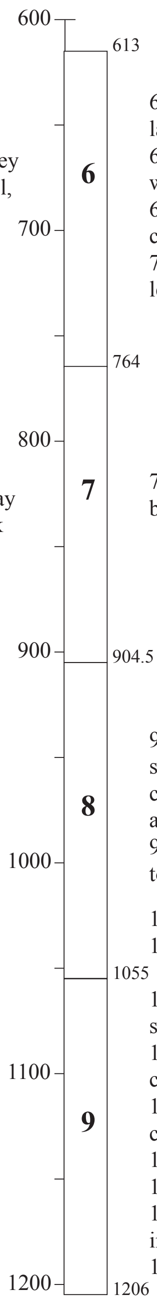
23.5 – 38.5: Brown, silty, clay, relatively dry
38.5: Sharp boundary from brown to dark grey
38.5 – 172: Dark grey, silty clay, some gravel, wet
60 – 79: Soft, lower density
114 – 126: Soft, low density
155 – 172: Soft, low density, muddy

● 172 – 193: Soft, low density homogenous, grey silty clay
193 – 213: Higher density, dark grey silty clay
284 – 313: High density, hard sediment, dark grey, silty clay, bioturbation.
All in all a very muddy/wet section, signs of displacements

313 – 462.5: Dark grey, silty clay, muddy to more consistent, bioturbation, high water content
347 – 349: Dropstone ϕ1.5 cm
347 – 440: Dropstone

● 462.5 – 470: Very dark clay with some consolidations
470 – 543: Grey with som consolidations
543 – 602.5: Dark grey with black layers in the beginning and light lenses, consolidations, coarse at 582 cm, and black parts
602.5 – 613: Lighter grey/brownish, silty clay with consolidated areas

Depth (cm)	Section	Lithology



613 – 675: Lighter grey clay with black layers and brown lenses
675 – 694.5: Lighter layer, dark grey clay with cconsolidated parts
694.5 – 713.5: Grey clay with light lenses, consolidated at 707 and 712 cm
713.5 – 764: Light grey clay, brownish lens at 719 cm, hole at 746-752 cm

764 – 904.5: Grey silty clay, very sticky, black layer at 818 cm

904.5 – 1055: Grey silty clay, lense of sandy silt at 950-953 cm, layers of consolidated material at 962-963, 976 and 1034 cm
968 – 974: Color changes from grey to light grey to brown

1055 – 1094: Dark grey silty clay
1094 – 1100.5: Slightly lighter grey with black layers
1100.5 – 1103: Black layer, consolidated, sticky
1103 – 1114: Slightly lighter grey, slightly coarser (silt), 1110.5-1115 cm consolidated
1115 – 1132: Dark grey silty clay, partly consolidated
1132 – 1135: Nearly black then lighter until 1140
1140 – 1153: Changes to reddish, most intensive at 1145-1150cm with IRD
1153 – 1206: Dark grey homogenous, consolidated 1155.5-1159 cm.
Dropstones ϕ 2cm at 1167 and 1170 cm

* Above point zero sediments were extremely soupy when splitting the section. Only half of the core half was "intact", held together by floral foam

● Samples taken from archive half for 14C dating at 200-201 and 500-501 cm

Core: GS16-204-23 CC

Depth (cm)	Section	Lithology
1206	10	1206 – 1356.5: Grey silty clay, homogenous with some reddish parts 1227-1230, 1262-1266 and lighter lenses at 1280.5-1236cm 1353 – 1356.5: Big hole
1356.5	11	1356.5 – 1368: Dark grey, silty clay, coarse in some parts, large forams! 1363 – 1367.5: Dropstone ф4cm, edgy, red sandstone? 1368 – 1417: 1383-1442 lighter part; dark grey silty clay, consolidated, some IRD 1410 – 1423: Sandy lens, rich in large forams 1423 – 1490: Dark grey silty clay, homogenous, smooth
1498	12	1498 – 1620: Grey silty clay, homogenous, some coarser grains at 1555-1559 cm 1595: Dropstone ф 1.5 cm 1620 – 1648: Darker grey, with IRD at 1630
1648	13	1648 – 1699: Dark grey clay, homogenous; coarsere black layer at 1680cm !1699 – 1715: Light grey foram sand, nearly white (just forams) at 1706.5-1707.5cm 1715 – 1730: Light grey to brownish clay, homogenous 1730 – 1745: Dark grey silty clay 1745 – 1753: Light grey to brownish clay, homogenous (bioturbation to next layer?) 1753 – 1798: Grey silty cly, homogenous
1798		

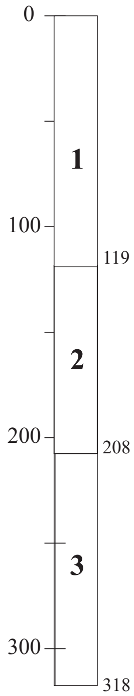
Depth (cm)	Section	Lithology
1798	14	1798 – 1943: Dark grey, silty clay Slightly lighter grey layers with IRD at 1800-1806, 1825-1827, 1847-1850, 1866-1872 and 1915-1943 cm
1943		

Shear strength (kPa) measured at the bottom of each section

Sec. #01	-
Sec. #02	-
Sec. #03	-
Sec. #04	113.76
Sec. #05	29.42
Sec. #06	41.19
Sec. #07	49.03
Sec. #08	74.53
Sec. #09	135.33
Sec. #10	66.69
Sec. #11	137.29
Sec. #12	107.87
Sec. #13	145.14
Sec. #14	31.38

Core: GS16-204-23 GC-A

Depth (cm) Section Lithology



0 – 11.5: Light brown, silty sand, low density
11.5: Boundary between light brown to darker brown
11.5 – 51: Brown sandy silt, darker brown intervals at 17.5-18.5 and 20-21.5cm
51 – 88: Sharp boundary, dark grey, smooth, homogenous silt
88 – 119: Boundary, lighter grey, firmer, dryer, sandy silt

119 – 208: Gradual transition from brownish grey, to lighter grey to dark grey
170 – 208: sandy/silty clay
189: Boundary between lighter grey and darker grey silty clay

189 – 244: Grey, silty clay, bioturbation
281: Sediments change from dryer, grey silt to wet, dark grey silty clay, homogenous

Station: GS16-204-24

Longitude	Latitude	Water depth	Date	Start time
58° 36,21	46° 22,77	2540 m	30.08.16	08:15

Coring Devices	Remarks
Multicore	A: 37,5cm, B: 37,5cm, C: 37,5cm, D: 36,5cm
CTD	Water samples taken (see report below). CTD 575
Gravity core (GC)	338,5 cm
Calypso core (CC)	2042 cm

CTD (Temperature, Salinity, Oxygen, Density profile)

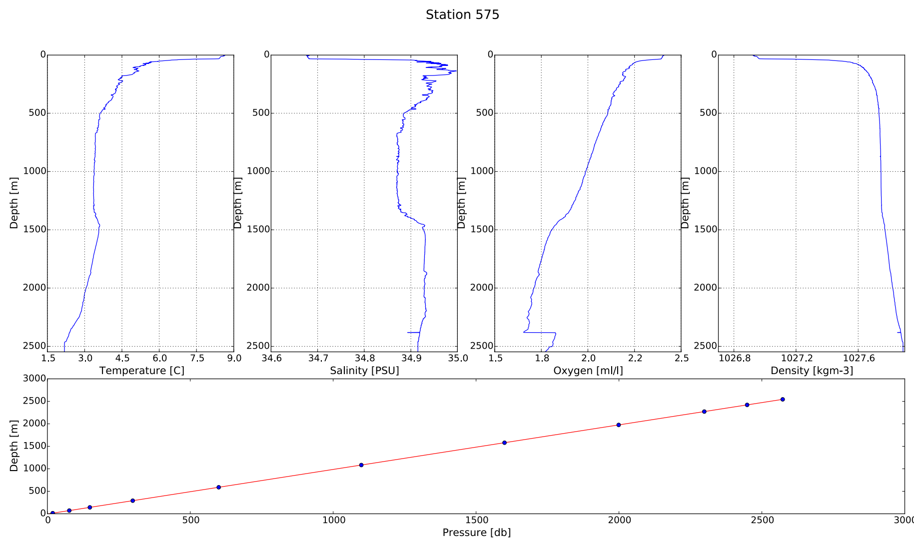
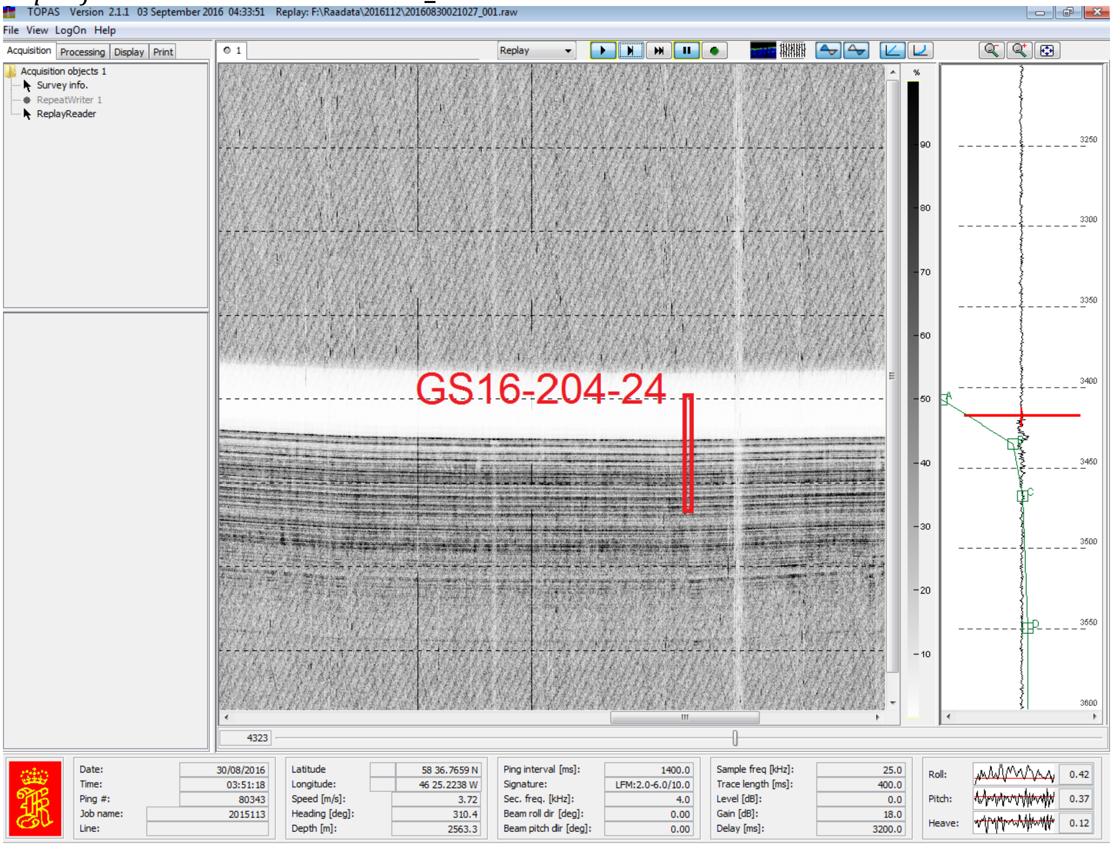


Figure 18: *CTD Profile 575- Station 24: Water samples taken for $\delta^{18}O$ analysis at 20 ($\delta^{13}C$); 80 ($\delta^{13}C$); 150; 300; 600; 1100; 1600 ($\delta^{13}C$); 2000; 2300; 2450; 2572 ($\delta^{13}C$) m water depth. Samples taken for $\delta^{13}C$ are indicated respectively.*

Topas profile at coring station

Topas file name: 20160830021027_001



Spectrophotometer (colour) and magnetic susceptibility

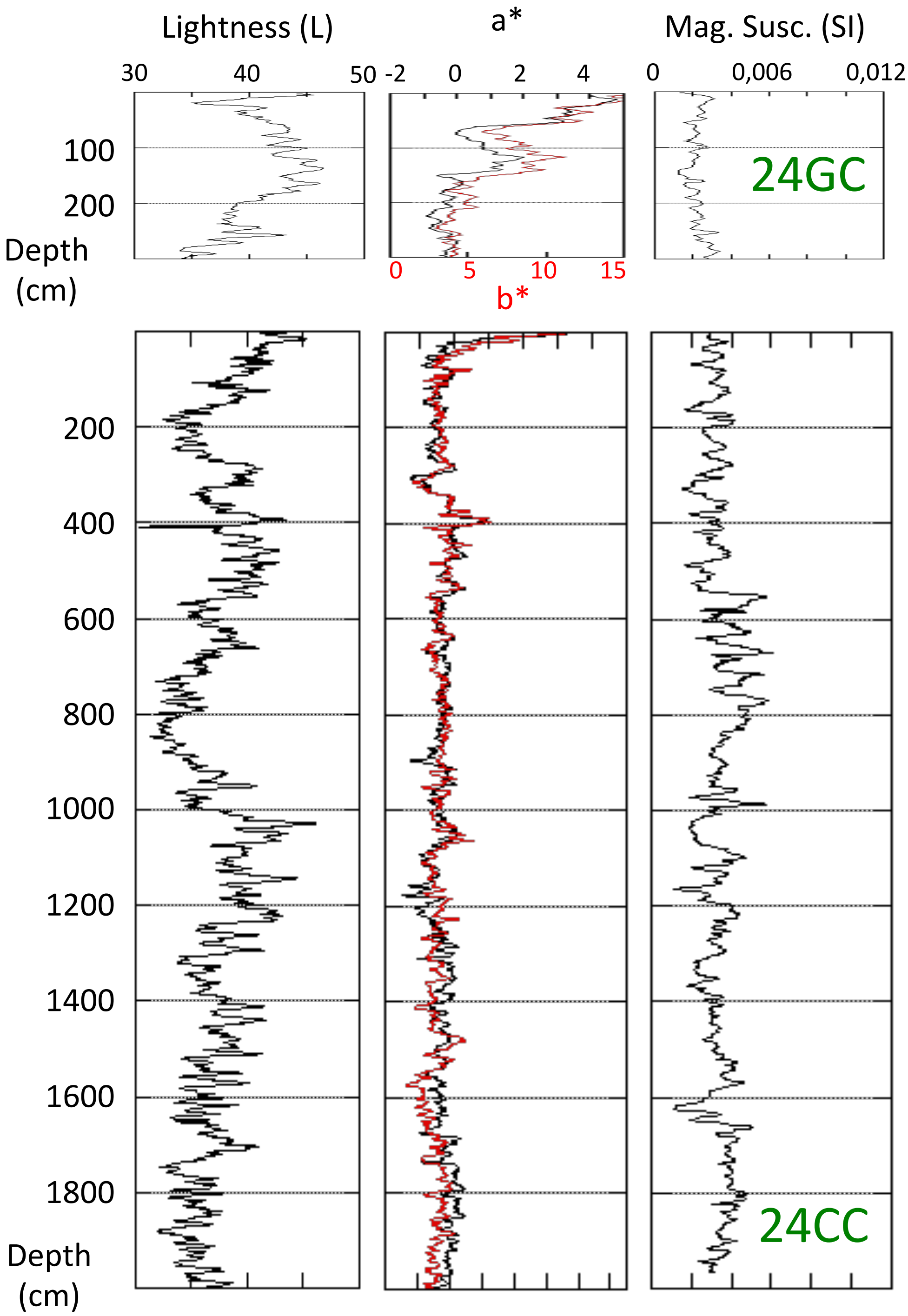


Figure 19: *Graphical correlation of sediment colour reflectance (L*; a*; b*) profiles for cores GS16-204-24 GC (top left& middle panel) and CC (lower left& middle panel). Graphical correlation of magnetic susceptibility (SI) profiles for cores GS16-204-24 GC (top right panel) and CC (lower right panel). All records are displayed on their individual depth scales in cm.*

Section pictures

Sec.# GS16-204-24-GC

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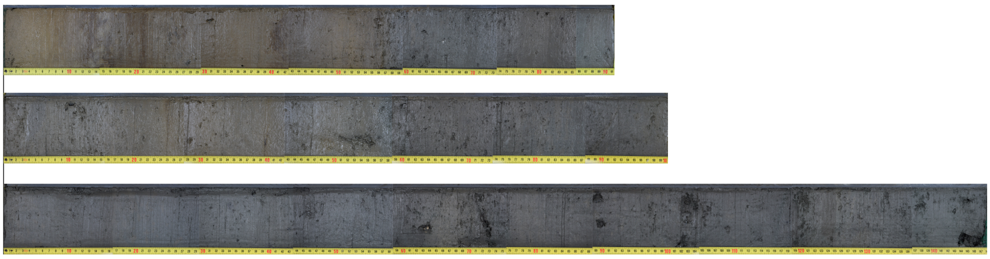

Sec.# GS16-204-24-CC

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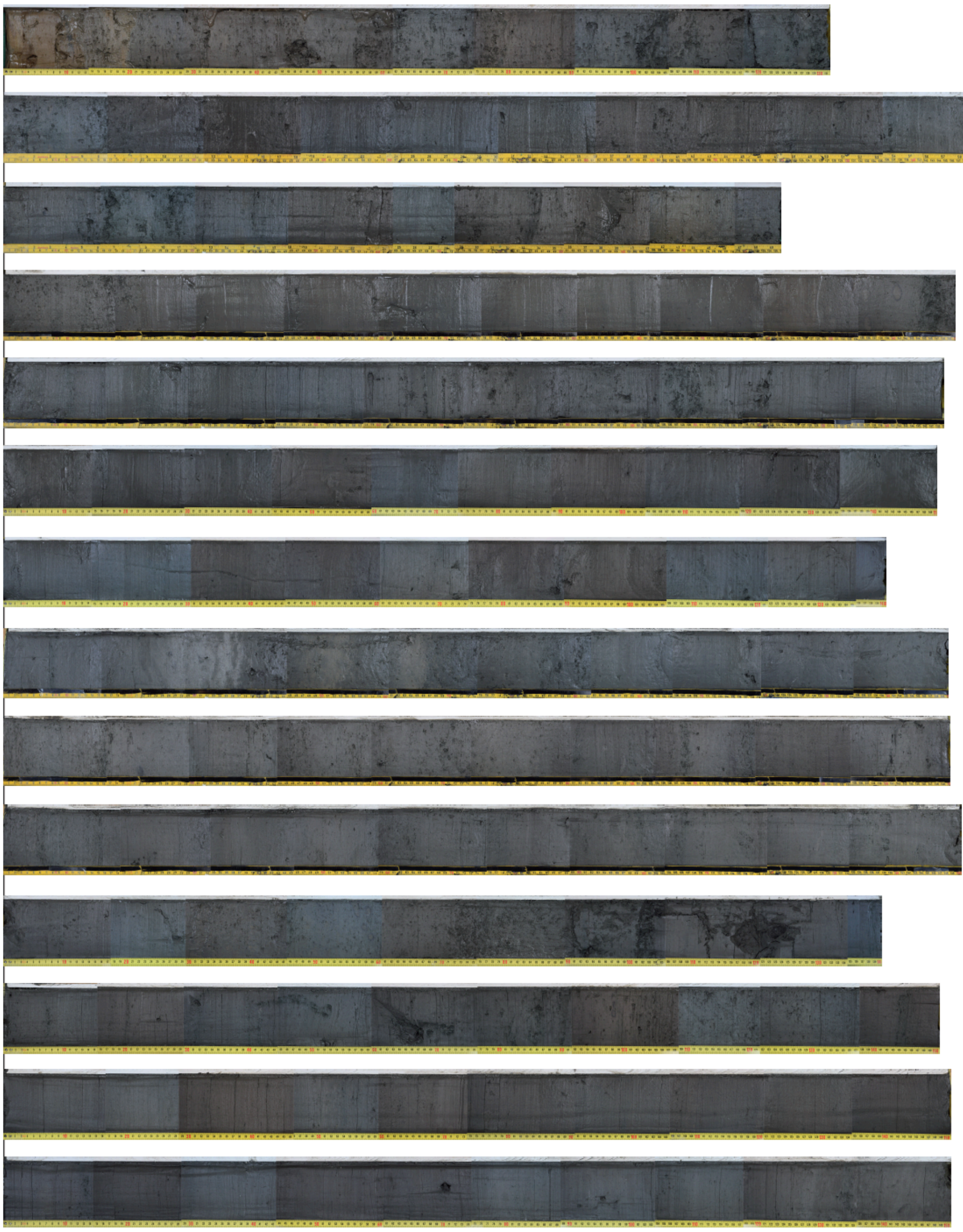


Lithology

Core: GS16-204-24 CC

Depth (cm)	Section	Lithology
0 – 132	1	0 – 20: Brown (0-3 cm light, foram sand) silty clay from 3 cm 20 – 132: Grey silty clay (hole at 33 cm), holes with water and consolidated clay at 45-49 and 56-63 cm 76 – 81: Lighter brownish, IRD 119: Brake that causes archive half to be shorter (also in the beginning compacted)
132 – 283	2 ●	132 – 274: Dark grey silty clay, some sand and gravel 274 – 283: Slightly lighter grey, gradual transition 140: IRD or gravel
283 – 409	3	283 – 369: Grey silty clay, homogenous 369 – 384: Transition to lighter grey, fine silty clay 384 – 404: Transition to more brownish-grey, some gravel, bioturbation 378 – 385: IRD, large dropstone ϕ 3cm 367.5 – 369: Dark grey interval, clay
409 – 559.5	4	409 – 432: Grey silty clay with consolidated clay 432 – 554: Grey clay, homogenous, brown layer at 473.5 & 537.5 cm with bioturbation, light grey lenses at 528-532, 543.4-546 and 550 cm (ϕ 3cm) with black frame 554 – 559.5: Dark grey consolidated clay
559.5 – 708.5	5 ●	559.5 – 626.5: Grey clay with consolidated layer at 560 cm and 623-625 (coarser), many of forams 625 – 644: 625-636 cm light, fine material; 636-644 cm light, consolidated (less water) 644 – 708.5: Grey clay, igh in forams, consolidated at 665-672 (also IRD) and 680cm
708.5 – 859	6	708.5 – 859: Grey, silty clay, consolidated material at 832cm, IRD ϕ 1cm at 839-840
859 – 999.5	7	859 – 999.5: Grey silty clay; 937-939cm consolidated
999.5 – 1150	8	999.5 – 1024 Grey, silty clay, darker layer of consolidated material at 1070cm 1024 – 1036: Light grey, silty sand, foram ooze, diffuse transitions 1036 – 1046: Grey silty clay, partly consolidated, IRD at 1040cm 1046 – 1054: Brownish grey, silty clay 1054 – 1061: Grey silty clay 1061 – 1065: Brownish grey, silty clay 1065 – 1150: Grey, silty clay, consolidated material at 1084-1096cm & 1116-1119cm (IRD)

● Samples taken from archive half for 14C dating at 200-201 and 570-571 cm

Core: GS16-204-24 CC

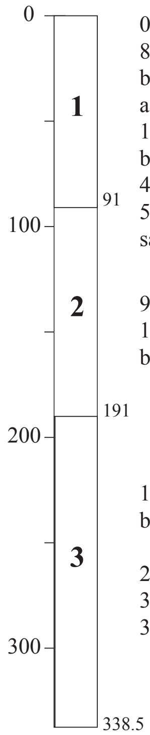
Depth (cm)	Section	Lithology
1150 – 1300.5	9	1150 – 1180: Grey silty clay, partly consolidated, dark lens at 1172 cm 1180 – 1238: Brownish grey, silty clay, some IRD 1239 – 1257.5: Dark grey, silty clay, some light grey lenses 1257.5 – 1265.5: Lighter grey, consolidated + IRD at 1258-1260 cm, coarser (more silt) 1265.5 – 1290: Dark grey, silty clay 1290 – 1300.5: Lighter grey, coarser silty clay, + sandy and gravel (IRD)
1300.5 – 1451	10	1300.5 – 1451: Grey, silty clay, homogenous. Many different layers visible based on color change, different shades of grey, forams
1451 – 1591	11	1451 – 1520: Grey, silty clay, homogenous, bioturbation shown as brown spots at 1480-1511 cm 1520 – 1591: Gradual transition, dark grey clay, homogenous
1591 – 1741.5	12	1591 – 1741.5: Dark grey, homogenous lay, gradual increasing silt content 1654 – 1690: Large dropstone ϕ 5cm 1682 – 1690: Bioturbation
1741.5 – 1891.5	13	1741.5 – 1795: Dark grey to brownish grey, silty clay 1795 – 1891.5: Dark grey silty clay, some black spots; Bioturbation at 1815-1820, 1849-1852 and 1860.5-1862.5 cm
1891.5 – 2042	14	1891.5 – 2016.5: Dark grey, silty clay, homogenous 2016.5: Gradual transition to lighter grey, sandy silt

Shear strength (kPa) measured at the bottom of each section

Sec. #01	58.84
Sec. #02	41.19
Sec. #03	72.57
Sec. #04	58.84
Sec. #05	68.65
Sec. #06	72.57
Sec. #07	105.91
Sec. #08	113.76
Sec. #09	149.06
Sec. #10	117.68
Sec. #11	148.37
Sec. #12	156.91
Sec. #13	166.71
Sec. #14	135.33

Core: GS16-204-24 GC

Depth (cm) Section Lithology



0 – 8: Light brown sand
8 – 18: Gradual transition to darker brown, a lot of bioturbation shown as light brown spots, silty sand
18 – 44: Brown silty sand, darker brown layer at 21-22cm, bioturbation
44 – 58: Greyish brown, silt with some sand
58 – 91: Gradual transition to brownish-grey, sandy silt

91 – 147.5: Greyish-brown, sandy silt, wet
147.5 – 191: Gradual transition to brownish-grey sandy silt, bioturbation

191 – 323: Brownish-grey, sandy silt, bioturbation at 191-214, 275-285 & 318-320cm

256 – 262: Brown silt, bioturbation?
323 – 228.5: Grey, silty clay
335 – 338.5: Depression in the sediment

Station: GS16-204-25

Longitude	Latitude	Water depth	Date	Start time
58° 13,29	45° 31,56	2274 m	31.08.16	12:30

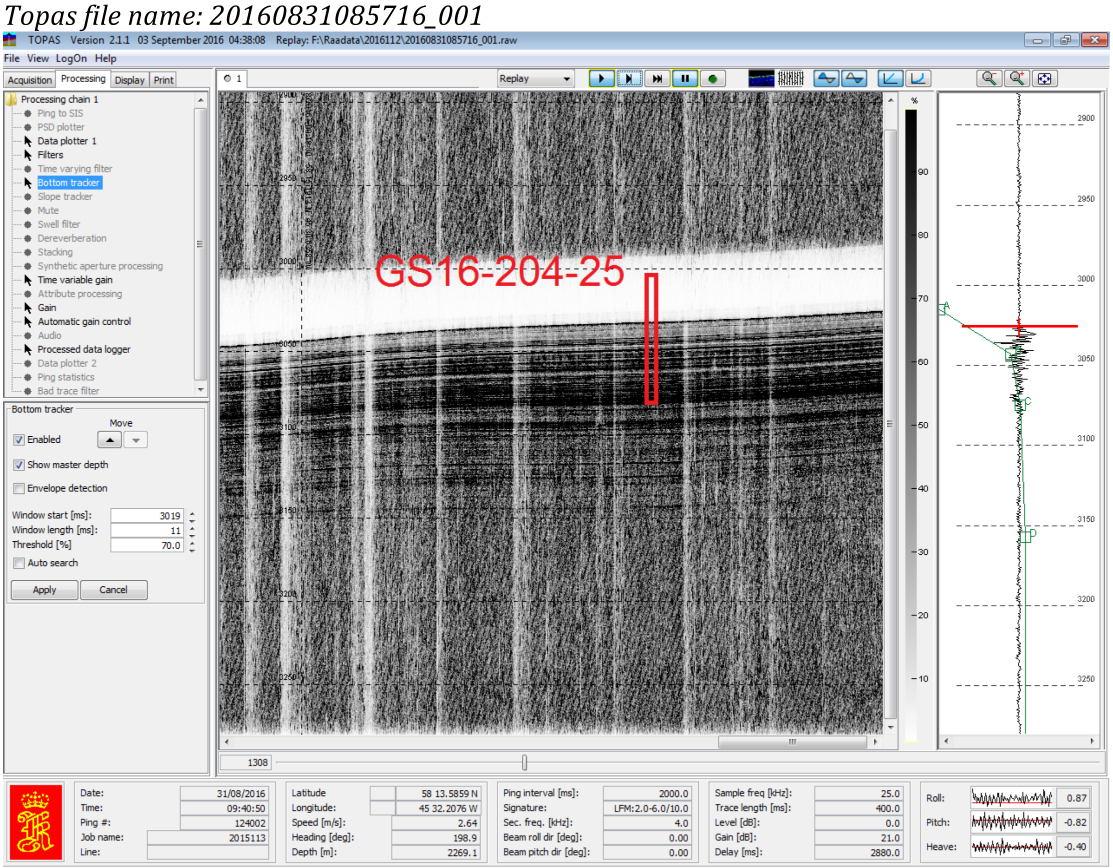
Coring Devices	Remarks
Gravity core (GC)	315 cm
Calypso core (CC)	1970,5 cm

CTD (Temperature, Salinity, Oxygen, Density profile)

Closely related to GS16-204-23

Topas profile at coring station

Topas file name: 20160831085716_001



Spectrophotometer (colour) and magnetic susceptibility

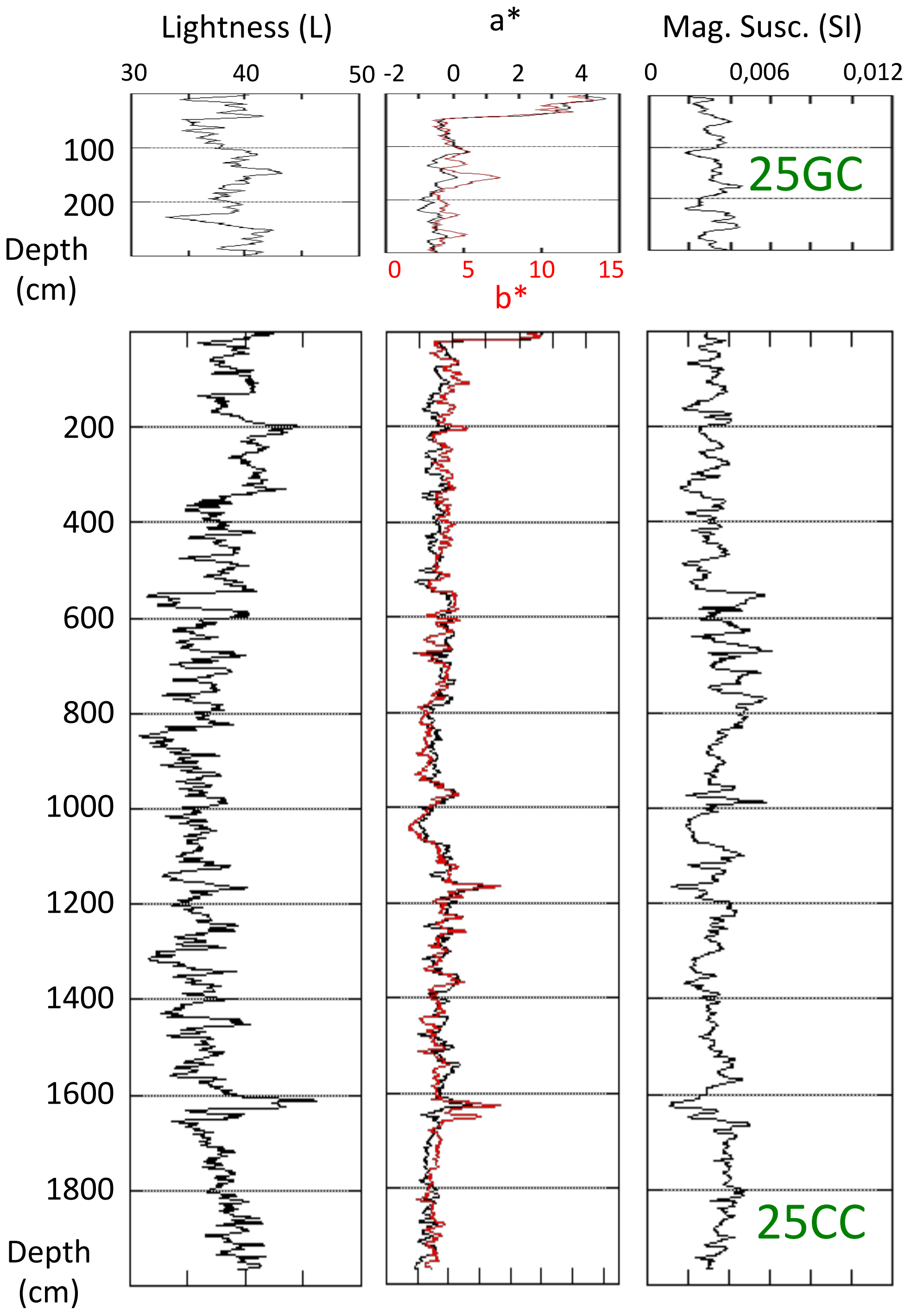
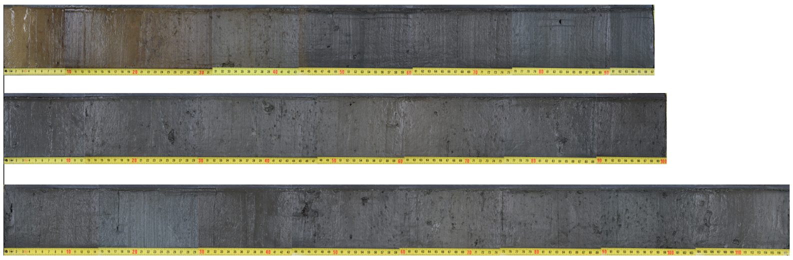


Figure 20*: Graphical correlation of sediment colour reflectance (L*; a*; b*) profiles for cores GS16-204-25 GC (top left& middle panel) and CC (lower left& middle panel). Graphical correlation of magnetic susceptibility (SI) profiles for cores GS16-204-25 GC (top right panel) and CC (lower right panel). All records are displayed on their individual depth scales in cm.*

Section pictures

Sec.# GS16-204-25-GC

1
2
3



Sec.# GS16-204-25-CC

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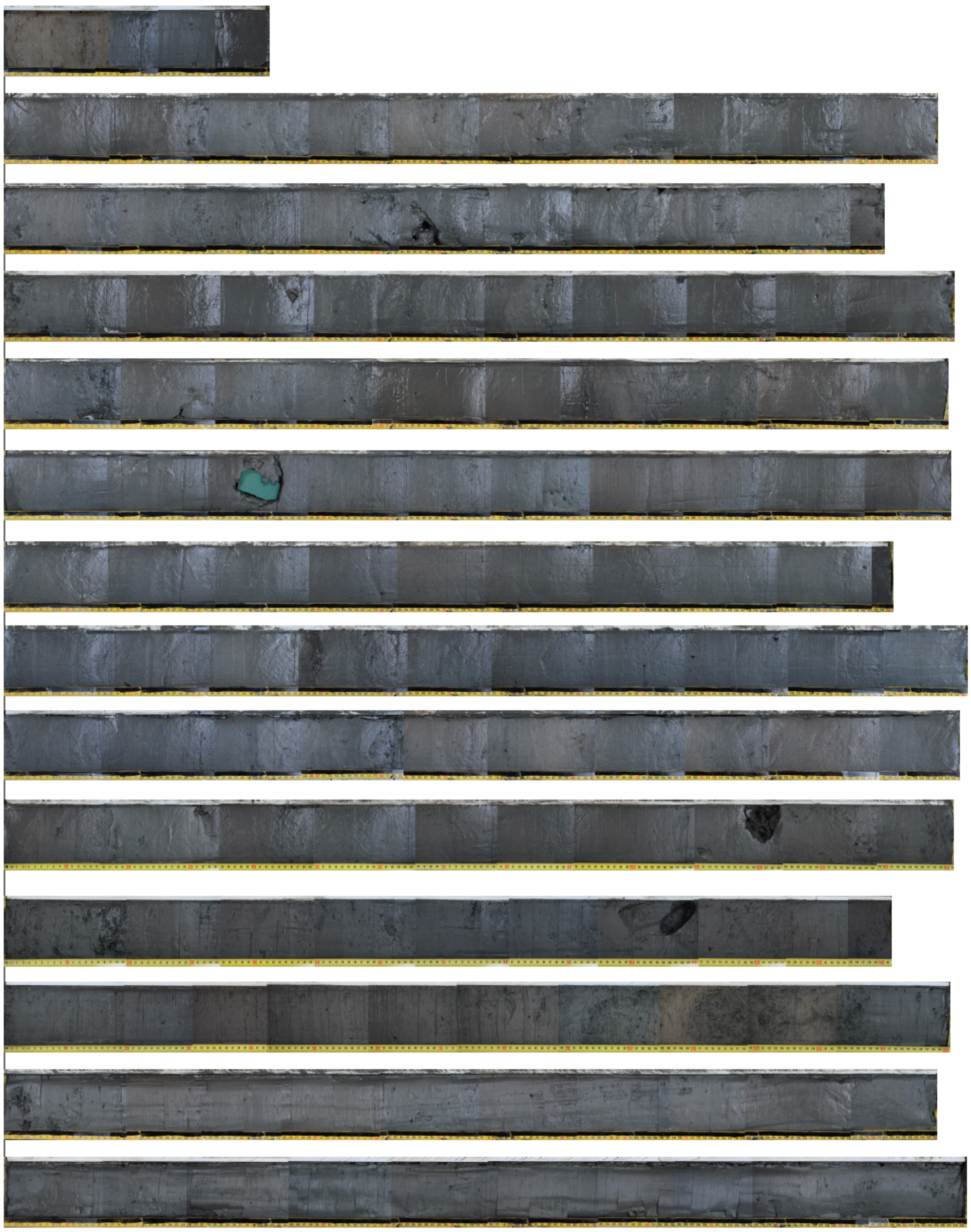


Lithology

Core: GS16-204-25 CC

Depth (cm)	Section	Lithology
0 – 42	1	0 – 17: Brown silty clay, IRD at 5.5 & 9.5cm, elongated and flat IRD, some sand. 17 – 42: Dark grey, sharp transition at 17cm, silty clay, very soft and high water content, especially at 33-42cm.
42 – 192,5	2	42 – 64.5: Silty clay, soft, grey 64.5 – 159: Lighter grey, consolidated between 126 – 145cm, less water, silty clay with coarser/ sandy particles, IRD at 68cm. 159 – 168.5: Finer silty clay 168.5 – 174: Darker silty clay 174 – 192.5:Lighter grey, silty clay, 179cm: red grain, IRD at 190cm
192,5 – 335	3	192.5 – 235: Light grey silty clay, consolidated at 209 and 230 cm 235 – 247: Darker grey, silty clay, higher water content 247 – 320: Uneven transition, grey silty clay (249-266cm disturbed, holes etc.) 301: Gap (diatomes? 1 piece, 1cm thick slice) 320 – 335: Slightly lighter, with sand and gravel (IRD)
335 – 485,5	4	335 – 350: Grey, consolidated silty clay 350 – 378: Darker grey, silty clay, homogenous, higher water content 378 – 389: Lighter grey 389 – 485.5: Darker grey, consolidated at 400 & 420; 416-421 lighter (no clear transition)
485,5 – 635,5	5	485.5 – 546.5: Lighter grey silty clay, layer with consolidations 500-502. IRD at 520cm and hole at 515cm 546.5 – 579: Darker grey silty clay, homogenous, a few black spots 577 – 579: Clear transition to darker, coarser (sandy) clay (forams + tephra) 579 – 590: Light grey with diffuse colour change, silty clay 590 – 635.5:Grey silty clay, consolidated at 597-605; light lenses at 505-509cm; 618-632 light grey spots large (less water)
635,5 – 786	6	635.5 – 644.5: Dark grey silty clay with lighter/brownish areas 644.5 – 742:Grey silty clay; consolidated at 649 & 658cm, dropstone (ϕ 5-7cm) at 671-678; darker coarser layer at 715-718cm; shells at 723cm; some black spots 742 – 758: Lighter silty clay with consolidations (black) esp. at 751cm 758 – 781: Grey silty clay, homogenous 781 – 786: Lighter grey silty clay; transition not straight
786 – 926	7	736 – 926.5: Dark grey silty clay, some black spots, getting bigger from 906cm
926 – 1077,5	8	926.5 – 953: Dark grey, silty clay, some black layers, boreholes at 947 cm, some consolidated areas, gradual transition at bottom 953 – 992: Grey silty clay, 974-977cm: coarser material, black, with forams; at 984: darker consolidated layer 992 – 1006.5: Grey with darker layer, 0.5cm wide lighter lenses 1006.5 – 1077.5: Dark grey, silty clay, some IRD (sandy); at 1011cm: consolidated material
1077,5 – 1227,5	9	1077.5 – 1116.5: Gradually getting lighter, silty clay; 1109.5 cm: foram rich; layer with IRD at bottom 1116.5 – 1117: Dark layer 1117 – 1133: Light grey with IRD (sandy); from 1129cm down: bioturbation? 1133 – 1154: Dark grey, silty clay with rough surface; 1150-1154 slightly darker; consolidated at 1154cm 1154 – 1161.5: Grey silty clay; at 1157cm: darker layer 1161.5 – 1173: Brown silty clay with IRD, bioturbation at top + bottom 1173 – 1196: Grey silty clay, few consolidated areas, bioturbation 1196 – 1227.5: Dark grey, silty clay, black spots; at 1211cm lens-shaped layer of darker material

Core: GS16-204-25 CC

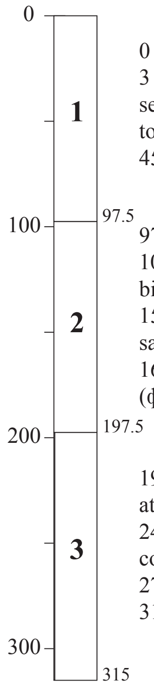
Depth (cm)	Section	Lithology
1227,5 – 1378,5	10	1227.5 – 1255: Dark grey to brownish to dark grey with brown spots, clayey silt, forams, consolidated at 1246 + 1251cm, slightly lighter grey towards bottom 1255 – 1261.5: Brownish, silty clay, bioturbation at bottom. At 1260cm: 1.5cm volcanic rock (IRD) 1261.5 – 1350.5: Dark grey with black and lighter lens-shaped layers, silty clay, forams; at 1290cm: shells (macrofossils); black layer at 1315-1317cm; ϕ 1cm URD at 1339cm + ϕ 5cm 1350.5 – 1378.5: IRD at 1345-1350; forams in layer between IRDs Grey, silty clay, many forams, sandy
1378,5 – 1520	11	1378.5 – Dark grey, silty clay, some sand 1405 – 1408: Bioturbation 1439 – 1442: IRD 1474 – 1481.5: Large dropstone (ϕ 7cm) removed (in separate bag) 1482.5 – 1488: Large dropstone (ϕ 6cm) removed (in separate bag) 1488 – 1520: Dark grey, silty clay, some small black spots
1520 – 1670	12	1520 – 1608.5: Dark grey, silty clay, some gravel, gradual transition to light grey 1527 – 1532: Bioturbation; (also at 1586-1588 & 1554-1557) 1808.5 – 1617: Light grey sand, no straight boundary 1623 – 1630 & 1645 – 1655: Brownish layers, gradual transition on both sides, dry, silty clay 1600 – 1601.5: Dropstone (ϕ 1.5cm) removed (in separate bag)
1670 – 1820,5	13	1670 – 1820.5: Dark grey, clay, relatively soft, homogenous
1820,5 – 1970,5	14	1820.5 – 1940: Dark grey, clay, relatively soft, homogenous, might be severely contaminated after cutting section into halves 1940 – 1970.5: Grey clay, more consistent, less contamination

Shear strength (kPa) measured at the bottom of each section

Sec. #01	25.50
Sec. #02	49.03
Sec. #03	62.76
Sec. #04	58.84
Sec. #05	47.07
Sec. #06	84.34
Sec. #07	94.14
Sec. #08	80.41
Sec. #09	78.45
Sec. #10	60.80
Sec. #11	131.41
Sec. #12	19.61
Sec. #13	19.61
Sec. #14	58.84

Core: GS16-204-25 GC

Depth (cm) | Section | Lithology



0 – 3: Light brown sand, forams
3 – 45: Gradual transition between several shades of brown and transition to finer sediment downwards, bioturbation
45 – 97.5: Sharp boundary to grey, silty clay

97.5 – 106: Grey, wet, silty clay
106: Gradual transition to lighter grey silt, bioturbation
154 – 165: Area with more brownish grey, sandy silt
165 – 197.5: Silty clay, grey, small stone (ф 1cm) at 182cm

197.5 – 245: Grey, wet, silty clay, bioturbation at: 210-216 and 239 cm
245 – 279: Lighter grey,silty clay, some consolidated particles, bioturbation
279 – 315: Gradual transition to darker grey, silty clay
319 – 315: Softer and wetter sediment

7. Mapping of possible object

A possible object on the sea floor south of Cape Farewell, Greenland.
While transiting from the Eirik Drift towards Reykjavik G.O. Sars passed just south of the last reported position of the Danish vessel Hans Hedtoft that collided with an iceberg and sank January 30, 1959. Given that the wreck of Hans Hedtoft is still to be located, it was decided to use the sophisticated multi-beam system on G.O. Sars to acquire the detailed sea floor bathymetry south of the collision position (59.5°N, 43.0°W) for a few hours on September 1, 2016.
An object the size of Hans Hedtoft is near the detection limit of the multi-beam system at the considerable depths in this area. Hence, no objects of interest were detected while the sea floor scanning took place. Post processing of the acquired bathymetry data (while G.O. Sars proceeded towards Reykjavik), did however reveal a small signal on an otherwise flat sea floor at 59° 08’10.4 N, 43° 11’20.6 W. The signal (shown in the figure below) is consistent with the size of the vessel Hans Hedtoft, but as it was acquired by a single multi-beam ping-line only, it could also be a noise-generated artifact. Another possibility is that the signal is some naturally occurring underwater topography (such as a big rock).
The location of the small signal, some 23 nautical miles SSW of the collision position reported by Hans Hedtoft in its SOS, is consistent with the expected drift of the vessel due to current and strong northerly winds during the 4 hours it stayed afloat after the SOS. Hence, while the signal detected by G.O. Sars is of an undetermined and somewhat dubious nature, we still feel obliged to report its exact position. Publishing this information will enable a ship passing by in the future to target the signal and determine whether it is just noise or a real object - even with more commonly available depth-sounding systems.

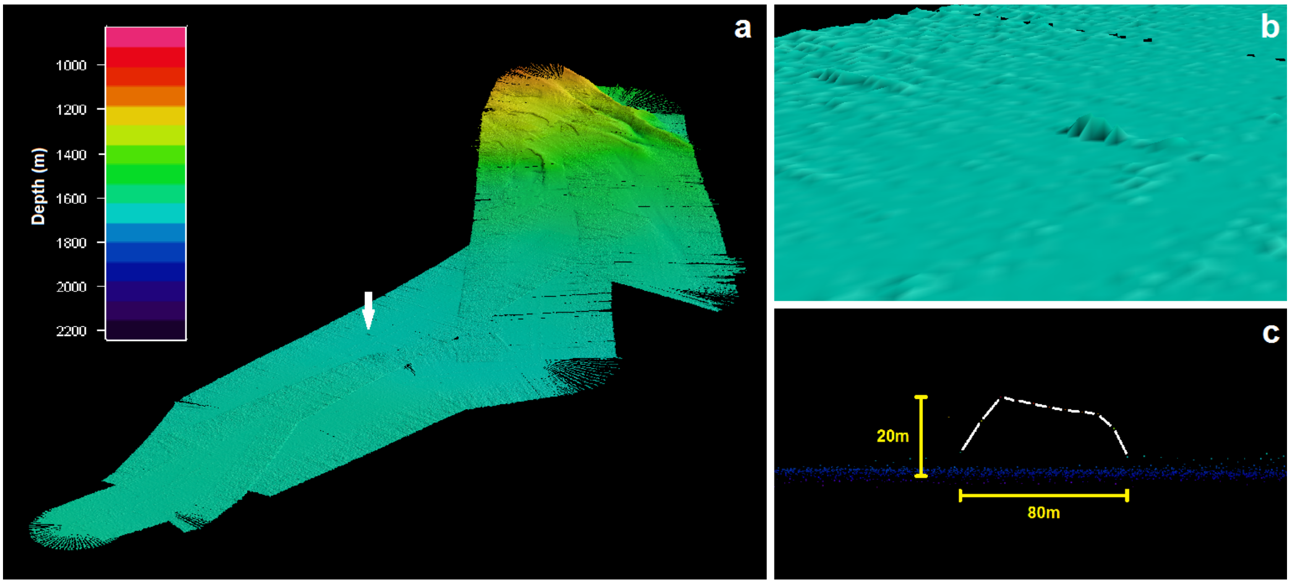


Figure 21: *Figure with panels displaying the G.O. Sars multi-beam data: (a) shows the bathymetry of the area surveyed south of Greenland indicating the small signal with a white arrow, (b) is a zoom in on the section with the small signal at 59° 08’10.4 N, 43° 11’20.6 W, while (c) shows the profile and dimensions of the signal along the single ping-line where it was detected.*

8. References

Hátún, H., A. B. Sandø, H. Drange, B. Hansen, and H. Valdimarsson (2005), Influence of the Atlantic Subpolar Gyre on the Thermohaline Circulation, *Science*, *309*(5742), 1841-1844. doi: 10.1126/science.1114777

Holliday, N. P., S. Bacon, J. Allen, and E. L. McDonagh (2009), Circulation and Transport in the Western Boundary Currents at Cape Farewell, Greenland, *Journal of Physical Oceanography*, *39*(8), 1854-1870. doi: doi:10.1175/2009JPO4160.1

Hunter, S., D. Wilkinson, E. Louarn, I. Nick McCave, E. Rohling, D. A. V. Stow, and S. Bacon (2007), Deep western boundary current dynamics and associated sedimentation on the Eirik Drift, Southern Greenland Margin, *Deep Sea Research Part I: Oceanographic Research Papers*, *54*(12), 2036-2066. doi: 10.1016/j.dsr.2007.09.007

McCave, I. N., and B. E. & Tucholke (1986), Deep current-controlled sedimentation in the western North Atlantic, *in: P.R. Vogt, B.E. Tucholke (Eds.), The Geology of North America: The Western North Atlantic Region,*, *Decade of North American Geology. Geological Society of America, Boulder* 451–468.

Appendix

A1: Equipment

Kongsberg Simrad Multibeam echo sounder

The Kongsberg Simrad Multibeam echo sounders EM300 and EM1002 are designed to do seabed mapping at variable depths, and therefore have a variable resolution
The echo sounders consist of three units:

- Transducer arrays
- Transceiver unit
- Operator station

Transducer arrays
The transducer arrays are different in form for the different models, but are used for both transmitting and receiving the pulses.

Transceiver unit
The transceiver unit is a wall-mounted cabinet with integrated shock and vibration absorbers. It contains transmit- and receive electronics, the processors for beam forming, bottom detection, and control of all parameters with respect to gain, ping rate and transmit angles.

Operator station
The operator station contains processors for beam forming, bottom detection and parameter control as well as the operator interface.
It detects:

- Depth and sounding positions
- Raw ranges and beam pointing angles
- Seabed imaging
- Vessel position and attitude
- Sound speed data
- System installation and setup parameters

The system does not require operator intervention during normal operation, but tracks the bottom automatically while adjusting mode, gain and range dependant parameters as required.

Data processing
There are three software that are commonly used during the processing process:

- The Neptune software, which is used for post processing of bathymetric data (i.e. cleaning and filtering of raw data etc.).
- The Triton software, which is used for the seabed sediment classification. This process extracts signal features from the seabed image data, and applies this data to a statistical classification procedure in order to obtain the best estimate for seabed sediment type as a function of position in the form of a map overlay.

- The Cfloor software is used for digital terrain modelling and plot generation. These terrain models can easily produce contour maps, 3D plots, combined bathymetry and acoustic imagery, depth profiles along specified routes, volume calculation etc.

TOPAS PS18 (Parametric Sub-bottom Profiler System)

The TOPAS PS18 system is a single, narrow beam sub-bottom profiler system with electronic roll, pitch and heave stabilisation. The range resolution is normally less than 0.3 m, and penetration capability is normally more than 150 m. These factors, however, depends on sediment, water depth and ambient noise.

The TOPAS are designed around a parametric antenna utilising the non-linear propagation characteristics of water to generate a low frequency acoustic pulse from a short high frequency burst or from the inter-modulation of two high frequency signals. The received echoes are amplified, digitized, processed and displayed online, and can be printed out during the process. Raw, unprocessed data may be stored for later processing.

There are several types of pulses that can be used, depending on the different depth and different use that is needed. Generally, high frequency gives high resolution, but low penetration, and for both, the Ricker- and Chirp pulse, the maximum and minimum frequency is 6 000 Hz and 500 Hz respectively.

The TOPAS system is divided into two main modes:
- High resolution
- High penetration

Ricker wavelet
The high resolution pulse is called the Ricker pulse, and gives detailed information about the top 5 – 10 m sediments in water depths less than 2 000 – 3 000 m. This mode gives short single pulses with power spectrums centred on 3.5 kHz. Ricker pulse is a wide-band wavelet and requires a high signal to noise ratio for optimal performance.

Ping intervals depends on wavelet type, water depth and operation mode. It range from 200 ms to 15 000 ms, but default ping/shot interval for Ricker pulse is 300 – 500 ms in shallow areas.

Chirp wavelet
The high penetration mode is called Chirp, and is used in very deep water, noisy environment, or where maximum penetration is desired. These pulses have much longer wavelengths than the Ricker pulse. Chirp wavelet is a coded wavelet where the signal energy is stretched out in time. Chirp waveform is for increasing the total transmitted energy, thereby increasing the signal to noise ratio and correspondingly the penetration.

Producing a burst consisting of two high frequency signals swept in opposite directions generates the Chirp wavelet. By filtering the received echoes in a matched filter or a deconvolution filter, the wavelet energy is compressed into a narrow peak with a 3 dB width of about 1/B, where B is the bandwidth of the sweep. The bandwidth is determined by the start and stop frequencies of the sweep, which is normally set to 2 and 5 kHz respectively. Larger bandwidth would give higher resolution, but lower penetration.

The ping interval is normally set to 1 000 ms (i.e. one ping / shot per second), and the ping duration of the Chirp to 10 ms. Long duration (max 100 ms) increases the amount of energy transmitted.

CTD

System overview

The 911*plus*CTD system includes:

- SBE 9*plus* Underwater Unit with sensors for C (conductivity), T (temperature), P (pressure) and O (oxygen), and a submersible pump.
- SBE 11*plus* Deck Unit
- Computer for displaying logging and read time date acquisition

SBE 9plus Underwater Unit

Standard underwater units have aluminium housings rated to 6 800 m (22 300 ft), and are supplied with two conductivity and two temperature sensors (fitted with a *TC Duct* and constant flow pump), and an internally mounted, temperature-compensated Paroscientific Digiquartz pressure sensor for 6 800 m (10 000 psia) full scale range. Input channels and bulkhead connectors (SBE 43 dissolved oxygen) are provided for an optional second (redundant) pair of temperature and conductivity sensors.

SBE 11plus Deck Unit

SBE 11plus Deck Units include RS-232 and IEEE-488 computer interfaces, NMEA 0183 interface for adding GPS position to CTD data, 12-bit A/D input channel for surface PAR sensor, switch-selectable 115/230 VAC operation, audio tape interface (data backup), LED readout for raw data, and audible bottom contact (or altimeter) alarm. Calibration coefficients are stored in EEPROM, and a separate microcontroller converts raw CTD data to temperature, depth, salinity, etc. The SBE 11*plus* is pre-wired for installation of the optional subcarrier modem (including water sampler control push buttons and status lights). Http://www.seabird.com/products/spec_sheets/911data.htm

Standard Carousel

The heart of the carousel is the magnetically actuated lanyard release. A pressure-proof electromagnet at each bottle position is energized on command to release the latch holding the bottle lanyard.The standard carousel includes the electronics / release assembly (12 – position), mounting hub, adapter plates, protective frame, and CTD extension stand – with a 9*plus* CTD underwater unit.

Sea Bird Software

SEATERM and SeatermAF – Terminal programs for setup and data uploading

SEASAVE – Real-time data acquisition and simultaneous keyboard control of bottle firing. A typical real-time CTD data plot shows how the software automatically marks

the display with bottle numbers, keeps track of which bottles have been fired, and creates a bottle data file during real-time data collection.
SBE Data Processing – Filtering, aligning, averaging, and display of CTD and auxiliary sensor data and derived variables.

Dredge

A big arctica dredge is a metal cage with an approximate size of 2mx1.5mx0.5m, with an opening in one end (see figure). The opening has metal teeth at both top and bottom to ensure that the dredge will serve its purpose no matter which side it settles on at the sea floor. A dredge was used to trawl the sea floor for the bivalve species *Arctica islandica*. The dredge was fastened to a wire and lowered to the sea floor, and thereafter dragged after the ship along the sea floor for 5-10 minutes at a speed of 2 knots.

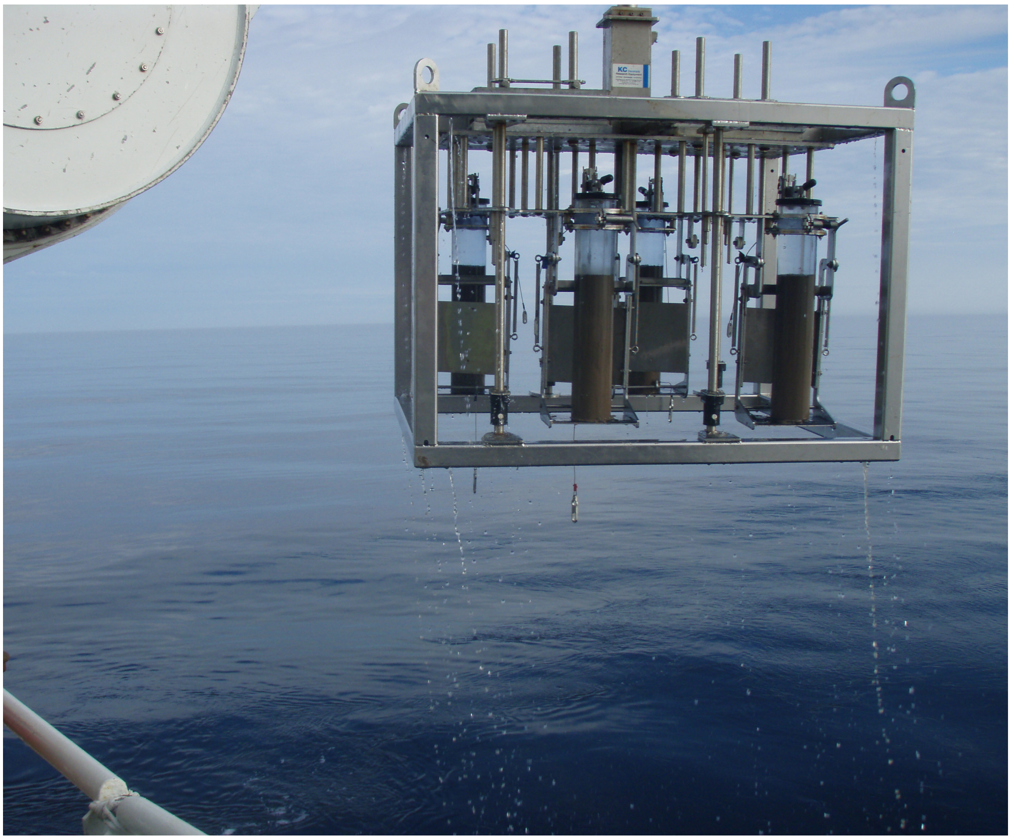
Appendix figure 1*: Shell dredge ready to be emptied on deck*

Multi-corer description

The multi-corer used on the cruise is a KC multi-corer (see figure 2.1), model 72.000 customized.
The corer is equipped with 4 tubes, each with a diameter of 110 mm and a length of 600mm. The sample tubes are transparent with a sleeve for a quick change system.

Principle of operation:

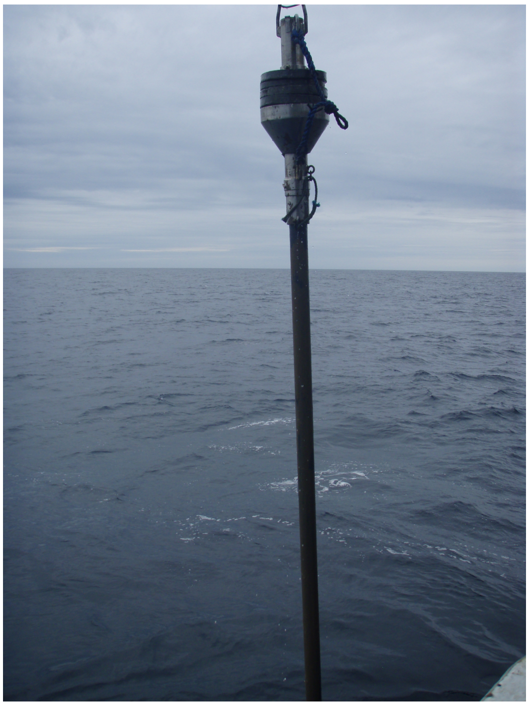
While the multi corer is lowered into the sea, there is a full flow through the sample tubes in order to obtain an undisturbed sample. The top of each sample tube has a spring-loaded lid, which is in open position during the sampling. When the sample has been taken the lid will close and the resulting vacuum will hold the sample until the shovel covers the end of the tube.
Upon raising the multi corer and as soon as the tubes are leaving the sediment, a spring-loaded shovel is pressed in position under the sample tubes. It turns down, having a space of approximately 1 cm to the end of the tube. Finally the shovel is lifted against the tube to avoid exit of the sample. Further information of the corer can be found at KC's homepage at: http://www.kc-denmark.dk/



Appendix figure 2: *Boarding of successfully recovered multicores.*

Gravity-corer description

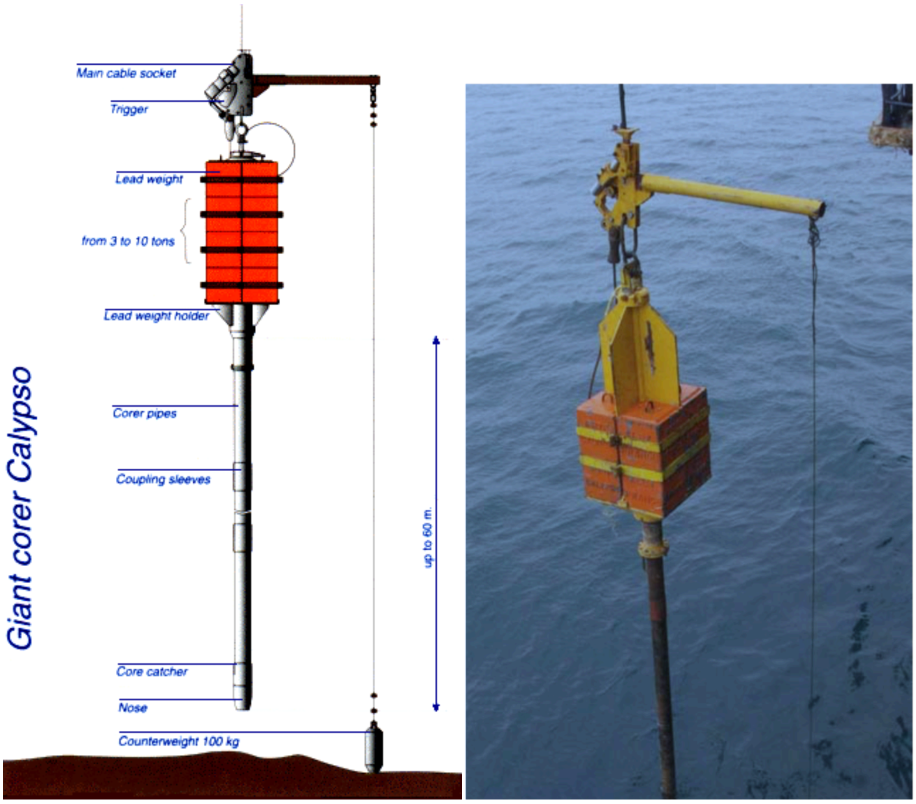
The GEO-UoB gravity coring system capable of taking up to 5m long cores was also employed. The core liner is rigged directly onto the weighted coring head with a cutting head/core catcher combo installed at the base of the liner.



Appendix figure 3: *A gravity core is retrieved and brought on board in vertical position.*

Calypso-corer description

The Calypso piston corer is developed by Kley France and IPEV and modified to use on R/V G.O. Sars by StigMonsen, UiB. It can be fitted with a tube of 21,5 meter, retrieving cores up to ca 20 m. The internal diameter of a Calypso core is about 10 cm.



Appendix figure 4: *Principles of the Calypso coring system.*

On-board core handling and analyses

Three different coring devices were applied on this cruise, a Multicorer, a Gravity corer and a Calypsocorer. With the Multicorer we get four tubes of undisturbed surface sediment samples up to 50 cm long. With the Gravitycorer we recover the upper 3-5 meters of the sediments depending on the properties of the sediments and the ability to penetrate the sediments with the applied weight of the coring equipment and the length of the tube. When the Calypsocorer is applied we have the ability to recover 21,5 meters of sediments.

Subsequent to the coring operation the cores were cut into sections, preferably 150 cm, and spilt into two equal halves, one for archive and one for work. Floral foam where put in the ends of the section for stabilisation of the sediments. The splitting was done with a handheld saw on a table designed for the operation. From each station one of the Multicores were drained and split. Shear strength measurements were taken in the bottom of every section.

After splitting, both halves of the cores were properly cleaned with a spatula, and a lithological description (grain-size, layering etc.) was made. Thin plastic film was put on the surface and the work section was subsequently measured for colour and magnetic susceptibility. High-resolution pictures were taken every 10 cm.

A hand-held Konica Minolta CM 600d spectrophotometer was used to measure the light reflectance of sediment core surfaces immediately after opening of the core. Any enclosed air-bubbles between the plastic foil and the sediment were carefully removed. Measurements were carried out every 1 cm by placing the device directly on the core surface. The spectrum of the reflected light is measured by a multi-segment light sensor, measuring at a 10 nm pitch between wavelengths of 400 to 700 nm

A hand-held Bartington MS3 Magnetic Susceptibility meter with a MS2E surface Scanning Sensor was used to measure the Magnetic Susceptibility of the sediments in the opened core. Measurements were carried out at 1cm intervals of all cores.

After processing all the core sections were enveloped in plastic, properly labelled and put in d-tubes for storage.

GS16-204-22 CC-B were processed normally, but the d-tubes were immediately frozen at-18° C.

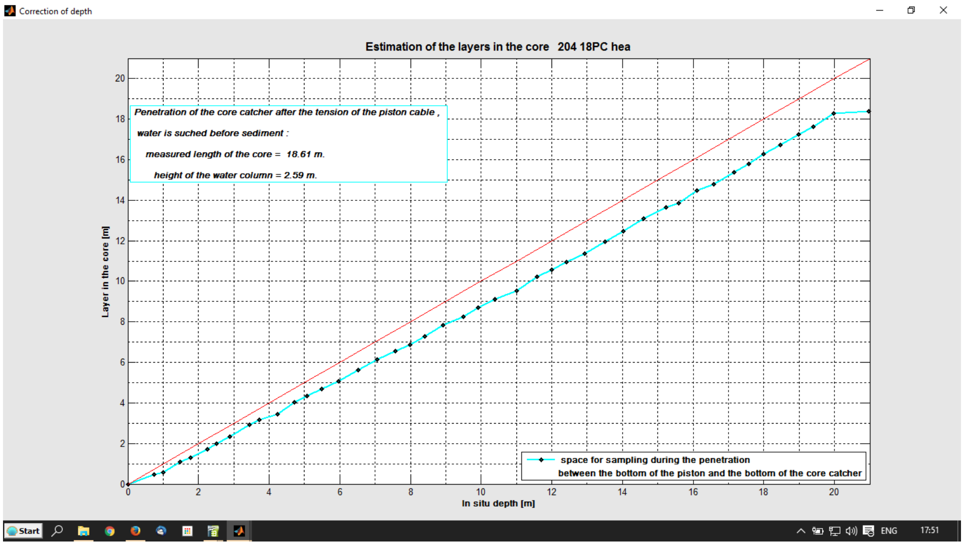
Water sample handling

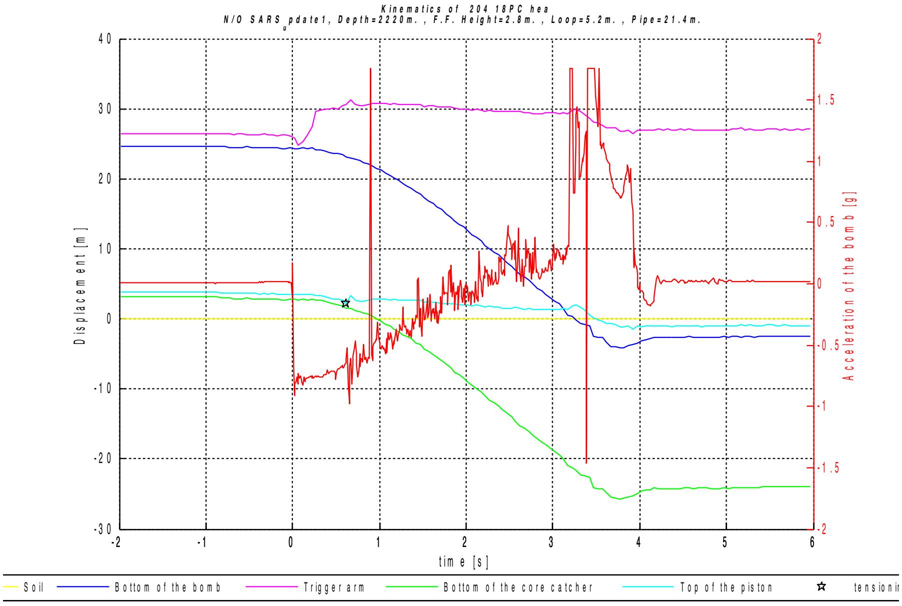
On nearly every station we obtained a CTD (conductivity, temperature, density) profile of the water column. Water samples (50 ml) were taken on different depths in order to analyse changes in oxygen and carbon isotopes with depth. Samples were preferably taken on 10, 20, 50, 100, 200, 400 m and then every 400 m below that. Additional water samples were taken for the CTD calibration at IMR.

Piston coring physics

During coring the movements of the trigger arm and the corer head were measured by using two NKE STPH sensors. The sensors measure both depth and acceleration. The data is used together with the kinematics module in the CINEMA software developed by IFREMER. The module is used to plot the graphics of kinematics and the graphic of the estimated place of the layers in the core regarding to the penetration.

Kinematics of GS06-204-18CC

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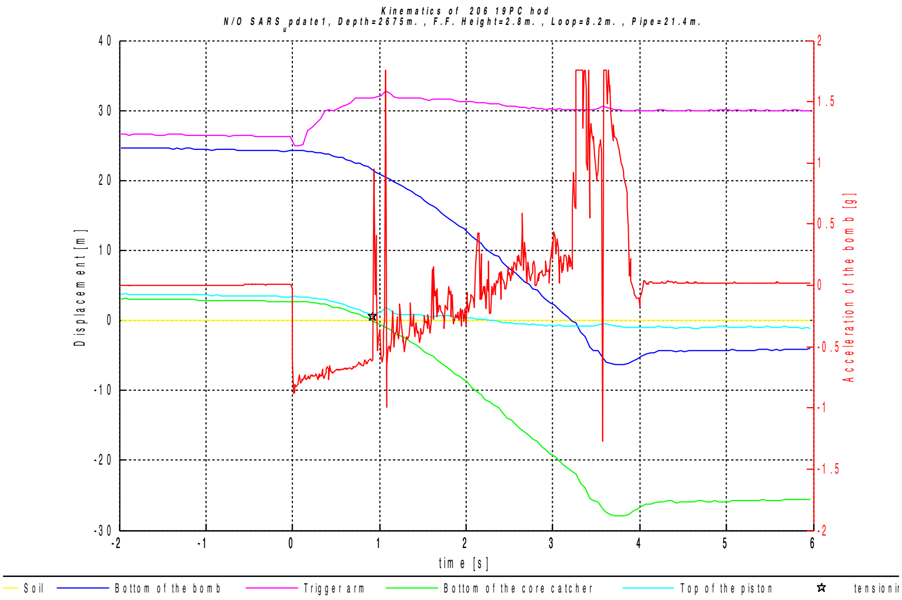
Displacement [m]
Acceleration of the bomb [g]
time [s]
Soil
Bottom of the bomb
Trigger arm
Bottom of the core catcher
Top of the piston
tensionin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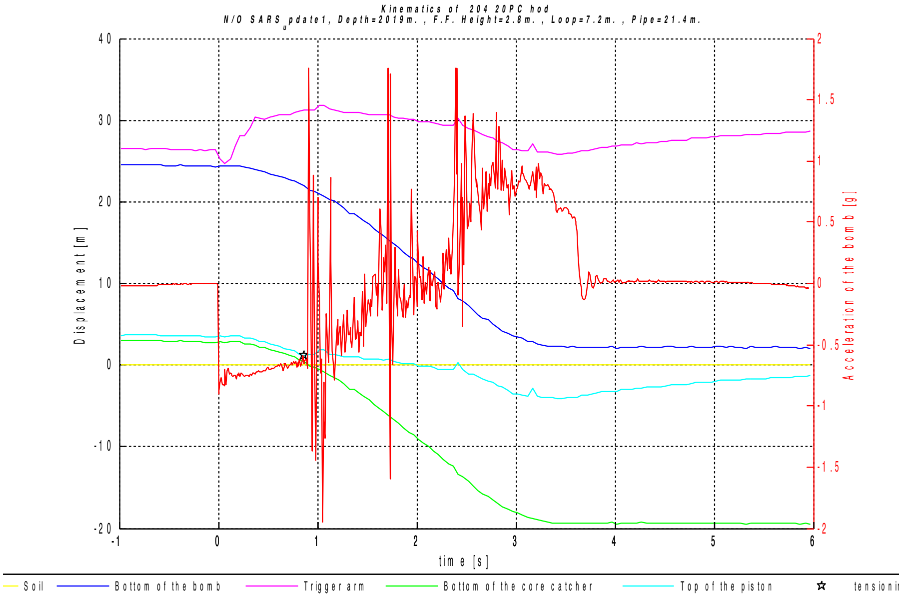
Displacement [m]
Acceleration of the bomb [g]
time [s]
Soil
Bottom of the bomb
Trigger arm
Bottom of the core catcher
Top of the piston
tensionin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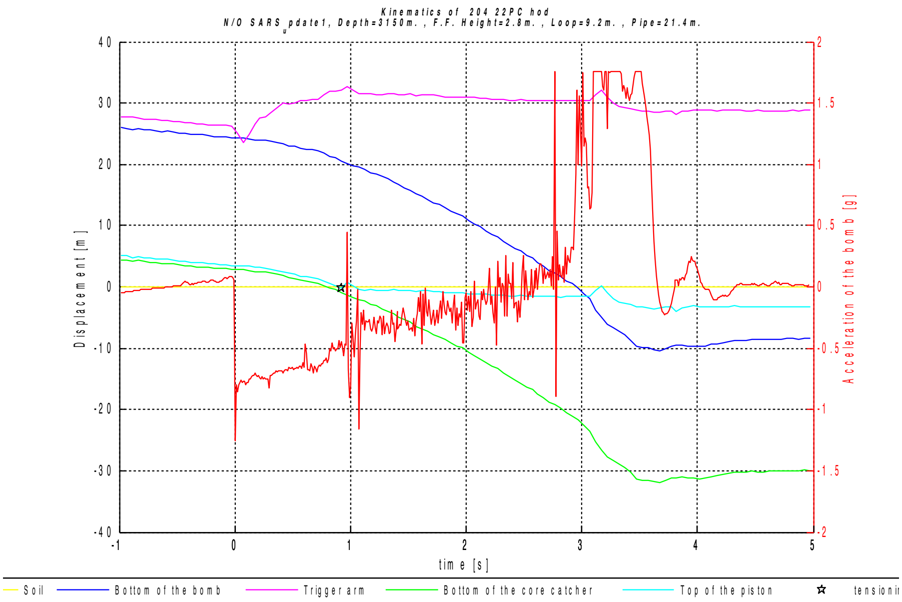
Acceleration of the bomb [g]
time [s]
Soil
Bottom of the bomb
Trigger arm
Bottom of the core catcher
Top of the piston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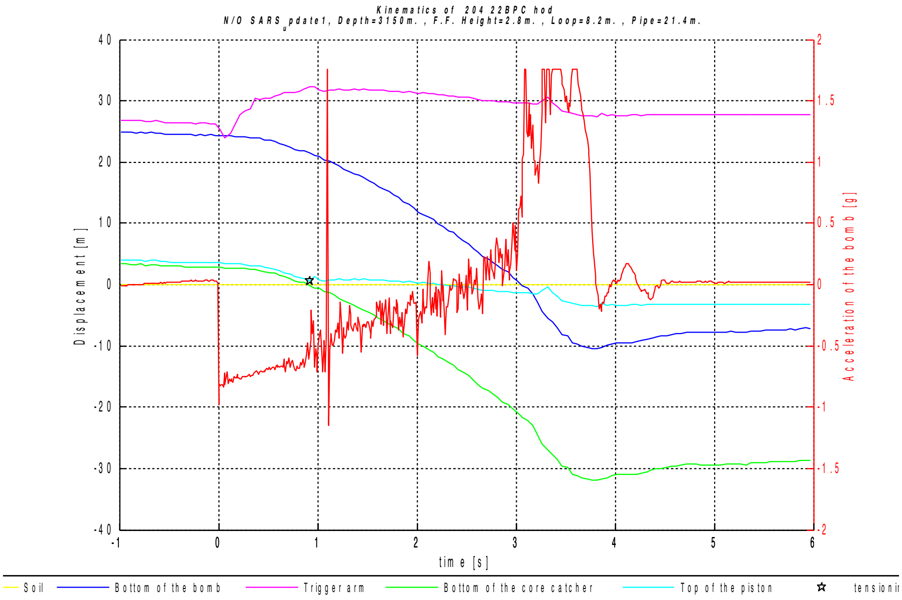
Displacement [m]
Acceleration of the bomb [g]
time [s]
Soil
Bottom of the bomb
Trigger arm
Bottom of the core catcher
Top of the piston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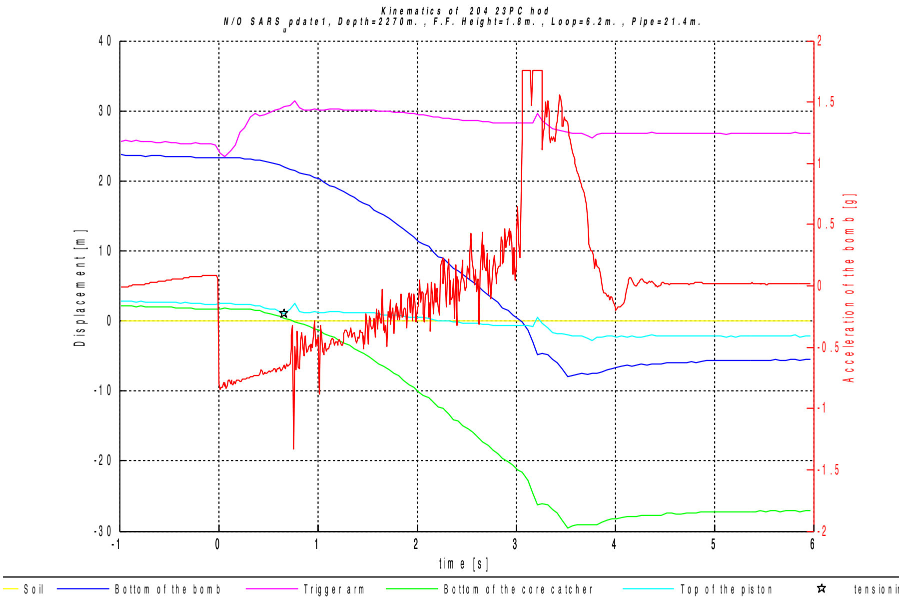
Acceleration of the bomb [g]
time [s]
Soil
Bottom of the bomb
Trigger arm
Bottom of the core catcher
Top of the piston
tensionin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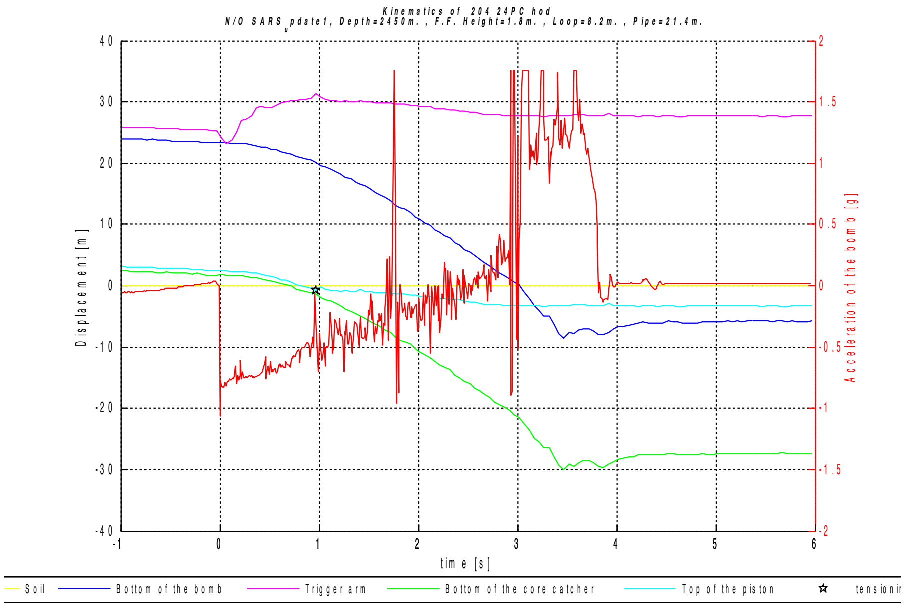
Displacement [m]
Acceleration of the bomb [g]
time [s]
Soil
Bottom of the bomb
Trigger arm
Bottom of the core catcher
Top of the piston
tensionin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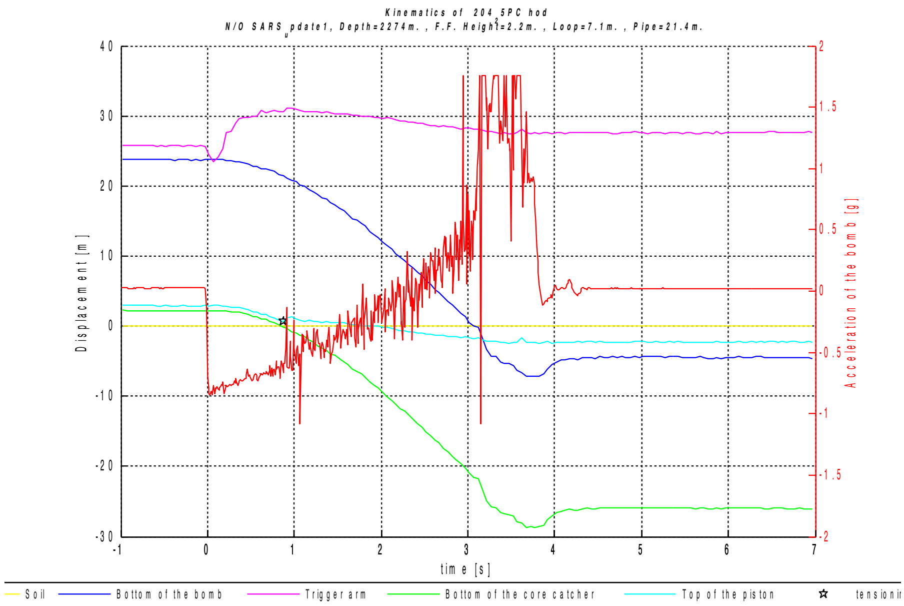
Displacement [m]
Acceleration of the bomb [g]
time [s]
Soil
Bottom of the bomb
Trigger arm
Bottom of the core catcher
Top of the piston
tensionir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Displacement [m]
Acceleration of the bomb [g]
time [s]
Soil
Bottom of the bomb
Trigger arm
Bottom of the core catcher
Top of the piston
tensionir