1973/76
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DEPARTMENT OF
MINERALS AND ENERGY

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

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Record 1973/76

PRESURVEY REPORT ON MARINE GEOPHYSICAL SURVEY, NO. 21 (MAGNETIC) NORTHWEST CONTINENTAL SHELF, 1973 (DIVISION OF NATIONAL MAPPING, CONTRACT NO. 3)

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CONTENTS

APPENDIXES

PLATES

SUMMARY

A marine magnetic survey is being made using M.V. Manly Cove in an area of the northwest continental shelf north of Port Hedland, extending about 180 km northward nearly to the edge of the shelf in the vicinity of the Rowley Shoals. The survey is being done on behalf of the Bureau of Mineral Resources (BMR) as part of a contract bathymetric survey by the Division of National Mapping. BMR is providing the magnetic equipment, assisting in its installation, and receiving and processing the results. A shore monitor magnetic station is being operated by BMR at Port Hedland. Navigation will be primarily by Shoran, operated by the contractor, but additional control will be provided by satellite Doppler equipment installed and operated by the Division of National Mapping.

The survey commenced at the end of April 1973. The contractor estimates completion by the middle of June. Division of National Mapping have allowed 3 months for completion of field work.

The bathymetric survey will record along traverses, striking north-northwest, at a spacing of 3 km. Previous BMR work used east-west lines at about 16-km spacing. The greater detail of the present work will permit estimates of depth to magnetic basement which should be superior in both reliability and number to those made previously. It will provide a valuable contribution to knowledge of basement structure which may assist in sedimentary structural interpretation and greater understanding of the regional geological setting.

1. INTRODUCTION

The Division of National Mapping (NATMAP) is carrying out a detailed hydrographic survey of the northwest continental shelf between Port Hedland and the Rowley Shoals (Plate 1). This is Contract No. 3 of the Division's program of hydrographic surveys of the Australian continental shelf. The lines are being run at a speed of 12 knots, conditions permitting, and at 3-km spacing. They are oriented north-northwest and extend from water depths of 20 metres to around 300 metres. BMR has taken advantage of the survey by installing a Geometrics proton precession magnetometer to obtain continuous magnetic profiles. The magnetometer is being operated and maintained by the contractor.

The shipboard magnetic installation is simple to operate. Only analogue recordings are being made, in the form of dual-channel strip chart recording at two different sensitivities. A paper speed of 12 inches per hour has been chosen as a reasonable compromise between accuracy and the constraints of manual digitization of the recorded data. The magnetic data will be correlated with the position information through time marks supplied automatically from a clock which has been integrated by BMR with its magnetic equipment.

Navigation data should be supplied by NATMAP after the survey is completed, in a form suitable for card punching and computer processing. Sampling of the navigational data at precise five-minute intervals will considerably simplify the processing of the magnetic data. Such time control is being supplied by the BMR clock.

A magnetic diurnal monitor is established and operated by BMR near Port Hedland. It was installed at the airport before the commencement of the survey. Errors arise through measuring the diurnal at a place remote from the field observations as the diurnal phase and amplitude vary somewhat erratically from place to place. Tie-lines are used to minimize the errors of observations. The intersection values can be used also for determining an average diurnal at the survey area. To obtain the best results, tie-lines should cross survey lines at right-angles. Angles of intersection less than 30 degrees should be avoided. The greater the number of tie-lines the better, provided they are fairly regularly spaced.

The magnetic data are being recorded in daily blocks starting at 0000 GMT. Each record is given a unique sequence number of the form SS/NNN where SS = survey number (21 in the BMR series) and NNN = sequence number. The first record obtained was 001, the next 002 and so on throughout the survey regardless of breaks in the work.

All information pertinent to the magnetic survey is annotated directly on the strip chart, as much as possible being done at the time of occurrence, e.g. hourly digital values and changes of course. Details such as lines, run, sequence numbers, and start and stop times are best entered on the chart when the day's record is checked after removal from the recorder.

In this report distances are normally given in metric units. However, ship's speed is still normally quoted in knots and corresponding distances are normally given in nautical miles, abbreviated to miles. Also, the charts in use on the magnetic recorders are printed with an inch scale and the recorders are geared to advance the chart paper in integral multiples of an inch. Since the report is intended for use as a guide to operating practice in the field, it seems appropriate for clarity to use mixed units.

2. GEOLOGY AND PREVIOUS GEOPHYSICS

Whitworth (1969) reviewed the geology and previous geophysics covering the area of the present magnetic survey.

The survey area appears from the combined evidence of geological mapping, drilling, and marine geophysical data to be underlain in the south by shallow basement consisting of Pilbara Block Archaean rocks and in the north by deepening basement overlain by Canning Basin equivalent sediments. Plate 1 shows the general location of the survey area relative to the coastline and continental shelf, two nearby exploration oil wells, and generalized geological structures. Plate 2 shows the traverses and magnetic profiles obtained in 1968 in the survey area and schematic representation of the traverses proposed for the present survey. The traverses observed in 1968 were about 16 km apart. The strong, erratic features in the south are the effects of the shallow Archaean rocks of the Yilgarn Block. However, it is noteworthy that very few magnetic features show obvious correlation from traverse to traverse. An exception may be the apparent line-ups between three adjacent traverses in the southwest, suggesting a north to northwest trend.

Since the BMR survey (Whitworth, 1969) there have been three subsidized marine seismic surveys by B.O.C. of Australia Pty Ltd, and one, the most recent, by Hematite Petroleum Pty Ltd (1973). They provide together a network of intersecting traverses on a general spacing of about 20 km in and around the present survey area. These seismic surveys were intended for petroleum exploration and regarded the top of Permian sediments as the deepest objective. This level was mapped in the Hematite survey from 2000 m depth near the southern margin of the present survey area to 5000 m depth about 40 km farther north, at what was called the limit of the Permian seismic event, apparently through deterioration of record quality. The present survey area extends about 100 km farther north.

The two nearest exploration oil wells drilled by B.O.C. on structural highs defined by seismic work near the outer margin of the continental shelf are Bedout No. 1, about 50 km east of the survey area and Picard No. 1, about 50 km west. (B.O.C., 1971, 1972). Bedout No. 1 was drilled to about 3070 m and bottomed in fresh basalt overlain successively by weathered basalt and middle to upper Triassic sandstone with interbeds of claystone. Picard No. 1 was drilled to about 4200 m and bottomed in middle to lower Jurassic sandstone interbedded with claystone, siltstone, and minor coal beds.

3. OBJECTIVES

The opportunity to carry out the magnetic survey is provided by the bathymetric survey of the area being carried out as a contract operation for the Division of National Mapping. The primary objective of the field activity is, therefore, to map the sea bottom surface. The magnetic recording is provided as an additional contractual service under the general control and direction of the Division of National Mapping. BMR provided technical assistance in installation of the BMR magnetic equipment, instructions on its use, and recommendations for survey procedures especially related to the magnetic recording.

The objective of the magnetic survey itself is to obtain the more detailed magnetic coverage of this area permitted by the closely spaced traverses of the bathymetric survey. This will provide a 3-km grid of magnetic data plus continuous profiles in the direction of traversing. The greater detail will permit better analysis and interpretation of the magnetic field in terms of magnetic basement depth and rock types, which may be of use in resolving basement and sedimentary structure as well as in consideration of regional crustal structure.

In addition, the efficiency and effectiveness of the operation will be considered with a view to future improvements.

4. NAVIGATION REQUIREMENTS

Position fixing on this survey is essentially an on-line process carried out by the contractor using SHORAN. Ranges to two transmitters are plotted on a range line chart, and the position co-ordinates are arrived at indirectly from the chart. For computation of the magnetic survey, the navigational data must be prepared in digital form and integrated with the digitized magnetic data on magnetic tape before the results can be processed through the computer. It would be unacceptable to obtain the navigational data in digital form by digitizing the positions plotted on the NATMAP track charts, because the accuracy would be too low.

However, the observed range line values of fixes will be logged and one must turn to these to obtain adequate positional accuracy for use in post-processing. An accuracy of ± 0.02 miles is desired; therefore time must be known to ± 5 seconds and range to better than ± 0.01 miles depending upon the SHORAN net configuration.

BMR considers time to be the prime variable as it is the only one in common with the magnetic recordings. A precision clock is being provided to give regular time-marks on the magnetic strip chart; five-minute time-marks will be recorded on the magnetic record.

In the opinion of NATMAP (P. O'Donnell, pers. comm.) five-minute time-marks appear adequate i.e. a fix every 0.5 mile assuming a ship's speed of 12 knots. If the SHORAN display can be frozen temporarily at the instant of the time-mark, high accuracy can be maintained without hurrying the observer who records them. A manual reset could be performed once the values had been logged. It is desirable to record distance values also at times of non-standard events such as course and speed changes. Positions could then be obtained by linear interpolation between values recorded, without recourse to other information.

Further advantages can be obtained by logging data on forms oriented to key-punching. The data sheets may then be punched readily at CSIRO with little editing or by contract at IBM or other firms. All that is required is the introduction of background tick marks on existing forms to ensure that each digit is clearly and correctly positioned ready for punching. An example of similar forms used in BMR is attached (Plate 5).

Accurate timing is essential to permit best use of the data. Five-minute time-marks are being recorded on a side pen; the two recording traces have zero shifts relative to the side pen. The time-marks should be checked for regularity from time to time to ensure that there are no paper feed problems. Special time-marks will be provided at the times of satellite fixes, and these should be marked accordingly.

Regular calibration of the recorder is needed to allow merging of the digitised 100-gamma and 1000-gamma traces in disturbed areas and to obtain data consistent to $\pm$ 1 gamma. Digitizing complications will be reduced if the recorder is recalibrated only at the start of each days recording, but checked at regular intervals. A six-hourly checking interval is considered adequate, but should the calibration shift by more than 0.05 inches, recalibration must be carried out and a more frequent checking interval adopted.

When the magnetometer is functioning properly, the noise level is generally 2 gammas peak-to-peak ($\pm$ 1 gamma), occasionally 3 gammas peak-to-peak. This is readily observed on the 100-gamma trace with a polarization cycle of 5 seconds, which should be used at all times. Higher noise levels can arise from a variety of causes. It will pay to start checking at the simplest possibility, working to the more complex. The most useful steps when investigating excessive noise are:

Check that the tuning is properly set for the magnetic field being measured, and cross-check against the expected field value (Plate 3).

Vary the tuning and inspect the result on the oscilloscope; the amplitude of the precession signal should reach a maximum and should be clearest when the equipment is properly tuned, and the signal should last for a reasonable length of time.

Check the oscillator and any other electronic parts easy to get at; fuses, polarization current and period of polarization, cycle rate etc.

Check all electrical plugs carefully, particularly at the winch and sensor; clean as necessary.

Inspect the cable and sensor for damage such as broken wiring, broken shielding, and earthing.

5. SHIPBOARD MAGNETIC OBSERVATIONS

All magnetic data will be recorded in analogue form. It is essential that the strip chart recording and annotated information are adequate for later processing requirements. All relevant data as well as the magnetic values should be annotated on the strip chart, so minimizing extra paper work. All non-standard events should be clearly marked on the record at the time at which they occur. These would include: start and end of lines, all changes in course and speed, instrument problems and modifications, calibrations, changes in tuning, satellite passes.

Records should correspond with the GMT day, i.e. run from 0000 to 2400 GMT, regardless of the lines being run. The only exceptions should be when the cruise begins and ends or when there is a major break in observations at sea. To provide a ready reference each record should be labelled with the date, Julian day number, start and stop times, record sequence number, and the lines or parts of lines run. A separate index list should be kept of this information.

The chosen paper speed is 12 inches per hour, which must be maintained for all magnetic recording. It is sometimes the practice to vary paper speed according to the rate of change in the magnetic field value, faster paper speed in areas of more rapid field change and vice versa. This permits equally accurate scaling from the chart for both slow and rapid variations. However, it requires continuous close attention to the recorder and additional annotation of chart speed changes. Both the changes and the annotations tend to introduce errors during the subsequent digitization. Therefore variable chart speed is unacceptable for both operational and data processing reasons. The D-MAC digitizer to be used has an accuracy of ± 0.5 mm; this is equivalent to ± 0.02 miles, assuming a paper speed of 12 inches per hour and a ship's speed of 12 knots; also, it represents about 6 seconds in magnetic record time and about 2 gammas difference in magnetic record intensity assuming 1000 gammas full-scale on a chart paper width of 10 inches. These accuracies will be adequate for high-accuracy work in all but the most extreme cases.

Two pens are used to record simultaneously at 100-gamma and 1000-gamma full-scale sensitivity. Normally only the 100-gamma trace will be digitized, but in magnetically disturbed areas this may be impossible and the low-sensitivity trace will supply the necessary backup. To recover the total magnetic field value the digital readout must be noted on the chart at regular intervals. Hourly intervals are proposed, not only to provide ample control most of the time, but also to allow a continual check on the recorder calibration.

The daily routine to be followed by the contractor's observers relative to the magnetic survey is set out in Appendix 1. The procedure to be followed in launching the magnetometer sensor and initiating recording is set out in Appendix 2.

6. SHORE MONITOR AT PORT HEDLAND

Magnetic observations are disturbed by time variation in the total field. For simplicity this can be split into components of two types:

Long-period - daily cycle or diurnal, reaching an amplitude of about 100 gammas.

Short-period - generally one hour or less, which may reach an amplitude of 1000 gammas or even more in extreme cases but are commonly within 100 gammas.

It is important to remove these temporal disturbances from the record made by the field magnetometer in order to permit reasonable analysis and interpretation of the spatial disturbances of the Earth's magnetic field which arise from geological and structural causes.

The long-period disturbances can be determined from the field record, although with degraded accuracy, providing there are sufficient line intersections to detect the total amplitude of the diurnal change in field strength. However, the short-period disturbances cannot be detected in this way. With the vessel travelling at 12 knots they will be indistinguishable from the record of many ordinary spatial field changes. It is the spatial changes with dimensions of this order which are most useful in calculating depth to magnetic basement. For these reasons a separate, stationary monitor recorder is required, operating as close as possible to the survey area, to provide a continuous record of the short-period disturbances. They are generally worldwide and simultaneous in their effect, but the amplitude varies from point to point. Correlation between the ship and monitor data for periods less than one hour permits effective removal of such events from the field record.

The short-period magnetic anomalies caused by the sediment/ basement susceptibility contrast are of low amplitude in all areas except where there is only a veneer of sediments. Amplitudes of less than 10 gammas are considered significant. Accurate observations on ship and shore are necessary to obtain this degree of accuracy in defining both the amplitude and the shape of such anomalies which are needed for depth estimation. On this survey, estimates of depth to magnetic basement are considered the most important objective.

7. SHORE MONITOR REQUIREMENTS

A shore magnetometer station will be operated at Port Hedland throughout the survey to provide diurnal information for the magnetic data being collected on board the Manly Cove.

For the shore station to be established and operated effectively the following action was required.

Accommodation

Accommodation was arranged to house the magnetometer and recording equipment, storage space for charts, inks, and spare parts and working space for the shore station operator. The magnetometer station was sited at Port Hedland airport. Alternatively, a suitable site would have been a house, garage, or shed, but it is essential that the chosen site is free from magnetic disturbances. Mains electricity is required.

Equipment required

Geometrics Magnetometer mod. G806

Chart recorder

Power supply

Batteries

Battery charger

Sensor head and stand

Instruction manuals

Operations instructions

Spare parts kit for all equipment

Clock

Radio (for time signals)

Tool kit

Log sheets

Stationery

Vehicle

Purchase order book

Petrol order book

Personnel

An operator was required to assist with the setting up of the shore station and to run it throughout the survey.

A technical officer (J. Grace) set up the equipment and ensured that it was operating satisfactorily before the survey commenced. The time required to set up the shore station and attend to shipboard operations was three days.

A technical assistant (Miss M. Amar) flew to Port Hedland on 28 April and commenced operation of the station on 29 April. Regular marine survey observations commenced on 30 April.

Vehicle

A station sedan for the use of the shore station operator was arranged through the BMR Vehicles Officer in Canberra.

Magnetometer and electronic equipment

The magnetometer, battery charger, chart recorder, and power supply were checked by the Maintenance and Testing group. This equipment was sent by air freight to Port Hedland.

Daily routine

The daily routine to be followed by the shore monitor operator is set out in Appendix 3.

8. REFERENCES

B.O.C. OF AUSTRALIA LIMITED, 1971 - Bedout No. 1, completion report. Bur. Miner. Resour. Aust. Petrol. Search Subs. Acts Rep. (unpubl.).

B.O.C. OF AUSTRALIA LIMITED, 1972 - Picard No. 1, completion report. Ibid. (unpubl.).

HEMATITE PETROLEUM PTY LTD, 1973 - Final report, 1972 seismic survey, north-west continental shelf, Western Australia. Bur. Miner. Resour. Aust. Petrol. Search Subs. Acts Rep. (unpubl.).

WHITWORTH, R., 1969 - Marine geophysical survey of the northwest continental shelf, 1968. Bur. Miner. Resour. Aust. Rec. 1969/99 (unpubl.).

APPENDIX 1: DAILY SHIPBOARD ROUTINE

1. Remove record each day at 0000 GMT and check that there is sufficient paper for the next 24 hours' operation.

2. Pull paper forward ½ metre and label with date, Julian day number, and chart sequence number.

3. Reset zero and full-scale deflections on recorder at the start of each days record, marking recalibration on chart.

4. Read magnetic field value from digital display each hour on the hour and write it on record against hour mark.

5. Label hour mark with day and hour with a pen; also mark times of all satellite fixes

6. Check tuning of magnetometer at regular intervals using oscilloscope; mark chart with new value if tuning range is changed

7. Check zero and full-scale calibration of recorder every six hours, but do not recalibrate unless error exceeds 0.05 inch; mark calibration on chart; make sure that a calibration check is made shortly before 0000 GMT, i.e. at end of day's record

8. Mark the start and end of each line with time and line number; should a big break in time be anticipated between the end of one line and the start of the next, turn off recorder and mark the break clearly

9. Note on the chart against the appropriate time-mark all course and speed changes and the times at which they occur

10. After the record is taken off, label the end with date, Julian day number, and chart sequence number; then note start and stop times of the record and lines traversed during the day; e.g. end line 05, line 06, line 07, start line 08; mark these on both the beginning and end of the record.

APPENDIX 2: PUTTING OUT THE MAGNETOMETER

1. Inform the ships' bridge of the intention to stream the magnetometer and await their acknowledgement that ship's speed has been reduced to 2 to 3 knots; use a similar procedure when picking the cable up.

2. Connect the lead from winch to power outlet (in centre deck) and switch on.

3. At the winch - remove the canvas cover,
   - unlash the sensor,
   - check that the buoy-rope is properly attached to the magnetometer sensor,
   - check that the coil of rope is free to uncoil without obstruction,
   - check that the rope is securely attached to the buoy at the shipboard end and that the buoy is adequately inflated,
   - unchain the reel,
   - unplug the sensor signal cable and tuck it under the elastic strap on the side of the reel,
   - switch on the winch motor,
   - lower the cable into the sea and allow the cable to reel out to the required length (200 m for recording),
   - stop the reel in such a position that the sensor signal cable can be reconnected without strain,
   - replace the chain through the reel,
   - connect the sensor signal cable, making sure it is pushed completely home,
   - replace the canvas cover,
   - disconnect the winch power cable at the winch, and stow it under the deck rail with the end wrapped in a waterproof bag.

4. At the equipment rack -
   - plug in the D.C. power supply and switch on power at the wall socket,
   - switch on the D.C. power supply,

- adjust the output to 28 volts,
- check all switch settings (see manual, page 3-2),
- switch on the power switch of the magnetometer system,
- monitor the Internal voltages, + 12V, -12V, +5V,
- switch the mode switch to 'normal' and the monitor switch to 'polarization' and check the polarizing current,
- switch the monitor switch to 'signal',
- adjust tuning to give the maximum signal.

5. At the recorder -

- check that the paper supply is adequate for 24 hours' operation; change if necessary,
- check the switch settings (see manual),
- turn on the power and chart switches,
- carry out zero and calibration checks,
- check that the event marker is operating properly,
- write the sensitivity and polarization rate on the chart.

6. Maintenance

<u>Winch</u>
- keep the cover on the winch whenever the winch is not being operated.
- keep the signal cable connector greased with a non-conducting grease such as silicone,
- keep the sensor head securely lashed when it is stowed,

<u>Recorder</u>
- clean the pens whenever a new roll of paper is installed and at other times if necessary for clean records.

APPENDIX 3: DIURNAL MONITORING

For the diurnal data collected to be of maximum reliability the shore station shall be visited regularly at not longer than 6-hour intervals, in particular at 000, 0600, and 1200 hours GMT.

The following procedures shall be followed:

Record labelling at the shore station

1 Remove the record each day at 0000 GMT and check that there is sufficient paper for the next 24 hours operation.

2 Pull paper forward 2 feet and label with date, Julian day number, and chart sequence number starting from 21/001.

3 Reset zero and full scale deflections on the recorder at the start of each day's record, marking 'recalibration' on the chart.

4 Read the magnetic field value from the digital display each hour on the hour when at the station, and write the value on the record against the hour mark.

5 Check zero and full-scale calibration of the recorder at every visit but do not recalibrate unless error is greater than 0.05 inches; mark 'calibration' on the chart; make sure a calibration is made shortly before 0000 GMT i.e. at the end of each day's record.

Record labelling in the office

6 Label with date, Julian day number, and chart sequence number at the end of the record taken off, then note the start and stop time of the recording at both the beginning and the end of the record.

7 Go through the record, reading off hourly values and logging them on the computation sheet; do not write hourly values on the strip chart, i.e. the only hourly values noted on it will be from the digital display.

Daily Log sheets - Note at the time of occurrence

1 All instrument adjustments, scale changes, calibration tests.

2 Any equipment faults or reasons for interruption in recording.

3 Any disturbances of the sensor head.

4 Times of visits to the station.

5 Any occurrence which causes unusual or irregular events on the record.

6. Start and stop times of chart.

7 Use a new sheet for each day.

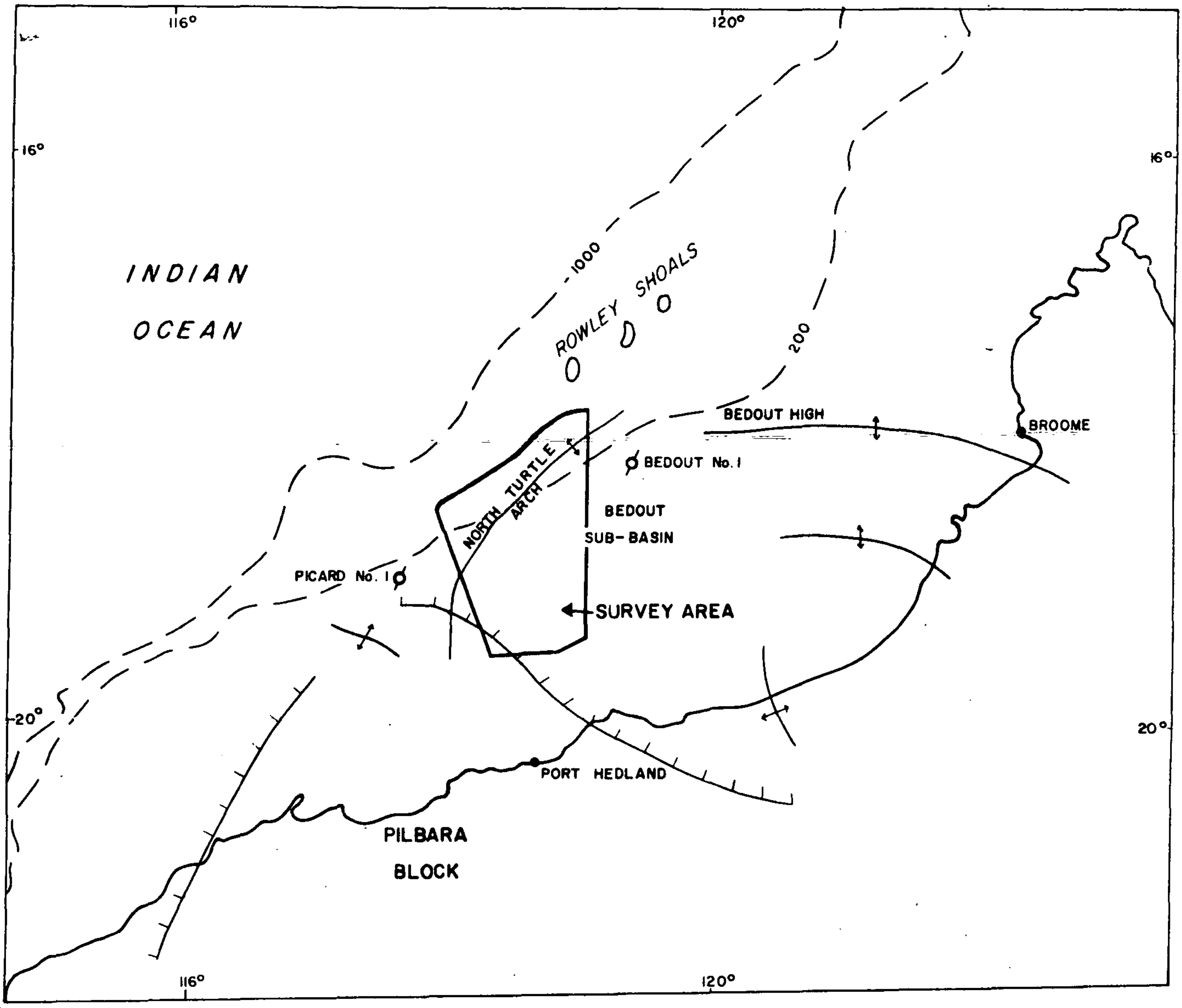
Magnetic Computation Sheet

1 List all hourly values on the Magnetic Computation Sheet; use a new sheet for each day starting from 0000 GMT.

2 Compute the diurnal value by subtracting the regional magnetic value computed from first five days' data.

3 Plot the hourly diurnal values.

4 Despatch the charts, plots and log sheets to BMR Canberra at frequent intervals, say, once weekly.



LEGEND

Dry well

High-angle fault

Anticline

-200- Bathymetric contour in metres

LOCALITY MAP

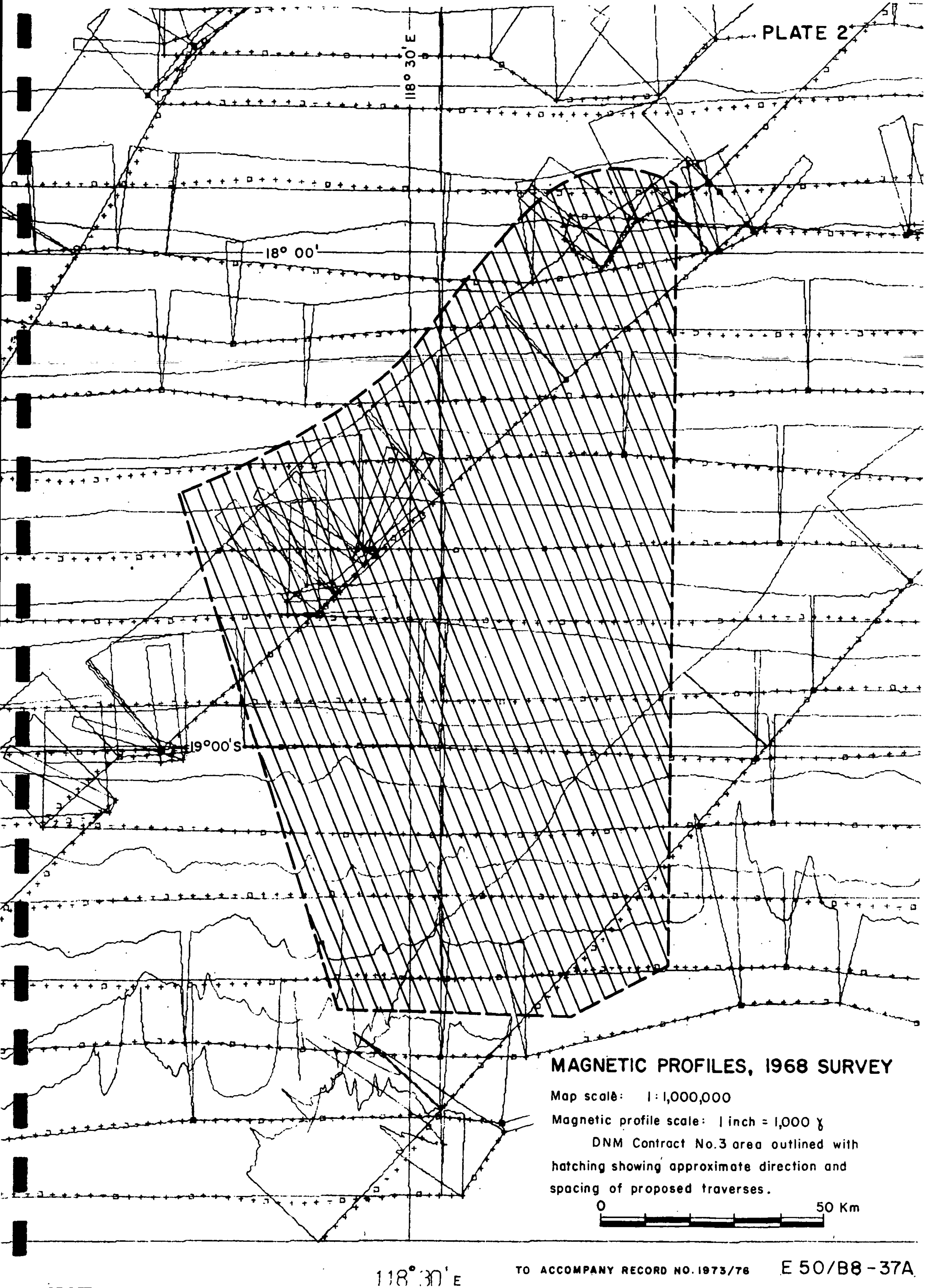
MARINE SURVEY No. 21 – 1973

100 50 0 50 100 150 200

KILOMETRES

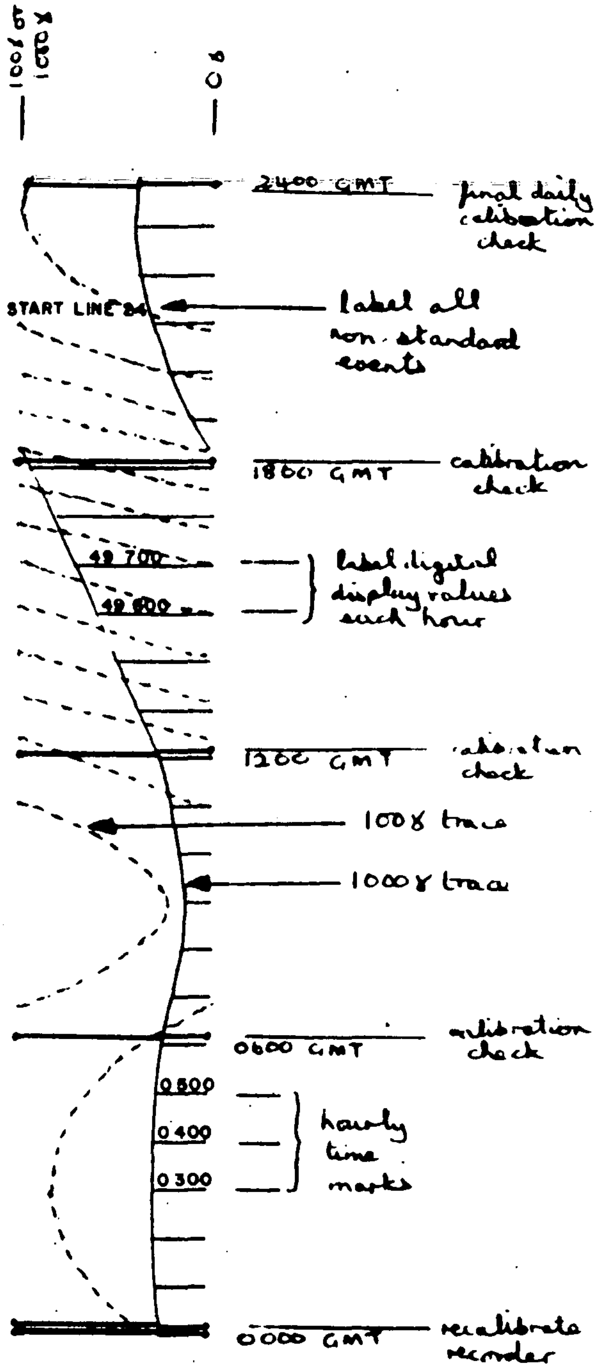
TO ACCOMPANY RECORD NO. 1973/76

E 50/B8–36A

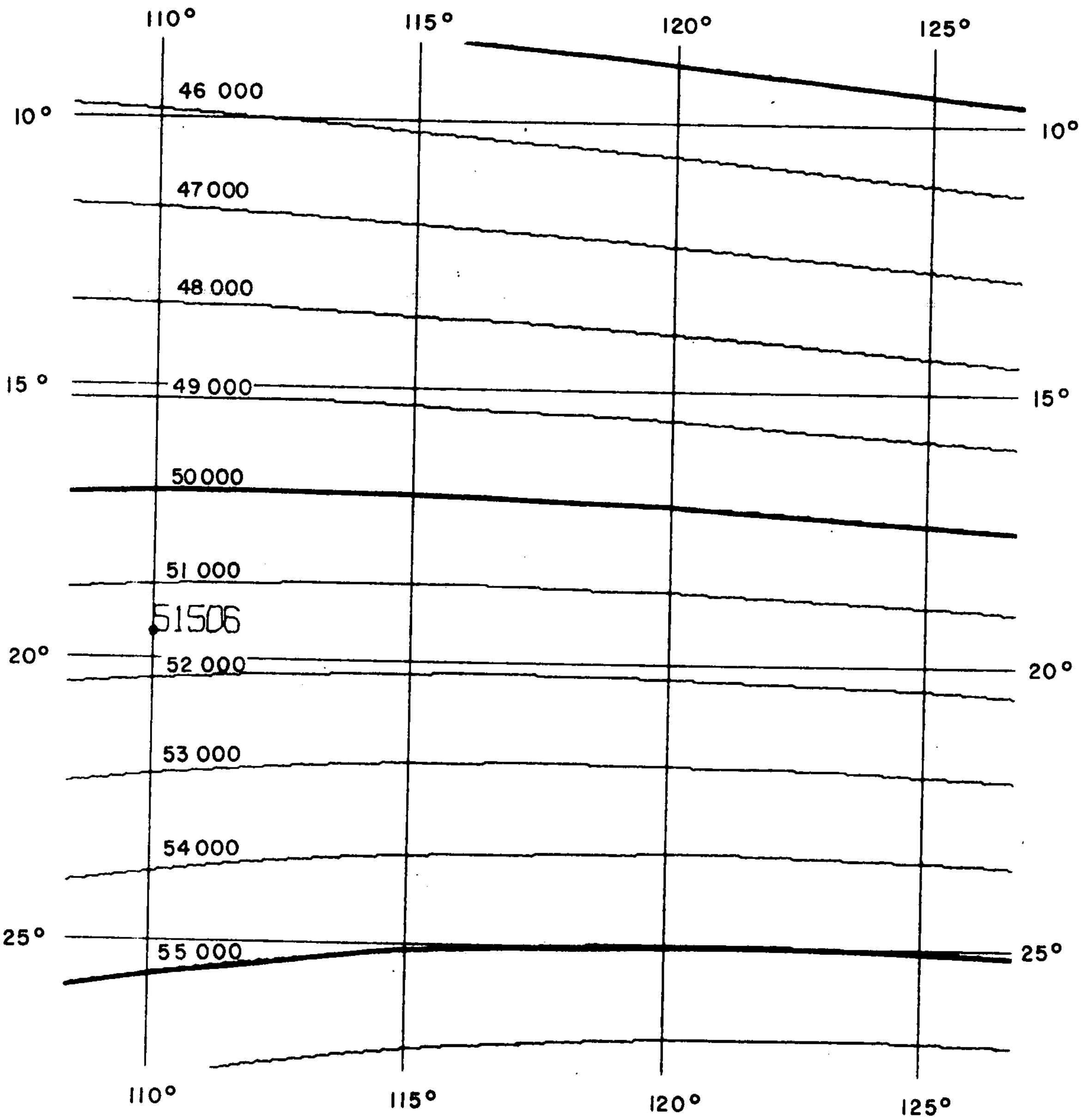


TO ACCOMPANY RECORD NO. 1973/76 E 50/B8-37A

PLATE 3



SCHEMATIC MAGNETOMETER RECORD



REGIONAL MAGNETIC FIELD

BASED ON I.G.R.F.

EPOCH 1970.0

PLATE 5

OBSERVER	SURVEY Nº	DAY

HEIGHT

H 16920

Geophysical Branch
Bureau of Mineral Resources
Geology and Geophysics

AREA	TRAV	DATE	FIELD METER	BASE METER

STATION	TIME	READING	CORR'N	AIR TEMP °C		REMARKS
				DRY	WET	

OBSERVER	SURVEY Nº	DAY

GRAVITY

H 22831

Geophysical Branch
Bureau of Mineral Resources
Geology and Geophysics

AREA	TRAV	DATE	FIELD METER	SCALE FACTOR

STATION	TIME	READING	INSTR TEMP °C	LATITUDE	LONGITUDE	REMARKS

SAMPLE DATA FORMS