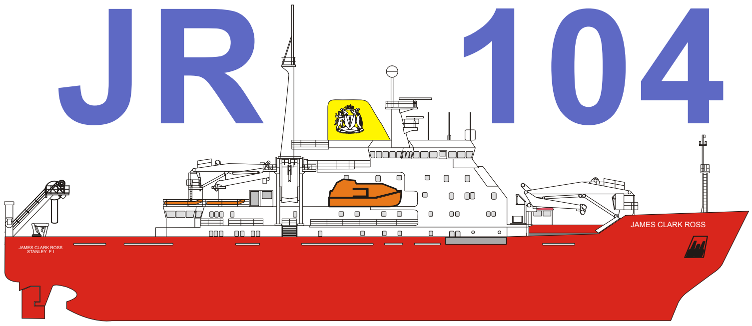
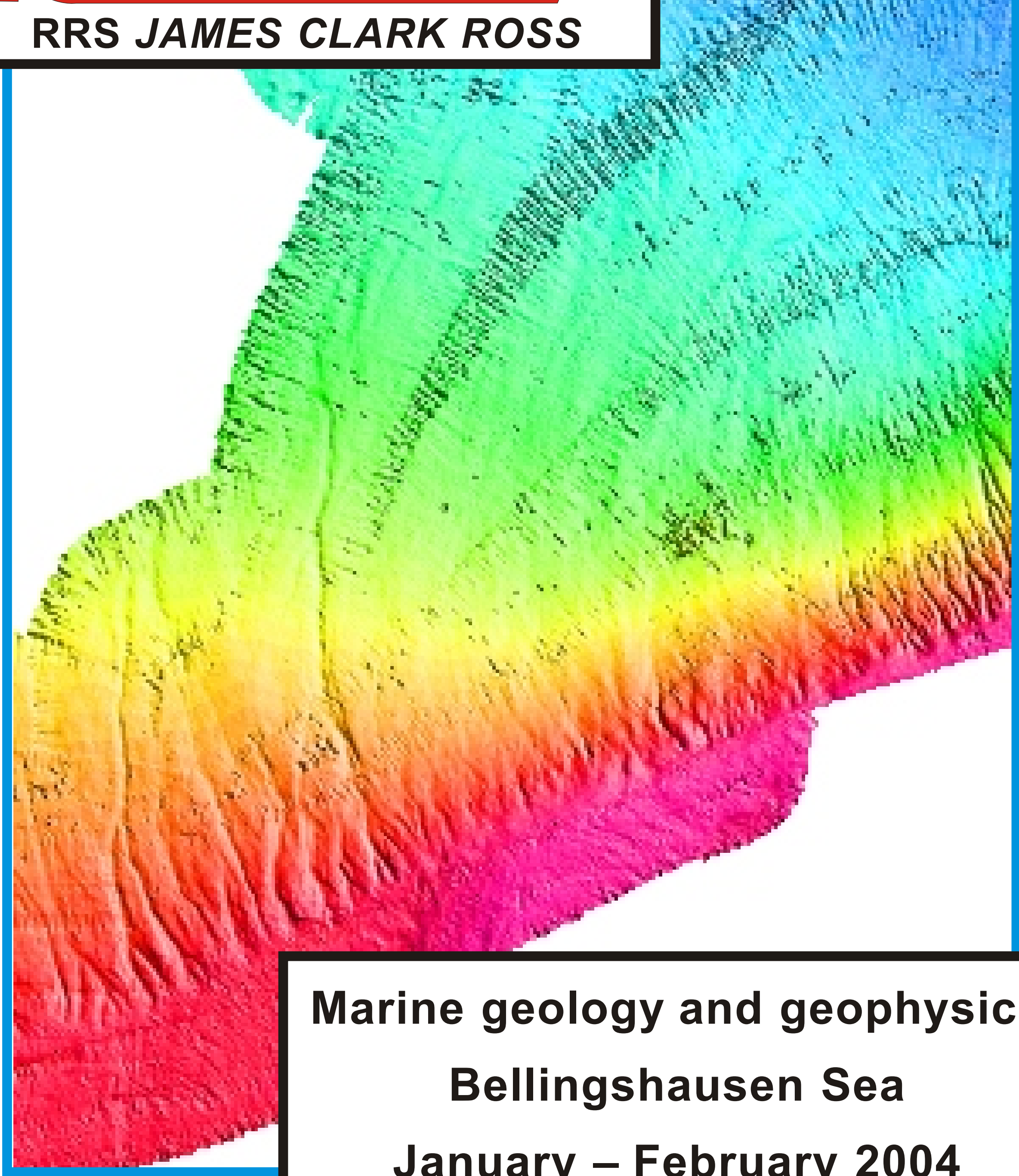
BAS Ref.: JR104 Copy No:

CRUISE REPORT

JR 104



RRS *JAMES CLARK ROSS*



Marine geology and geophysics

Bellingshausen Sea

January – February 2004

BAS Ref.: JR104 Copy No:

CRUISE REPORT

RRS *James Clark Ross*

Cruise JR104

January to February 2004

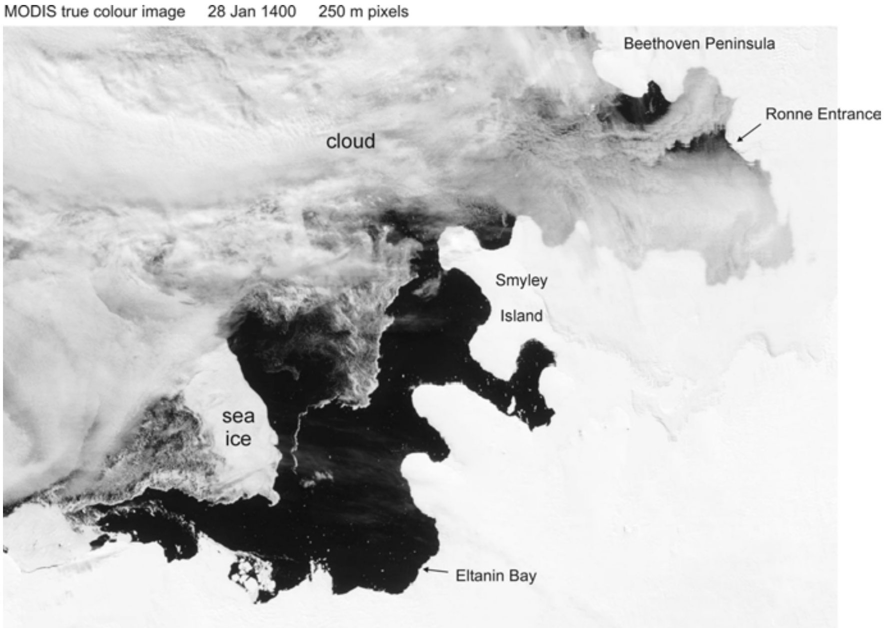
Multibeam echo sounding, TOPAS sub-bottom profiling
and sediment coring

Continental shelf and slope in the Bellingshausen Sea

R.D. Larter
with contributions from A. Tait, C.J. Pudsey, M.O. Preston, C. Ó Cofaigh, P. Morris, C.-D. Hillenbrand, J. Evans, J.A. Dowdeswell and S.F. Bremner

Distribution:

1. Headquarters - Archives
2. Headquarters - Geological Sciences Division (for circulation)
3. RRS *James Clark Ross* (for circulation)
4. Dr R D Larter
5. Dr C J Pudsey
6. JR50 participants (for circulation)
7. Directorate (for circulation)
8. BAS Technical Services (for circulation)
9. Prof. J A Dowdeswell (Scott Polar Research Institute)



Frontispiece: ice conditions in the Bellingshausen Sea, (a) as seen from space (top, MODIS satellite image, 1400 on 28th January 2004) showing open water in the Ronne Entrance and Eltanin Bay, and (b) from the ship (~0400 on 31st January at core station BC356, NW of Smyley Island; photo courtesy of Emma Wilson).

Back cover: four scientists, a doc and a core. Carol, Emma, Claus-Dieter, Jeff and Colm with freshly recovered sections of core GC380 (photo courtesy of Steve Bremner).

Contents

Figures

Tables

1. SUMMARY

The data and samples collected on cruise JR104 will form the main basis for a study of glacial-interglacial changes in the southern Bellingshausen Sea. Reconnaissance data collected on previous cruises suggested that this area contained the outlet of a very large ice drainage basin during late Quaternary glacial periods. These data were used as the basis for an Antarctic Funding Initiative (AFI) proposal to carry out the first systematic investigation of the former ice drainage basin. The ship time for JR104 was allocated to support the resulting project (AFI4/17).

The scientific questions set out in the AFI proposal were:

- What was the extent of the ice drainage basin, and what sub-glacial processes operated on the shelf?
- When, and how rapidly, did ice retreat from the continental shelf?
- What processes control the development and stability of Antarctic trough-mouth fans?

On cruise JR104 these questions were addressed by collecting swath bathymetry (EM120) data, acoustic sub-bottom profiler (TOPAS) data, and sediment cores from selected areas on the continental shelf and slope. The programme of data collection was very successful, despite the fact that parts of the area investigated were still covered by first year sea ice. Although the limits on ship time that can be allocated through AFI were a tight constraint, unusually good weather resulted in no downtime due to adverse conditions, and the data and samples collected should be sufficient to achieve the main objectives of the project. The enthusiasm, hard work and professionalism of the RRS *James Clark Ross* officers and crew, and of the BAS Technical Services personnel on board, contributed greatly to the success of the cruise.

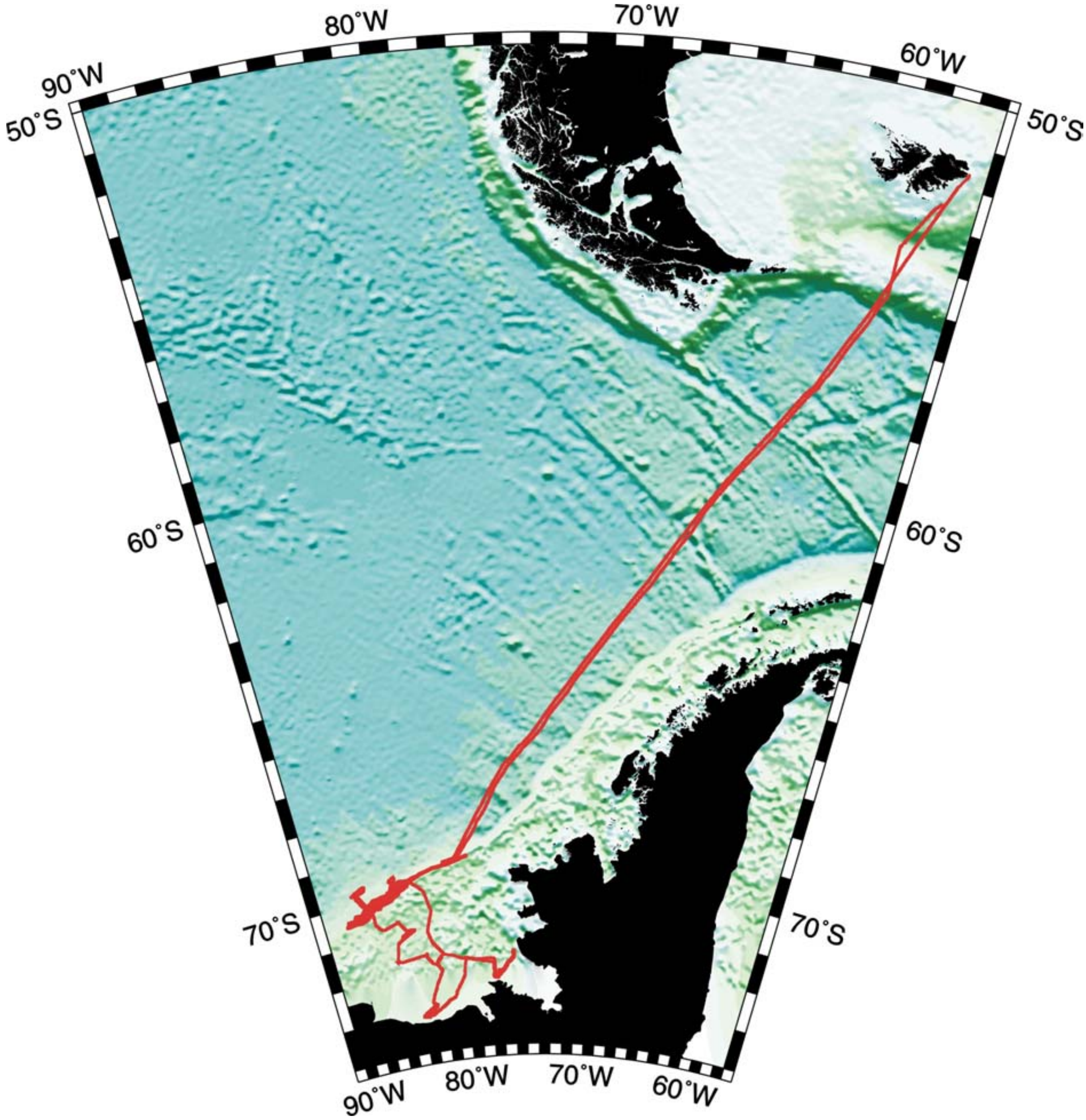


Fig. 1. Track of RRS *James Clark Ross* during cruise JR104 (red) overlaid on shaded-relief display of predicted bathymetry of Smith & Sandwell (*Science*, **277**, 1956–1962, 1997). A larger scale track chart is included as a fold out at the back of this report.

2. LIST OF PERSONNEL

2.1 Scientific and Technical (13)

R.D. Larter	BAS	Chief Scientist
C.J. Pudsey	BAS	Marine Geologist/AFI Co-Investigator
P. Morris	BAS	Geophysicist/Database Manager
C.-D. Hillenbrand	BAS	Marine Geologist
J.A. Dowdeswell	University of Cambridge	Glaciologist/AFI Co-Investigator
C. Ó Cofaigh	University of Cambridge	Glacial Geologist
J. Evans	University of Cambridge	Glacial Geologist
S.F. Bremner	BAS	Head of ETS (Mechanical Engineer)
A.M. Tait	BAS	ETS (Mechanical Engineer)
M.O. Preston	BAS	ETS (Electronic Engineer)
P.C.D. Lens	BAS	ITS (Computer Engineer)
R. Dodson	BAS	ITS (Computer Engineer)
E.J. Wilson	BASMU	Doctor

BAS = British Antarctic Survey; BASMU = BAS Medical Unit; ETS = BAS Engineering Technology Section; ITS = BAS Information Technology Section; AFI = Antarctic Funding Initiative.

2.2 Ship's Company (28)

M.J.S. Burgan	Master
D.B.G. Gooberman	Chief Officer
D.J. King	2nd Officer
P.I. Clarke	3rd Officer
J.W. Summers	Deck Officer
D.E. Anderson	Chief Engineer
C. Smith	2nd Engineer
J.S. Stevenson	3rd Engineer
T. Elliott	4th Engineer
M.E.P. Gloistein	Radio Officer
D.P. Trevett	Deck Engineer
A.K. Rowe	Electrical Engineer
R.J. Turner	Purser
D.J. Peck	Bosun
A.M. Bowen	Seaman
M.J. Taylor	Seaman
I. Raper	Seaman
G.A. Dale	Seaman
K.J. Holmes	Seaman
M.T. Rowe	Seaman
A.I. Macaskill	Motorman
B.D. Smith	Motorman
W.J. Hume	Chief Cook
W.R. Hyslop	2nd Cook
L.J. Jones	Senior Steward
N.R. Greenwood	Steward
G. Raworth	Steward
M. Weirs	Steward

3. TIMETABLE OF EVENTS

January 2004

21 Crew handover and start of mobilisation for cruise JR104 at FIPASS.
22 Complete mobilisation.
23 RRS *James Clark Ross* departs from FIPASS at 0900 local time (1200Z) and anchors in Port William to carry out emergency drills. Weigh anchor and start passage to Bellingshausen Sea at 1530Z. Deploy magnetometer at 1910Z.
24–27 Passage to Bellingshausen Sea, collecting multibeam echo sounder, TOPAS and magnetic data continuously. Recover magnetometer at 2006Z on 27th January.
28–29 Multibeam echo sounder and TOPAS survey in shelf edge region, and coring on uppermost part of trough mouth fan.
30 Collecting survey data along route to Ronne Entrance.
31 Multibeam echo sounder and TOPAS survey, and coring in Ronne Entrance.

February 2004

1 Collecting survey data along route to Eltanin Bay.
2 Multibeam echo sounder and TOPAS survey, and coring in Eltanin Bay.
3 Multibeam echo sounder and TOPAS survey, and coring in mid-shelf part of glacial trough.
4 Multibeam echo sounder and TOPAS survey, and coring in outer shelf part of glacial trough.
5 Multibeam echo sounder and TOPAS survey in shelf edge region.
6 Multibeam echo sounder and TOPAS survey, and coring on the trough mouth fan, and survey of the shelf edge at the western edge of the trough.
7 Multibeam echo sounder and TOPAS survey, and coring on the eastern flank of the trough mouth fan.
8 Multibeam echo sounder and TOPAS survey along continental margin to the east of the main glacial trough. Deploy magnetometer at 0555Z.
9–12 Passage to Falkland Islands, collecting multibeam echo sounder, TOPAS and magnetic data continuously. Recover magnetometer at 2352Z on 12th February.
13 RRS *James Clark Ross* arrives FIPASS at 0810 local time (1110Z). Complete demobilisation.

4. LIST OF SCIENTIFIC EQUIPMENT USED

4.1 Echo Sounders

Kongsberg Simrad EM120 multibeam echo sounder
Kongsberg Simrad TOPAS PS018 sub-bottom profiler
Kongsberg Simrad EA500 (Bridge navigational echo sounder)
Kongsberg Simrad sonar synchronisation unit (SSU)
10 kHz Precision Echo Sounder and 10 kHz pinger (for coring)

4.2 Coring equipment and winches

Duncan and Associates 3m/6m gravity corer
Duncan and Associates box corer (300 mm square box)
30-tonne traction winch and CLAM wire monitoring system

4.3 Potential Field Equipment

Shipboard three-component magnetometer (STCM)
SeaSpy towed Overhauser magnetometer

4.4 Sound velocity profiling systems

Sound velocity probe and dedicated winch
XBTs (T5 and T7 probes)
Acoustic Doppler Current Profiler (ADCP)
Thermosalinograph (part of BAS Oceanlogger)

4.5 Navigation

Trimble 4000DS GPS receiver
Skyfix differential GPS demodulator (input to Trimble receiver)
Ashtech G24 GPS+GLONASS receiver
Leica MX 400
2 x Ashtech G12
Ashtech 3D GPS receiver
Seapath (input to EM120 and TOPAS)
TSS300 heave, roll and pitch sensor
Chernikeeff Aquaprobe Mk5 electromagnetic speed log
Sperry doppler speed log
Gyro

4.6 Data Logging

NOAA Scientific Computer System (SCS) system

5. INTRODUCTION

The purpose of cruise JR104 was to collect data and samples for the Antarctic Funding Initiative (AFI) project *Glacial-interglacial changes in the lost drainage basin of the West Antarctic Ice Sheet* (AFI4/17). The focus of this project is an area in the southern Bellingshausen Sea that reconnaissance data suggest contained the outlet of a very large ice drainage basin during late Quaternary glacial periods. The AFI funding for the project is a split award, shared between the British Antarctic Survey (award ref.: NER/G/S/2002/00009) and the University of Cambridge (Scott Polar Research Institute; award ref.: NER/G/S/2002/00192). The cruise was originally intended to start and end at Rothera but, owing to cancellation of another cruise, it was brought forward a year and inserted into the ship's itinerary between port calls at Port Stanley. Six days were added to the duration of the cruise to compensate for the increased passage time.

The existence of the large, late Quaternary ice drainage basin that is the focus of the AFI project was interpreted on the basis of reconnaissance data collected on cruise JR04 (1993) and cruises of R/V *Polarstern* in 1994 and 1995 (Cunningham et al., 1994, 2002; Nitsche et al. 1997, 2000; Larter et al., 2001). This basin may have drained an area of the West Antarctic Ice Sheet (WAIS) exceeding 300,000 km^2 during glacial periods (Fig. 2), which is equivalent to more than 15% of the grounded area of the modern WAIS. Furthermore, in view of the fact that the modern net surface mass balance in parts of the interpreted drainage basin is more than four times the Antarctic average (Vaughan et al., 1999; Turner et al., 2002), it was probably responsible for an amount of ice discharge disproportionate to its area.

It has been inferred that ice flow paths in the drainage basin converged on the continental shelf in the southern Bellingshausen Sea, forming a wide ice stream that flowed to the continental shelf edge between 84°30'W and 88°W (Larter et al., 2001). If this interpretation is correct, it makes the Bellingshausen Sea an important region for investigation of glacial-interglacial changes in the WAIS. Such investigations, combined with modelling studies, are expected to provide clues regarding the future stability of the WAIS.

The main aim of this cruise was to carry out the first systematic investigation of the former ice drainage basin in the southern Bellingshausen Sea, using sediment cores, the EM120 multibeam echo sounder and the TOPAS sub-bottom profiling system on RRS *James Clark Ross* (JCR). These data and samples will allow us to address questions about the timing and rate of grounding line retreat from the continental shelf, the dynamic character of the ice that covered the shelf, and its influence on glaciomarine processes on the adjacent continental slope.

In this report we use the provisional name ‘Belgica Trough’ to refer to the trough that is more than 550 m deep along its entire length from Eltanin Bay to the continental shelf edge between 84°30’W and 88°W. Similarly we use the name ‘Belgica Fan’ to refer to the large sedimentary deposit on the continental slope extending northwest from the mouth of the trough. The *Belgica* was the vessel on which Lieutenant Adrien de Gerlache led an expedition to the area between 1897 and 1899. The members of that expedition became the first explorers to winter in the Antarctic after the *Belgica* became beset in ice on 2nd March 1898, at 71°30’S, 85°16’W (location marked on fold-out track chart at back of this report).

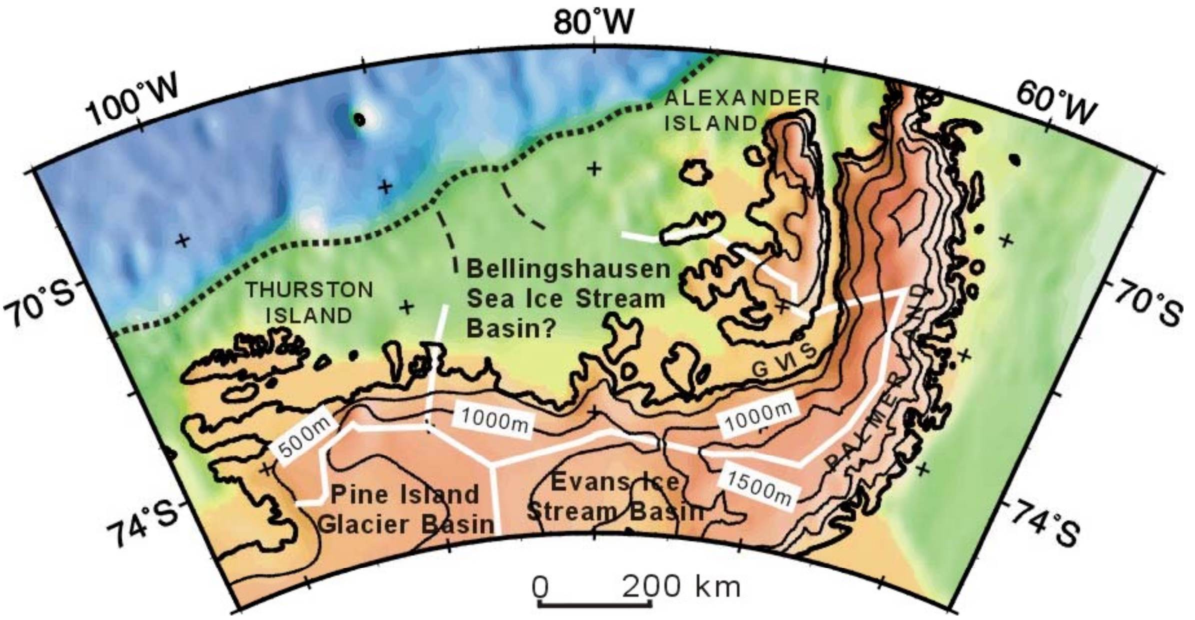


Fig. 2. Topographic map (500 m contour interval) showing main ice drainage basins around area of interest. Thick white lines mark boundaries of basins, including limits of Bellingshausen drainage basin inferred prior to cruise JR104. Dashed lines show boundaries of the main glacial trough in the Bellingshausen Sea, as inferred from reconnaissance data before cruise JR104. Dotted line marks continental margin. G VI S is George VI Sound.

References

Cunningham, A.P, Larter, R.D. & Barker, P.F., 1994. Glacially prograded sequences on the Bellingshausen Sea continental magin near 90°W. *Terra Antartica*, **1**, 267–268.

Cunningham, A.P., Larter, R.D., Barker, P.F., Gohl, K. & Nitsche, F.O, 2002. Tectonic evolution of the Pacific margin of Antarctica 2. Structure of Late Cretaceous–early Tertiary plate boundaries in the Bellingshausen Sea from seismic reflection and gravity data. *J. Geophys. Res.*, **107**(B12), 2346, doi: 10.1029/2002JB001897.

Larter, R.D., Cunningham, A.P., Nitsche, F.O. & Gohl, K., 2001. A major glacial continental margin depocentre in the Bellingshausen Sea, Antarctica (abstract). *In*: Dowdeswell, J.A. & Ó Cofaigh, C. (eds), *Glacier-Influenced Sedimentation on High Latitude Continental Margins, Programme & Abstracts*, meeting 29–30 March 2001, University of Bristol, 37. Copy reproduced in Appendix 1.

Nitsche, F.O., Gohl, K., Vanneste, K. & Miller, H., 1997. Seismic expression of glacially-deposited sequences in the Bellingshausen and Amundsen Seas, West Antarctica. *In*: Barker, P.F. & Cooper, A.K. (eds), *Geology and Seismic Stratigraphy of the Antarctic Margin, 2*. AGU, Antarctic Research Series, 71, 95–108.

Nitsche, F.O., Cunningham, A.P., Larter, R.D. & Gohl, K., 2000. Geometry and development of glacial continental margin depositional systems in the Bellingshausen Sea. *Mar.Geol.*, **162**, 277–302.

Turner, J., Lachlan-Cope, T.A., Marshall, G.J., Morris, E.M., Mulvaney, R. & Winter, W., 2002. Spatial variability of Antarctic Peninsula net surface mass balance. *J. Geophys. Res.*, 107(D13), 4173, doi:10.1029/2001JD000755.

Vaughan, D.G., Bamber, J.L., Giovinetto, M., Russell, J. & Cooper, A.P.R., 1999. Reassessment of net surface mass balance in Antarctica. *J. Clim.*, **12**, 933–946.

6. NARRATIVE

Most members of the scientific party for JR104 arrived in Stanley a week before the start of the cruise. This was necessary because of the limited number of places available to BAS on the 20th January flight from Brize Norton, together with the fact that the port call before the cruise coincided with the mid-season crew change. Steve Bremner, Pete Lens and Mark Preston were on the 20th January flight, arriving in the Falklands on the 21st January.

JCR arrived at FIPASS in the morning of 20th January, returning from combined Biological Sciences and Geological Sciences cruises around South Georgia. Peter Morris was already onboard. The handover of the vessel to the incoming ship's company could not take place until late afternoon on 21st January, when the senior officers arriving on that day's flight reached the ship. However, starting early on 21st January, the outgoing Chief Officer (Andrew Liddell) and Deck Engineer (Simon Wright) arranged for the container holding the new coring equipment purchased for this cruise to be unloaded and the main pieces to be installed on deck. As a result, most of the work necessary to mobilise JR104 was completed that day, and on the following day it was possible to hold a practice session to refine procedures for handling the new gravity corer. The practice session also highlighted some desirable modifications to the handling equipment, which were implemented before departure.

Outbound Passage

The ship sailed from FIPASS at 0900 (local; UTC-3 hours) on 23rd January, and moved to anchor in Port William to carry out emergency drills. After the drills were completed, we started to make our way out of Port William and began the passage to the Bellingshausen Sea at 1230. Logging of data from the EM120 (survey JR104a) and TOPAS systems was started to the east of Cape Pembroke, at 1615Z and 1653Z respectively. At 1910Z we slowed to deploy the towed magnetometer, and then continued to the Bellingshausen Sea collecting EM120, TOPAS and magnetic data along the entire passage route. Our passage route was offset a short distance to the south of a great circle to extend existing swath bathymetry data coverage in Drake Passage.

Conditions were unusually benign while crossing Drake Passage and we made rapid progress. New EM120 surveys were started after crossing Burdwood Bank (JR104c, started 1034Z on 24th January) and the Hero Fracture Zone (JR104d, started 2103Z on 25th January).

While on passage one XBT (T5 probe) was deployed each day in order to obtain sound velocity profiles for input to the multibeam echo sounder (EM120) system. During the rest of the cruise one or more XBTs were deployed on most days (T5 or T7 probe, depending on water depth; see Table 2).

Continental shelf edge and slope, part 1

In the afternoon of 27th January our passage route began to converge with the Bellingshausen Sea continental slope and we started a new EM120 survey (JR104e, started 1601Z). Most of the EM120 data collected over the following two weeks were logged as part of this survey, including all of the data from the continental shelf edge and slope, and data from the Ronne Entrance. Continuing to the southwest we encountered increasing concentrations of icebergs and brash ice, and recovered the towed magnetometer at 2006Z on 27th January so as not to risk damaging or losing it.

We reached the continental shelf edge at the eastern edge of our study area (69° 21'S, 80° 00'W) in the early evening on 27th January. At this point we turned to head approximately WSW through a series of waypoints along the shelf edge, picked on the basis of sparse existing data. Overnight, increasing concentrations of first year sea ice were encountered and we diverted to the north of the planned line to avoid an area of dense pack. During the following morning we managed to work back to the intended line and then continued westward along it. However, at 1500Z on 28th January and at 70° 25'S, 87°30'W, the ship encountered much denser pack, which slowed progress and caused a lot of noise on the EM120 and TOPAS data. At this point we were still 45 km from the intended western end of the survey but turned to run back ENE, adding a second survey line to the south of the first one with the two EM120 swaths just overlapping. This second line was interrupted to test the new box corer at a site on the uppermost part of the continental slope that was selected on the basis of TOPAS data collected along the first line. After successful recovery of a box core (BC351), the second survey line was continued to 84°W, a short distance beyond the point at which the eastern margin of the Belgica Trough reaches the shelf edge. Continuing any further east would have taken us into another area of dense pack. Turning back WSW again at 0600Z on 29th January, we added a third survey line across the mouth of the trough, to the south of the previous two.

On reaching the western limit of the previous lines at about 1500Z on 29th January we found that the edge of the dense pack had migrated about 5 km west in the preceding 24 hours. We turned just before reaching the edge of the dense pack and started a fourth survey line to the south of the previous ones. We broke off from this line to core at three locations on the uppermost part of the continental slope that had been picked from the survey data already collected (GC352–GC354 and BC355). Gravity core GC353 was at the same location as BC351. GC354 and BC355 were also at a single station. The gravity coring was successful, but the box corer failed to trigger on either of two attempts at the last site.

The approach to the Ronne Entrance

Having made a good start to work in the area where the Belgica Trough reaches the continental shelf break, it was time to try to trace the source of the ice that had flowed through the trough. Satellite images received on the Dartcom system, MODIS satellite images forwarded from Cambridge by Alex Tate, and observations from the ship, all suggested that we would soon encounter dense pack if we attempted to go directly south along the trough. However, the satellite images clearly showed that there was open water in the Ronne Entrance and Eltanin Bay, and suggested that we might find an easier route through to these areas by heading south between 83° and 82°W. Therefore, on leaving the site of BC355 at 0710Z on 30th January, we moved to the northern edge of the area we had already surveyed and then went eastwards, adding another survey line to the north of the previous ones. This took us beyond the northern limit of the dense pack encountered near 84°W on previous lines.

Heading south between 83° and 82°W, we found open water to almost 71°S, where we started to encounter a loose scatter of ice floes. Continuing south from 71°S the concentration of ice floes increased over the next 10–20 km, but we did not encounter ice that was as densely packed as that at the western end of the shelf edge survey area. The ice did not seriously impede the ship's progress, although the related noise did have an adverse effect on EM120 and TOPAS data. Our route southwards initially took us over a part of the shelf that is >500 m deep, lying to the east of a bank shallower than 500 m that defines the eastern margin of the mouth of the Belgica Trough. Further south our route took us across the bank, reaching a minimum depth of <400 m and demonstrating that the bank is continuous with another area where soundings shallower than 500 m have been recorded to the southeast. The continuity of the bank meant that any trough deeper than 500 m linking the Ronne Entrance to the Belgica Trough must lie south of 71°35'S. Sparse soundings on the Data Collector Sheet supplied by the Hydrographic Office suggested that such a tributary trough might be present to the north and northeast of Smyley Island, trending WNW–ESE. Once far enough south, we turned to head ESE towards the Ronne Entrance along the supposed axis of this trough, as inferred from three lines of soundings on the Data Collector Sheet. This line took us through fairly dense pack for about four hours, but on reaching 71°43'S, 80°20'W early on 31st January we emerged into relatively open water. Shortly after this we stopped to collect cores at a site in the axis of the tributary trough (BC356 and GC357).

The Ronne Entrance

On leaving the core site we continued ESE along the axis of the tributary trough for several hours, then altered course eastward to run obliquely up its northern flank. On reaching 77°30'W we turned southwards to run a survey line across the trough. The EM120 data on this line revealed features that indicated past glacial flow towards WNW. However, as this line only crossed the central and southern parts of the mouth of the Ronne Entrance, it remained possible that ice flow out of the northern part might not have followed parallel flow paths. To test this possibility another survey line was collected heading NE from near Smyley Island and extending across the northern part of the mouth of the Ronne Entrance. After we had crossed the trough axis on this line, water depth gradually decreased to less than 600 m, then it started to increase northwards again near the northern end of the line. As there was a possibility that the high we had just crossed was a former drainage basin divide, we continued due north for about 20 km, and were rewarded by some spectacular, NNW–SSE trending lineations. Two gravity cores, GC358 and GC359, were collected in the area of these lineations.

Early on 1st February, survey data were collected on another line across the mouth of the Ronne Entrance, on the southeast side of the first line. This line was interrupted in the early hours of the morning to collect cores from a till sheet on the northern flank of the trough (GC360 and BC361). On reaching the southern limit of previously collected data, near Smyley Island, two additional short survey lines were added to extend coverage over WNW–ESE trending lineations and drumlins in this area. We then continued to retrace the route we had taken approaching the Ronne Entrance, first going north to the axis of the trough, and then WNW along its axis.

Eltanin Bay

At 2100Z on 1st February we stopped running parallel to our previous track and turned south towards Carroll Inlet and Eltanin Bay. Our objectives in this area were to collect reconnaissance data defining the positions of other troughs that might have been tributaries to the Belgica Trough, to obtain some indications of palaeo-ice flow directions, and to collect cores that would provide a record of deglaciation of the inner shelf and allow characterization of the tills derived from each tributary.

Our route took us across a bank shallower than 300 m to the northeast of Smyley Island, then over a trough deeper than 800 m to the northeast of Carroll Inlet. While crossing the bank we started a new EM120 survey (JR104f, started 0015Z on 2nd February). A gravity core and a box core were collected in the trough (GC362 and BC363). We then headed southwest to an area in Eltanin Bay where reconnaissance data collected on R/V *Polarstern* in 1994 and R/V *Nathaniel B Palmer* in 1999 indicated the existence of a trough more than 1000 m deep.

While surveying the trough in Eltanin Bay we reached the southernmost point during the cruise, at 73°07.4'S, 83°26.8'W, which we believe to be the furthest south that the ship has ever been in the Pacific sector. Cores were collected at two sites in this area, one in the middle of the trough (BC364 and GC365) and the other on its eastern flank (GC366). The only successful Sound Velocity Probe (SVP) deployment during the cruise was carried out at the first of these sites. An XBT (XBT12; file T7_00016.edf) was deployed as we moved off from this site so that the water velocity profile derived from it could be compared directly with the SVP profile (see Fig. 18).

Exploration of the Belgica Trough

Leaving Eltanin Bay early on 3rd February we headed NNE, running obliquely across the Belgica Trough and passing through variable concentrations of sea ice. On reaching 72°S, 81°45'W, having crossed the trough axis, we turned to head NW, running approximately parallel to the trend of the trough inferred from sparse reconnaissance data. After following this course for about 20 km we turned to head NE to search for the NE margin of the trough, and also to find out whether or not palaeo-ice flow indicators near this margin suggested that ice flowing from the Ronne Entrance had fed into the Belgica Trough. EM120 data revealed a steep slope rising to the NE near 71°40'S, 81°40'W, which probably represents the margin of the trough. From this point we returned towards the middle of the trough, collecting survey data on another line, on the NW side of the previous line.

Once back to the middle of the Belgica Trough we resumed a NW course. After following this course for about 40 km we stopped to collect a gravity core in order to obtain a record of deglaciation of the mid-shelf part of the trough. The first attempt (GC367) recovered only 27 cm of sediment, and mud adhering to one side of the corer showed that it had fallen over on the sea floor. A second core (GC368) was collected 0.2 km north of the first station and was slightly more successful, recovering 81 cm. A box core was also collected nearby (BC369).

From the mid-trough core sites we headed westwards to search for the SW margin of the Belgica Trough, and to look for any evidence of palaeo-ice flow into the trough from the SW. As we proceeded westwards we encountered increasing concentrations of sea ice, until eventually it was only possible to obtain any useful sonar data at very slow speeds. Satellite images received on the Dartcom system, and MODIS satellite images forwarded from Cambridge, indicated that the edge of the dense pack ice lay along an E–W line at about 71°15'S, only about 40 km to the north of the westward line we were running along. In the light of this information it was decided that the advantages of making rapid progress to get clear of the ice outweighed the short-term adverse effect on sonar data quality. By increasing propulsion power and disregarding data quality we were able to progress at 8–9 kts through the first-year ice.

A gravity core was collected near the western margin of the Belgica Trough (GC370). Locally more open ice conditions in the vicinity of this core site allowed some useful EM120 data to be collected defining the SW margin of the trough. Once a water depth shallower than 500 m had been reached, we turned to head north and get clear from the ice. On reaching 71°15'S, 84°55'W, in the morning of 4th February, we emerged into relatively open water.

Once in open water we headed ENE to collect survey data that would define the shape of the central part and NE flank of the Belgica Trough in this area. The EM120 data on this line revealed a clear set of NNW–SSE trending mega-scale glacial lineations, so after reaching the NE margin of the trough we collected survey data along two additional lines parallel to this one. After completing this mini-survey we turned to head NNW, approximately following a palaeo-ice flow line near the NE margin of the trough. After following this course for about 40 km we stopped to collect a gravity core (GC371) in order to obtain a record of deglaciation of the outer shelf part of the trough and to investigate the provenance of till near its NE margin.

On leaving this core site the active EM120 survey was changed back to JR104e (at 2010Z), so that further data recorded on the outer shelf and slope were recorded as part of the same survey as the data collected earlier in that area. We headed WSW to intersect multichannel seismic line (MCS) BAS923-22, which had been collected on cruise JR04 in 1993 and revealed an intermittent surface sediment layer. Before reaching the intersection with the MCS line we crossed a ~10-km wide, sharply-defined zone in which the depth was about 25 m greater than that of the surrounding sea floor. After turning to follow the MCS line towards the shelf edge, we re-crossed this feature. It seems likely that the feature is continuous with a relatively deep area at the shelf break at the western edge of the Belgica Trough mouth. If so, the EM120 data collected on these two lines suggest that it is a sinuous, second-order trough within the Belgica Trough, and that sea-floor depth increases along it towards the shelf edge. TOPAS revealed a sub-bottom reflection locally within the second-order trough, so we stopped to collect a gravity core and box core near its northern margin on the MCS line (GC372 and BC373). Another gravity core (GC374) was collected from a location 10 km further north, outside the second-order trough.

Continental shelf edge and slope, part 2

Returning to the shelf edge area, we collected additional survey data and filled gaps in EM120 data coverage along the southern edge of the area surveyed during the first part of the cruise. The new survey lines were between 86°20’W and 83°30’W, and together with the data collected earlier these gave us continuous EM120 data coverage of the shelf edge between 87°30’W and 84°05’W. The only gap then left in coverage of the shelf edge across the Belgica Trough mouth was at its western edge.

In the early evening of 5th February we crossed the area of existing EM120 data coverage near 86°W to start adding to the northern, continental slope side of the survey. Data were collected along three more survey lines between 86°15’W and 87°30’W, and a gravity core was collected on the upper slope in this area (GC375). During recovery of the corer, it was found that the wire had become wrapped around the core head. The wire was disentangled from the core head by lowering the corer onto a convenient ice floe (see section 8.4.4, p.34).

During the morning of 6th February we tracked the northwest edge of the existing survey area to its western limit, then collected survey data along four additional short lines further west, filling the last gap in coverage of the shelf edge across the mouth of the Belgica Trough. The end of the first of these lines was the westernmost point reached during the cruise, at 70°30.4'S, 88°20.2'W. The turn at the end of this line was close to the N–S trending edge of some quite dense pack, so in the eight days since we were in this area previously, the edge of the pack had migrated 25 km west. After completing this western part of the survey we headed back northeastward, adding one more survey line on the northwest side of the existing survey. Opposite the middle of the trough mouth we turned to head NNW, directly down the gentle slope of the Belgica Fan, and collected a transect of gravity cores at different depths on the fan (GC376 at 1014m, GC377 at 1608m, and GC378 at 2182m). A box core (BC379) was also collected near the last of these three sites.

Survey data were collected on two short, along-slope survey lines in the mid-slope region before we returned to the upper slope survey area. The EM120 and TOPAS data collected on the along-slope lines suggested that the mid-slope on the central part of the Belgica Fan is a very uniform environment. On reaching the edge of the main survey area again we followed it as far as the northeast limit of the fan. The EM120 data revealed linear gullies running down this flank of the fan. In order to investigate the nature of the sediment transported down these gullies, a gravity core was collected just to the west of the distal part of the most prominent gully, at a depth of 2150 m (GC380). A SVP cast was carried out at the same location, but the probe recorded no data. Further investigation revealed problems with hardware components in the probe (see section 8.7).

We returned to the upper slope site where the box core had failed to trigger twice during the earlier part of the cruise (BC355). This time it triggered successfully, but only recovered a very small surface sample. The original station number was retained. While still on station a short SVP cast, to a depth of just 20 m, was carried out to test the probe. This cast resulted in creation of a file, but it was zero bytes in size.

The final core site (GC381) was at 1953 m depth on the relatively steep slope to the east of the Belgica Fan. This site was chosen to investigate differences between sediments on the fan and on this steeper slope. The mid-slope region was targeted because it shows less morphological variability than the upper slope. On the transit from BC355 to this site a diversion was made to fill a gap in EM120 data coverage of the shelf edge between 84°05'W and 83°33'W.

The towed magnetometer was deployed as we moved off from the last core site (recording started at 0555Z). Before starting passage back to Port Stanley we extended the survey of the part of the continental margin we had run along on the approach to the main survey area, as this provided an interesting contrast to the area at the mouth of the Belgica Trough. Most of the original line had been along the shelf edge or just landward of it. Survey data were collected along a new line just to the north of the original line, with the two EM120 swaths just overlapping. At 80°40'W we crossed to the south side of the original survey line because eastward of this longitude it ran along the slope and the original EM120 swath did not extend as far as the shelf edge. This line was continued along the shelf edge to 79°W, at which point we turned and added another overlapping swath along the slope as far as 80°50'W. Turning to head eastwards again, one further swath was collected along the slope as far as 79°51'W before leaving the area.

Return passage

The return passage started from 69°18'S, 79°51'W at 1930Z on 8th February. The passage track was positioned to the southeast of the outbound track, such that the EM120 swaths just overlapped. The return track was maintained in this relative position all along the Antarctic Peninsula continental rise and through Drake Passage, until reaching 54°50'S, 59°30'W. EM120, TOPAS and magnetic data were collected along the entire passage route. The outbound EM120 surveys were reactivated at appropriate times so that new data from the same areas were recorded as part of the same surveys (JR104d reactivated at 0104Z on 9th January; JR104c reactivated at 1904Z on 10th January; JR104a reactivated at 0524Z on 12th January). During the passage one XBT (T5 probe) was deployed each day in order to obtain sound velocity profiles for input to the EM120 system. We made good progress during the first part of the passage with a moderate following wind. However, conditions deteriorated on the afternoon of 11th February, slowing progress during the remainder of the passage. Early on 12th January, at the foot of the slope on the south side of Burdwood Bank, we collected data for calibration of the EM120 system by surveying along the same ~10 km-long line in both directions. On reaching 54°50'S, 59°30'W, near the top of the slope on the south side of Burdwood Bank, we went due north to 54°S. This allowed us to fill a gap in magnetic data coverage south of the Falkland Islands on the remaining passage track, as we headed towards Cape Pembroke. At 2352Z on 12th February we slowed to recover the towed magnetometer. We stopped logging data from the TOPAS and EM120 systems at 0240Z and 0244Z, respectively, on 13th February. The ship docked at FIPASS at 0810 (local time; UTC-3) on 13th February, arriving in very stormy conditions.

Demobilisation

The coring equipment was dismantled and packed into a container during the morning and early afternoon of 13th February. Selected core sections were packed into wooden boxes, to be sent back to the UK by sea freight. The Cool Specimen Room was required for a subsequent cruise, so remaining core sections were stowed in the starboard Tween Deck Cool Store, to return to the UK on the ship. Most members of the JR104 scientific party departed from the Falkland Islands on 14th February. The exceptions were Peter Morris and Mark Preston, who were staying on for the next cruise.

7. PRELIMINARY RESULTS

7.1 EM120 Multibeam Swath Bathymetry and TOPAS Investigations

Colm Ó Cofaigh, Julian A. Dowdeswell and Jeffrey Evans

This section provides an overview of the main sea-floor glacial and glacially-related bedforms observed on the swath bathymetric and TOPAS records from the Belgica Trough and the Ronne Entrance, as well as the adjoining continental slope. These data provide evidence for a major palaeo-outlet of the West Antarctic Ice Sheet draining through Belgica Trough, and emanating from Eltanin Bay and the Ronne Entrance. This ice extended to the outer continental shelf, and probably reached the shelf edge, at the last glacial maximum.

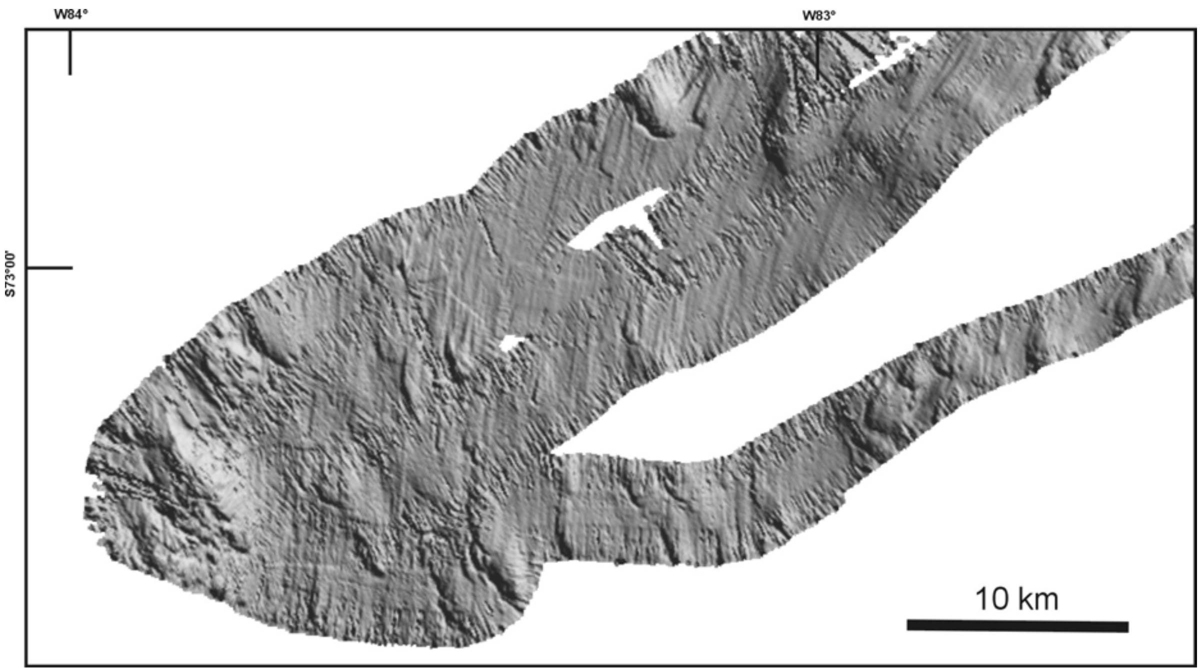


Fig. 3. Unprocessed EM120 swath bathymetric shaded relief image of drumlins and lineations in Eltanin Bay. The bedforms record north north-easterly ice flow out of the bay towards Belgica Trough. Grid cell size = 75 m x 75 m.

Streamlined subglacial bedforms on the floor of Eltanin Bay were imaged by multibeam swath bathymetry during the cruise and record palaeo-ice flow out of the bay and into Belgica Trough. Drumlins, some with crescentic overdeepenings around their stoss ends, occur in the inner bay between 73°08'S and about 72°50'W (Fig. 3). The drumlins evolve into mega-scale glacial lineations (MSGL) downflow north of 72°40'S. The orientation of the streamlined bedforms indicate that ice flow was initially north north-east out of the bay to as far north as 72°25'S before it swung around to the northwest where MSGL in water depths of about 700 m demonstrate flow of grounded ice down the axis of Belgica Trough. The distribution of the streamlined subglacial bedforms indicates that flow from Eltanin Bay was convergent with ice flow from immediately west of Smyley Island.

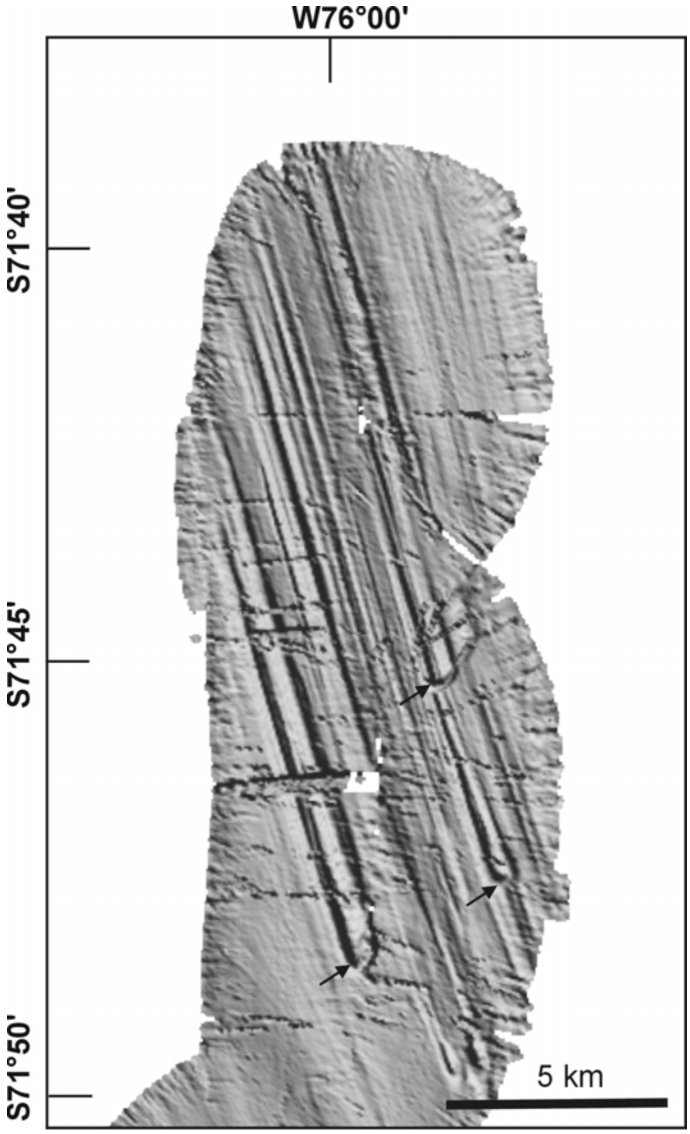


Fig. 4. Unprocessed EM120 multibeam swath bathymetric image of highly-attenuated drumlins and mega-scale glacial lineations indicating north north-west ice flow out of the Ronne Entrance. These subglacial bedforms occur in water depths of 600-700 m. Note crescentic overdeepening around the stoss end of some of the bedforms (arrowed) implying initiation from a point source. Grid cell size = 50 m x 50 m.

Geophysical data were also acquired from the Ronne Entrance. Multibeam data from this area show glacial geomorphological evidence for ice flow out of the Ronne Entrance that bifurcated and flowed both north north-west into the trough west of Latady island (Fig. 4), and west north-west into the head of Belgica Trough.

The north north-west orientated bedforms comprise well-developed, attenuated drumlins and MSGL up to 13 km long in water depths of 600–700 m. Both types of bedform occur in the same area and several bedforms initiate at a point source – typically characterised by a crescentic shaped overdeepening at their stoss-end (Fig. 4). Interestingly, streamlined bedforms are absent from across much of the centre of the mouth of the Ronne Entrance but occur on the sides of the trough. Whether this records a glacio-dynamic response to the bathymetry in this area will be the subject of further investigation. The second flow set of crudely streamlined bedforms from the south side of the mouth of the Ronne Entrance indicates west north-west flow towards Belgica Trough. This flow trajectory is also supported by MSGL at about 71°50'S and between 78°49'W and 79°33'W.

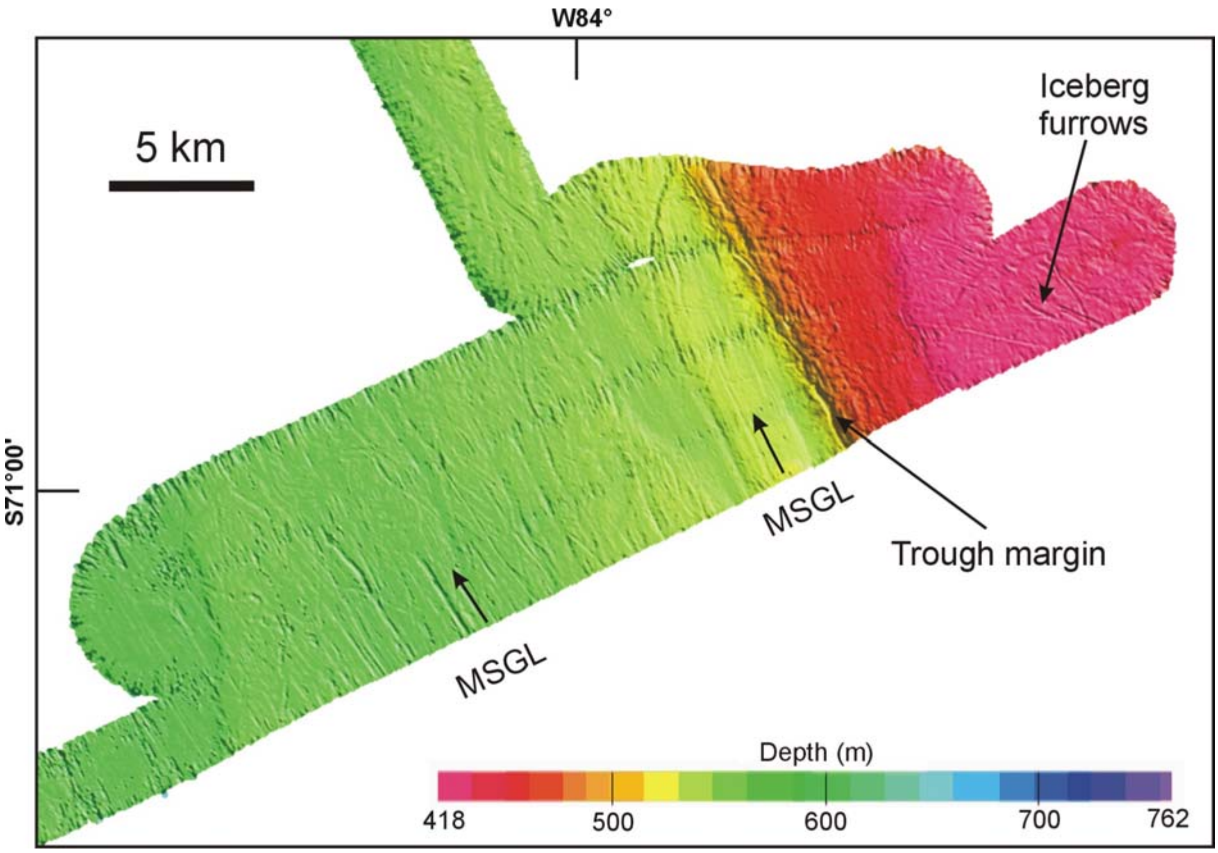
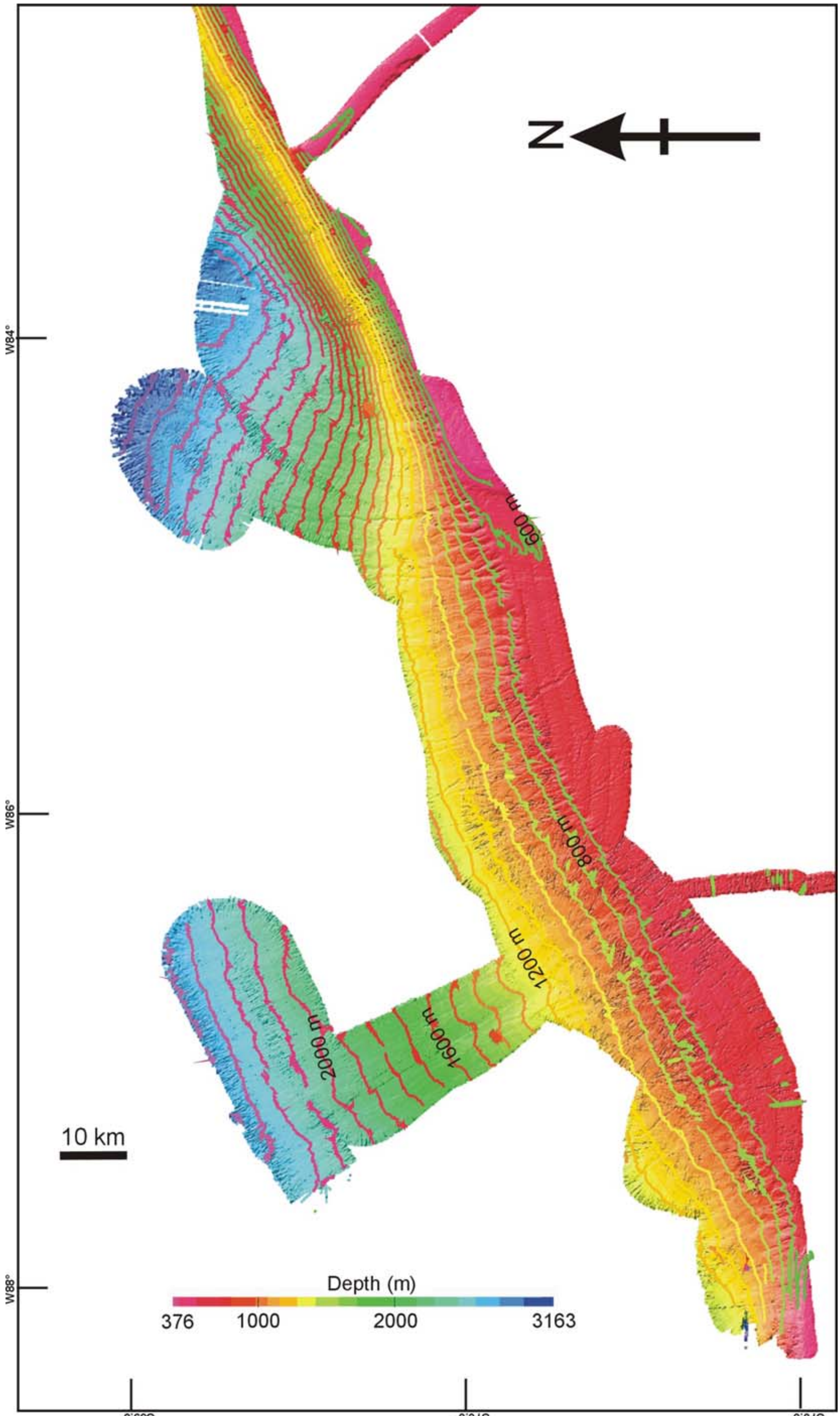


Fig. 5. Unprocessed EM120 multibeam swath bathymetric colour shaded relief image of mega-scale glacial lineations (MSGL) in outer Belgica Trough in water depths of 560–620 m. Note prominent trough margin and iceberg furrows in water depths of less than 500 m.

Swath bathymetric data from the middle and outer part of Belgica Trough show MSGL up to at least 11 km long (note: this is a minimum estimate as it is limited by the swath coverage) (Fig. 5). The MSGL demonstrate north-westward orientated flow of grounded ice along the axis of Belgica Trough to at least 70°42'S which is within 60 km of the shelf edge. Extensive iceberg scour marks are present on the sea-floor at the shelf edge. The relationship of sea-floor morphology to bathymetry is shown by a block of swath data collected between 71°10'S, 84°51W and 70°55'S, 83°30'W (Fig. 5). Here MSGL that record northwesterly ice flow along the trough axis are preserved in water depths of about 560–620 m. MSGL disappear in water depths of less than 500 m and are replaced by iceberg scours, which are visible on a shallower bank immediately east of the trough margin (Fig. 5).

Swath bathymetric data were acquired from the upper and middle continental slope along 380 km of the Bellingshausen Sea margin between 88°20'W and 79°W. Upper slope contours are fairly straight in plan view but below about 1000 m water depth the contours exhibit a distinct bulge-shape which extends down to about 2400 m (the deepest part of our swath bathymetric coverage) (Fig. 6). This outward bulging of the slope contours is limited to the area directly in front of Belgica Trough and we interpret this pattern as a trough mouth fan. Belgica Trough itself is about 150 km wide where it reaches the continental shelf edge, and the shelf break is at a water depth of about 700 m. Iceberg scours are present on the sea floor at, and in-shore of, the shelf edge. The surface of the upper slope in front of the trough is gullied. Gullies coalesce downslope to form channels of low sinuosity which can reach up 43 km in length (Fig. 6). The gullies extend along the shelf edge in front of the trough and also occur laterally to the trough mouth. However, they are not a continuous feature all the way along the shelf edge (Fig. 6). TOPAS records from the continental slope in front of the trough show the presence of acoustically transparent lenses of sediment, which are interpreted as debris flow deposits. The TOPAS records show that the debris flows have been locally incised by the gullies.

Fig. 6 (opposite). EM120 colour shaded relief image of continental slope in front of Belgica Trough. Note the outward bulge in bathymetric contours in front of the trough mouth indicative of a trough mouth fan. Grid cell size = 100 m x100 m.


N
600 m
800 m
1200 m
1600 m
2000 m
10 km
Depth (m)
376
1000
2000
3163
W84°
W86°
W88°
S69.5°
S70.0°
S70.5°

7.2 Box coring

Claus-Dieter Hillenbrand

Box coring during JR104 recovered two different types of surface sediments in the study area. On the continental slope and on the outer and middle shelf surface sediments (assumed to be Holocene in age) consist of brown foraminifera-bearing muds, foraminiferal muds, and foraminiferal oozes (BC351, BC355, BC356, BC369, BC373, BC379). The foraminiferal assemblage is dominated by the planktonic species *Neogloboquadrina pachyderma* sin. The foraminiferal carbonate found in these sediments will be used for AMS ^{14}C dating. Gravel grains and cobbles lay on top of the foraminifera-bearing sediments (Fig. 7). The gravels and cobbles, which are interpreted as dropstones, are often covered with thin manganese coatings, pointing to sedimentation rates less than 1 cm/kyr. The occurrence of silt- and clay-sized particles within the foraminifera-bearing units supports the idea that these deposits represent condensed units rather than residual sediments. Only at site BC355, located on the upper slope on eastern flank of the Belgica Fan, is a very high sand content observed, suggesting that the deposition of foraminiferal ooze there resulted from current-induced winnowing.

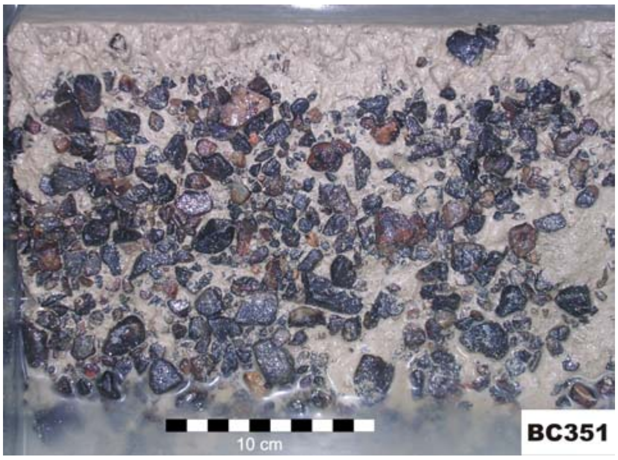


Fig. 7: Photo of box core BC351. Surface sediment: foraminiferal mud. Note the high abundance of pebbles and gravel grains, which are partly coated by manganese (visible by the brown and black colours).

Olive to brown, diatom-bearing muds and diatomaceous muds were found on the inner shelf below 600 metres water depth (BC361, BC363, BC364). The surface sediments at these sites lack coarse-grained terrigenous detritus (see Fig. 17). Holocene sedimentation rates there are assumed to be significantly higher than at the sites where foraminifera-bearing sediments were recovered. The sediments underlying the diatom-bearing, as well as the foraminifera-bearing, top layers contain significant amounts of terrigenous sand and gravel and are virtually barren of biogenic material. They were probably deposited at the transition from the last glacial to the present interglacial. At one site on the inner shelf in the Ronne

Entrance (BC361), a grey, massive diamicton was recovered at the base of the box corer (Fig. 8). This sedimentary unit is interpreted as a deformable till deposited during the last glacial period or a waterlain till deposited during the subsequent deglaciation phase.

Fig. 8: Photo of split subcore Y of box corer BC361. Sediments: 0-17 cm: brown olive, bioturbated diatomaceous mud; 17-23 cm: grey, massive diamict. Note the rounded cobble (gabbro) at the base of the subcore.

8. EQUIPMENT PERFORMANCE

8.1 EM120 Multibeam Echo Sounder

Peter Morris and Carol Pudsey

The swath system performed well throughout the cruise. Very few problems have been experienced with the EM120 on any cruise this season, which leads to the conclusion that most of the more annoying quirks found in previous years have been sorted out. This is due partly to a software upgrade last summer but probably more crucially to finally getting the sonar sequencing unit (SSU) working properly.

The only obvious software problem was that when the main survey became too large the screen refresh on the acquisition computer was not able to redraw the line and coverage displays correctly. The data recorded to file however was unaffected and could be replayed correctly on the Neptune computer.

This was the first cruise in which the EM120 had been operated extensively in ice. When the ship is actively cutting through sea ice the swath signal deteriorates very seriously, but with only a few metres of open water alongside the signal returns. Thus if the ship can follow leads of more open water quite good results are possible. In ice we did not really witness the progressive degradation one normally observes as the sea becomes rougher. Either a good signal was recorded or rubbish. The very calm sea conditions encountered on the shelf enabled high beam angles to be used for most of the detailed survey work.

TOPAS can seriously affect the quality of the swath record. This is not a problem in shallow waters where the respective transmissions can be controlled by the SSU but becomes serious in deep, flat oceanic areas where the TOPAS ping rate needs to be higher than that of the EM120 in order to get sufficiently detailed coverage. The TOPAS transmission affects the central portion of the swath beams. The effect can be reduced, though not removed, by maintaining a small allowable bottom detection range on the EM120 and by choosing an appropriate TOPAS ping rate (i.e. one that is not an exact multiple of the EM120 ping rate). Processing of data affected by TOPAS requires some care. The main cleaning rule in Neptune considers all points in a grid square, fits a surface to this and then rejects any point more than, typically, two standard deviations from this plane. In data with TOPAS contamination the calculated plane is often far removed from the true seabed with the result that most of the real seabed reflections are rejected as well. This leads to very poor gridded data. The only really effective way of getting round this in Neptune seems to be to use a general cleaning rule that has no effect whatsoever (e.g. removing all points deeper than 10,000 metres) and then doing all the editing by hand on a correlation plot.

During the course of the present survey it was necessary to combine our newly acquired data with older swath data acquired by the R/V *Nathaniel B Palmer* and R/V *Polarstern*. This is most easily performed using the 'MB' software as the R/V *Nathaniel B Palmer* data is held as MB files. The MB system accepts raw Simrad files (as format 56). The MB manual recommends that if any cleaning or other data manipulation is to be carried out on Simrad data using MB these should first be changed from MB format 56 to format 57. All files from the main survey area were transformed in this way. The command used for making the change (to a single file in this example) is of the form:

```
mbcopy -I0001_20040127_160122_raw.all -F56/57 -OJR104_20040127_160122_raw.all.mb57
```

Any Simrad data edited using Neptune as opposed to MB needs to be exported from BINSTAT as ASCII xyz data before input to the MB gridding routines (as format 0).

In order to follow our outward track home again it was necessary to restore some surveys from Neptune to the acquisition computer so as to provide a Bridge display of the earlier coverage that the navigating officer could follow. This was achieved simply by re-creating the appropriate raw and processed directories on the acquisition computer and then using ftp to transfer all the contents of the processed directory, plus the raw directory 'loglines' file, back from Neptune. It was not necessary to copy back any raw data files.

8.2 TOPAS Sub-Bottom Profiler

Peter Morris and Carol Pudsey

The TOPAS system was used extensively during the cruise. It performed well with only three serious problems.

1. It stopped because all the file space available for logging was used up (general operator negligence!)
2. It stopped when two fuses blew in the 50V power supply (fixed promptly by the ETS engineer, Mark Preston). After replacing the fuses the problem did not recur. Earlier during the cruise the 50V supply had switched itself off for no apparent reason, as it

had done on the previous cruise as well. This problem was overcome by power cycling the system

3. The only problem encountered with the SSU during the trip was when EM120, EA500 and TOPAS were running under synchronisation but, for some reason, the ‘time add-on’ to the TOPAS listening time was set to zero. The EM120 transmission pulse appeared on the TOPAS record and tracked the sea bed return so that it looked like the base of a thick till layer. A reboot of the SSU and insertion of a reasonable value for TOPAS ‘time add-on’ (25–30%) solved the problem, which did not recur.

Sea ice affects the TOPAS record quite badly. It results in many high amplitude signals that produce dark traces on the paper record.

In water depths of less than 1000 m it is preferable to run TOPAS using a ‘burst’ rather than a ‘chirp’ pulse, as this gives a much sharper record. However, with the reduced signal-to-noise ratio of the burst pulse a strong 100 Hz background signal became evident, sometimes becoming so strong as to nearly drown out the TOPAS return, especially when combined with ice noise. This comes from somewhere on the ship and has caused a problem for many years. Its source remains unknown though it does seem to vary in intensity during the day. Switching off the ship’s cathodic protection system, a known source of noise on previous cruises, caused no reduction in the 100 Hz signal.

On JR104, most TOPAS data was recorded using a 20 kHz sample rate rather than the 10 kHz generally used before. This is the highest sampling rate possible consistent with a full 400 ms record. There appeared to be an improvement to data resolution.

In reasonably shallow water, when the EM120 and TOPAS both run under SSU control, it is possible to use the ‘time add on’ to TOPAS on the SSU as a means of controlling the ping rate and ensuring that excessive numbers of pings do not occur. In very shallow water, however, it is better to use a ‘fixed time’ as opposed to a ‘calculated’ setting on the EM120 control on the SSU to control the data acquisition rate.

The automatic annotation of the EPC plotter introduced on the previous cruise (JR103) worked well and proved to be very useful. The timing lines on the record are the true 5-minute intervals derived from the radiocode clock. The printed times, derived from the SCS, are late, i.e. a printed time of 05:14:54 a little <u>after</u> a timing line means that the timing line is that for 05:15. Over the course of the cruise the timing lines and annotations seemed to drift apart somewhat. If possible it would be desirable to have a slightly more robust system.

8.3 Single Beam Echo Sounders

8.3.1 EA500

The Kongsberg Simrad EA500 12 kHz echo sounder, the control console for which is located on the Bridge, was used for navigational purposes. The depths recorded by this system were logged on the NOAA data logging system. However, it should be noted that interference from other sonar systems results in some spurious depth readings, particularly when the TOPAS system is operated with a chirp transmission and not synchronized through the SSU. The main periods when TOPAS was operated in this mode were in deep water while on passage to and from the main study area.

8.3.2 Precision Echo Sounder (PES)

The 10 kHz PES was used to monitor pinger signals during box coring operations and at some gravity core sites. For successful coring, dredging and full ocean depth CTD operations it is essential to retain such a facility in an area close to the Winch Control Room, so that the person directing operations can monitor pinger signals. The PES worked satisfactorily on this cruise. If the PES is removed, or fails and is judged to be beyond repair, it must be replaced by another system that allows pinger signals to be monitored from the Winch Control Room.

8.4 Gravity Corer

Carol Pudsey

The gravity corer manufactured by Duncan & Associates was used for the first time on this cruise and worked well, recovering a core at every site. The only damage sustained was the mangling of two core catchers, and considerable abrasion to both core cutters, while coring diamicts.

8.4.1 Mobilisation

The coring equipment (gravity corer, box corer and all spares and consumables including core liners) was shipped south in a standard container. The container was unstuffed and the components set in place on deck on 21st January (Fig. 9). For reports on the box corer see sections 8.5 and 9.2.

Fig. 9. Installation of corer tables and chute.

The gravity corer rests on a handling table in three sections, each 2 m long, and a launching chute; the setup requires the stern bulwark to be lowered. It was decided to position the aft end of the launching chute flush with the transom, rather than overhanging by 0.5 m as had been envisaged; this was considered safer in the event of a following sea washing over the deck. The chute was fastened down with webbing straps over the stern roller, as the stern bulwark has no bolt attachment points. All the half-penny weights were stacked on the head; it was necessary to lift the head into a vertical position to secure them, as in the horizontal position the securing bolts flexed so that the top plate could not be fitted.

The gravity corer and its handling table required some modifications before and during practice deployments on 22nd January. The first problem was that the barrel support brackets were found to be about 2” too short, i.e. the cross-poles resting on them supported the core barrel flange plate 2” below the head flange plate. Fortunately the brackets could be raised the required amount by resting them on the pins which were designed as securing pins. This was a less stable arrangement but worked during the cruise.

During the first attempts at deployment, with a 3 m barrel, the corners of the headstock repeatedly got stuck in the angle between the horizontal tables and the inclined chute; also the core cutter fouled the small roller at the outboard end of the chute. We fitted a wooden spacer in the angle and a sheet of plywood over the central 1 metre width of the chute to make a smooth path for the corer (Fig. 10). We also fitted plywood boards vertically along the sides of the tables to stop the core head sliding sideways and fouling the support brackets (Fig. 11).

Deployment was carried out using the coring warp on the central block of the stern gantry. A steadying line was rigged from two ring-bolts in the deck just forward of the tables; one person controlled this line while three others steadied the core head as it was lifted outboard (Fig. 12). The lift was usually not quite straight, and the lifting bracket on the head was observed to be flexing. It had been load-tested for 1 tonne, but only with a straight pull. We replaced it with a more flexible arrangement of two shackles and two hammer-locks attached to the swivel on the end of the coring wire (Fig. 13).

Fig. 10. Plywood sheet being fitted to the launching chute.

Fig. 11. Plywood sides fitted to the core tables.

Fig. 12. Deployment in the Bellingshausen Sea. The blue rope on the core head is the steadying line. All personnel working near the open stern wear safety harnesses.

Fig. 13. Swivel, hammerlocks and shackle.

The small winch supplied to pull the corer inboard along the tables on recovery proved inadequate; its mounting bracket flexed so much at the first attempt that we removed the winch. The bracket was left in place as a (rather weak) stop at the forward end of the table.

The big trawl winch was mounted on the stern in readiness for a subsequent cruise, and we used a wire pennant on the trawl winch for corer recovery (Fig. 14). If the trawl winch were not there, a pennant could be led to a mooring winch via a deck-mounted turning block.

Fig. 14. Pennant on the trawl winch used to haul in the corer.

Fig. 15. View from FIPASS of the 6 m corer being recovered.

Several practice deployments were carried out, with the corer lifted outboard and vertical then recovered (Fig. 15). One sample of Stanley Harbour mud was taken.

8.4.2 Deployment procedure

1. Assemble 3 m or 6 m barrel with liner, core catcher and core cutter. The barrel rests on the cross-poles.
2. Fit barrel to head (we used the quick-release mechanism during the cruise but the flange plates can also be bolted together).
3. Remove the cross-bar nearest the head and lift the corer approx 2 m outboard on the coring wire, steadying as above. At this stage it is supported by the wire at the inboard end and the barrel resting on a cross-bar at the outboard end.
4. Lower the head on to the table and remove the next cross-bar.
5. The 6 m barrel has one more cross-bar.
6. Lift outboard and down the chute. When the corer reaches a vertical position (gantry well outboard) the steadying line can be pulled clear.
7. Lower (60 m/min) to within 70–80 m of the seabed, as determined by the EM120 depth. After the first 2–3 stations we stopped using a pinger with the gravity corer as

the exact depth of the run-in, and the amount of over-run, are not critical. Check with the Bridge that you are OK to take the core.

8. Run in to seabed at 60–80 m/minute. We normally used 60 m/min, but used 80 m/min if the stern was moving significantly in a swell.
9. When the weight of the corer comes off the wire, allow 10–15 m of over-run and stop paying out.

8.4.3 Recovery procedure

1. Haul gently (15 decreasing to10 m/min) and note the pull-out force.
2. Haul fast (75 m/min); slow down near the surface.
3. Bring the corer inboard so that the lowest metre of the barrel is just leaning against the transom and remove as much mud as possible with the pressure washer. It is much easier to do this outboard than to get a lot of mud on the deck.
4. Lift inboard and set down on the tables. Wash the rest of the mud from the barrel and bring the end of the pennant to the core head and make fast.
5. Slack off the coring warp, haul slowly on the pennant, stop when the core head is a few inches from the inboard end of the table.
6. Insert the cross-bars. The 6 m barrel requires 2 people to lift it when full of sediment. When empty it is almost balanced by the weight of the head.
7. Unscrew the core cutter and retain for CC sample. Do this before –
8. Undo the quick-release mechanism and detach the barrel, slide it sideways on to the support brackets, secure it with locating pins. Secure the head with webbing straps.
9. Remove the liner from the barrel and (resting it on the extrusion tray) measure the length of recovered sediment and mark the liner into 1 metre lengths.
10. Turn the liner round and re-insert the top (empty) end into the barrel so that the lowest metre of sediment protrudes forward of the extrusion tray. Saw to length and apply end-caps. Repeat until you reach the top of the core. The reason for doing it this way is that as each length is cut and lowered to the deck it is the original right way up. Thus you avoid tipping wet sediment out of the top of the liner.
11. Take the sections into the wet lab, wash and dry them, mark up and tape the end-caps on. Transfer to cool stow.
12. The top section should be cut some 20 cm over length, secured in a vertical position (in a bucket in the wet lab is fine) and left to settle for at least 12 hours. It can then be

trimmed by sawing in the usual way with the liner horizontal. We did try sawing some vertically, but this gets a lot of plastic swarf in the top of the mud.

8.4.4 Operational performance

We used the gravity corer at a total of 21 sites (14 with the 3 m barrel and 7 with the 6 m barrel) in water depths from 720 to 2200 m (Table 1). Recovery with the 3 m barrel was 0.27–1.98 m and with the 6 m barrel it was 1.57–3.75 m. In almost all cases the depth of penetration (mud on the outside of the barrel) was considerably greater than the amount of mud recovered. Such apparent shortening is a well-known effect of gravity coring. On the first attempt at site GC367, the corer evidently fell over as we observed no additional pull-out tension and on recovery one side of the corer was covered in soft mud; the liner contained 0.27 m of mud. The corer was re-rigged and deployed again as GC368, which recovered 0.81 m of sediment.

Having sorted out the deployment and recovery procedure before leaving harbour, few problems were experienced during the stations, though the quick-release mechanism could be a little stubborn. One cold night the pressure washer froze up and the ordinary hose had to be used. The most awkward potential problem was the possibility of the wire fouling one of the many angular parts of the core head. Although the over-run wire will generally tend to fall away from the corer on the seabed, there is always the chance of something fouling. At GC375 we brought the corer up with the wire caught round the bottom of the fin section and hanging some 30° to the vertical. In this position the corer was unstable and it would have been hazardous to go near it to attach a crane hook. Rather than lower it nearly 800 m to the sea bed again to take the weight off, we backed down on a convenient ice floe and lowered the corer on to the ice. This provided a relatively soft landing, and the wire came free. For future use the core head should be faired off by rounding the corners and attaching bars between the fin section and the weight stand, so there is nowhere for the wire to foul.

8.5 Box Corer

Claus-Dieter Hillenbrand

8.5.1 Operations

During JR104 a box corer (box dimensions 30 x 30 x 95.5–97.5 cm) was deployed at nine sites in order to recover undisturbed surface sediments. The coring locations and core recoveries are given in Table 1, and the locations are also shown on a large-scale fold-out track chart at the back of this report. The box corer frame was fixed to the deck on the starboard side and the corer was deployed via the mid-ships gantry. With the spades tensioned, the corer was lifted out of its frame and moved over the rail. The security bolt was removed from the trigger mechanism by pulling on a rope fixed to it. After veering the box corer to 50 metres, lowering was stopped and a pinger was fixed to the wire. The box corer was lowered at 60 m/min down to c. 30–40 m above the seafloor and was veered at c. 15 m/min into the seabed. The progress of the pinger and the corer near the seabed was monitored using the Precision Echo Sounder (PES). Haul speed was 70 m/min.

Fig. 16. Attachment of shackles to the bar on the top of the box corer. The hook of the trigger is inserted into the uppermost shackle (indicated by the thumb).

At sites with very soft or sandy surface sediments (BC355, BC361, BC363) the box corer triggered only after repeated attempts. The failure was probably caused by too little freedom of movement between the bar from which the box corer was supported and the hook of the trigger mechanism. The problem was solved by connecting two shackles to the bar (Fig. 16), thereby increasing the sensitivity of the trigger mechanism. Visual inspection after recovery revealed that the cored sediment was often inclined to one side of the box (e.g. Fig. 17), indicating that the box corer had fallen over onto the seabed after both spades had closed.

Fig. 17: Photo of box core BC364. Surface sediment: muddy diatomaceous ooze. Note the tilting of the recovered sediment package

8.5.2 Sampling procedures

After the recovery of the box corer, most of the sea water was removed from the box using a rubber tube as a siphon. Photographs of the sediment surface were taken and lithology, sedimentary structures, sediment colour, and presence of benthic organisms were described. Sampling procedures included sampling of the uppermost centimetre of the sediment column (sample volume 22 x 11.5 x 1 cm) for preparation of smear slides for shipboard microscopical analyses and for geochemical, granulometric, micropalaeontological and mineralogical investigations, which will be carried out after the cruise. In addition, three plastic liner segments (c. 85 x 8 cm) were pushed into the sediment to recover three short cores of up to 40 cm length. The spades were partly opened to allow withdrawal of these subsamples. The rest of the sediment was emptied into a metal bin and discarded. At two sites, where the recovered volume was low (BC355, BC356), the entire contents of the box corer were emptied into this bin to become a bag sample. The liner segments were closed with plastic caps and taped. All samples were stored at a temperature of 4° C onboard JCR.

8.6 Cable Logging and Monitoring (CLAM) System

Carol Pudsey

This new system offers many improvements over the Seametrix system, particularly in the winch-driver's screen display. The record of wire tension, however, is totally inadequate for seeing small changes in real time. The y axis of 10 tons full-scale cannot be changed (less than helpful for seeing the weight of a 0.3 ton box corer on 2000 m of wire) and the digital read-out is very "bitty": e.g. it was common to see the weight flickering between 0.80/0.96 tons. We requested a real-time chart record of wire tension, but ETS could not arrange this because of poor documentation of the CLAM system; the tension signal could not be located in the wiring.

8.7 Sound Velocity Probe (SVP)

Mark Preston

Two SVP casts were made during the cruise (Table 3). The first cast was on 2nd February in Eltanin Bay. The probe was checked and programmed in the UIC Room, then carried outside, attached to the wire and lowered to 750 m. After the cast the probe was left outside. It was connected to the dedicated laptop via the data cable, the file containing the sound velocity profile was downloaded, and then the unit was powered down. The sound velocity profile recorded is very similar to the one calculated from the XBT cast made on departing from the same station (Fig. 18).

The next SVP cast was on 7th February over the continental slope. The probe was powered up outside and programmed for the cast. It was lowered to 1000 m, but after the cast it was found that no file had been recorded. A few hours later, early on 8th February, at test deployment to 20 m water depth was carried out. On this occasion a data file was created, but it was zero bytes in size. While still connected to the laptop via the data cable after this deployment, the probe stopped communicating. Removing the red plug on the probe, waiting a few seconds and then replacing the plug caused communications to restart, but it could no longer be programmed for a new cast. At this point the probe was taken into the UIC Room for further investigation. A cast was simulated by immersing the probe in a bucket of water, but no file was recorded. Examination of the real time data revealed that the probe was detecting valid sound velocities, which should trigger the recording of a file. Furthermore, the behaviour of the probe was highly erratic: sometimes it would stop communicating with the laptop, sometimes it would accept programming and sometimes not, and sometimes it reported spurious real time data (e.g. battery voltage ~45 V instead of ~12.5 V).

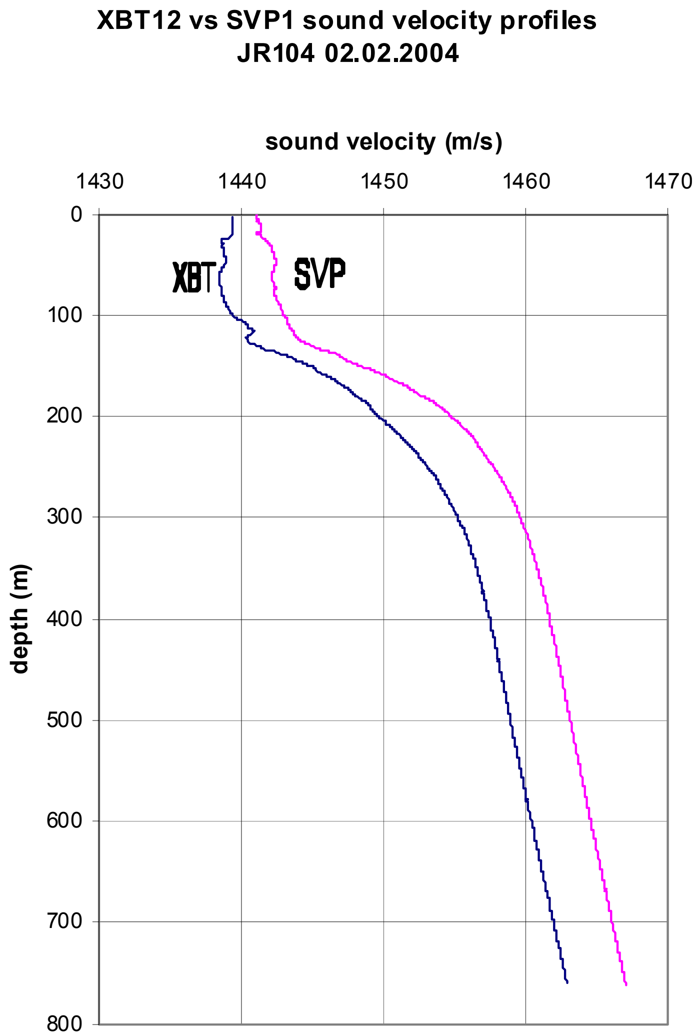


Fig. 18. Comparison of sound velocity profiles calculated from XBT and recorded by the SVP in Eltanin Bay on 2nd February.

The probe was opened up and the electronics were removed from the cylinder for inspection. There were no immediately obvious problems (e.g. loose wires or chips not seated). As the probe had failed after being left on deck for several days, the temperature sensitivity of the circuitry was investigated using freezer spray and a heat gun. It was found that the probe electronics could be started and stopped by alternately warming and cooling the Dallas real time clock chip. At this point it appeared that a short-term solution might be to keep the probe in the lab until shortly before a cast. After several hours in the lab the probe was closed again and reassembled into its frame. However, programming for another cast failed. Examination of the real time data revealed a value for battery voltage of ~45 V. The probe was powered down and up again. This resulted in a reasonable battery voltage value, but problems were still encountered in trying to program the probe for another cast. An attempt to inspect the contents of the probe D drive directly returned a variety of error messages such as ‘Format allocation table corrupt’ and ‘Divide by zero error’. Futher attempts to simulate a cast by immersing the probe in water in the laboratory failed. The probe will need to be returned to the manufacturers.

8.8 Expendable Bathythermograph (XBT) System

Twenty five XBT casts were made during the cruise (Table 2). Eleven of these were T7 probes, which record to a maximum depth of 760 m. Only one of the T7 probes failed. Fourteen casts were made with T5 probes, which record to a maximum depth of 1860 m. Five of the T5 probes failed before reaching 350 m, which represents a rather high failure rate. Three of the failed T5 probes were from one box, all with serial numbers beginning with 3074, so we may have been unfortunate and received a bad batch. The XBT probes used on this cruise were all obtained free of charge as part of an agreement with the Hydrographic Office that has now been discontinued. The Hydrographic Office will be notified about the poor performance of this batch of XBT probes.

The XBT system on which the data were recorded worked well throughout the cruise. Sound velocity profiles were calculated from the XBT data using an option on the system, assuming a constant salinity. Salinity values were read from the Oceanlogger display and input to the XBT system manually. The uncontaminated seawater supply to the Oceanlogger had to be switched off for long periods during the cruise because of problems caused by sea ice (see following section). On these occasions the most recent valid salinity measurement was used. The Extended Data Files (.edf), which include the calculated sound velocity profiles, were transferred to the multibeam data processing workstation via a 3½” floppy disk, and the data were then imported into the multibeam data acquisition system across the network. The use of 3½” floppy disks to transfer data from the XBT system to the Unix network may seem rather primitive, but in practice it is quicker than opening an ftp connection to transfer each file.

8.9 Oceanlogger

The Oceanlogger was operated during the cruise in order to monitor changes in surface water properties that could affect sound propagation, and to provide surface water salinity values for calculation of sound velocity profiles from XBT data. Whenever the ship was moving through sea ice, the pump that supplies uncontaminated seawater to the Oceanlogger had to be stopped because fragments of ice clogged the filters. From 28th January until 6th February the uncontaminated seawater supply was off more often than it was on, resulting in loss of Oceanlogger data for an aggregate period of about eight days. The approximate periods during which the uncontaminated seawater supply was off were:

1500Z on 28th January to 1200Z on 30th January
1800Z on 30th January to 1513Z on 31st January
1900Z on 31st Janaury to 1300Z on 4th February
2000Z on 4th February to 1100Z on 5th February
0000Z on 6th February to 2246Z on 6th February

8.10 Magnetometers

Peter Morris

The SeaSPY Overhauser magnetometer was towed on the long transits to and from Stanley. It worked well and delivered high quality data during the whole time it was deployed.

The 'new' shipboard three-component magnetometer (STCM), now relocated to the 'old' STCM position behind the funnel, ran continuously without obvious problems.

8.11 Navigation Systems

The navigational systems on board comprised:

8.11.1 Trimble 4000DS GPS Receiver

This was the principal scientific navigation unit and operated in differential location mode. The differential corrections were derived from a Racal Skyfix unit via an Inmarsat feed and applied in real time by the GPS receiver. The position fixes calculated by the GPS unit were logged to the NOAA Scientific Computing System (SCS).

8.11.2 Ashtech GG24 GPS/GLONASS Receiver

This was operated throughout the cruise and is known to produce fixes that are more accurate than those of the standalone (i.e. non-differential) GPS receivers. The position fixes calculated by this system were logged to the NOAA SCS.

8.11.3 Ashtech G12 GPS System

This dual redundant GPS unit is used by the ship's dynamic positioning system.

8.11.4 Leica MX 400 GPS Receiver

This system is primarily for Bridge use. The data from this differential GPS were logged onto a navigation PC on the Bridge but not by the NOAA SCS.

8.11.5 Ashtech 3D GPS and TSS300 Systems

These instruments provide heading, pitch, roll and heave information. Data from both systems were logged to the NOAA SCS.

8.11.6 Seapath System

This combined differential GPS and motion reference unit provides navigational data for the Kongsberg Simrad EM120 multibeam and TOPAS sub-bottom profiler systems. Data from this unit were logged onto both the Kongsberg Simrad systems and the NOAA SCS.

8.12 NOAA Shipboard Computing System

Since the summer of 2000, the main shipboard data logging system has been a Windows NT based system provided by the U.S. National Oceanic and Atmospheric Administration (NOAA), called the Scientific Computer System (SCS). The SCS program allows data to be logged centrally on a server featuring RAID disk tolerance. Time stamping of data is achieved by synchronising to a GPS receiver. The SCS is also a NTP server which allows other machines onboard to synchronise their time.

Data on the SCS system is stored in two formats:

RAW data written to disk in exactly the same format it was sent from the instrument.
ACO ASCII Comma Delimited, data is stored in plain ASCII text.

Once the Data has been logged to disk the ACO files are exported to the Level C of the former ABC data logging system using NFS. A process on the Level C reads the data in and writes to the Level C database. The Level C continues to be used to allow scientists to use existing routines to extract data.

The following data streams were logged to the SCS during JR104:

Stream name	Data Source
gps_glos	Ashtech GG24 GPS/GLONASS Receiver
gps_ash	Ashtech 3D GPS
gps_nmea	Trimble 4000DS GPS Receiver
anemom	Anemometer
tsshrp	TSS300 heave, roll and pitch sensor
oceanlog	Oceanlogger
em_log	Chernikeeff Aquaprobe Mk5 electromagnetic speed log
new_stcm	New shipboard three-component magnetometer
dop_log	Sperry doppler speed log (water speed)
sim500	Kongsberg Simrad EA500 single-beam echo sounder (12 kHz)
em120	Kongsberg Simrad EM120 multibeam echo sounder (12 kHz)
winch	Cable Logging and Monitoring (CLAM) System
seatex	Seapath combined differential GPS and motion reference unit
seaspy	SeaSpy towed Overhauser magnetometer
adcp	Acoustic Doppler Current Profiler
gyro	Gyro
streamstates	Status log of other data streams

9. BAS ENGINEERING TECHNOLOGY SECTION REPORT ON CORING

Andy Tait

9.1 Gravity Corer

9.1.1 Initial Set Up

The corer table consists of three identical 2m-long horizontal support tables and one fan tailed angled one. The tables were set up on the centre line of the aft deck, underneath the stern gantry. The fan-tailed table was secured via tight lashes to the stern roller, such that it did not extend outboard of the roller. This required the bulwark to be lowered for the duration of the cruise.

The remaining three tables were bolted together and to the deck matrix. The most fwd of the tables did not line up with the matrix and this was chained to eyebolts in the deck.

The side hangers were inserted into the tables at equal intervals along the length of the tables. Each hanger provided a hook to support a tube, which could be placed across the width of the tables. These supported the core barrels as they were inserted and removed from the corer weight stand.

The hangers were also designed to store the unused core barrel and facilitate the liner's removal onto a sawing platform, from where the core could be processed.

Initially a 6-metre barrel was placed on the port side of the table and a 3-metre one placed on the other side. Each barrel was lashed to the side hangers via tight lashes and secured to the deck when not in use.

The main weight stand was lifted in to place using the main coring wire via the stern gantry. The weight stand was drawn as far fwd on the table as possible in order to facilitate the removal of the core barrels.

9.1.2 Preparation

The plastic corer liners are cut to 3m lengths (for the 3m corer) or left uncut for the 6m cores. Each liner is marked with a line along its length and a number of equally spaced arrows, to indicate the direction in which the core is taken (Arrows pointing towards the top of the core).

A core catcher is fitted to the bottom of each core liner and two wraps of 1" wide insulation tape are used to secure it to the liner.

The core barrel to be used (either 3m or 6m) has its end capped by screwing on a steel core cutter. The prepared liner (c/w catcher) is then inserted into the core barrel, where the liner is pushed fully home on to the core cutter.

The chosen barrel size is then rolled over the steel tubes (inserted into the hooks of the hanging supports) and aligned with the corer weight stand. The holes in the flange of the corer barrel are aligned with the four quick release pins in the weight stand. The barrels are slid on to the pins and retained by two quick release steel plates. These in turn are secured by the use of two securing pins, which are then cable tied for further safety.

The head of the weight stand is connected to the main coring warp using a 10-Tonne swivel, which is connected using two Hammer Lock links, to two 5-Tonne shackles and secured through two lifting holes, in the centre tube of the weight stand.

A rope is fed through the bottom of the 10-Tonne swivel and fastened to the deck on one side. The rope is then fed through an eyebolt in the deck during deployment, in order to steady the corer.

9.1.3 Deployment

With the barrel attached to the weight stand, deployment can commence. With all but the most aft cross tubes removed, the corer’s weight is taken on the main coring warp and driven aft by the stern gantry towards the remaining cross tube. Once the head of the weight stand is close to the cross tube, the corer is landed on the table and the tube is removed.

Once the end of the core barrel is sufficiently aft for the core cutter to slide down the fantailed table, the corer is lifted by the coring warp and driven using the stern gantry, out board of the stern of the ship to its vertical position.

The steadying rope is recovered and the corer lowered at approximately 60 m/min to within 50 m of the seabed. The corer is then lowered between 60 and 80 m/min (depending on conditions) in to the seabed. Confirmation the corer has hit the seabed is observed by the sudden reduction of tension on the coring warp, displayed on the winch control monitor.

The corer is then raised slowly out off the seabed. The tension on the coring warp again indicates when the corer is free of the seabed. Once clear, it is raised to the sea surface at approximately 80 m/min.

9.1.4 Recovery

The corer is raised from the sea surface and steadied against the stern roller. The corer is then pressure washed down, to remove as much mud from the outer surface of the corer as possible.

The corer weight stand is then landed as far along the horizontal support tables as possible. The tension on the coring warp is relaxed and a separate recovery wire is attached just below the 10-Tonne swivel. The recovery wire from the net drum winch is used to pull the corer to the far end of the support tables.

Once the corer is back in its deployment position, the core cutter is then removed. Once this is complete, the barrel can be removed in the reverse manner to its assembly.

Once the barrel is secured in its hanging supports, the core liner can be removed, cut in to sections, capped and removed for analysis.

Further cleaning of the barrel with the pressure washer is usually necessary before the next liner can be inserted.

9.1.5 Issues

1. The poor height alignment of the barrels required excessive manual lifting of the barrels during assembly and disassembly stages. This heavy and difficult work greatly increased the potential risk of back injuries.
2. The supplied recovery winch and bracket were not fit for purpose. The bracket, which was secured only in two places to one of the horizontal tables, was insubstantial and distorted on use. The winch had too lower gear ratio to be of any practical use when recovering the corer and was not used.
3. Recovery of the corer was achieved by the use of the net drum winch, which is not standard ship's fit. Future recoveries will need to be done using a diverter sheave and the stb-mooring winch. This will require the use of a roller being fitted to the head of the most fwd support tables.
4. The core cutter was forced between the wood planks during deployment, which prevented the corer from sliding.

9.1.6 Recommended modifications

1. A bolt on roller will be required to allow a recovery wire to be used via a diverter sheave (bolted to the deck) to the stb mooring winch.

2. Side panels will be required to cover the up-stands, to prevent the corer catching on them during deployment.
3. Up-stand heights need to be modified to provide the correct alignment of the core barrels.
4. Bars are required to be fitted on each corner of head weight and down to its faceplate to prevent the coring wire getting snagged during recovery.
5. All threads on corer barrels and core cutters need to be cleaned and greased.
6. The fantail table needs to be covered with plywood to aid the corer's deployment and recovery.
7. A single lifting pin on top of weight stand is required to replace the current arrangement of shackles and links.

9.2 Box Corer

9.2.1 Initial Set Up

The box core is stored in its frame, which is bolted to the stb deck outside of the water-bottle annex. The box corer is located in the frame by four location pins, which must removed before deployment.

The Trigger unit is connected to the main coring warp via a 5-Tonne swivel and shackle.

9.2.2 Preparation

The trigger unit has a safety pin, which must be inserted into the trigger to prevent the trigger from operating while it is being handled during deployment.

The two box corer recovery wires are secured to the trigger via shackles, each shackle being cable tied for additional safety.

The trigger unit's weight is taken by the main coring warp and positioned via the side gantry above the corer. The trigger hook is then engaged around the corer's lifting pin. The corer shovel arms are then set back, to the extent that recovery wires allow.

9.2.3 Deployment

The four location pins, securing the corer to its stand are removed. The corer is then lifted clear of its frame and deployed outboard of the ship's rail. The safety pin is removed, the corer is then lowered 50 m below the sea surface, and a pinger unit is fitted to the wire.

The corer is lowered at about 60 m/min to within 50 m of the seabed. The corer is then lowered in to the seabed at 15–20 m/min. Confirmation the corer has hit the sea bed is observed by the sudden reduction of tension on the coring warp displayed on the winch control monitor.

The corer is raised slowly out of the seabed. The tension on the coring warp again indicates when the corer is free of the seabed. Once clear, it is raised to the sea surface at approximately 80 m/min.

9.2.4 Recovery

The pinger is raised to the height of the ship's rail and removed. The corer itself is then raised above the ship's rail and guided into its frame and secured in place by the four securing pins.

The two shackles connecting the recovery wires to the trigger are then disconnected.

The inspection covers on top of the corer are opened and any excess water was siphoned off from the recovered sample.

The top 10mm of the sample is removed by hand. Then a number of 850 mm-long core liners are pushed through the sample and removed in various ways, in order to preserve the undisturbed sample. They are then capped and removed for analysis.

The remaining sample is released into a bucket positioned under the corer and disposed of. Finally, the corer is cleaned and made ready for the next deployment.

9.2.5 Issues

1. On a number of occasions the trigger failed to release the corer. The trigger unit being trapped between the cheeks of the lifting pin could have caused this. Two 4¾-Tonne shackles were linked together, with one end being inserted around the corer's lifting pin and the other being placed in the hook of the trigger unit. No further failures were then recorded when using this method.

9.2.6 Recommended Modifications

1. The current lifting pin should be removed and a single ½" steel hooped bar should be welded in its place. Sufficient space should be allowed for, in order that the trigger unit cannot be trapped, if allowed to slip round horizontally.

9.3 Summary

In general the coring equipment has proved very reliable and relatively easy to deploy and recover. A number of modifications will be necessary, as detailed above, if this equipment is to be hired out in the future.

9.3.1 Highest Priority Recommendations

1. It is vital that the alignment issue for the gravity corer (Section 9.1.6 recommendation #3) be addressed in order to prevent future back injuries occurring.
2. A roller must be fitted at the fwd end of the support tables to allow a recovery wire to be used via a diverter sheave and the stb mooring winch (Section 9.1.6 recommendation #1).

10. ACKNOWLEDGEMENTS

We thank all of the officers and crew of the RRS *James Clark Ross* for helping to make this a successful and enjoyable cruise. Once again, the quality of support for the scientific programme from all of the ship's company was second-to-none. We are grateful to Jerry for indulging our ambition to work in areas of dense ice cover, and to Dave, Dave and Paul, for successfully navigating our way through them. Mike Gloistein succeeded in keeping a temperamental Dartcom satellite receiver going, which helped us find areas of open water. Alex Tate augmented our sea ice intelligence by sending MODIS satellite images that he had downloaded at BAS on a daily basis. The Engineers kept everything running smoothly so that no time was lost due to mechanical problems. Rich and the Galley crew kept everyone well fed, and Rich tried his best to keep up our levels of fitness. We thank Emma the Doctor for compiling the web diaries and assisting with the mud, in addition to her normal duties.

Steve and Andy of the BAS Engineering Technology Section did an excellent job in operating, and making last minute modifications to, our new coring equipment. Working together with John Summers, Dave Peck and Doug Trevett they ensured that coring operations were carried out successfully and safely. Doug also battled against insuperable odds to try to keep the uncontaminated seawater supply running, despite the problems caused by ice.

Thanks are also due to many in the BAS Operations, Logistics and Personnel Sections, and to Pauline and Myriam in the Stanley office, for arranging everything that made this cruise possible at unusually short notice.

11. ACRONYMS

ADCP	Acoustic Doppler Current Profiler
AFI	Antarctic Funding Initiative
AMS	Accelerator Mass Spectrometer
BAS	British Antarctic Survey
BASMU	British Antarctic Survey Medical Unit
CLAM	Cable Logging And Monitoring system
CTD	Conductivity-Temperature-Depth
ETS	Engineering Technology Section
FIPASS	Falkland Islands Port And Storage System
GPS	Global Positioning System
ITS	Information Technology Section
JCR	RRS *James Clark Ross*
MCS	Multi-Channel Seismic
MODIS	MODerate resolution Imaging Spectroradiometer
MSGL	Mega-Scale Glacial Lineations
NOAA	U.S. National Oceanic and Atmospheric Administration
PES	Precision Echo Sounder
SCS	Shipboard Computing System
SSU	Sonar Sequencing Unit
STCM	Shipboard Three-Component Magnetometer
TOPAS	TOpographic PArametric Sonar
SVP	Sound Velocity Probe
UIC	Underway Instrumentation and Control room
WAIS	West Antarctic Ice Sheet
XBT	Expendable Bathythermograph

12. CRUISE STATISTICS

Total cruise duration (1200/023–1110/044)		21.0 days
Time on passage (north of 69°S)		8.9 days
Time in study area		12.1 days
Gravity and box coring	1.5 days	
SVP stations	0.1 days	
Total station time		**1.6 days**
Waiting on weather/ice/mechanical problems		Negligible

Underway data collection in study area	**10.5 days**
during which:	
EM120	10.5 days
TOPAS	10.5 days
STCM	10.5 days
Towed magnetometer	0.6 days
Oceanlogger	2.4 days

Average underway (i.e. excluding station time) speed in study area was 10.8 kts (20 km/hr). About 9 days of underway data collection were on the continental shelf and uppermost continental slope (mean water depth 600 m), while the other 1.5 days were on the middle continental slope (mean water depth 1500 m). Assuming EM120 swath fan 120°, mean swath widths were ~2.1 km and ~5.2 km in these areas, respectively. Thus, area covered by EM120 multibeam data was ~9100 km^2 on the shelf and uppermost slope, and ~3700 km^2 on the middle slope, so **total area covered by EM120 data in study area was ~12,800 km^2**.

Underway data collection on passage	**8.4 days**
during which:	
EM120	8.4 days
TOPAS	8.3 days
STCM	8.4 days
Towed magnetometer	8.1 days
Oceanlogger	8.0 days

Average speed on passage was 11.9 kts (22 km/hr).
Assuming mean water depth 3500 m and EM120 swath fan 120°, swath width ~12 km, so **area covered by EM120 data on passage ~53,200 km^2**.
Therefore, **total area covered by EM120 data during cruise ~66,000 km^2**.

Data volumes recorded:

EM120 raw	5.3 Gigabytes
EM120 processed	5.3 Gigabytes
TOPAS	6.2 Gigabytes
SCS	0.8 Gigabytes
Total	**17.6 Gigabytes**

13. RECOMMENDATIONS

The following is a list specific recommendations arising from sections 8 and 9 of this report:

1. The height of the stands on the sides of the gravity corer tables that support the core barrels need to be modified to provide the correct alignment of the core barrels with the core head. This will facilitate handling of the barrels and reduce the risk of back injuries.

2. A bolt on roller needs to be fitted to the forward end of the gravity corer tables to allow a recovery wire to be used via a diverter sheave (bolted to the deck) to the starboard mooring winch.

3. Desirable enhancements to the CLAM system would be an option to choose between different display scales for the wire tension record and the facility to produce a real-time chart record of wire tension.

4. The SVP will need to be returned to the manufacturer, and the temperature sensitivity of the repaired or replacement probe should be tested in the laboratory before it is sent to sea.

5. It would be desirable if the drift of time annotations on the TOPAS paper record could be eliminated.

6. If the PES is removed, or fails and is judged to be beyond repair, it must be replaced by another system that allows pinger signals to be monitored from the Winch Control Room.

In addition to the above, further recommendations regarding modifications to the coring equipment are listed in sections 9.1.6 and 9.2.6.

Table 1. Core stations (complied by CDH)

Station	Latitude S	Longitude W	Water depth (m)	Core Recovery (m)	Time on Station	Location	Remarks
BC351	70° 05.2´	86° 11.6´	1041	0.34	2155-2313/028	Trough Mouth Fan (TMF), upper slope	
GC352	70° 15.4´	86° 21.9´	718	1.44	2040-2145/029	shelf break	
GC353	70° 05.2´	86° 11.3´	1041	2.90	2330/029-0040/030	TMF, upper slope	same location as BC351
GC354	70° 00.3´	84° 53.4´	788	1.97	0420-0530/030	TMF, uppermost slope	
BC355	70° 00.3´	84° 53.3´	788	c. 0.02	0530-0710/030 and	TMF, uppermost slope	same location as GC354;
					0005-0105/039		three attempts
BC356	71° 46.1´	80° 06.6´	565	0.11	0340-0445/031	inner shelf N of Smyley Island	
GC357	71° 46.0´	80° 06.6´	565	1.04	0445-0545/031	inner shelf N of Smyley Island	same location as BC356
GC358	71° 44.1´	76° 02.2´	690	0.94	2210-2305/031	inner shelf W of Beethoven Peninsula	
GC359	71° 43.1´	76° 02.3´	685	1.53	2315/031-0000/032	inner shelf W of Beethoven Peninsula	
GC360	71° 59.7´	76° 33.1´	633	1.71	0355-0455/032	inner shelf N of Ronne Entrance	
BC361	71° 59.6´	76° 33.2´	633	0.37	0455-0620/032	inner shelf N of Ronne Entrance	same location as GC360
GC362	72° 35.8´	80° 49.8´	845	1.86	0350-0450/033	trough exiting Carroll Inlet, inner shelf	
BC363	72° 35.7´	80° 49.8´	846	0.40	0450-0645/033	trough exiting Carroll Inlet, inner shelf	same location as GC362
BC364	72° 59.0´	83° 26.4´	1010	0.45	1905-2030/033	Eltanin Bay, inner shelf	
GC365	72° 59.0´	83° 26.6´	1011	2.43	2030-2145/033	Eltanin Bay, inner shelf	same location as BC364
GC366	72° 50.7´	82° 36.9´	617	1.39	0115-0155/034	Eltanin Bay, inner shelf	
GC367	71° 34.8´	82° 51.6´	591	0.27	1925-2005/034	Belgica Trough, middle shelf	GC fallen over
GC368	71° 34.7´	82° 51.6´	588	0.81	2005-2050/034	Belgica Trough, middle shelf	same location as GC367
BC369	71° 34.6´	82° 51.6´	587	0.41	2145-2250/034	Belgica Trough, middle shelf	same location as GC367/368
GC370	71° 39.0´	84° 48.3´	533	1.88	0405-0500/035	middle shelf W of Belgica Trough	
GC371	70° 39.2´	84° 32.4´	595	1.91	920-2005/035	Belgica Trough, outer shelf	
GC372	70° 36.3´	86° 15.2´	676	1.96	0030-0120/036	in second order trough, outer shelf	
BC373	70° 36.3´	86° 15.2´	675	0.23	0120-0220/036	In second order trough, outer shelf	same location as GC372
GC374	70° 30.0´	86° 14.2´	650	1.96	0340-0425/036	outer shelf NE of second order trough	
GC375	70° 16.3´	86° 49.5´	877	0.75	0330-0433/037	TMF, upper slope	
GC376	70° 13.3´	86° 54.3´	1016	2.60	2055-2154/037	TMF, upper slope	
GC377	69° 57.4´	86° 52.9´	1608	3.26	2340/037-0100/038	TMF, slope	
GC378	69° 46.0´	87° 21.7´	2182	2.65	0330-0505/038	TMF, slope	
BC379	69° 45.9´	87° 25.1´	2222	0.38	0525-0700/038	TMF, slope	same location as GC378
GC380	69° 38.5´	84° 30.7´	2150	3.75	1940-2100/038	flank of channel in TMF, slope	
GC381	69° 43.3´	83° 41.9´	1953	1.04	0415-0540/039	slope E of TMF	

Table 2. XBT Stations (compiled by JE & RDL)

Cast no.	Filename	Time/date	Latitude S	Longitude W	Water depth (m)	Cast length (m)	Serial Number	Geographical Location	Remarks
1	T5_00004	0236/024	53° 36.8'	58° 56.4'	1939	156	?	Falkland Trough	Failed
2	T5_00005	1323/024	55° 47.3'	60° 25.3'	4159	1830	?	Drake Passage	
3	T5_00006	1125/025	59° 38.5'	64° 32.1'	3591	1830	301826	Drake Passage	
4	T5_00007	1135/026	63° 40.1'	69° 52.7'	3664	1830	301822	Drake Passage	
5	T5_00009	1214/027	67° 38.9'	77° 05.6'	3034	1830	301831	W of Peninsula	
6	T7_00010	2240/027	69° 23.5'	80° 29.6'	660	656	290173	Shelf edge	
7	T7_00011	1225/028	70° 13.2'	86° 23.1'	829	760	290174	Slope, in sea ice	
8	T7_00012	1634/029	70° 29.6'	87° 17.5'	673	673	290172	Outermost shelf, in sea ice	
9	T7_00013	1218/030	69° 52.3'	82° 41.5'	520	520	290171	Outermost shelf, no sea ice	
10	T7_00014	1709/031	72° 10.2'	76° 59.4'	669	669	290168	Off Smyley Island	
11	T7_00015	0649/033	72° 36.0'	80° 49.5'	842	760	?	Off Carroll Inlet	
12	T7_00016	2149/033	72° 59.3'	83° 26.9'	1015	760	290735	Eltanin Bay	
13	T7_00017	1120/034	71° 59.6'	81° 46.6'	705	684	58710	Inner Belgica Trough	
14	T7_00018	1542/035	70° 59.7'	84° 15.4'	618	602	58713	Middle Belgica Trough	
15	T7_00019	1523/036	69° 51.9'	83° 54.8'	834	747	?	On slope NE of fan	
16	T5_00020	1642/037	70° 23.9'	88° 06.0'	1227	6	301823	West end of margin survey	Failed
17	T5_00021	1648/037	70° 24.0'	88° 03.5'	1200	1221	307411	West end of margin survey	Repeat cast
18	T5_00022	0104/038	69° 57.2'	86° 53.3'	1617	1617	301827	Continental slope	
19	T5_00023	2208/038	69° 38.8'	84° 30.8'	2145	70	307412	Continental slope (GC380)	Failed
20	T5_00024	2212/038	69° 39.1'	84° 31.0'	2136	1830	?	Continental slope (GC380)	Repeat cast
21	T5_00025	1800/040	65° 45.5'	73° 03.1'	3421	1830	307407	Crest of Drift 5	
22	T5_00026	1632/041	61° 50.2'	66° 58.1'	3855	1830	307406	South of Hero FZ	
23	T5_00027	1717/042	57° 18.2'	61° 29.0'	3681	305	307405	Drake Passage	Failed
24	T5_00028	1729/042	57° 17.6'	61° 28.1'	3640	216	307404	Drake Passage	Failed
25	T7_00029	1632/043	53° 31.7'	59° 21.5'	1709	0	59323	Falkland Trough	Failed

Table 3. SVP Stations

Cast no.	Filename	Time/date	Latitude S	Longitude W	Water depth (m)	Cast length (m)	Geographical Location
1	20040203_012131.asvp	2109/033	72° 59.0'	83° 26.6'	1015	750	Eltanin Bay
12	No data recorded	2130/038	69° 38.5'	84° 30.7'	2156	1000	middle continental slope (GC380)

APPENDIX 1

Abstract of presentation at meeting on *Glacier-Influenced Sedimentation on High-Latitude Continental Margins*, held at University of Bristol, 29–30 March 2001

The interpretations outlined in this abstract formed the basis for the Antarctic Funding Initiative proposal that led to the cruise.

A MAJOR GLACIAL CONTINENTAL MARGIN DEPOCENTRE IN THE BELLINGSHAUSEN SEA, ANTARCTICA

R.D. Larter[1], **A.P. Cunningham**[1], **F.O. Nitsche**[2,3] and **K. Gohl**[2]

1. British Antarctic Survey, High Cross, Madingley Road, Cambridge CB3 0ET, UK
2. Alfred Wegener Institute for Polar and Marine Research, P.O. Box 120161, 27515 Bremerhaven, Germany.
3. Present address: Institute of Geophysics, ETH-Hoenggerberg, CH-8093, Zurich, Switzerland.

Seismic reflection and echo-sounding profiles reveal a 150-km wide trough which runs across the outer continental shelf in the Bellingshausen Sea, between 84–88°W. The water depth in the deepest part of the trough is 685 m, but both flanks rise to shallower than 420 m. In the outermost 20–30 km of the trough the sea floor has a slight landward dip, such that the deepest part of the shelf break is at 660 m. Seaward of the trough the upper continental slope is remarkably smooth and has a dip of 1.5°, whereas the upper slope angle to either side of the trough mouth is >4°. Seismic profiles show that upper slope all along this part of the margin has prograded and is underlain by parallel-layered foreset deposits. Seismic profiles along the trough reveal a complex history of progradation and aggradation, including an interval when the depositional shelf break retreated at least 60 km from the pre-existing shelf edge.

We interpret the trough as the locus of a major ice stream which flowed to the edge of the continental shelf during glacial intervals. The catchment basin of this ice stream probably encompassed the Bryan Coast of Ellsworth Land, south-western Palmer Land and southern Alexander Island. At times when the ice stream extended to the continental shelf edge the total area of the catchment basin would have been >300,000 km^2. A recent study estimates that the onshore part of this catchment has a modern net surface mass balance of >600 kg m^{-2} a^{-1}, which is about four times the Antarctic average (Vaughan et al., 1999). This high input, together with the size of the catchment and the dimensions of the trough, suggest to us that the trough was one of the main ice drainage pathways from the West Antarctic Ice Sheet at times of maximum ice extent.

Vaughan, D.G., Bamber, J.L., Giovinetto, M., Russell, J. & Cooper, A.P.R., 1999. Reassessment of net surface mass balance in Antarctica. *J. Clim.* 12, 933-946.

APPENDIX 2

Typical Sonar System Parameter Settings

A2.1 EM120 Acquisition Parameters

MBES screen, "EM120 Runtime Menu"
Ping Mode: Auto
Sector Coverage
    Max Port Angle: 50–70°
    Max Starboard Angle: 50–70°
    Angular Coverage: Manual
    Beam Spacing: Equidistant
Pitch stabilization: On
Yaw stabilization: Off (not used because of need to make many small course alterations in ice)
Min Depth: used to constrain depth when in ice or using TOPAS chirp Tx on fixed cycle
Max Depth: used to constrain depth when in ice or using TOPAS chirp Tx on fixed cycle

Sound Speed Profile
    Current Sound Profile: jr104_xbt??.asvp
Sound Speed at Transducer:
    From: Profile
    Sensor Offset: 0.0 m/s
    Filter: 60 s

Filtering
    Spike Filter Strength: Medium
    Aeration: Off
    Sector Tracking: On
    Slope: On
    Interference: Off
    Range Gate: Normal
Absorption Coefficient
    Absorption (dB/km): 1.00
Seabed Imaging
    TVG Crossover (deg) 6

A2.2 TOPAS Acquisition Parameters in < 1000 m Water Depth

Parasource Menu
Level: 100%
Ping interval: 0 ms (this enables external trigger)
Pulseform: Burst
Period: 1 or 2
Secondary frequency: 2800 Hz

Acquisition Menu

Ch_no:	0	
Speed of sound (m/s):	1500	
Sample rate:	20000 Hz	
Trace length (ms):	400	
Gain:	18 – 26 dB	
Filter:	1.00 kHz	
Delay:	Manual	(External tends to cause frequent delay changes, especially when there is ice noise)

Processing Menu

Channel no: 0
Filter: ON
Low stop: 1200 Low pass: 4800
High pass: 1700 High stop: 5200
Processing (deconvolution): OFF
Swell: ON
Threshold: 60%
traces: 1
TVG: OFF or AUTO or MAN (all used at different times)
When MAN used, Slope: 30 – 60 dB
Start point: Manual or Tracking or External
Dereverb: OFF
Stacking: OFF
AVC: OFF
Scale (%): 700 – 1000
Attribute: INST.AMP

LOG/Replay Menu

Medium: DISK
Rate (ms): 1000
Channel: 0
File size (Mb) 10

A2.3 TOPAS Acquisition Parameters in > 1000 m Water Depth

Parasource Menu

Level: 90 – 100%
Ping interval: 4000 – 5000 ms
Pulseform: Chirp
Chirp start frequency (Hz): 1500
Chirp stop frequency (Hz): 5000
Length (ms): 15

Acquisition Menu

Ch_no: 0
Speed of sound (m/s): 1500
Sample rate: 20000 Hz

Trace length (ms):	400		
Gain:	21 – 32 dB		
Filter:	1.00 kHz		
Delay:	Manual or External		

Processing Menu

Channel no: 0

Filter: ON

Low stop:	1200	Low pass:	4800
High pass:	1700	High stop:	5200

Processing (deconvolution): DECONV

Filter factor (ppm): 1

Swell: ON

Threshold: 60%

traces: 1

TVG: OFF or AUTO or MAN (all used at different times)

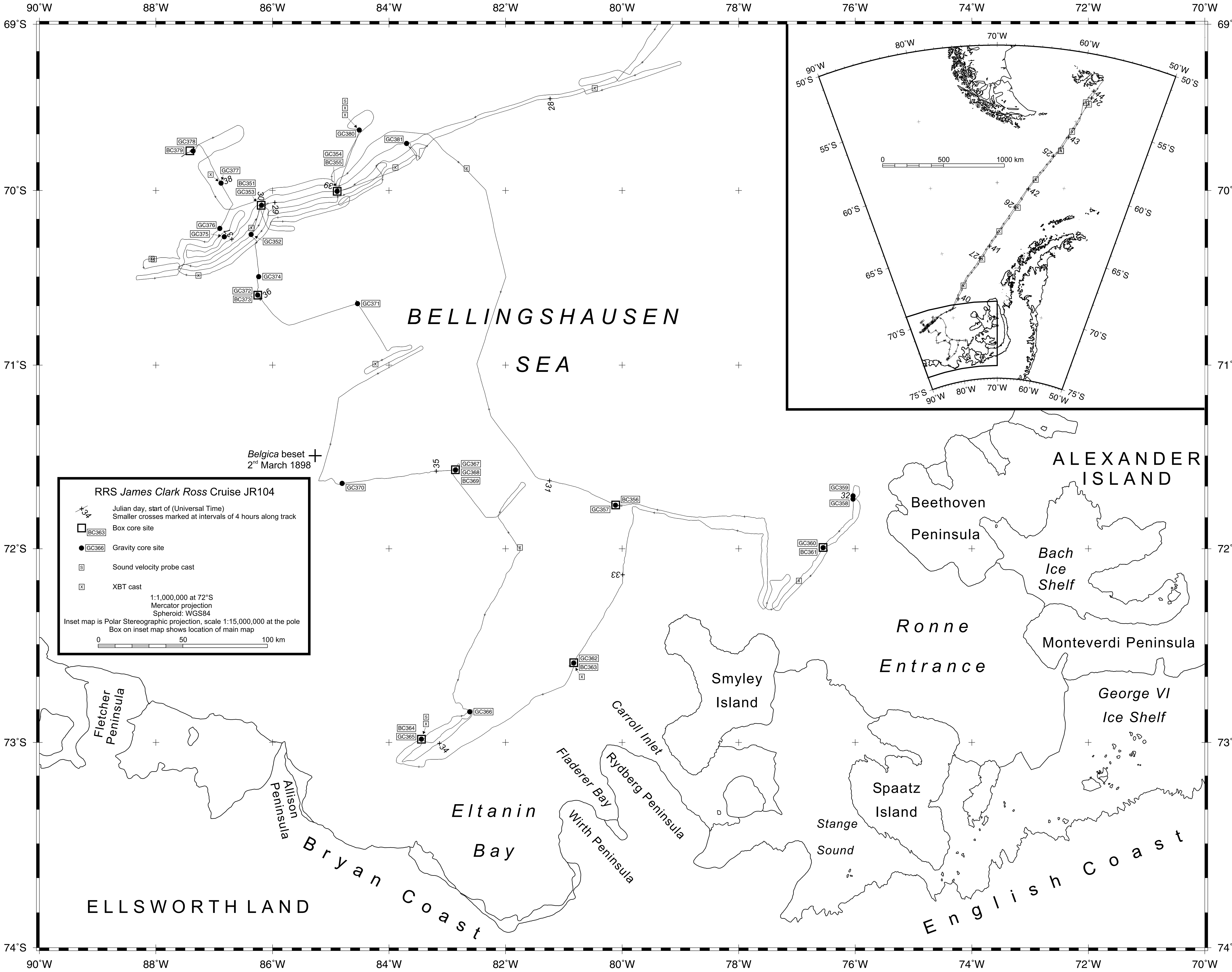
When MAN used, Slope: 30 – 60 dB

Start point: Manual or Tracking or External

Dereverb:	OFF
Stacking:	OFF
AVC:	OFF
Scale (%):	1000 – 1500
Attribute:	INST.AMP

LOG/Replay Menu

Medium:	DISK
Rate (ms):	1000
Channel:	0
File size (Mb)	10



RRS James Clark Ross Cruise JR104
Julian day, start of (Universal Time)
Smaller crosses marked at intervals of 4 hours along track
Box core site
Gravity core site
Sound velocity probe cast
XBT cast
1:1,000,000 at 72°S
Mercator projection
Spheroid: WGS84
Inset map is Polar Stereographic projection, scale 1:15,000,000 at the pole
Box on inset map shows location of main map
0
50
100 km
BELLINGSHAUSEN
SEA
Belgica beset
2nd March 1898
ALEXANDER
ISLAND
Beethoven
Peninsula
Bach
Ice
Shelf
Ronne
Entrance
Monteverdi Peninsula
George VI
Ice Shelf
Smyley
Island
Carroll Inlet
Fladerer Bay
Rydberg Peninsula
Wirth Peninsula
Spaatz
Island
Stange
Sound
Eltanin
Bay
Fletcher
Peninsula
Allison
Peninsula
Bryan Coast
English Coast
ELLSWORTH LAND
90°W
88°W
86°W
84°W
82°W
80°W
78°W
76°W
74°W
72°W
70°W
69°S
70°S
71°S
72°S
73°S
74°S

Four Scientists, a Doc and a Core