

FINAL

JR93

Cruise Report

November – December 2003

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JR93 Cruise Report

Project Title: GSCM

Programme: ADGPS

Introduction

Cruise JR93 continued the work begun during JR69, investigating the Shackleton Fracture Zone in Drake Passage. On this occasion, our four days additional to passage were used to extend bathymetric coverage of the fracture zone, and to sample the sea bed at six sites by rock dredging.

The ship sailed from FIPASS at 13:00 on 28th November 2003. After a slightly windy transit, weather conditions were almost ideal throughout the period of data acquisition, resulting in high-quality bathymetry.

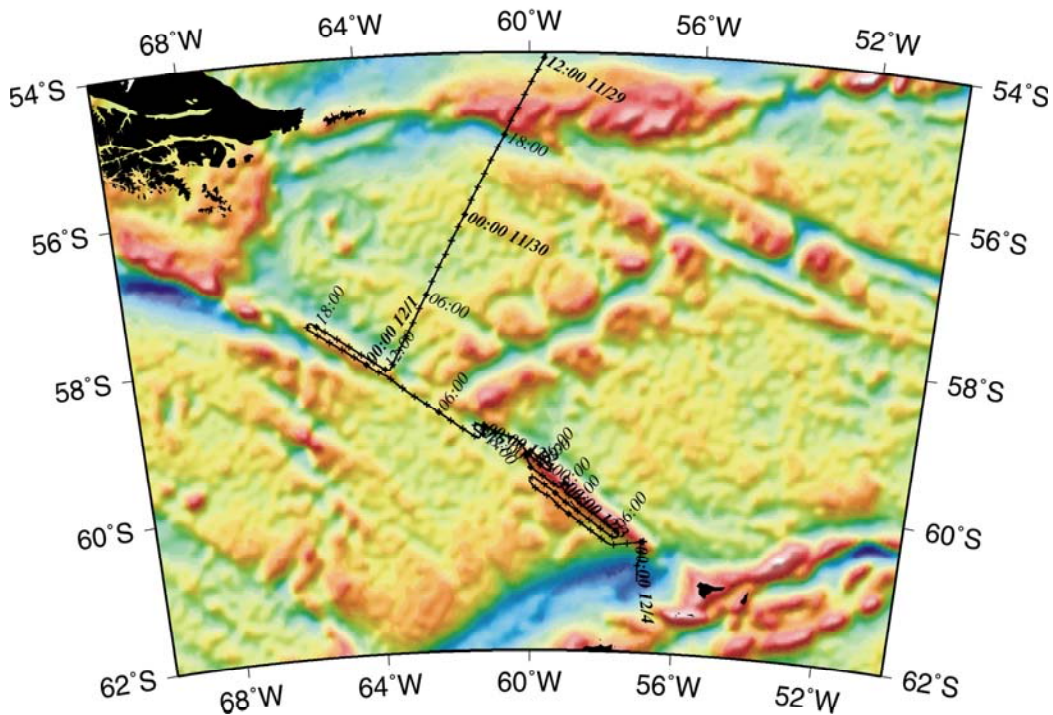


Fig. 1 Track plot for JR93

The southbound transit from the Falkland Islands was used to add another bathymetric swath to the existing coverage. On arrival at the work area, lines were run parallel to the fracture zone, extending coverage by some 60 km to the NW.

Science Objectives

It's generally believed that the glaciation of Antarctica was a direct consequence of its thermal isolation by the Antarctic Circumpolar Current. For the current to form, there had to be a circumpolar, deep-water pathway, and the last impediment to that lay at what is today Drake Passage.

If opening had a direct and immediate effect on global climate, then we expect major tectonic events (i.e. the creation of deep seaways) in the region at around 33 and 15 million years ago, when the oxygen isotope record says it became suddenly cooler. But the truth is, we don't know exactly when or even how Drake Passage opened. The story is complicated by the possible presence of fragments of continent, which may have blocked the passage even after separation of South America from Antarctica.

We believe that these fragments may not, in fact, be continental, and that they may not have existed during the early opening of Drake Passage. Our task during JR93 was to sample the biggest fragment, to determine its nature and age. We planned to do this by:

- i. bathymetric mapping, to examine the processes of crustal formation and search for sampling sites,
- ii. dredging any sediment-free areas of basement rock for samples.

Event Log

Significant events during the cruise were recorded in the online Event Log, created by J. Robst (Table I). This software allows events to be viewed from anywhere on the ship, via the intranet. Unusually for work in these latitudes, the programme was almost without adverse incident, and most tasks were completed according to plan.

JR93 Personnel

LIVERMORE Roy A	Ch/Scientist
TATE Alexander	Data Man
COOPER Pat	Electronics
ROBST Jeremy	Computing

Ship's Company

ELLIOTT Christopher R	Master
PATERSON Robert C	Ch/Off
LIDDELL Andrew	2nd/Off
GOLDING Michael B	3rd/Off
BEATON Liam A	Cadet
CONNELLY Peadar M	Cadet
WADDICOR Charles A	R/O
CUTTING David	Ch/Eng
ARMOUR Gerard J	2nd/Eng
POOLE Anthony W	3rd/Eng
EADIE Steven J	4th/Eng
WRIGHT Simon A	Deck Eng
DUNBAR Nicholas J	Elec
GIBSON James S	Purser
STEWART George M	Bosun
WILLIAMS David O	B' Mate
JENKINS Derek G	SG1
JOLLY Lester	SG1
BLABY Marc A	SG1
LOVERIDGE Daniel Nolan	SG1
ROBINSHAW Mark	MG1
SMITH Sidney F	MG1
MACINTYRE Duncan N	Ch Cook
COLLINS Raymond R	2nd Cook
PRATLEY Clifford R	Sr Stwd
LEE Derek W	Stwd
NEWALL James	Stwd
WESTON Kenneth	Stwd

Table I JR93 Eventlog

Time	Latitude	Longitude	Sea Surface Temp	Line Number	EM120 Centre Depth	Comment
28/11/2003 20:35:00	-51.760060	-57.690640	7	1	77.7	EM120 started line 1 (jr93 transit)
28/11/2003 21:02:00	-51.814990	-57.736450	7	1	4086.72	heavy seas, wind 30 kts
28/11/2003 22:03:00	-51.932120	-57.833950	6.94	2	103.81	heavy seas, wind still 30 kts
29/11/2003 02:53:00	-52.582860	-58.382140	6.68	7	274.1	Wind 20 kts.
29/11/2003 16:37:00	-54.844060	-60.361900	5.36	21	810.72	dropping off Burdwood Bank
29/11/2003 22:14:00	-55.837290	-61.258390	4.61	26	4282.35	XBT 1 launched
30/11/2003 11:32:00	-58.186470	-63.516860	2.06	39	3762.34	XBT2 launched
30/11/2003 11:39:00	-58.205020	-63.537210	2.04	1	3158.87	commence line jr93_sfz with new sound profile
30/11/2003 17:32:00	-57.578070	-65.236000	4.09	6	4041.73	XBT 3 deployed
30/11/2003 18:29:00	-57.510590	-65.407130	4.26	7	2879.6	waypoint reached heading south west
30/11/2003 18:34:00	-57.505070	-65.433230	4.48	8	2644.33	XBT sound velocity entered. jr93_2.asvp taken north of polar front
30/11/2003 19:15:00	-57.588680	-65.494510	4.24	8	3556.4	waypoint reached. Heading south east on parallel survey line
01/12/2003 10:08:00	-59.026790	-61.163260	0.73	24	3701.49	end of line - turning into dredge station
01/12/2003 12:14:00	-59.058520	-61.180660	0.81	26	3989.72	towed mag recovered
01/12/2003 12:41:00	-59.024870	-61.166090	0.77	28	3682.21	on site for first CTD - mag in
01/12/2003 15:22:00	-59.024920	-61.166740	0.82	28	3717.0	Dredge DR.173 deployed

01/12/2003 17:09:00	-59.02493	-61.16647	1.11	28	3716.9	Dredge DR173 off bottom
01/12/2003 21:27:00	-58.99969	-61.19166	0.77	29	3935.8	Dredge DR.174 deployed
01/12/2003 23:23:00	-58.9917	-61.18251	0.93	31	3995.6	Dredge off bottom D174
02/12/2003 10:35:00	-59.35429	-59.98648	0.36	43	2255.4	Dredge DR.175 reaches seabed
02/12/2003 12:11:00	-59.36314	-60.00385	0.39	44	2236.86	Dredge DR.175 recovered from seabed
02/12/2003 13:45:00	-59.39924	-60.13303	0.41	44	2740.39	Dredge DR.176 deployed
02/12/2003 16:04:00	-59.38774	-60.10972	0.6	46	2345.27	Dredge DR.176 recovered from seabed
02/12/2003 22:20:00	-59.75762	-59.0914	0.19	55	2219.75	Dredge DR.177 reaches seabed
02/12/2003 23:31:00	-59.75107	-59.07857	0.15	55	2123.58	Dredge DR.177 recovered from seabed
03/12/2003 14:19:38	-59.72272	-59.99697	0.60	69	3871.94	turning for final track to DR178
04/12/2003 01:12:47	-60.51205	-56.90874	-0.01	80	1863.08	Dredge DR.178 reaches seabed
04/12/2003 02:27:19	-60.51734	-56.92208	-0.11	80	1716.44	Dredge DR.178 recovered from seabed

JCR Eventlogs v3.0 JPR 02/12/2003

Rock Dredging

A program of rock sampling using a dredge was planned at six sites, two in a small pull-apart basin in the central Drake Passage (DR173, DR174), and four on the Shackleton Fracture Zone ridge (DR176 - DR178; Fig. 2).

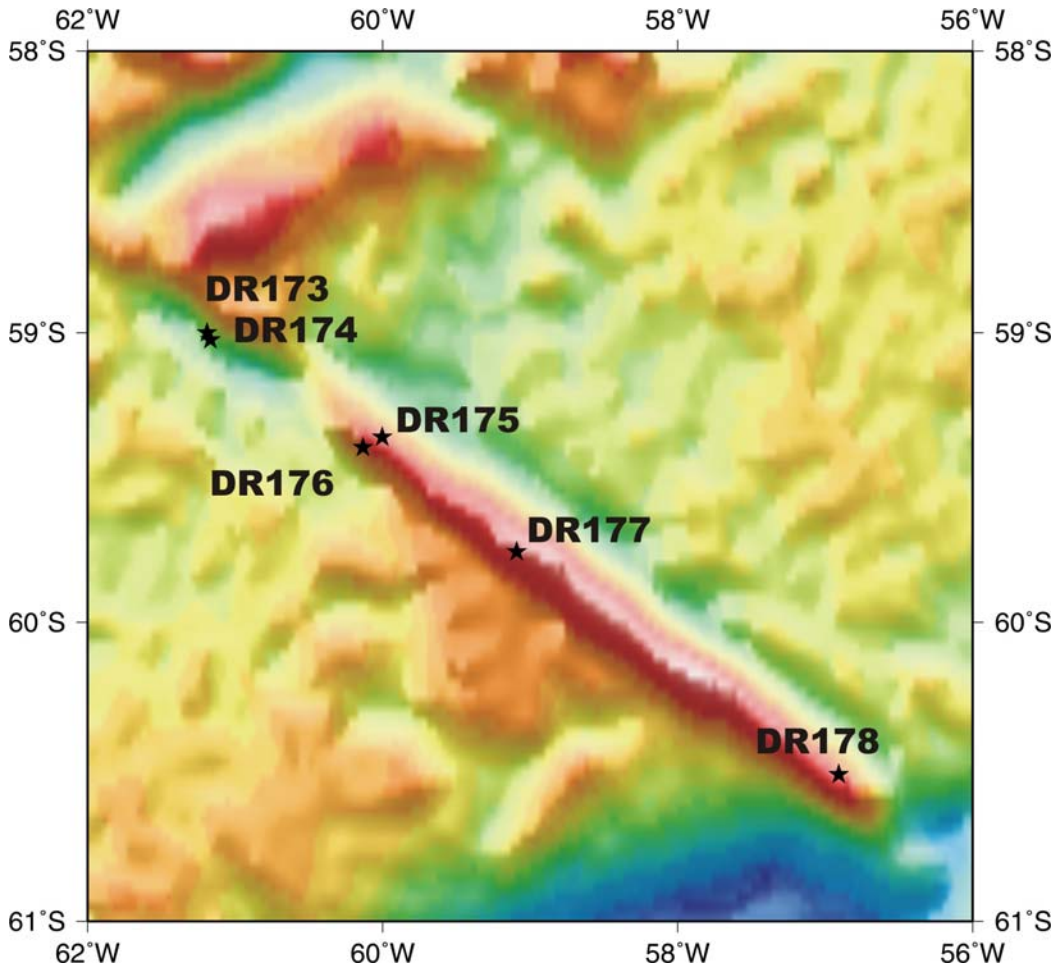


Fig. 2 JR93 Dredge sites

The first two were conducted by dragging the dredge along elevated features near the centre of the basin.

The procedure adopted was as follows:

- i. ship stopped at starting site,
- ii. pinger fitted 200 m above dredge,
- iii. PES used to follow progress of dredge,
- iv. dredge lowered at 75 m/min to sea floor,
- v. ship moves ahead at 0.7 kt,
- vi. wire-out monitor observed to detect 'snags',
- vii. dredge path of up to 1 km followed,
- viii. dredge lifted from sea bed and recovered at 75 m/min.

The greater success at sites DR175 – DR178 was attributed to the greater slope on the Shackleton FZ ridge. The RVS dredge design means that the dredge bag swivels when it is being towed, which tends to lift the jaws of the dredge clear of the sea bed. Hence, there was no recovery in the first two dredges. On a reasonably steep slope, however, the jaws can bite into the sea bed, producing very noticeable ‘snags’, and a good recovery.

Dredge Rig

The rigging arrangement used for rock dredging on JR93 is shown in Figs. 3 and 4.

Equipment Used:

- Dredges & Chain (provided by from UKOR)
- Thirty tonne traction winch system
- Steel coring warp - 16.8 mm [3x19(9/9/1) 1960 Gal RH Ord]
- Stern Gantry
- Starboard Mooring winch - Deck handling

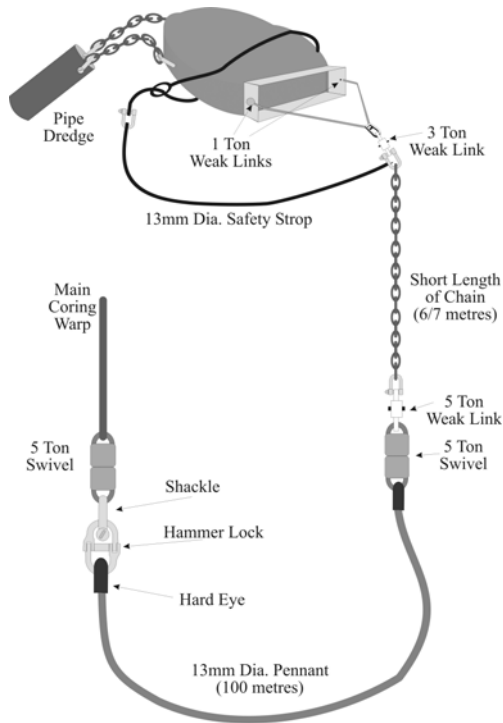


Fig. 3 Dredge rig

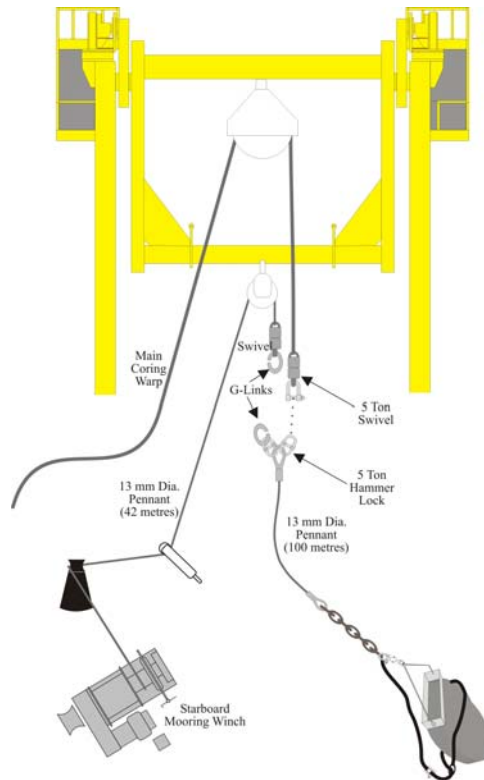


Fig. 4 Dredge deployment



Fig. 5 Dredge deployment from aft deck

Deployment

The method of deployment is shown in Figs. 4 and 5.

The 42 m pennant and the 100 m pennants are attached by means of the G-links. This is then wound on to the mooring winch barrel until the dredge clears the deck. It is then deployed over the stern by means of the gantry. The pennants are paid away until the G-links are above the stern roller when it is attached to the main warp. The weight having been passed to the main warp, the G-links are separated and the dredge deployed; a pinger is attached 200 m up the main warp. Recovery is just the reverse of this procedure.

The winch was operated at 75 metre/minute during the mid water veering and hauling operations. Once the dredge was deemed to be approaching the seabed it was stopped and position checked before being lowered onto the seabed. The winch continued to veer until the dredge; chain and approximately 50 metres of the pennant were on the seabed. The instruction was then given to move the ship at 0.7 knots along the selected track. During this time the winch was hauled or veered to maintain the pinger approximately 150 metres above the seabed.

Observations

The only problem/delay caused by winch operations during the dredge operations occurred on the first haul. Unfortunately while preparing the main coring warp it's spooling gear had become disengaged. It was therefore necessary to use time on its

recovery to correct the alignment. This in total probably added approximately half an hour to the first dredge's recovery. No further problems were experienced.

Recommendation

Modifications of dredge and alternative designs to be investigated, to provide BAS with its own dredging facility, capable of sampling slopes and level surfaces, such as ridge crests. Rock dredges and associated equipment, such as pingers, should be kept on board at all times. When replacing the PES, consideration should be given to how future dredging operations will be conducted.

Dredge	Latitude	Longitude	Haul Size	Type
DR173	59° 1.50'S 59° 1.49'S	61° 10.00'W 61° 9.98'W	Small; bucket only	Pebbles and mud in bucket only
DR174	58° 59.98'S 58° 59.50'S	61° 11.50'W 61° 10.95'W	Small; bucket only	Stiff diatom mud in bucket
DR175	59° 21.26'S 59° 21.79'S	59° 59.19'W 60° 0.23'W	Very large; bag and bucket full	Mixed sizes, very large boulders to pebbles, mainly basaltic; some erratics
DR176	59° 23.95'S 59° 23.26'S	60° 7.98'W 60° 6.58'W	Large; bag half full, bucket full	Mixed sizes; mainly basaltic
DR177	59° 45.46'S 59° 45.07'S	59° 5.48'W 59° 4.72'W	Large; bag half full; bucket full	Mixed sizes; mainly basaltic
DR178	60° 30.72'S 60° 31.05'S	56° 54.52'W 56° 55.32'W	Very large; bag full; bucket full	Mixed sizes, mainly fractured basalt

Table I JR93 Dredge stations



Fig. 6 Dredge DR175 recovery

Echo Sounding

Sound Velocity Profiles

Three XBT dips were taken on the outbound transit (see Table I). TK20 probes were deployed over the starboard quarter, and maximum depth achieved. The results of XBT2 were used for subsequent EM120 acquisition. At dredge station 1, a trial CTD cast was made to full ocean depth by the JR94 personnel, who supplied a copy of the data for use with EM120. This profile was then used for all succeeding data acquisition with EM120.

EM120 Operation

The Mermaid acquisition system functioned satisfactorily throughout. Problems associated with incrementing file (line) numbers appear to have been corrected, and there were no system crashes. Raw data were automatically copied onto the Neptune machine every minute, and stored in one-hour files on the path:

```
/users/simrad/neptune/neptune/em120/raw/survey name/file name
```

An example of *survey name/file name* was:

```
jr93_sfz_survey/0001_20031130_114139_raw.all
```

Depth Processing using MB-SYSTEM

Swath Bathymetry data were cleaned and processed using MB-System v5.0. MB is primarily a Unix command line package used to process a wide variety of bathymetry data formats. One main advantage of the program is that different bathymetry sources can be processed and gridded together. It is closely integrated with GMT (Generic Mapping Tools), with most of the plotting and grid commands outputting GMT scripts that can be run 'as is' or modified if needed. After MB has been set up (*setup mb* at the Unix command line), an overview of the program can be found by typing *man mb_system*. It is advisable to *setup* GMT at the same time.

The following steps were used to process the raw data into gridded output.

Copying the data

EM120 data corresponds to MB format 56. The MB manual suggests that this format does not contain the necessary space to flag/unflag bad data and advises that all such data be copied into MB format 57. This was accomplished using the following assuming that you are in the raw data directory (see em120 section):

```
foreach f (*.all)
    mb_copy -F56/57 -I$f -O'output directory'/$f.mb57
end
cd 'output directory'
ls *.mb57 > raw_datalist
```

Older EM12 (MB format 51) data described later was similarly copied using `-F51/57`. This was a time consuming step (30 minutes for a 50 hours survey) but only needed to be done once. A text file (`raw_datalist`) containing the names of all the `.mb57` files is created to be used in subsequent MB commands. MB v5 can now process data based on its suffix so no additional info (such as 57) is needed in the text file.

Creating auxillary files

Auxillary files are created to make other processes such as cleaning and gridding quicker to complete. In this and other processes files are created with the same root name but with different suffixes. Three types of files are created; `.inf` files contain basic header information for each file (lat/lon limits, min/max depth etc), `.fbt` contain bathymetry data in a form more easily processed by MB and `.fnv` contain navigation data in a similar format. All three are created using the following command within the directory containing the `.mb57` data:

```
mbdatalist -Iraw_datalist -F-1 -O
```

F-1 is the MB format for text lists of data files. By default the auxillary files are created in the same directory. Again this is a lengthy step but only need be done once and speeds up every subsequent action.

Cleaning the data

Data can be cleaned automatically or manually. The command `mbclean` has various options to run through the raw data and remove bad pings. The following are some of the more useful options

```
mbclean -Iraw_datalist -F-1
-A100 (absolute deviation away from a median depth -100m here)
-B500/5000 (simple high/low filter - only accept 500m - 5000m here)
-C1 (maximum ping to ping slope angle -  $\tan^{-1} 1 = 45^\circ$ )
-G0.9/1.1 (proportional deviation from median depth)
-M1 (flags the ping rather than zeroing it)
-X5 (flags last 5 pings at either end of the swath ping)
```

There are many other options found in the `mbclean` man pages. Data collected on JR93 was cleaned using the above options but there was a tendency to remove too many pings that were considered good when inspected manually. Calm weather on both the passage and the main survey meant that very little data needed to be flagged though `mbclean` removed nearly a third of all pings. The main culprits seemed to be the `-A` and `-C` options. Indeed, even with the slope option set to `-C4` ($>75^\circ$), there were still a large number of pings flagged for excessive slopes. Further testing of the `mbclean` command is needed to find a variety of options that will provide a light cleaning to both almost clean and very noisy data alike.

Since the JR93 dataset was fairly small and acquired under good conditions, it was decided to clean the data manually to preserve as much depth information as possible. This was performed using a graphical editor within MB called by the command `mbedit`. This contains an intuitive interface where the user can flag bad data on a line by line basis. Generally the data collected on JR93 needed only minor cleaning, mostly of the outer beams and in some cases when the EM120 had locked onto a false multiple of the seafloor.

Both ways of cleaning the data create two additional files, a .esf file which holds the flagging information and a .par file which contains a whole variety of edits including cleaning and navigation fixes.

Fixing navigational errors

This was not a problem for JR93 but worth reviewing for data collected on other ships with less reliable GPS fixes. An interactive graphical program called by `mbnavedit` allows the user to check the positional information in each raw file and flag erroneous values. These can be replaced by an interpolated value using data from lines directly before and after. Output from this editing is stored in .nve files while the .par files are updated to include navigation edits also.

Additional editing such as applying sound velocity profiles (see next section for `svp`'s used) post data collection and editing sidescan data can be performed within MB but were not used during this cruise.

Processing the data

The command `mbprocess` takes information from the .par file and processes the .mb57 data to produce a final output file. If the input file is called `data.all.mb57`, the processed file becomes `data.allp.mb57`. `mbprocess` also creates additional auxillary files (.inf, .fnv, .fbt). The command takes the form of:

```
mbprocess -Iraw_datalist -F-1
```

A text file containing the names of all the processed data can then be created (`proc_datalist` on this cruise). If at some point the user decides to go back and re-clean the data or edit the navigation for a single file, `mbprocess` can be run with the same command and it will process only the newly edited files.

To recap, the processes and the files they create are:

Input	Process	Output
Data.all.raw	mbcopy	Data.all.raw.mb57
Data.all.raw.mb57	mbdatalist	Data.all.raw.mb57.inf
		Data.all.raw.mb57.fbt
		Data.all.raw.mb57.fnv
Data.all.raw.mb57	mbclean/mbedit	Data.all.raw.mb57.esf
		Data.all.raw.mb57.par
Data.all.raw.mb57	mbnavedit	Data.all.raw.mb57.nve
		Data.all.raw.mb57.par (modified)
Data.all.raw.mb57	mbprocess	Data.allp.raw.mb57
		Data.allp.raw.mb57.inf
		Data.allp.raw.mb57.fbt

Gridding the data

The command *mbgrid* with its associated options produces a user defined grid as well as a GMT script that can be run straight away or modified to take advantage of the range of mapping options available within GMT. However, the majority of GMT's functions are already embedded within the *mbgrid* command so it was generally unnecessary to alter the script produced. The command and some of the more common options are:

```
mbgrid -Iproc_datalist -O 'grid filename'
-R-65/-57.5/-60.5/-57.5 (bounding co-ords, min long/max long/min lat/max lat)
-E500/500/meters (grid resolution; 500m in this case)
-F1 (type of filter used; 1=gaussian weighting, 2=median weighting)
-C3 (spline interpolation into data free areas, 1500m in this case (grid
resolution x 3)
-M (outputs separate grids of standard deviation and data density)
-N (outputs null values as NaN. Useful for GMT and Matlab)
-W2 (width of the gaussian weighting function: twice the grid spacing in this
case)
-K'background grid' (Adds a regional background grid behind the survey data)
```

Running the command produces an output.grd and an output.grd.cmd. Running the latter GMT script produces output.grd.ps, which can be viewed in *xv* or *ghostview*.

More advanced maps can be generated from the .grd files using the MB macro *mbm_grdplot*. Another macro, *mbm_plot* is also useful for producing initial plots of swath data and for constructing cruise tracks. See their respective man pages for more details of the options available.

Adding additional data from previous cruises

Several earlier JCR cruises have either conducted swath bathymetry surveys over the Shackleton Fracture Zone or have imaged a part of it in transit to the Peninsula. In addition there are also EM12 data collected by the Spanish vessel *Hesperides* collected in 1997. These data can be usefully combined within MB to provide a more complete grid of the fracture zone. A common directory structure was setup to keep some order amongst the different surveys. The main directory, *mb_data* contains a series of survey sub-directories. These are usually parts of cruises (*jr71_transit_1*, *jr71_transit_2* for example). Each survey contains a processing, *grd* and *ps* directory. The processing directories hold all the .mb57 raw files, all the edits and all the processed data. The *grd* and *ps* directories hold all the grids and postscript files respectively.

A combined_grids directory was created under *mb_data* to contain a text file (*combined_datalist*) with the following:

```
../jr93_sfz_survey/processing/proc_datalist -1 100
../hes97_area4/processing/proc_datalist -1 20.0
../hes97_area4_extra/processing/proc_datalist -1 20.0
../jr93_transit_north/processing/proc_datalist -1 10.0
../jr93_transit_south/processing/proc_datalist -1 10.0
../jr59_1/processing/proc_datalist -1 10.0
```

```

../jr69a_survey/processing/proc_datalist -1 1.0
../jr69c_survey/processing/proc_datalist -1 1.0
../jr69b_survey/processing/raw_datalist -1 0.1
../jr81_transit_1/processing/raw_datalist -1 0.1
../jr81_transit_2/processing/raw_datalist -1 0.1
../jr84_transit_1/processing/raw_datalist -1 0.1
../jr59_2/processing/raw_datalist -1 0.1
../jr67/processing/raw_datalist -1 0.1
../jr71_1/processing/raw_datalist -1 0.1
../jr71_2/processing/raw_datalist -1 0.1

```

This gives the location of each datalist, its format (MB format -1 means treat as a list of files), and a weighting factor. When gridding overlapping surveys, the weighting determines which survey has precedence. It makes sense to give a higher weighting to fairly clean lines. Note that some of the lines refer to raw datalists as time constraints meant that not all surveys could be manually cleaned and hence processed. These surveys were thus given a very low weighting. Figure 7 shows a combined grid of the Shackleton Fracture Zone (SFZ) area at a 500m resolution. Illumination is from the northeast.

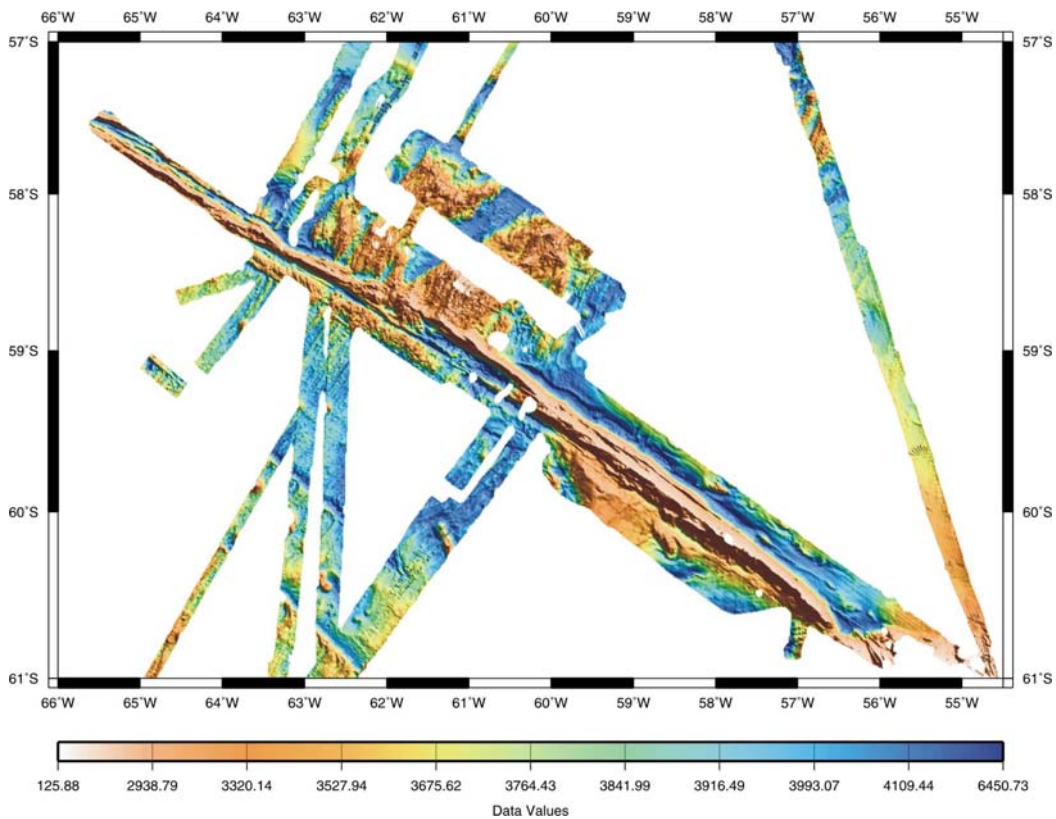


Figure 7 – Bathymetry grid of the Shackleton Fracture Zone

Observations

MB-System v5.0 performed well and provides a useful way of combining different bathymetry datasets. There were a few bugs found that should be brought to the attention of the software developers

1. *mbedit* has forward and backwards buttons to move through the swath files. However, pushing the backwards button crashed the application. The middle mouse button has the same functionality as the backwards button but this did not cause a crash.
2. Raw files copied from the EM120 machine were occasionally unable to be opened by *mbedit*/*mbedit*. Most of these files were very small and caused by problems changing survey line names in the EM120 software. Even though *mbedit* could not open the bad data, a .esf and .par file would be generated, essentially empty, for the data. These would be ignored when running *mbprocess*. Similarly an empty .nve and .par file would be produced when trying to open the bad data in *mbedit*. However, *mbprocess* would terminate every time a bad datafile was found that had an associated .nve file.
3. There is missing text in the -A option of the *mbgrid* man page.

Recommendations

1. Inform MB software developers of bugs.
2. Test the *mbclean* command on various datasets to see whether the excessive cleaning found was due to a bug or incorrect parameter setting (user error).
3. Locate and clean remaining datasets in the SFZ area to be used as a basemap for subsequent surveys. The current size of the mb_data directory is ~14Gb.

Precision Echo Sounder

The PES was operated at each dredge station to monitor the depth of the pinger, and hence to ensure contact with the bottom. The system worked without fault. Any future changes to this system must ensure that good communications between the operator and the winch driver are possible.

Magnetic Field Measurement

SeaSpy

The SeaSpy towed magnetometer is an enhanced proton precession instrument, which makes use of the so-called ‘overhauser effect’ to increase sensitivity and reduce power requirements. It was deployed during southbound transit, and whilst underway during JR93 survey. Deployment was over the port stern, passing the tow cable through a fairlead, protected by a clear plastic sleeve. The unit was found to be light and easy to deploy and recover, which was accomplished at a ship speed of 5 knots. Operation was faultless, and high quality data obtained throughout its operation. Towing depth was always less than a metre or two beneath the surface at tow speeds of up to 11 knots. A spare transceiver has been purchased for this unit, and is stored in the electronics lab adjacent to the UIC.



Fig. 7 Seaspy towfish and cable reel

STCM

The original STCM was not functioning, but the newer system ran throughout the leg, and was logged by the SCS system. A compensation manoeuvre was completed on the return leg, crossing the Falkland Trough.

Acknowledgements

We thank members of the JR94 scientific party, and members of BAS travelling to Rothera for their assistance with watchkeeping and rock dredging.