Bureau of Mineral Resources, Geology & Geophysics

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NSW - PHOSPHORITES
BMR MARINE SURVEY 71

EXPLANATORY NOTES TO ACCOMPANY RELEASE OF NON-SEISMIC DATA

by

E.John Mowat and Jim Kossatz

Bureau of Mineral Resources, Geology & Geophysics

DIVISION OF MARINE GEOSCIENCES & PETROLEUM GEOLOGY

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FIGURE 1.

SCALE 1:5000000 TRACK MAP EDITION OF 1988/02/05

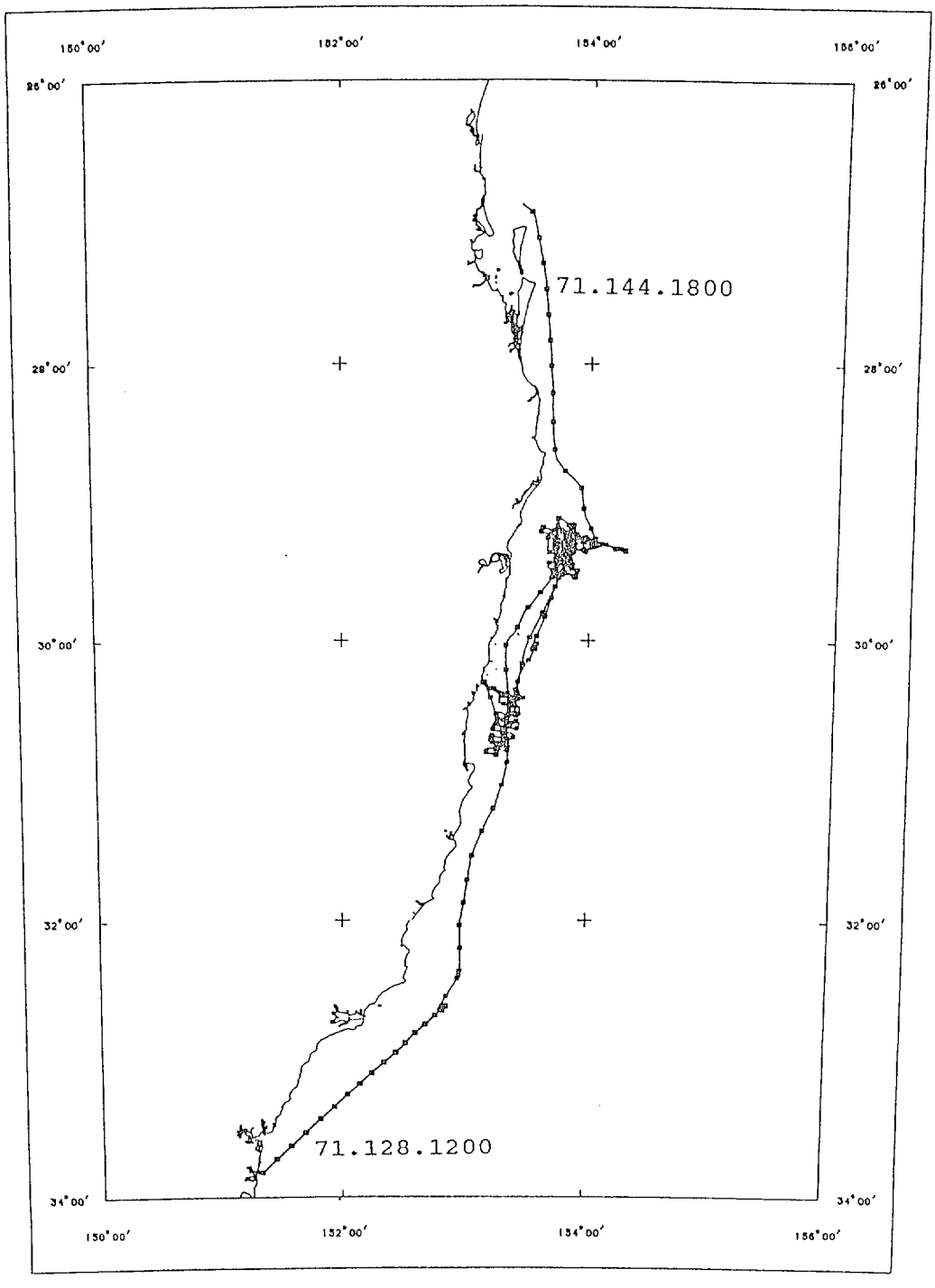


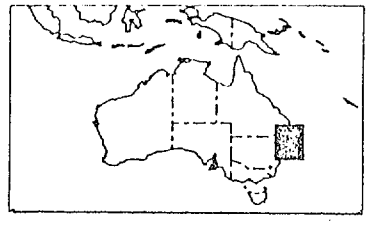
FIGURE 1. Track map of Survey 71.

AUSTRALIAN NATIONAL SPHEROID
LAMBERT'S CONFORMAL PROJECTION
WITH STANDARD PARALLELS
AT 28°00' AND 32°00' SOUTH

MARINE SURVEY 71 - 1987

TRACK MAP

LOCALITY WITHIN AUSTRALIAN REGION



INTRODUCTION

The aim of the BMR Marine Survey 71 was to study the marine sedimentary deposits on the continental shelf and upper slope off the east coast of Australia. This involved the collection of geological samples and geophysical data from latitudes 26deg. to 34deg. South and longitudes 151deg. to 155deg. East. See Figure 1 for track map and location.

The purpose of this report is to summarise the processing techniques applied to the non-seismic geophysical data. The survey was conducted between 8 May and 28 May 1987 and formed part of BMR project 9131.03 (1986/87).

GEOPHYSICAL SYSTEMS & PERFORMANCE

The following non-seismic geophysical systems were employed during Survey 71:

Navigation

Three totally independent navigation techniques were run simultaneously;

1. Magnavox Global Positioning System (GPS) T-Set, giving continous 2-D positioning to within 30 m RMS, during periods of satellite availability and good orbital geometry.

2. Decca HIFIX Radio Navigation System, utilizing three shore-based transponders. This system has a potential accuracy to within 5 metres at optimum operational capabilities.

3. Dead Reckoning (DR) systems, incorporating TRANSIT satellite navigators, gyro compasses, and sonar dopplers. The primary system, consisted of a Magnavox MX1107RS dual-channel satellite navigator, with speed input from Magnavox MX610D sonar doppler and headings from an Arma-Brown gyro-compass. The secondary system, consisted of a Magnavox MX1142 single channel satellite navigator, with speed input from Raytheon DSN 450 sonar doppler and headings from a Robertson gyro-compass. These systems have a potential accuracy of 0.2km at fixes rising to around 1km between fixes in deep water.

Performance Comments:

1. The Magnavox Global Positioning System (GPS) T-Set was only used for a limited period (5-6 hours/day) when a sufficient number of satellites were available with good orbital geometry to calculate the navigation data. During that time the reliability was excellent.

2. Determination of the reliability and performance of the HIFIX radio navigation system is yet to be determined. This data is still to be processed with software modifications under review.

3. Both TRANSIT satellite navigators/DR systems generally performed reliably with data being recorded every 10 seconds. Both gyro-compasses performed satisfactorily for the entire survey. Both sonar-dopplers performed satisfactorily in low sea states but performance deteriorated in high sea states.

Overall the GPS T-Set was the primary navigation system, when it was available, followed by the HIFIX radio navigation system. These two systems were backed up by the two DR satellite navigation systems (MX1107RS and MX1142) for the remainder of the survey. In addition, a paddle log of the ships speed was interfaced to the DAS and all satellite fix details were transferred and recorded onto tape.

The percentages of the total time that each system was the primary navigation system during the cruise is;

T-Set :2.3%

Radio Nav. :Not yet determined.

Dead Reckoning :97.7% *

* To be corrected when radio navigation is processed.

Bathymetric Systems

Raytheon Deep-sea Bathymetric System, with a maximum power output of 2 kW at 12 kHz. This system, purchased in the early 1970's, was of very sophisticated design for its day, providing in addition to digital depths and various alarm flags, an automatic tracking facility that should theoretically provide usable bathymetric data even in marginal recording conditions. A 3.5 kHz system was installed in Melbourne during 1985. This system included an additional 8 transducers bringing the total to 16.

An additional HP1000 M-Series computer using the 'HADES' program was used as an aid to running a water depth recorder located in the winchroom.

Performance Comments:

Data quality was generally good except for short periods when sea states were high. The extensive processing required to retrieve acceptable bathymetric data is described fully later in this report.

Magnetics

Two Geometrics G801/803 proton precession magnetometers were installed in the instrument room. Magnetics were acquired from the single channel sensor towed astern of the vessel for short periods during the survey.

Performance Comments:

Performance was not as good as expected with noise levels in excess of 6nT. Final data have been improved by filtering.

Gravity

Gravity data were recorded for most of the survey from a Bodenseewerk KSS-31 marine gravity meter.

Performance Comments:

The KSS-31 is a highly sophisticated single-axis marine gravity meter with extensive microprocessor control. The KSS-31 is designed to be interfaced to an external navigation system that can provide speed and heading input at a rate of as fast as 1 second; the speed and heading are then used by the processor to provide gyro corrections to the gravity meter to improve performance in heavy seas or during turns. For Survey 71, satisfactory gravity data have been achieved with appropriate post-survey filtering, except at sample sites where poor speed control and continuous vessel manoeuvring have produced erratic Eotvos corrections.

Due to a gyroscopic bearing malfunction in the gravity meter, no data were acquired between 71.134.000000 and 71.135.033500. There were also a number of smaller gaps. Poor quality data were deleted between 71.131.064500 and 71.134.000000 during the period just prior to the bearing failure.

DATA ACQUISITION SYSTEM (DAS)

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 (gravity, Magnavox MX1107RS and MX1142RS,) or through a BMR-designed 16-bit digital multiplexer (eg, magnetics, bathymetry) and attached gyro-log interface (for both sonar dopplers and gyro-compasses). After preliminary processing, data are then plotted on strip-chart recorders and track plotters, and data listings are output to a number 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 with 128 channels of data being recorded. Due to technical faults, there are a number of small gaps in the data. 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 ,minutes and seconds)
3 - Master clock time at acquisition (hours, minutes and seconds)
4 - Latitude (radians)
5 - Longitude (radians)
6 - Speed (knots) - best estimate
7 - Heading (degrees) - best estimate
8 - Magnetometer No 1 (nT)
9 - Magnetometer No 2 (nT) not used
10 - Bathymetry No 1 (metres)(3.5KHz)
11 - Bathymetry No 2 (metres)(12KHz)
12 - Magnavox sonar doppler - fore/aft (knots)
13 - Magnavox sonar doppler - port/starboard (knots)
14 - Raytheon sonar doppler - fore/aft (knots)
15 - Raytheon sonar doppler - port/starboard (knots)
16 - Paddle log of ship's speed (knots)
17 - Not used
18 - Arma-Brown gyro-compass (degrees)
19 - Robertson gyro-compass (degrees)
20 - Not used
21 - Miniranger 1 not used
22 - Miniranger 2 not used
23 - Miniranger 3 not used
24 - Miniranger 4 not used
25 - HIFIX fine A
26 - HIFIX fine B
27 - HIFIX fine C
28 - HIFIX coarse A
29 - HIFIX coarse B
30 - HIFIX coarse C
31 - Reserved for multiplexed data
32 - Reserved for multiplexed data
33 - Reserved for multiplexed data
34 - Reserved for multiplexed data
35 - Reserved for multiplexed data
36 - Reserved for multiplexed data
37 - Reserved for multiplexed data
38 - Reserved for multiplexed data
39 - Reserved for multiplexed data
40 - Reserved for multiplexed data
41 - T-Set not used
42 - T-Set Time (GMT seconds x 2)
43 - T-Set Dilution of Precision (DOP)
44 - T-Set Latitude (radians)
45 - T-Set Longitude (radians)
46 - T-Set Height above Geoid (metres)
47 - T-Set Speed (knots) x 10
48 - T-Set Course (degrees) x 10

49 - T-Set Frequency Bias
50 - T-Set GMT (.hhmmss)
51 - Latitude (radians) from MX1107RS
52 - Longitude (radians) from MX1107RS
53 - Speed (knots) from MX1107RS
54 - Heading (degrees) from MX1107RS
55 - Latitude (degrees) from MX1142RS
56 - Longitude (degrees) from MX1142RS
57 - Speed (knots) from MX1142RS
58 - Course (degrees) from MX1142RS
59 - Latitude from spare log (radians)
60 - Longitude from spare log (radians)
61 - Speed from spare log (knots)
62 - Course from spare log (degrees)
63 - Latitude from radio nav (radians)
64 - Longitude from radio nav (radians)
65 - Speed from radio nav (knots)
66 - Course from radio nav (degrees)
67 - GMT from MX1107RS (.hhmmss)
68 - DR time from MX1142RS
69 - Lat tude from MX1107RS (radians)
70 - Longitude from MX1107RS (radians)
71 - Speed from MX1107RS (knots)
72 - Heading from MX1107RS (degrees)
73 - GMT from MX1142RS (.hhmmss)
74 - DR time MX1142RS (.hhmmss)
75 - Latitude MX1142RS (radians)
76 - Longitude MX1142RS (radians)
77 - Speed from MX1142RS (knots)
78 - Heading from MX1142RS (degrees)
79 - Gravity (μms^{-2} x 10)
80 - Not used
81 - ACX (ms**-2 x 1000)
82 - ACY (ms**-2 x 1000)
83 - Mag. anomaly No.1 (nT)
84 - Mag. anomaly No.2 (nT) not used
85 - Mag. differences (nT)
86 - Shot times (.hhmmssdd)
87 - Shot point number
88-128 not used

DATA PROCESSING

The data were processed on an 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; medium filter of magnetics and gravity; manual editing of problem areas; computation of incremental latitudes and longitudes; anti-alias filtering (smoothing) of magnetics, gravity, incremental latitudes and longitudes; production of final check plots; and 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, GPS system and radio nav system; computation of final Eotvos-corrected gravity, including a correction for gravity meter drift; and final data editing (particularly gravity data during turns).

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

PHASE 1

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.

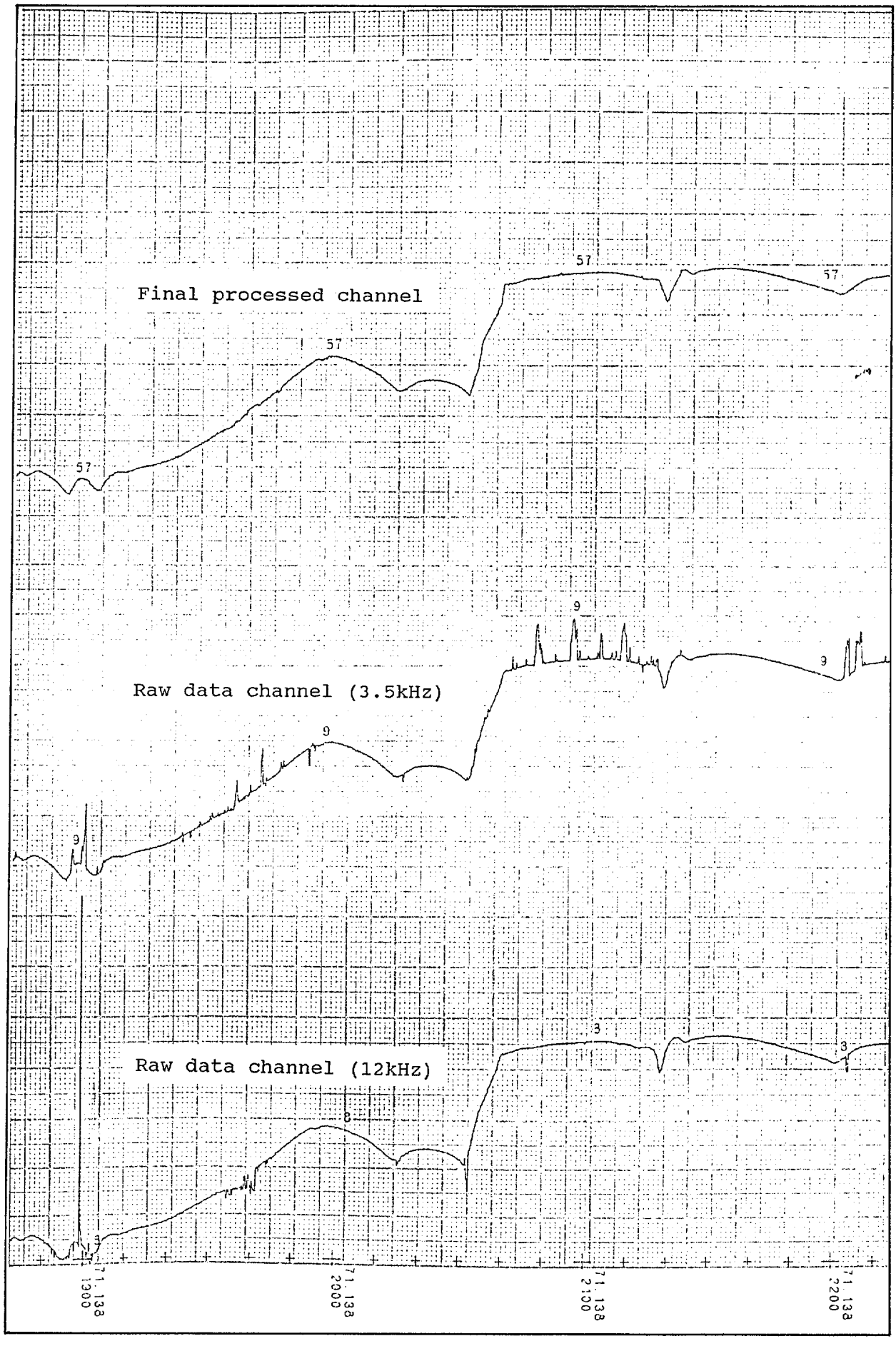
GMUL2: This applies various conversion factors to the data, when required, using a parameter file.

SALVG (Water depth recovery): Briefly stated, the problem of bathymetry recovery is to fill 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 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

TABLE 2: Processing channel allocations

1	-	Clock (survey & day number)
2	-	GMT acquisition time from computer clock (hours ,minutes and seconds)
3	-	Master clock time at acquisition (hours, minutes and seconds)
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) not used
12	-	Magnetic gradient
13	-	Gravity (μms^{-2} x 0.1)
14	-	ACX (ms**-2 x 1000)
15	-	ACY (ms** 2 x 1000)
16	-	Magnavox sonar doppler - fore/aft (knots)
17	-	Magnavox sonar doppler - port/starboard (knots)
18	-	Raytheon sonar doppler - fore/aft (knots)
19	-	Raytheon sonar doppler - port/starboard (knots)
20	-	Paddle log of ship's speed (knots)
21	-	T-Set Latitude (radians)
22	-	T-Set Longitude (radians)
23	-	Arma-Brown gyro-compass (degrees)
24	-	Robertson gyro-compass (degrees)
25	-	Shot times (.hhmmssdd)
26	-	Shot point number
27	-	Miniranger 2 not used
28	-	Miniranger 3 not used
29	-	Miniranger 4 not used
30	-	HIFIX Fine A
31	-	HIFIX Fine B
32	-	HIFIX Fine C
33	-	HIFIX Coarse A
34	-	HIFIX Coarse B
35	-	HIFIX Coarse C
36	-	T-Set height above Geoid (metres)
37	-	T-Set speed (knots)
38	-	T-Set course (degrees)
39	-	T-Set frequecy bias
40	-	Latitude (radians) MX1107RS
41	-	Longitude (radians) MX1107RS
42	-	Speed (knots) MX1107RS
43	-	Heading (degrees) MX1107RS
44	-	Latitude (radians) MX1142RS
45	-	Longitude (radians) MX1142RS
46	-	Speed (knots) MX1142RS
47	-	Coarse (degrees)
48-64		Not used. Temporary processed data.

FIGURE 2. Bathymetric traces before and after processing by program SALVG.



is accepted and is used to replace the previous first tie point. If the difference is greater than the threshhold, 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. The success of this process, which is routinely applied to all Rig Seismic bathymetric data, can be seen in the 'before' and 'after' plots of Figure 2.

VARPL: All raw data channels requiring processing were plotted as strip charts 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. They 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 raised to the power 10), 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.

FDATA: The magnetic, gravity, and Magnavox and Raytheon 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 gravity and magnetic data were filtered as an anti-aliasing measure prior to resampling to 60-second data.

DELTA: Incremental (delta) latitude/longitudes were produced every 10 seconds by combining the ship speed with the headings from the Arma-Brown and Robertson gyro-compasses. 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 were then used in the Phase 2 processing to compute the DR vector over each satellite fix interval.

VARPL/EDATA: As the final stage of the Phase 1 processing, all processed 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

Phase 2 processing encompasses the following steps -
(1) Re-formatting and production of assessment listings of satellite fixes;
(2) Assessment of satellite fixes and deletion of those considered dubious or unacceptable;
(3) Constrainment of DR track to remaining satellite fixes and computation of 1-minute positions for each DR system;
(4) Selection of a suitable mix of navigation systems to produce final positions;
(5) Application of Eotvos and drift corrections to gravity data and conversion to absolute values;
(6) Final plots and editing as necessary.

In rather more detail, the programs applied were as follows -

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

SATFX: Extraction of the satellite data from the original field tapes and produce two files of satfix data relevant to the two navigation systems (MX1107RS and MX1142).

M0742: Amalgamation of the two satfix files and removal of any duplicate entries.

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 (Table 3).

Table 3: Sample satellite fix listing from Survey 71. Headings are follows:-
FIX - fix number within file;
FIXTIME - time of fix to nearest minute;
LAT, LONG - fix position adjusted to nearest minute;
SYSTEM - indicates MX1107 or MX1142 fix;
SAT - satellite ID code;
OK - Y or N indicates fix accepted or rejected by satellite navigator;
ELEV - maximum of elevation during fix, in degrees;
COUNT - number of doppler counts received during pass;
ITER - number of iterations required for fix to compute;
GEOM - geometry of pass;
ERROR, DIR - distance (nautical miles) and bearing (degrees) of fix update (based on shipboard DR data);
SLT, SLN - standard deviation of latitude and longitude (metres);
CODE - error code, blank if fix accepted by MX1107 or MX1142;
COURSE, SPEED - course (degrees) and speed (knots) of ship at time of fix.

TABLE 3. Sample satellite fix listing.

FIX	FIX TIME	LAT	LONG	SYSTEM	SAT	OK	ELEV	COUNT	ITER	GEOM	ERROR	DIR	SLT	SLN	CODE	COURSE	SPEED
1	71.128.042400	33 52.108	151 13.176	1107	300	N	12	25	3	NW	.07	278	0	0		204.8	0.0
2	71.128.054800	33 52.120	151 13.301	1142	500	Y	52	32	2		.10	112	0	0		204.8	0.0
3	71.128.064300	33 52.101	151 13.238	1107	110	Y	50	19	2	NE	.02	326	0	0		205.0	0.0
4	71.128.073600	33 52.072	151 13.254	1107	500	Y	23	25	3	NW	.03	19	0	0		204.8	0.0
5	71.128.083000	33 50.248	151 15.865	1107	110	Y	23	27	4	NW	.01	263	0	0		37.8	9.7
6	71.128.092600	33 46.888	151 23.135	1107	200	Y	33	31	2	NW	.03	224	0	0		45.3	8.0
7	71.128.102700	33 41.041	151 30.316	1107	130	Y	60	36	3	NW	.10	299	0	0		47.8	8.1
8	71.128.113400	33 34.589	151 38.381	1107	480	Y	37	34	3	SE	.07	298	0	0		48.8	8.2
9	71.128.121200	33 31.022	151 42.932	1142	130	N	6	19	3		.10	193	0	0	1	48.5	8.4
10	71.128.125300	33 27.019	151 47.959	1107	300	Y	13	23	3	SE	.09	308	0	0		49.8	8.7
11	71.128.132200	33 24.463	151 51.461	1107	480	Y	33	35	3	SW	0.00	91	0	0		49.8	7.4
12	71.128.144000	33 17.424	152 .168	1107	300	Y	70	33	2	SW	.09	287	0	0		48.3	7.6
13	71.128.160900	33 10.170	152 9.590	1107	500	N	8	21	5	SE	.04	336	0	0	1	48.5	6.7
14	71.128.162800	33 8.643	152 11.434	1107	300	N	6	17	4	SW	.03	285	0	0	1	48.8	6.8
15	71.128.165300	33 6.764	152 13.744	1107	110	N	3	14	5	SE	.25	248	0	0	1	49.5	7.0
16	71.128.175600	33 1.867	152 20.344	1107	500	Y	69	37	3	SE	.09	291	0	0		50.7	6.9
17	71.128.183800	32 58.794	152 24.502	1107	110	Y	50	34	3	SE	.04	334	0	0		49.5	6.5
18	71.128.192500	32 55.582	152 28.752	1107	200	Y	29	31	3	SE	.02	263	0	0		48.5	5.4
19	71.128.194600	32 54.249	152 30.398	1107	500	Y	16	27	3	SW	.05	162	0	0		41.0	5.5
20	71.128.202500	32 51.409	152 33.336	1107	110	Y	22	28	3	SW	.04	349	0	0		42.8	6.1
21	71.128.211000	32 48.175	152 37.139	1107	200	Y	40	34	3	SW	.02	123	0	0		46.8	5.7
22	71.128.222200	32 43.885	152 43.109	1107	130	Y	61	34	3	SW	.11	147	0	0		45.3	5.7
23	71.128.230200	32 41.133	152 46.564	1107	480	Y	23	30	3	NE	.26	92	0	0		45.5	7.7
24	71.129.005100	32 37.640	152 50.438	1107	480	Y	51	37	3	NW	3.07	214	0	0		59.7	1.7
25	71.129.020200	32 37.372	152 51.619	1107	300	Y	66	39	3	NE	1.45	164	0	0		40.5	1.7
26	71.129.034900	32 39.284	152 49.938	1107	300	Y	19	27	5	NW	3.07	210	0	0		59.0	2.1
27	71.129.052500	32 38.792	152 49.531	1107	500	Y	42	36	3	NE	2.41	182	0	0		59.3	.7
28	71.129.055400	32 38.998	152 49.227	1107	110	Y	24	30	3	NE	.79	200	0	0		58.2	0.0
29	71.129.063100	32 39.153	152 49.238	1142	200	Y	9	16	2		.70	237	0	0		44.5	1.8
30	71.129.071300	32 38.928	152 48.861	1107	500	Y	29	32	3	NW	2.24	214	0	0		31.0	1.2
31	71.129.074100	32 35.327	152 50.068	1107	110	Y	47	33	3	NW	.70	200	0	0		30.5	9.6

SAT12: During each pass of this program for each satellite fix assessment 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 round of assessment (and usually at least three rounds 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. The effect of this process can be seen in the example in Figures 3 and 4 where a satellite fix at 71.130.124000 was removed.

FIGURE 3. satellite fix assessment plot - prior to processing.

Legend.
N,V,Y (north) and E,U,X (East) current vectors for DR systems 1,2 & 3. (1 divn = 1 n.mile)
1,3,5 (North) and 2,4,6 (East) error vector for DR systems 1,2 & 3. (1 divn = 1 n.mile)

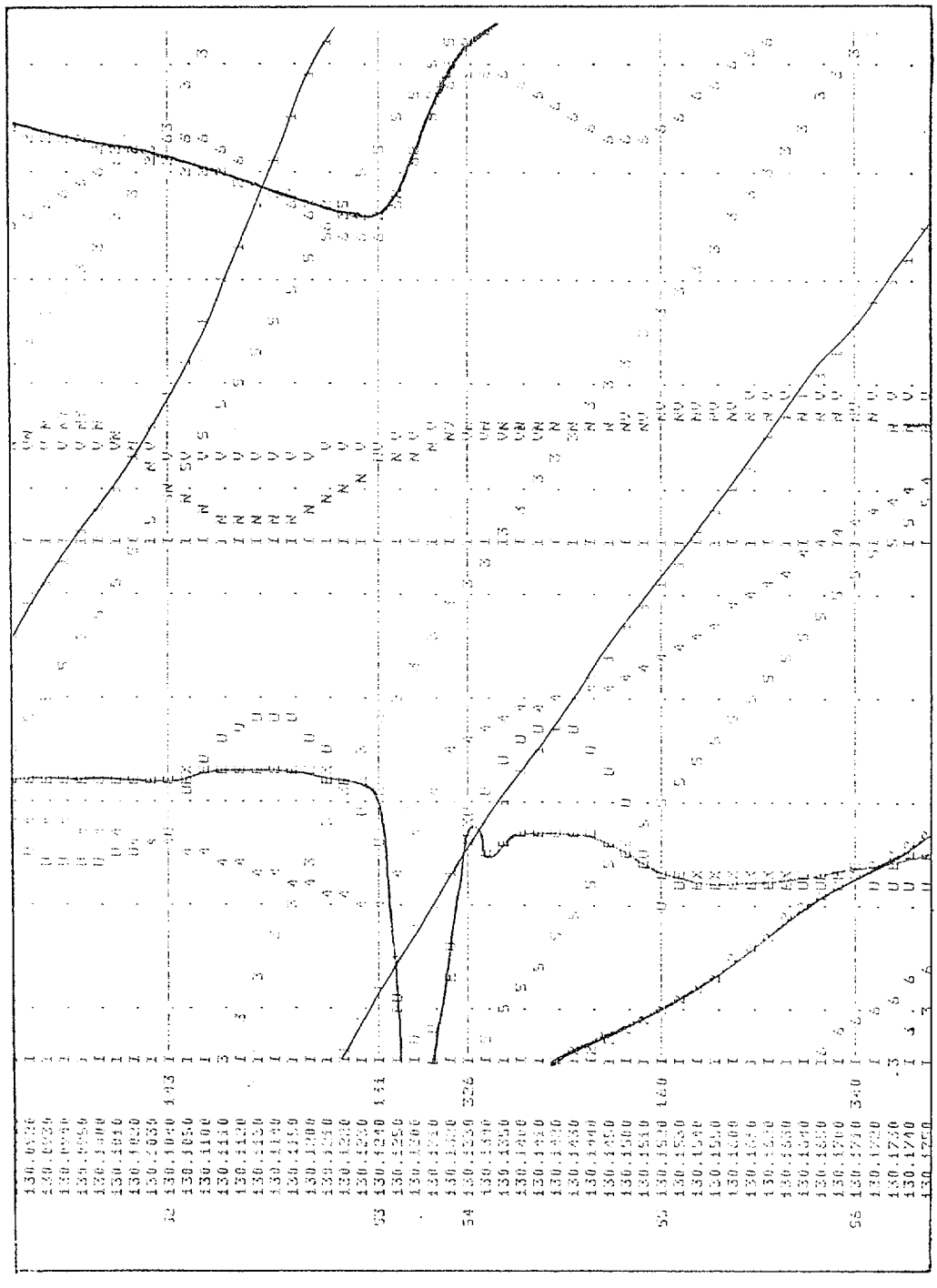
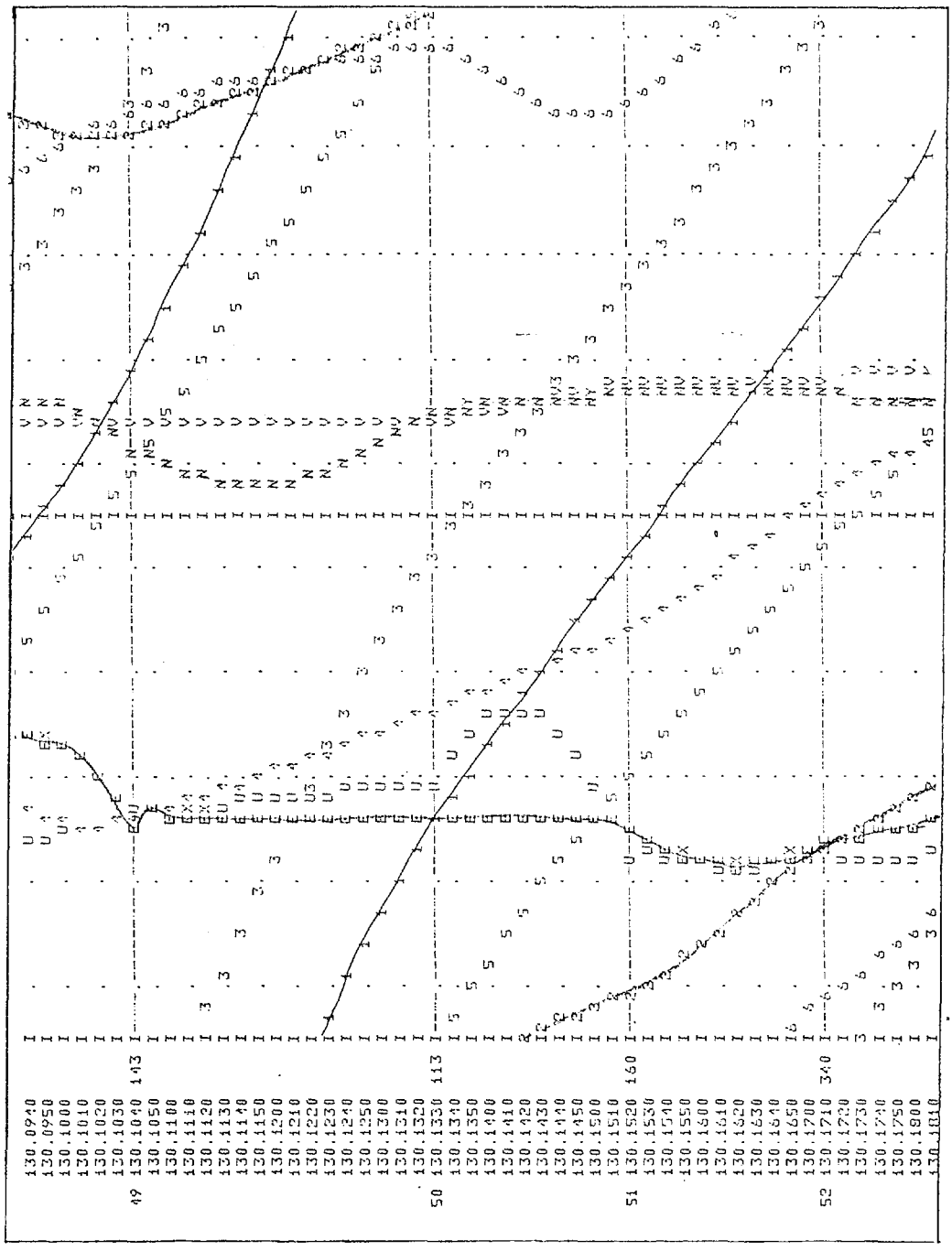


FIGURE 4. Satellite fix assessment plot - post processing.

Legend

N,V,Y (North) and E,U,X (East) current vectors for DR systems 1,2 & 3. (1 divn = 1 n.mile)

1,3,5 (North) and 2,4,6 (East) error vector for DR systems 1,2 & 3. (1 divn = 1 n.mile)



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 acting at all times between satellite fixes and applies those currents to the DR data to compute positions.

LGYRO: Computes the difference in position, in metres, between two navigation systems (GPS and DR,in this case); this is used as a guide to the relative quality of the two systems to allow selection of the 'mix' of systems to be used in the final navigation.

FINAV: Performs the following functions -

(1) Computes final 1-minute positions based on a 'mix' of DR systems, Global Positioning System and HIFIX (radio nav) according to a file specified by the user. The final navigation is shown at small scale in Figure 1 page 2.

(2) The gravity data (which was in mgals relative to an arbitrary datum) was converted to absolute values corrected for meter drift and with Eotvos corrections applied; no mistie analysis has been applied. Final data are relative to the Isogal 84 datum (See BMR Report No.261 by Peter Wellman, et al. Gravity base-station network values, Australia.)

Gravity ties were performed in Sydney, New South Wales prior to the survey, and in Brisbane, Queensland at the end of the survey. Summary of results are as follows:

Pre NSW - Phosphorites (Sydney)
Meter value: -7214.5 μms^{-2}.....Corrected Value: 9803868.0 μms^{-2}
Date & Time 8/5/87 0505 hrs (GMT)

Post NSW - Phosphorites (Brisbane)
Meter value: -12487.1 μms^{-2}.....Corrected value: 9804006.6 μms^{-2}
Date & Time 28/5/87 0640 hrs (GMT)

Drift = +2.5 μms^{-2}. Over duration of survey (20 days)

VARPL/EDATA : As a final check, the Phase 2 positions, water depths, magnetic, and gravity data were plotted and editing applied as necessary. Program FIXTM was then used to re-block the data to 8 channels x 60 records per block. As a final editing stage, the residual gravity spikes at turns are removed (EDATA) and the gravity channel is smoothed by a filter of 15 minute period to remove any remaining sea noise (MUFF).

On completion of all data processing, the final data is allocated to specific channels as per Table 4.

Table 4: Final channel allocations.

Channel No	(Ex Channel No)*	Contents
1		Time (SS.DDD)
2		Time (.HHMMSS)
3	(63)	Latitude (radians)
4	(64)	Longitude (radians) (relative to 100deg E)
5	(57)	Water depth (metres)
6	(62)	Gravity (μms^{-2} * 0.1)
7	(58)	Magnetometer No. 1 (nT)

* Intermediate processing channel.

MAP PRODUCTION

Track Maps

Track maps were produced (using Lambert Conformal projection) of the standard 1:1000000 map areas covering the NSW - Phosphorites survey area (Survey 71). The track maps are: Brisbane (SG56); Armidale (SH56); and Sydney (SI56).

Profile Maps

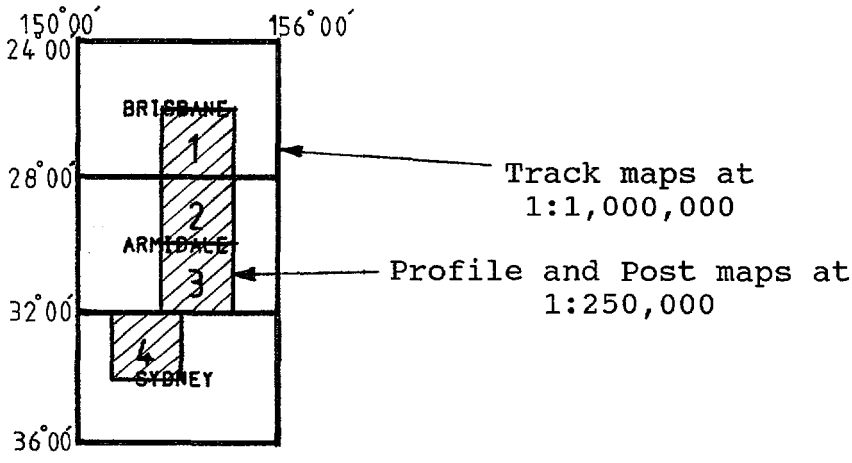
Profile maps were produced (using Lambert Conformal projection) at a scale of 1:250000. This is a suitable scale to cover the area in four maps for each data type. Profile maps are: Residual Magnetic Anomaly; Free-air Anomaly; and Bathymetric.

Posted Value Maps

Posted Value maps were produced (using Lambert Conformal projection) of the same four areas and at the same scale as the profile maps. These maps are: Observed Gravity Values; Total Magnetic Field Values; Observed Magnetic Anomaly Values; and Bathymetric Values.

Map areas are shown in Figure 5.

Figure 5.



DATA AVAILABILITY

The NSW - Phosphorites non-seismic data are available as Digital Data (Magnetic Tape) and Maps.

Digital Data (Magnetic Tape)

(1) Navigation Data only. Product Code: M-71N0001T
9-track, 1600 bpi, phase-encoded, ASCII records of
80 characters per record, 10x1-minute records per block; or

(2) Navigation and Geophysical Data. Product Code: M-71N0002T
9-track,1600bpi, phase encoded, ASCII records of
80 characters per record, 10x1-minute records per block.

Enquiries concerning these data should be addressed to -

Chief Scientist,
Division of Marine Geosciences &
Petroleum Geology,
Bureau of Mineral Resources,
GPO Box 378
Canberra ACT 2601 Australia

Maps

	Sheet name	Sheet number	Product code
(1)	Track Maps		
	BRISBANE (SG56)	1	M-71M0001P
	ARMADALE (SH56)	2	M-71M0002P
	SYDNEY (SI56)	3	M-71M0003P
(2)	Profile Maps		
	Bathymetric Profiles	2,3 and 4	M-71M0010P
	Free-Air Anomaly Profiles	1 to 4	M-71M0008P
	Residual Magnetic Anomaly Profiles	2 and 3	M-71M0009P
(3)	Post Maps		
	Bathymetric Values	2,3 and 4	M-71M0006P
	Observed Gravity Values	1 to 4	M-71M0007P
	Total Magnetic Field Values	2 and 3	M-71M0004P
	Observed Magnetic Anomaly Values	2 and 3	M-71M0005P

Enquiries concerning this report and maps of this data should be addressed to:

Copy Service
Bureau of Mineral Resources
GPO Box 378
Canberra ACT 2601 Australia