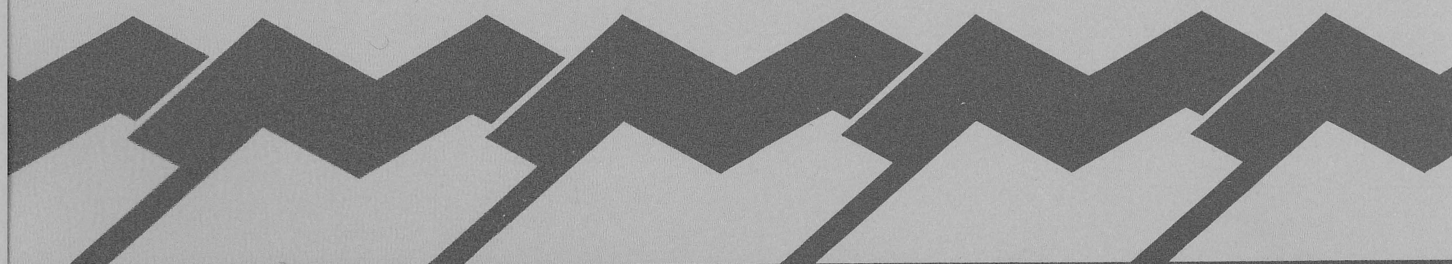


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Bureau of Mineral Resources, Geology & Geophysics

DIVISION OF MARINE GEOSCIENCES & PETROLEUM GEOLOGY



R E C O R D

RECORD 1990/37

BMR MARINE SURVEY 46
LORD HOWE RISE

EXPLANATORY NOTES TO ACCOMPANY RELEASE OF
NON-SEISMIC DATA

by

Alfio PARISI, Maureen O'CONNOR,

Ruth HALLETT and Craig PENNEY

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INTRODUCTION

The Lord Howe research cruise (BMR Marine Survey 46) was the first research cruise using the *RV RIG SEISMIC* to be carried out under BMR's new initiative in marine geoscience and formed part of the "shake-down" cruise for the vessel.

The region under investigation includes the Tasman Basin, Dampier Ridge, Lord Howe Basin and Lord Howe Rise proper.

This report summarises the processing techniques applied to the non-seismic geophysical data on Survey 46 which was conducted between 3rd and 12th February 1985.

GEOPHYSICAL SYSTEMS & PERFORMANCE

The following non-seismic geophysical systems were employed :

Navigation

Navigation for the cruise was obtained from two dead reckoning (DR) systems, incorporating TRANSIT satellite navigators, gyro compasses, and sonar doppler speed logs. The primary system consisted of a Magnavox MX1107RS dual-channel short-count satellite navigator, with speed input from Magnavox MX610D dual axis sonar doppler, and headings from an Arma-Brown gyro-compass. The secondary system, consisted of a Magnavox MX1142 single channel short-count satellite navigator, with speed input from Raytheon DSN 450 dual axis sonar doppler and headings from a Robertson gyro-compass. These systems have a potential accuracy of 0.2km at fixes deteriorating to around 1km between fixes in deep water.

Problems were experienced with the sonar-dopplers suffering loss of track during moderately rough sea and particularly when heading into the weather. The Magnavox sonar-doppler was also adversely affected by interference from the 3.5kHz echo sounder. Extensive processing was required to retrieve velocities from these periods of poor data.

Bathymetric Systems

Two Raytheon Deep-sea Bathymetric 3.5 kHz & 12 kHz Systems, providing both analogue and digital depths, various alarm flags and an automatic tracking facility that should theoretically provide usable bathymetric data even in marginal recording conditions.

Problems were encountered with the 3.5 kHz echo sounder during the trip that made it unusable. The 12 kHz echo sounder produced usable data as deep as 5000 metres for most of the cruise. The process required to retrieve acceptable digital data is described fully later in this report.

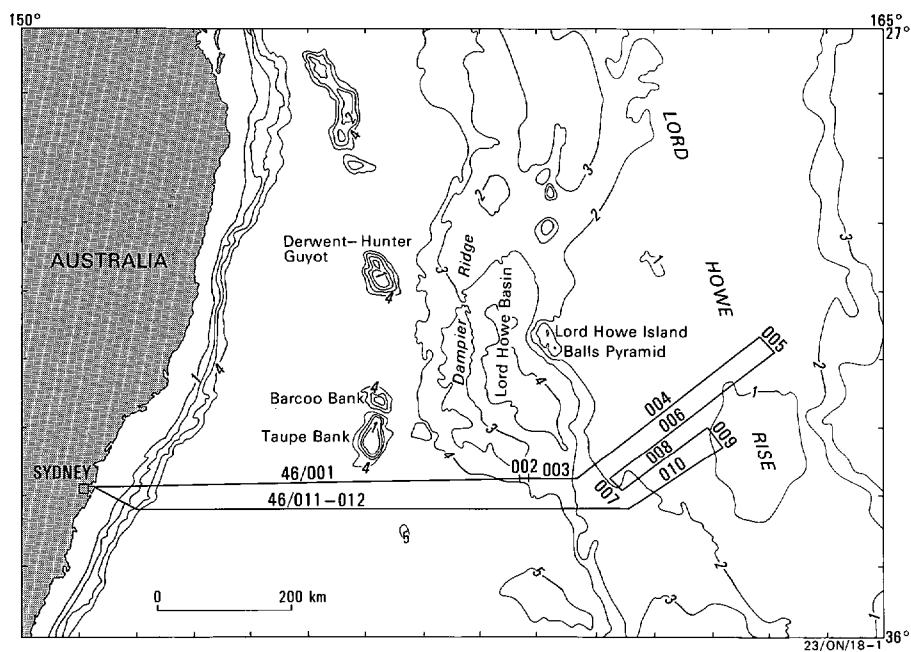


FIGURE 1: Bathymetry of the Tasman Sea showing Rig Seismic lines in the Lord Howe Rise Area.

Magnetics

Two Geometrics G801/803 proton precession magnetometers were configured as a gradiometer and towed astern of the vessel for all lines during the survey and the 1400 kms transit between Sydney and the Lord Howe Rise .

The data quality was good, although problems did arise from interference between the two magnetometers when their polarisation periods overlapped. This was overcome by staggering the polarisation period of each recorder thereby removing the overlap. Gradiometer processing has not been applied, and the final data are equivalent to those from a single sensor system.

DATA ACQUISITION SYSTEM

The shipboard DAS is based on a Hewlett-Packard (HP) 1000 F-Series 16-bit minicomputer. The DAS programs run under the HP Real Time Executive (RTE-6/VM) disc-based operating system, which allows a multiprogramming environment and a large number of interactive users. Data are acquired either directly from the appropriate device through an RS-232C interface eg. Magnavox MX1107RS and MX1142 or through a BMR-designed 16-bit digital multiplexer (magnetics, bathymetry) and attached gyro-log interface (for both sonar dopplers and gyro-compasses). After preliminary processing, data were plotted on strip-chart recorders and listed on a variety of printers. The data were recorded on 9-track, 1600 bpi, phase-encoded magnetic tape in HP's 32-bit floating-point format.

Data were acquired and saved at a 10-second rate, regardless of ship speed and independently of the seismic acquisition system. The data were written to tape in 1 minute (6 record) blocks. The channels that were recorded are listed in Table 1.

TABLE 1: Field tape channel allocations (Raw field data)

- 1 - Clock (survey & day number)
- 2 - GMT acquisition time from computer clock (hours,mins,secs)
- 3 - Master clock met acquisition (hours, mins,secs)
- 4 - Latitude (radians)
- 5 - longitude (radians)
- 6 - Speed (knots) - best estimate
- 7 - Heading (degrees) - best estimate
- 8 - GMT from MX1107RS (hours,mins,secs)
- 9 - DR time from MX1107RS (hours,mins,secs)
- 10 - Latitudes (radians) from MX1107RS
- 11 - Longitude (radians) from MX1107RS
- 12 - Speed (knots) from MX1107RS
- 13 - Heading (degrees) from MX1107RS
- 14 - Set (degrees) from MX1107RS
- 15 - Drift (knots) from MX1107RS
- 16 - Set/Drift flag
- 17 - Magnetometer No 1 (nT)
- 18 - Magnetometer No 2 (nT)
- 19 - Bathymetry No 1 (metres)(3.5 kHz)
- 20 - Bathymetry No 2 (metres)(12 kHz)
- 21 - Log reading Magnavox sonar doppler(clicks per n.mile)
- 22 - 28 Not used
- 29 - AGRF Magnetic anomaly No 1 (nT)
- 30 - AGRF Magnetic anomaly No 2 (nT)

DATA PROCESSING

The data were processed on a Hewlett-Packard 1000 F-Series minicomputer utilising similar hardware and the same operating system as the DAS. The processing was applied in two phases, as follows:

Phase 1: (Geophysical)

Transcription of field tapes; correction of time errors; production of raw data plots; bulk editing (principally deletion of bad data segments); retrieval of water depth data; assessment and retrieval of velocities; median filtering of magnetics; manual-editing of problem areas; computation of incremental latitudes and longitudes; anti-alias filtering of magnetics; resample 10 second data to 1 minute data; production of final check plots; final editing.

Phase 2: (Navigation)

Tying of the dead-reckoning (DR) track to the satellite fixes using a cubic spline fitting technique to model ocean currents; assessment and deletion of poor quality satellite fixes; computation of final positions for each DR system; computation of final ship position from an appropriate mix of the available DR systems.

A brief summary of the processing steps of each phase is as follows, with some detail of the techniques applied.

PHASE 1 PROCESSING

FCOPY All field tapes were transcribed to processing tapes with several field tapes being combined into a single processing tape. Processing tapes were separated at obvious breaks (such as recording system crashes), or after about seven days recording. Time jumps (positive or negative) were reported for processing in the next phase.

FIXTM: Time jumps reported in *FCOPY* were corrected, either automatically, or with a file of manual time corrections. Data channels were re-ordered (table 2) to simplify further processing.

VARPL: All raw data channels requiring processing were plotted as strip records on a drum plotter. These plots were used to determine where editing was required and as a first guide for the setting of filter parameters. These plots also confirm that editing is acceptable.

FTAPE: This program was used for a variety of tasks as follows:-

- (1) Removal of hardware/software flags in the bathymetric data. The Raytheon echo-sounder system provides, in addition to digital bathymetry, 'flags' indicating that the echo-sounder has lost track or that the digitiser gate is searching for an echo. These flags were removed, as appropriate, and such values were replaced by the number 1.0E10 (10 billion), to indicate absent data.
- (2) 'Bulk' deletions were done of any large blocks of irretrievable data in particular channels.
- (3) Automatic interpolations were done across data gaps of up to 120 seconds for selected data channels.

GMUL2 Speed log data (recorded as 'clicks' per nautical mile) were reduced to knots.

SALVG: (Water depth recovery) Briefly stated, the problem of bathymetry recovery is to fill in all the gaps left after the Raytheon hardware/software flags were removed and to discriminate against the bad bathymetric values that still remain. To accomplish this, a file was first created of manually digitised water depths at selected points, this file was then read in conjunction with the processing data file. *SALVG* then performs a straight line interpolation between adjacent tie points and compares the interpolated depth with the 10-second digital depth. If the difference is less than a user-specified threshold, then the digital depth is accepted and is used to replace the previous first tie point. If the difference is greater than the threshold, then the 10-second digital depth is replaced by the interpolated depth. In this way, the program tracks along the acceptable water depths, providing the threshold is small enough to reject bad data and large enough to accept good data. In the case of good digital data being totally unacceptable, as during poor sea conditions, the threshold was set to a very small number (0.01m) and the process became one of very simple linear interpolation between adjacent tie points. In practice the interval between manually digitised tie points varied from several hours in the case of good digital 10-second data, to several minutes in the case of poor 10-second data or a very rugged sea bed.

FDATA: The magnetic and Magnavox speed log data were filtered using a sophisticated form of the median filter, a highly successful spike deletion tool.

EDATA: This is a utility program used for the manual editing of problem areas that are not amenable to filtering or automatic editing.

MUFF: This program uses a SINC function filter to smooth selected data channels. All velocity channels were smoothed to provide acceptable speeds, while magnetic data were filtered as an anti-aliasing measure prior to resampling to 60 sec. data.

TABLE 2 : Processing channel allocations

- 1 - Clock (survey & day number)
- 2 - GMT acquisition time from computer clock (hours, mins, secs)
- 3 - Master clock time at acquisition (hours, mins, secs)
- 4 - Latitude (radians)
- 5 - Longitude (radians)
- 6 - Heading (degrees) - best estimate
- 7 - Speed (Knots) - best estimate
- 8 - Bathymetry No 1 (metres) (3.5kHz)
- 9 - Bathymetry No 2 (metres) (12kHz)
- 10 - Magnetometer No 1 (nT)
- 11 - Magnetometer No 2 (nT)
- 12 - GMT from Magnavox MX1107RS sat nav. (hours, mins, secs)
- 13 - Dead reckoned time from MX1107RS (hours, mins, secs)
- 14 - Latitude (radians) MX1107RS
- 15 - Longitude (radians) MX1107RS
- 16 - Course (degrees) MX1107RS
- 17 - Speed (knots) MX1107RS
- 18 - Set (degrees) MX1107RS
- 19 - Drift (knots) MX1107RS
- 20 - Set/Drift flag
- 21 - Log reading Magnavox sonar doppler (n.miles)
- 22 - 32 Not used
- 33 - AGRF magnetic anomaly No 1 (nT)
- 34 - AGRF magnetic anomaly No 2 (nT)
- 35 - Delta latitude
- 36 - Delta longitude
- 37 - 41 not used
- 42 - Filtered delta latitude
- 43 - Filtered delta longitude
- 44 - 64 Not used. Temporary processed data.

DELTA: Incremental (delta) latitude/longitudes were produced every 10 seconds by combining the ships heading from the Arma-Brown gyro-compass and speeds from the Magnavox sonar-doppler and the MX1107RS. This effectively gave two distinct dead-reckoning (DR) systems.

INTEG: The filtered incremental latitude/longitudes were re-integrated over running 60-second intervals. These 60-second incremental distances are then used in the Phase 2 processing to compute the DR vector over each satellite fix interval.

VARPL/ As the final stage of the Phase 1 processing, all processed
EDATA: channels were plotted again as 'strip' plots with program VARPL. Program EDATA was then used to correct any minor residual data problems.

RESAM: The processed files are then resampled to 1-minute data files in preparation for phase 2 processing.

PHASE 2 PROCESSING

Phase 2 processing encompasses the following steps -

- (1) A Satfix data file was produced using the manually recorded Satellite fixes from the two satellite navigation systems (MX1107RS and MX1142), with duplicate fixes removed;
- (2) Re-formatting and production of assessment listing of satellite fixes;
- (3) Assessment of satellite fixes and deletion of those considered dubious or unacceptable;
- (4) Constraintment of DR track to remaining satellite fixes and computation of 1-minute positions for each DR system;
- (5) Selection of a suitable mix of navigation systems to produce final positions and
- (6) Final plots and editing as necessary.

In more detail, the programs applied were as follows -

CONCT: Concatenation of all parts of the survey into a single 1-minute data file; FIXTM was then used to correct any time jumps.

RESAF: Re-format the ASCII parameter file of satellite fixes and adjust each fix to the nearest whole minute of survey time using the ship speed and heading applying at that time in the Phase 1 data file.

FIXES: Produce a listing of the satellite fixes for assessment purposes.

SAT12: A number of passes of this program are required to fully assess and edit the satellite fixes. During each pass a number of options are called, as follows :

SATEL: Reads in the file of satellite fixes and stores them in memory. Any fix intervals with dubious speeds (too low or too high) or any intervals that are very short (<15 minutes) or very long (>120 minutes) are flagged in the output listing.

DRNAV: Uses the incremental latitude/longitudes stored on the Phase 1 file and the satellite fix information to compute the DR path (or DR vector) for each satellite fix interval. This is saved as an ASCII parameter file.

CALNV: Reads the DR file created by DRNAV and computes the ratio of the average DR velocity to the velocity computed from successive satellite fixes. This is done for each DR system used, and the results are listed.

CALPL: Produces a line printer plot of the velocity ratios for each satellite fix interval.

CFACT: Uses the DR file and a user-created file of calibration factor intervals to compute velocity calibration factors for each DR system.

APPROX: Uses the calibration factors computed in CFACT and the DR file to produce an approximately calibrated DR file.

ASSES: Uses the approximately calibrated DR file created by APPROX to produce a line printer plot of the current and summed error vectors at and between satellite fixes. The plot is produced at a 10-minute sample interval.

The basis of the processing is that option 'ASSES' takes the summed latitude and longitude error vectors at each fix (ie. a running sum of the DR position to satellite fix position vectors at the time of each fix) and uses a piece-wise cubic polynomial curve-fitting function (the Akima spline) to compute error vectors at all times between satellite fixes. It is assumed that the ensuing smooth variation of the error vector is due to ocean currents, winds, etc. Poor quality fixes will produce unrealistic or large and variable ocean currents. At each pass of assessment (and usually at least three passes are required for each file), the satellite fixes are checked wherever the summed error and current vectors suggest a problem, and those fixes of poor quality are deleted for the next program run.

SAT3: Uses the final file of satellite fixes and the DR data to produce final positions for each DR system. This program again uses the Akima spline to compute the assumed currents at all times between satellite fixes and applies those currents to the DR data to compute positions.

FINAV: Computes final 1-minute positions based on a 'mix' of DR systems according to a file specified by the user. Figure 2 shows the final track map.

VARPL: As a final check, the Phase 2 positions, water depths and magnetic data were plotted and editing applied as necessary.

FIXTM: Used to re-block the data to 8 channels x 60 records per block. The final channel allocation is summarized in Table 3.

TABLE 3: Final channel allocations.

Channel No	Contents
1	Time (SS.DDD)
2	Time (.HHMMSS)
3	Latitude (radians)
4	Longitude (radians) (relative to 100°E)
5	Water depth (metres)
6	not used
7	Magnetometer No 1 (nT)
8	Magnetometer No 2 (nT)

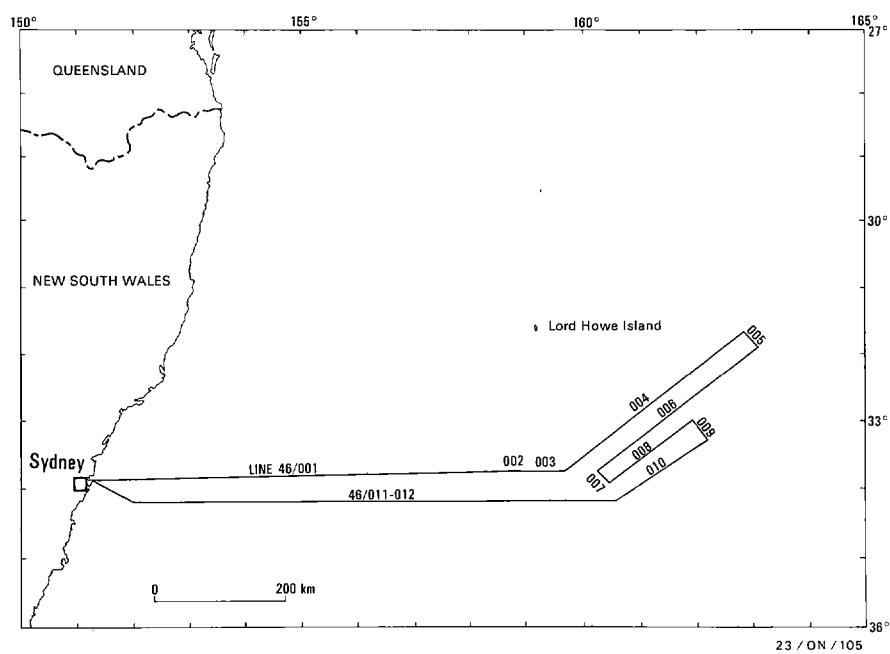


FIGURE 2: Track Map of Survey 46

DATA AVAILABILITY

Digital Data

Magnetic Tape (9-track, 1600 bpi, phase-encoded) ASCII records, 80 characters per record, 10x1-minute records per block.

	<u>Product Code</u>
(A) Navigation data only	M-46N0001T
(B) Navigation and Geophysical data	M-46N0002T

Enquiries concerning these data should be addressed to -

Marketing Manager
Division of Marine Geoscience & Petroleum Geology
Bureau of Mineral Resources,
GPO Box 378
Canberra, ACT 2601, Australia

Maps

Maps are produced using Lambert Conformal projection and are available in both paper and film output.

<u>Track Maps</u>	<u>Product Code</u>
1:1000000	M-46M0001P
1:2500000	M-46M0002P

Profile Maps

Magnetic Profiles (1:1000000)	M-46M0003P
Magnetic Profiles (1:2500000)	M-46M0008P
Bathymetric Profiles (1:1000000)	M-46M0004P
Bathymetric Profiles (1:2500000)	M-46M0009P

Post Maps

Magnetic Posted Values (1:1000000)	M-46M0005P
Magnetic Anomaly Posted Values (1:1000000)	M-46M0006P
Bathymetric Posted Values (1:1000000)	M-46M0007P

Enquires concering this report and these products should be addressed to :

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