BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

BMR RECORD 1984/32

RECORD

Marine Geophysical Survey of the West Woodlark Basin,
M.V. 'Tapini', 1984 - Cruise Report.

by

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ABSTRACT

In July/August 1984 a sparker seismic and magnetic survey of the West Woodlark Basin (PNG) was conducted by BMR, CCOP/EA and the Geological Survey of PNG on the M.V. 'Tapini'. The survey was aimed at studying the tectonic development of the Basin and to assist identification of favourable sites at the spreading axis for future investigation and sampling of polymetallic hydrothermal mineral deposits. 5 north-south lines were surveyed across the basin, including two which coincided with lines previously mapped by H.M.A.S. 'Cook' using SEABEAM. Geophysical coverage amounted to 660 line-km seismic and 1000 line-km magnetics.

Crustal extension has produced extensive normal faulting. At the basin margins, steep slopes and escarpments are indicative of large fault displacements. The central part of the basin has water depths of 2-3 km and is floored by oceanic crust with rough surface expression and little or no sediment cover. Magnetic Anomaly 1 (0-0.72 m.y.) is very distinctive on all lines and occurs as an essentially linear band from the postulated transform at 154'12' E longitude to the termination of the spreading system at 151'45' E longitude. Spreading rate diminishes to the west from about 4.6 cm/yr to 2.7 cm/yr. The magnetic lineation pattern beyond M.A. 1 is not clear, though spreading probably commenced between 1.8-2.5 m.y. (M.A. 2/2A). Early opening appears to have been complex with apparent southward migration or jump of the spreading axis in the eastern part of the region.

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1. INTRODUCTION

This report describes operational details and preliminary geoscientific results of a marine geophysical survey conducted in Papua New Guinea waters of the West Woodlark Basin during July/August 1984.

It is well known that significant polymetallic hydrothermal mineral deposits are associated with rift systems such as the Woodlark Basin (Rona, 1984). The survey was aimed at elucidation of the structure and tectonics of the West Woodlark Basin so as to allow identification of favourable sites for future investigation and sampling of possible metallic mineralization. The work was concentrated along two lines surveyed by H.M.A.S. 'Cook' in June 1983 using SEABEAM (swath-mapping sonar), and was also conducted farther to the east as N-S reconnaissance lines across the basin.

The survey was a joint co-operative undertaking by (i) Bureau of Mineral Resources, Geology & Geophysics - Canberra, (ii) United Nations Committee for the Co-ordination of Joint Prospecting for Mineral Resources in Asian Offshore Areas (CCOP/EA) - Bangkok, and (iii) Geological Survey of Papua New Guinea (GSPNG). The satellite navigation system used during the survey was provided on loan by the Committee for Co-ordination of Joint Prospecting for Mineral Resources in South Pacific Offshore Areas (CCOP/SOPAC).

The 19 metre survey vessel M.V. 'Tapini' (Figure 1), of the PNG Department of Transport & Civil Aviation (Maritime Division) was sub-chartered by BMR for the Woodlark Basin work. It had been fitted with geophysical survey equipment by CCOP/EA and GSPNG for engineering/bathymetric investigations of eight major harbour sites throughout PNG.

Cruise participants included Richard Reid (geophysicist - CCOP/ EA), Peter Hill (geophysicist - BMR), Joe Buleka (engineering geologist - GSPNG), Vahu Oru and Ronald Gawi (technical officers - GSPNG). The ship was commanded by the captain, Joseph Buka and operated with the assistance of six crew members.

The ship sailed from Lae on 26 July and arrived in Port Moresby on 7 August 1984 - seven days were spent in the West Woodlark Basin survey area.

2. OUTLINE OF TECTONIC ENVIRONMENT OF THE WEST WOODLARK BASIN

The Solomon Sea/Woodlark Basin region has been the subject of a number of recent research papers (Weissel & others, 1982; Davies & others, 1984; Taylor, 1984).

The tectonic elements of the area are indicated in Figure 2. Overall oblique convergence of the major Indo-Australian and Pacific Plates in the Cenozoic has produced fragmentation into a mosaic of sub-plates with complex boundary interactions and marginal basin development. The Woodlark Basin has formed as a result of seafloor spreading since the early Pliocene. East-trending rift segments began propagating westward splitting the palaeo-Papuan Peninsula and separating the Woodlark and Pocklington Rises. The westward propagation has proceeded at an average rate of 12 cm/year, equal to the rate of subduction of the spreading system eastwards beneath the Solomon Islands. In the eastern Woodlark Basin total opening rates along the transform-segmented spreading axis have varied temporally and spatially between 56 and 72 mm/year (Taylor, 1984). Northward subduction of the Solomon Sea Plate at the New Britain Trench has accommodated the Woodlark Basin spreading. It has been suggested that "slab pull" associated with this subduction may be responsible for the Solomon Sea/ Indo-Australian Plate separation.

3. SURVEY METHODS, AND EQUIPMENT

The survey was conducted with a single-channel sparker seismic system and towed magnetometer. Ship positioning was by satellite navigation (U.S. Navy Navigation Satellite System). Details of the equipment are provided in Table 1, while Figure 3 shows the seismic steamer layout and configuration of geophysical sources and sensors while underway. Both streamers were used during the survey, and some experimentation was done to obtain optimum results under various conditions of sea-state. It was found however that there was no major difference in performance between the two - the EG & G 8-element streamer had the advantage that the length of cable available allowed it to be towed further behind the boat (beyond the wake turbulence), but had the disadvantage of fewer hydrophone elements (cf., the 40 elements of the Special streamer).

The spark array was towed at a depth of 3-4 m and operated at 4.5 kJoule output initially, later increased to 6.5 kJoule. The firing rate was set at 4 seconds except over the deeper part of the basin where an 8 second shot interval was used. Optimum signal was achieved by passing the pre-amplified output from the streamer through two sets of Krohn-Hite filters set for a passband of 60-1000 Hz. The magnetometer was cycled at 6 seconds.

During the survey, sea and weather conditions were not conducive to high quality seismic recording due to high background noise levels. Seas were moderate-rough, with winds from the east or south-east ranging in strength from 10-35 knots. Nevertheless, given the relatively low power of the system and extreme water depths (2-3 km), the results are considered quite satisfactory.

TABLE 1. GEOPHYSICAL SURVEY EQUIPMENT

NAVIGATION:	Magnavox MX 4102 Satellite Navigator
SEISMIC:	EG & G Control Bank Model 231 (100-1000 Joule)
	EG & G Power Supply Model 232A
	EG & G Capacitor Bank Model 233A (3.5 kJoule)
	EG & G Capacitor Bank Type 233 (2 kJoule) 3-electrode spark array
	EG & G streamer cable Model 265 (8 hydrophone elements)
	Special streamer cable - 4 active sections (10 elements/section)
	EPC Graphic Recorder Model 3200
	Krohn-Hite Model 3700 filter units
MAGNETICS:	Geometrics G801/803 marine-airborne proton magnetometer
	Hewlett-Packard Model 7130A chart recorder.

Lines traversed during this survey (designated as Survey 45 in the BMR marine data base) have been plotted by computer in Figures 4 & 5, together with the previous 1970 BMR Survey 05 lines (Tilbury, 1975) and the 1983 H.M.A.S. 'Cook' SEABEAM traverses. Both seismic and magnetic data were collected on Lines 1, 2, 3, 4 & 5, while only magnetic data were acquired for Lines 4A & 5A. The magnetic data for the Milne Bay area (western part of Line 5A) were collected while on route to Alotau, and though not directly relevant to the West Woodlark Basin study, may prove useful for other regional investigations. Lines 2 & 3 were designed to follow the SEABEAM traverses as closely as the navigation system and prevailing sea-state/ ocean current situation would allow. Due to current and wind, the ship's drift was typically 1-2 knots to the west.

With only the magnetometer being towed, the ship was run at full speed (about 8 knots), however while seismic recording the ship's speed was reduced and maintained at an average of about 4 knots so as to improve signal/noise levels. Total geophysical coverage amounted to 660 line-km seismic and 1000 line-km magnetics.

4. DATA PROCESSING

During the survey a continuous record of navigational data was maintained in two logs - (i) satellite fixes (showing time, position and quality parameters of fix) & (ii) dead- reckoning (change of speed or heading of ship). Both seismic and magnetic data were recorded in analogue form as paper charts.

On return to BMR, the navigational data were re-assessed, and from the dead-reckoning data and all satisfactory satellite fixes a navigation computer file was created. This file of 1-minute navigational data included calculated position derived from adjustment of the dead-reckoned values to the fixes using time linear interpolation. The magnetic and seismic records were digitized at 5-minute intervals to extract total magnetic intensity values and two-way sea-floor reflection times, respectively. The reflection times were converted to water depths by the adoption of 1500 m/s as the water velocity. The magnetic and bathymetry data were merged with the navigation file and incorporated as 1-minute values by linear interpolation of the 5-minute data. Subsequent processing and plotting was based on the resultant data file.

5. PRESENTATION OF RESULTS

The seismic sections for Lines 1-5 are presented in Figures 6-10, respectively. The original sections were photographically reduced, cut according to delay time and patched together for more continuity of seismic horizons and improved readability. The records are 2.0 s full scale, except for some deeper parts of the Woodlark Basin where an increase to 4.0 s full scale was made.

Figure 5 shows the bathymetry profiles for the West Woodlark Basin. Profiles from an earlier BMR survey (05) completed in 1970, have been included.

The magnetic anomaly profiles for the West Woodlark Basin are plotted in Figure 12, and those for the Milne Bay area are shown in figure 13. Again the 1970 BMR profiles have been included. The reference field on which the magnetic anomaly values are based was taken as the AGRF (Petkovic & Whitworth, 1975) for the 1970 data and the IGRF (Peddie, 1982) for the current survey (45). No corrections for diurnal variations in the earth's field have been applied to the 1984 data, nor has any attempt been made to tie magnetic or bathymetric profiles at track crossings.

6. PRELIMINARY INTERPRETATION

Interpretation of the West Woodlark Basin data is presented as line drawings of the seismic profiles showing principal elements of contained structure and stratigraphy, and as correlation of observed magnetic anomalies with those expected from a seafloor spreading model based on the geomagnetic reversal time scale (Figure 14).

The trans-basin sections show a rugged seafloor topography, generally with steep escarpments at the margins of the basin descending to a floor of variable relief at depths of 2-3 km. The basin morphology appears to have developed by extensive normal block faulting and overall subsidence accompanying the rifting process. The central part of the basin is occupied by young volcanic basement with irregular outcrop and subcrop beneath thin sediment cover (generally less than 100 m). The volcanic basement, presumed to be Quaternary basaltic oceanic crust, has suffered significant disruption through axial (E-W) normal block-faulting caused by active extension. Normal faulting at the margins of the basin is generally more spectacularly developed, however. No pronounced topographical expression of the spreading axis can be discerned, though there is a suggestion on some lines (including SEABEAM) that it is marked by a subdued rift valley. Axial zones with no significant or slightly negative relief are typical of slow- intermediate spreading rates of about 4 cm/yr (Rona,1984).

The thickest sedimentary section is observed in the NW of the area. The basal part of the sequence is at least 1000 m thick and consists of gently folded and faulted beds, probably of the Mio-Pliocene sediments and volcanics of the Trobriand Basin. The unconformably overlying unit is an onlapping sequence of high amplitude, parallel reflections 700 m thick, which is interpreted as mainly Quaternary shallow marine carbonates. Large-scale slumping of the upper part of this unit is evident on the slopes north of the axis of the basin, and is characterized by humpy seafloor topography and loss of internal reflection coherence. Diffracting acoustic basement beneath the sediments is likely to be composed of volcanics - possibly of Palaeocene-Eocene island arc origin, but may be younger.

In the deeper central part of the basin Quaternary sedimentation is present as a thin veneer over the more flat-lying parts of the basement (generally toward the basin margins), and as sediment ponds within local topographic lows of irregular volcanic terrain or within fault-bounded 'graben'. The volcanics in the centre of the basin are virtually bare of sediment cover, but as expected there is a general increase in sediment accumulation toward the basin margins, with an average of about 150-200 m of young sediment present at the base of the marginal slopes.

On the magnetic anomaly profiles, central Magnetic Anomaly (M.A.) 1 is clearly indicated. From the width of M.A.1, total spreading rates of about 4.6 cm/yr for the eastern part of the West Woodlark Basin, decreasing to about 2.7 cm/yr to the west, are inferred. The width of M.A.1 is less than the width of exposed or thinly covered volcanic basement (presumed oceanic crust) indicating that spreading commenced well before 0.72 m.y. There is some suggestion of M.A. J, 2 and possibly 2A in the eastern profiles, but the seafloor magnetization pattern is not clear. The onset of spreading is estimated at roughly 1.8-2.5 m.y.

(1) M.A. 1 occurs as an almost linear band (Figure 15), defining a spreading axis that runs from the postulated transform at 154'12' longitude (Taylor, 1984) in the east to about 151'45' longitude in the west where the magnetic lineations die out. At this point seafloor spreading may terminate at a transform oriented NNW (Figure 15), in line with a zone of depressed seafloor and probable crustal weakness. It is likely that plate divergence continues to the west with thinning of the crust by normal faulting.

(2) Though M.A. 1 forms an essentially linear band, there is suggestion of some deviation at about 152'50' longitude (Figure 15). This may represent a transform-linked dextral offset in the spreading axis of about 14 km. M.A. 1 and the spreading axis to the east of the possible transform are asymmetrically located with respect to both the basin margins and the zone of exposed/poorly sedimented oceanic volcanics. Relative southward migration or jump of the spreading axis prior to 0.72 m.y. is implied.

7. CONCLUSIONS

By the acquisition of 660 line - km seismic and 1000 line - km magnetic data the survey has provided additional new information on the physiography, structure and sedimentation within the West Woodlark Basin and adjacent areas. It has been possible to map the area floored by oceanic crust and locate the position of the spreading axis.

Seafloor spreading began at about 1.8 - 2.5 m.y. and proceeded during the last 1 m.y. at a rate of about 4.6 cm/yr in the east of the West Woodlark Basin, decreasing westward to about 2.7 cm/yr near the termination of the spreading system at 151'45' longitude. M.A. 1 magnetization in the seafloor forms an approximately linear band. Minor deviation suggests possible existence of a transform at about 152'50' longitude with dextral offset in the spreading axis of about 14 km. The early stages of seafloor spreading in the eastern part of the West Woodlark Basin appear to have been complex and relative southward migration or jump of the spreading axis has apparently occurred.

8. REFERENCES

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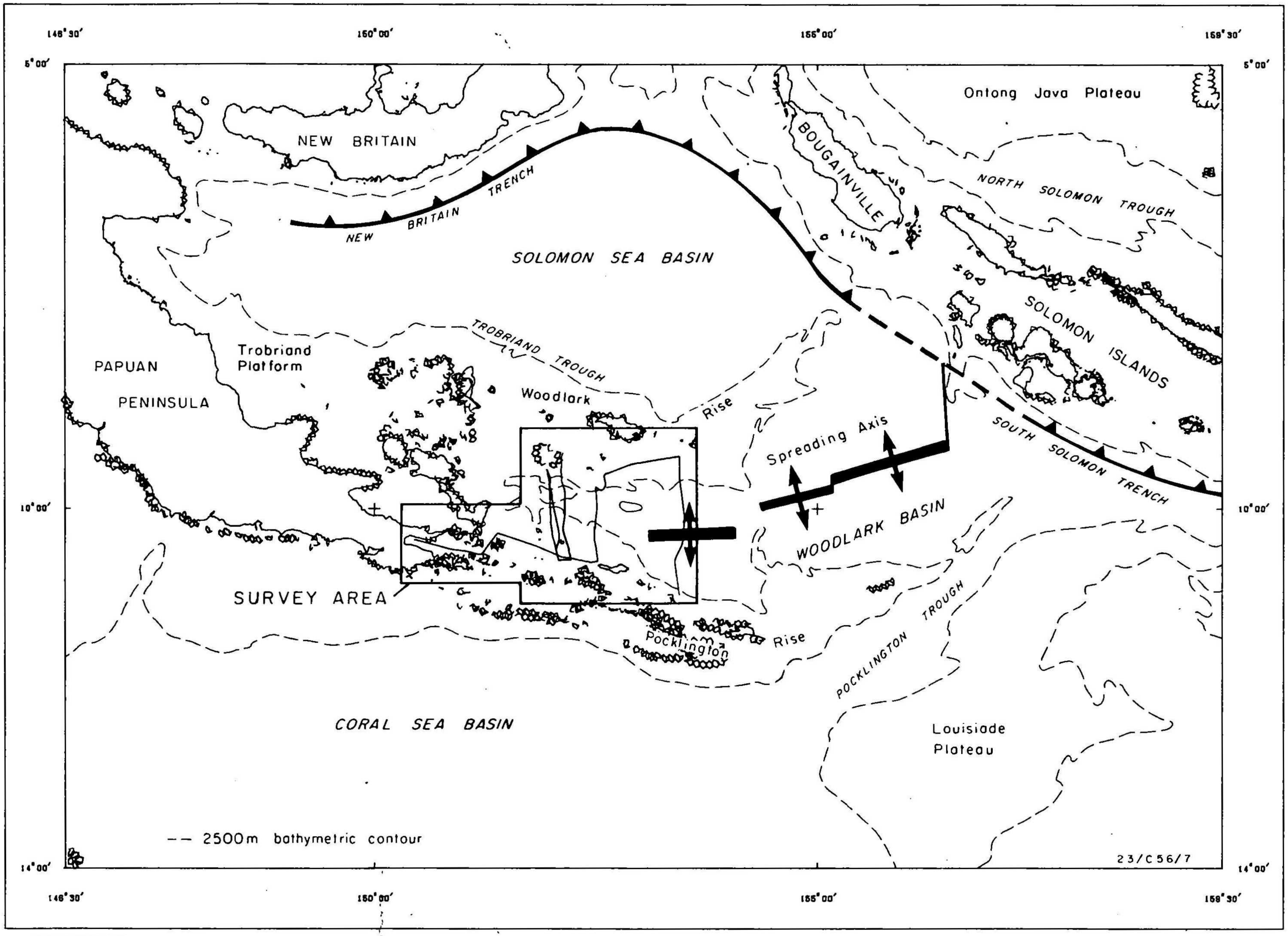
Record 1984/32 23/C56/6

Figure 1 : M.V. 'Tapini'

LOCATION MAP & TECTONIC SETTING

SCALE 1:6442193

EDITION OF 1984/09/12



Record 1984/32

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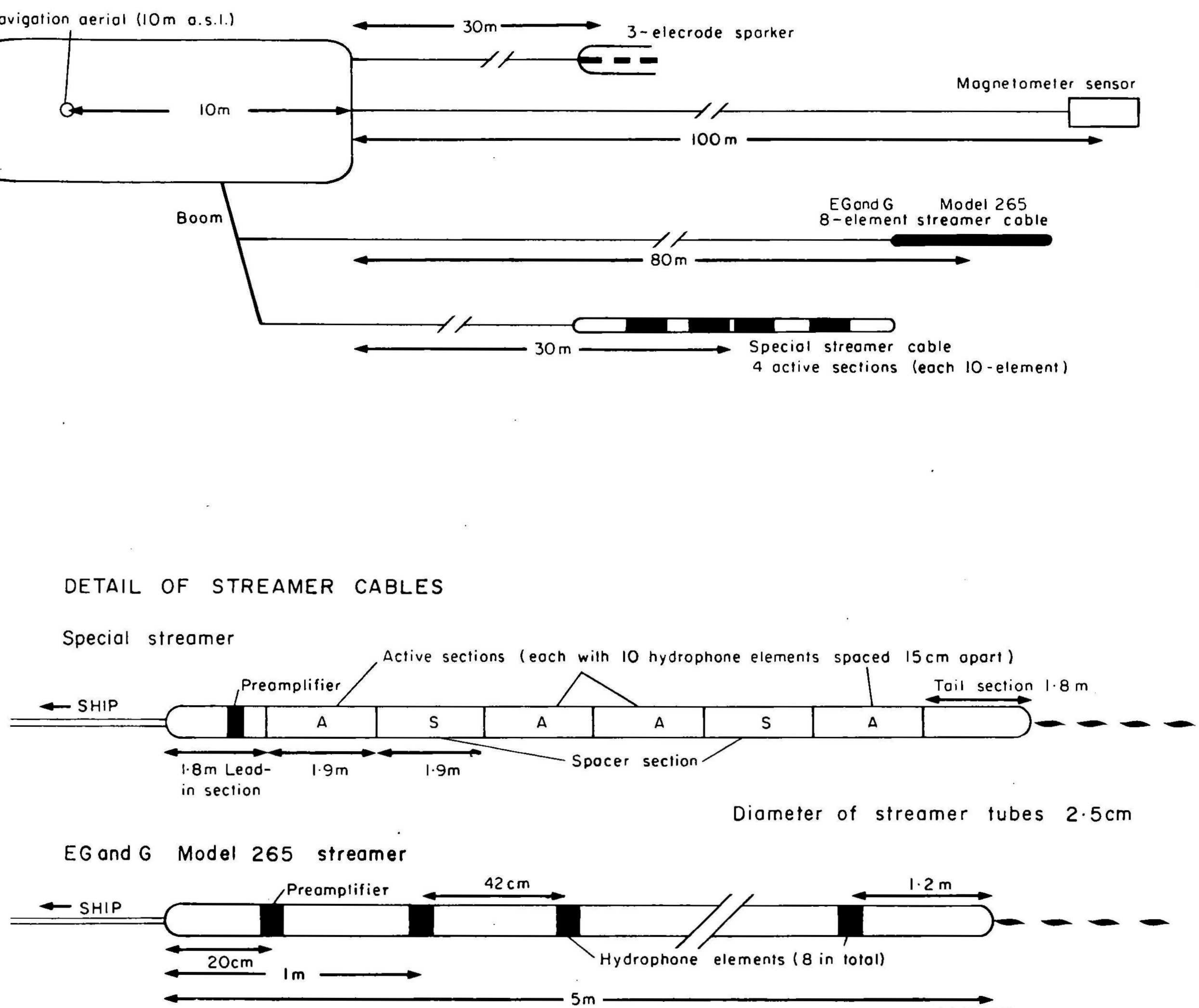
UNIVERSAL MERCATOR PROJECTION
WITH NATURAL SCALE CORRECT
AT LATITUDE 0 00

Figure 2: LOCATION MAP & TECTONIC SETTING



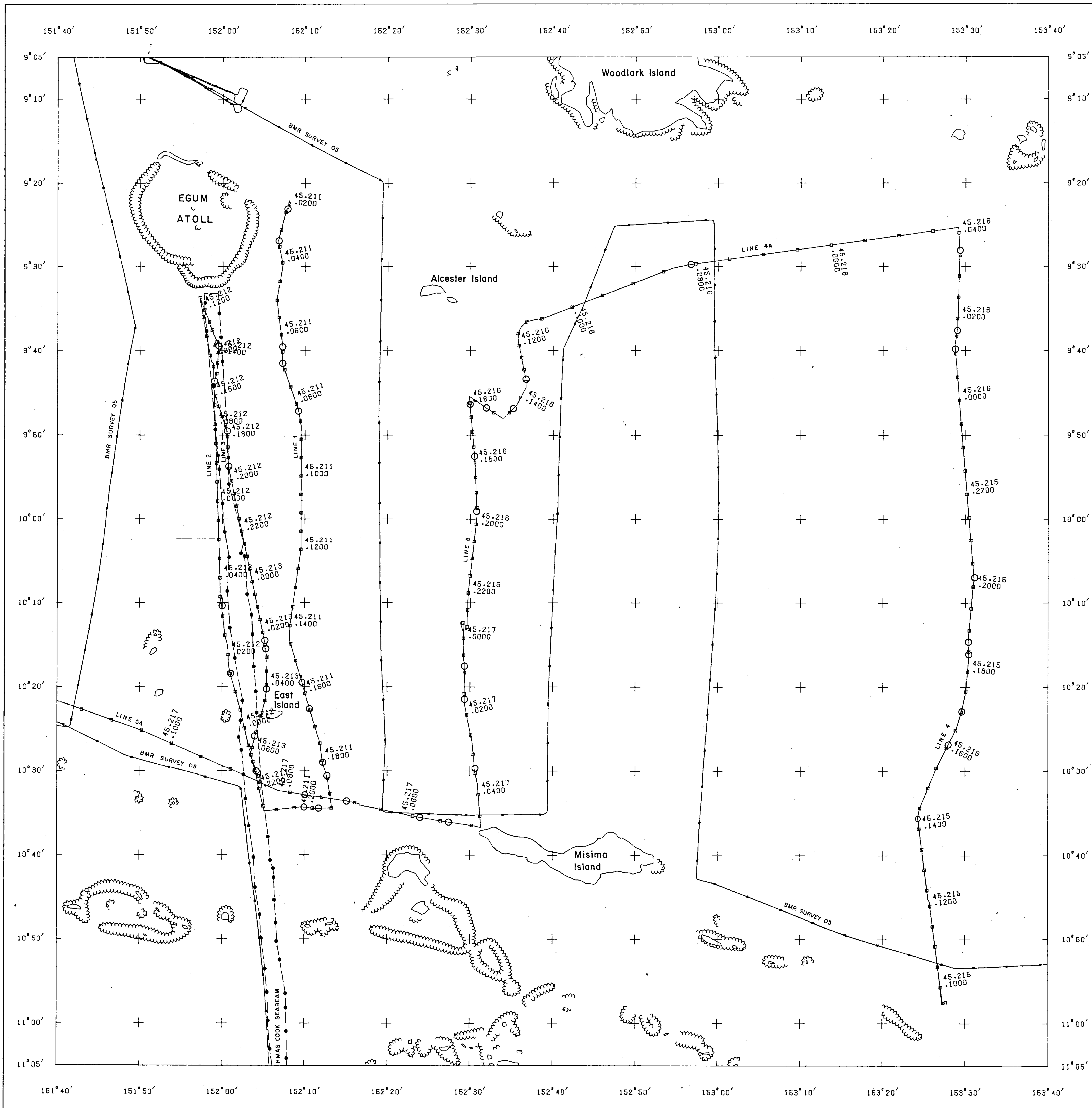
Record 1984/32 23/C56/8

Figure 3: Geophysical system configuration during survey

SURVEY LINES - WEST WOODLARK BASIN

SCALE 1:600000

EDITION OF 1984/09/14



Record 1984/32

23/C56-9

45·217 ·0200 *M.V. Tapini position*
Survey 45
Julian day 217
GMT time (hr, min) 0200

○ *Good satellite fix*

—•—•— *HMAS COOK traverse*

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WITH NATURAL SCALE CORRECT
AT LATITUDE 8 30

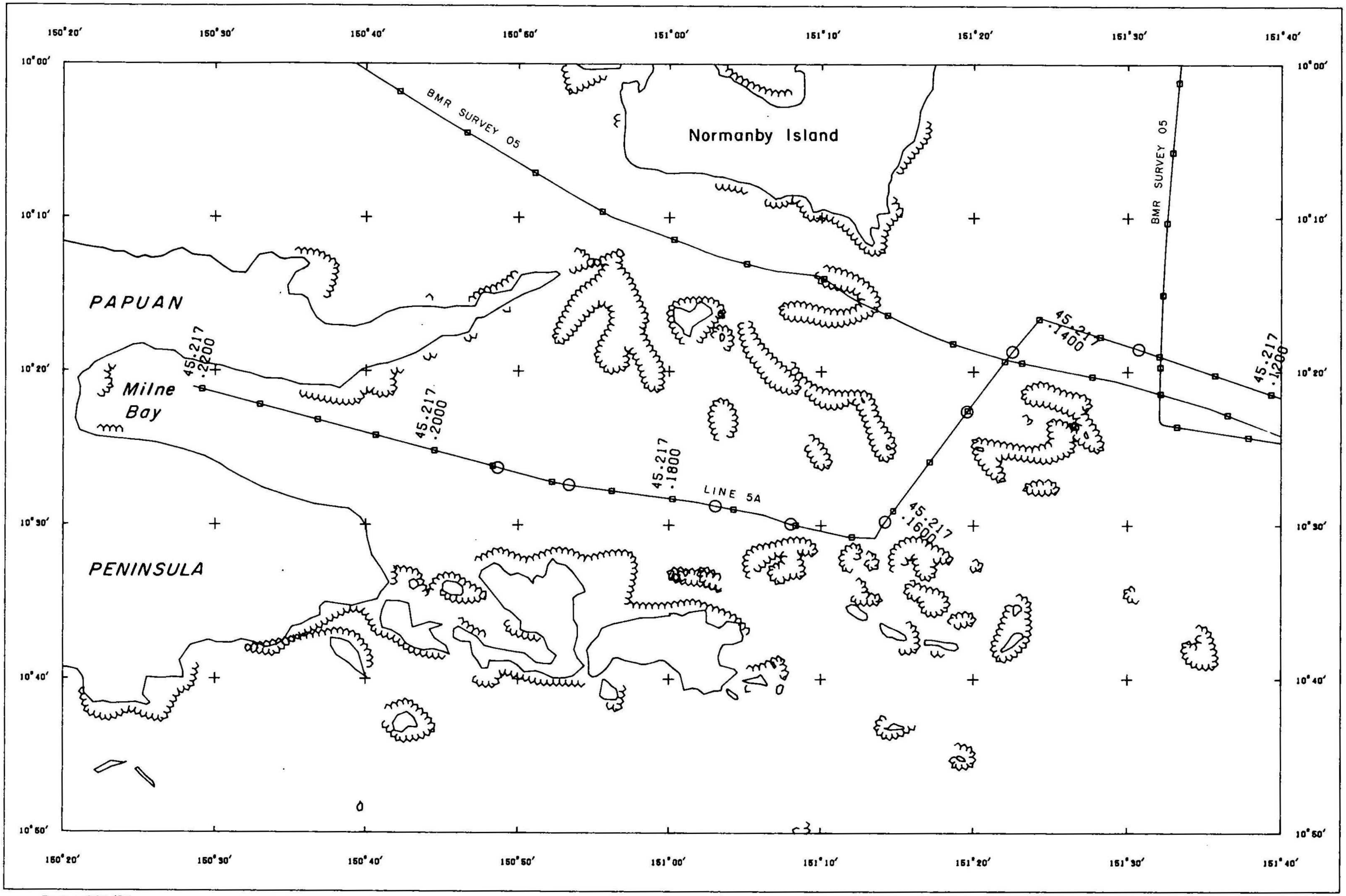
Figure 4: SURVEY LINES - WEST WOODLARK BASIN

SURVEY LINES

SCALE 1:600000

MILNE BAY AREA

EDITION OF 1984/09/11



Record 1984/32

23/C56-10

○ *Satellite fixes*

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WITH NATURAL SCALE CORRECT
AT LATITUDE 8 30

Figure 5: SURVEY LINES
MILNE BAY AREA

Figure 6

WEST WOODLARK BASIN SEISMIC SECTIONS
LINE 1

Figure 7

WEST WOODLARK BASIN SEISMIC SECTIONS
LINE 2

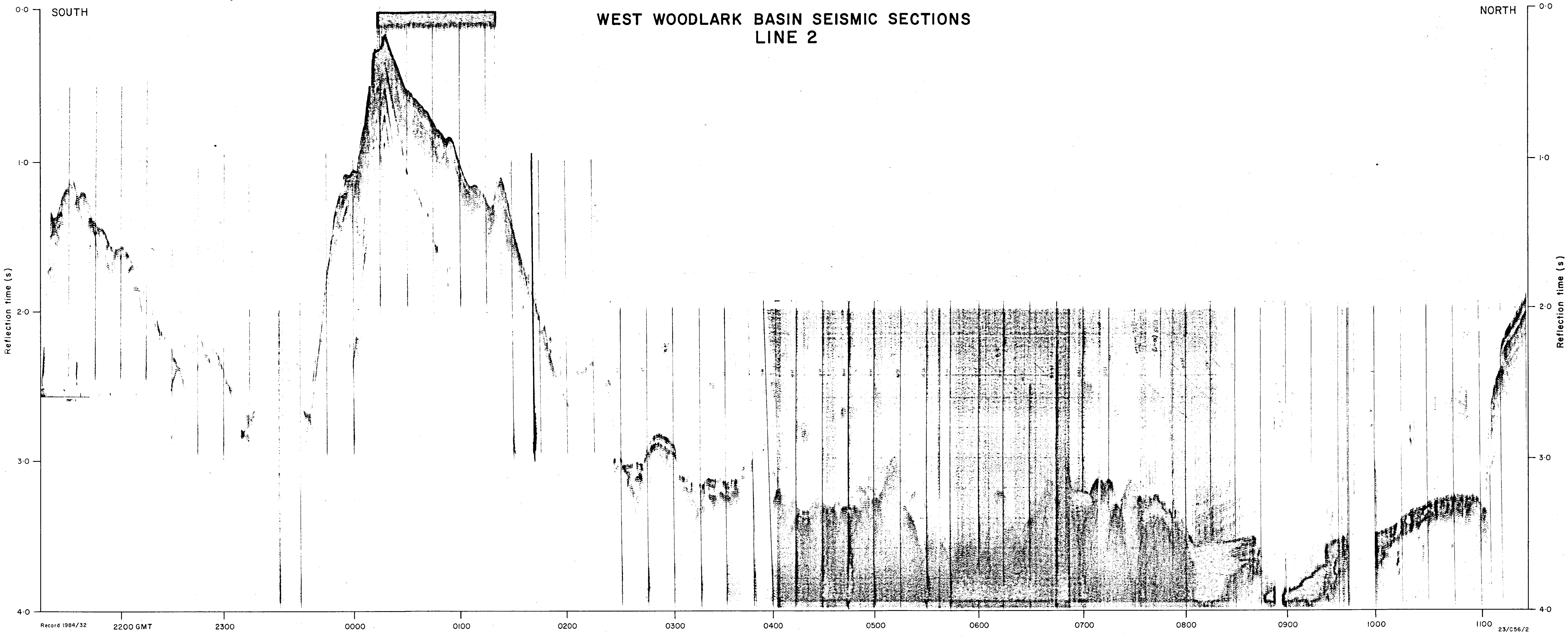


Figure 8


WEST WOODLARK BASIN SEISMIC SECTIONS
LINE 3
NORTH
SOUTH
Reflection time (s)
0·0
1·0
2·0
3·0
4·0
←1·0 s delay
←1·0 s delay
4·0 s full scale
1200GMT
1300
1400
1500
1600
1700
1800
1900
2000
2100
2200
2300
0000
0100
0200
0300
0400
0500
0600
0700
Record 1984/32
23/C56/3

Figure 9

WEST WOODLARK BASIN SEISMIC SECTIONS
LINE 4

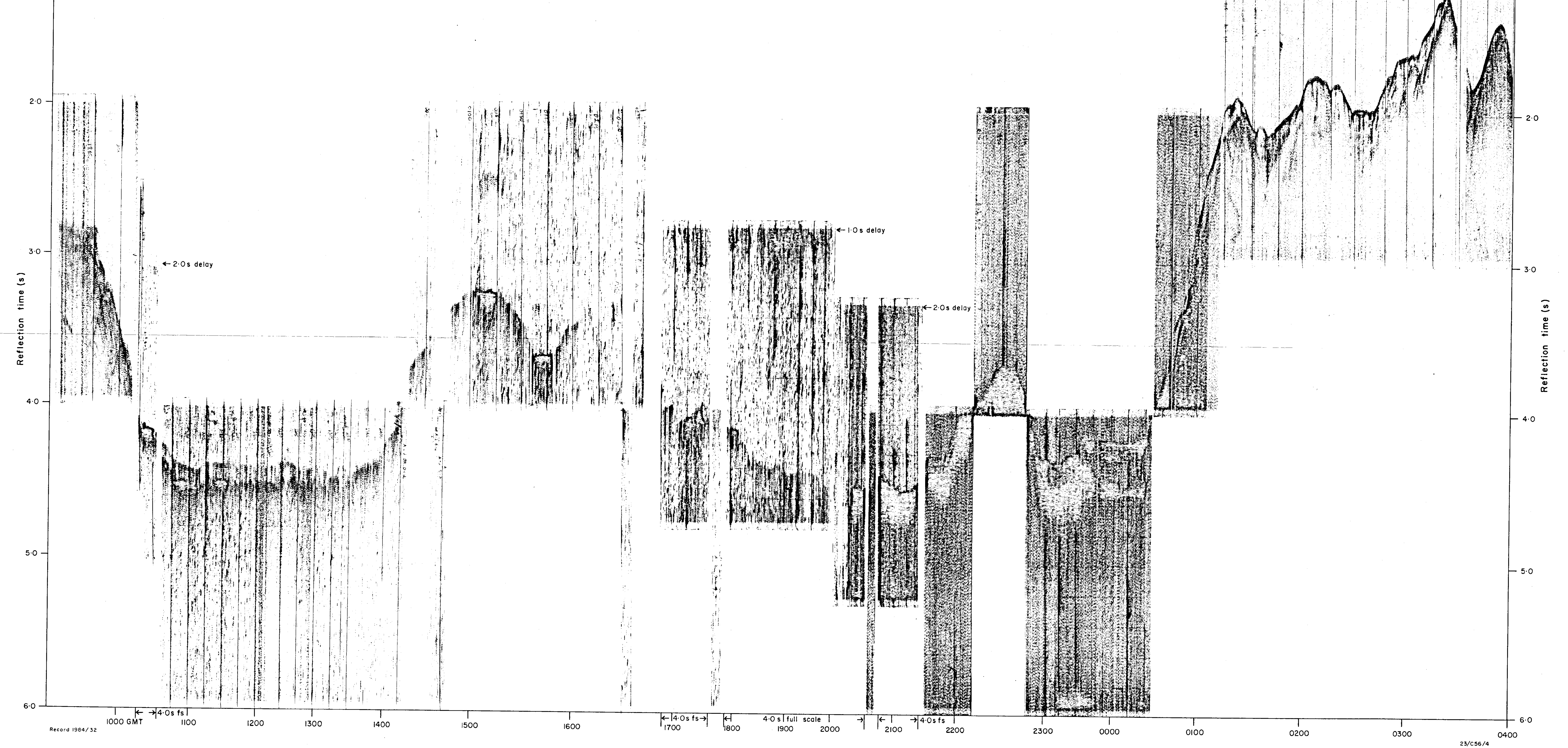


Figure 10


WEST WOODLARK BASIN SEISMIC SECTIONS
LINE 5
NORTH
SOUTH
Reflection time (s)
0·0
1·0
2·0
3·0
4·0
5·0
6·0
←1·0s delay
4·0s full scale
1200 GMT
1300
1400
1500
1600
1700
1800
1900
2000
2100
2200
2300
0000
0100
0200
0300
0400
Record 1984/32
23/C56/5

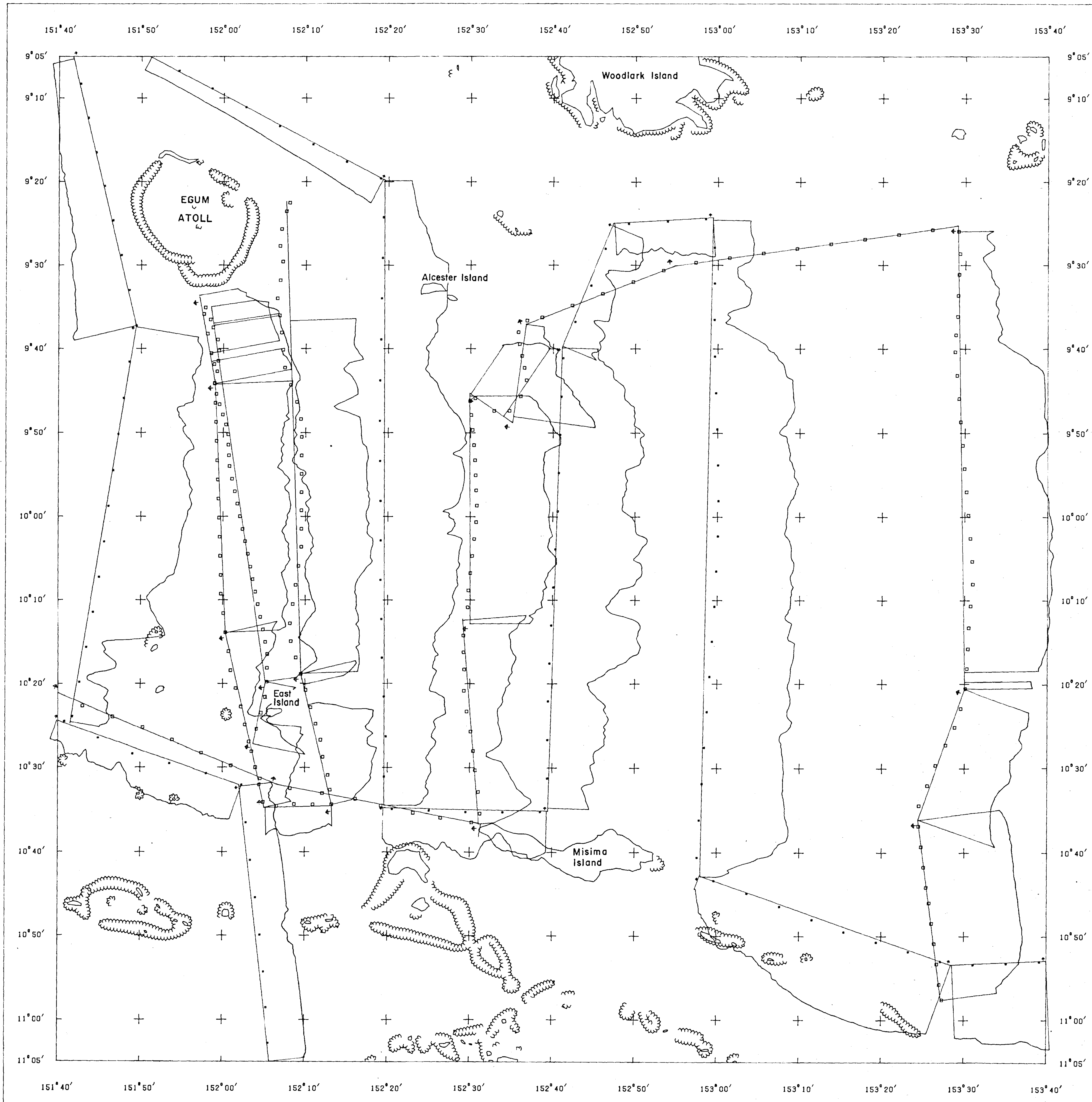
Figure II

BATHYMETRY PROFILES

SCALE 1:600000

WEST WOODLARK BASIN

EDITION OF 1984/10/03



Record 1984/32

▫ Survey 45 (1984) half-hourly positions
• Survey 05 (1970) half-hourly positions

Profile scale 1000m
Profile baseline value: 0m
Positive direction of profile

23/C55-11

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WITH NATURAL SCALE CORRECT
AT LATITUDE 8 30

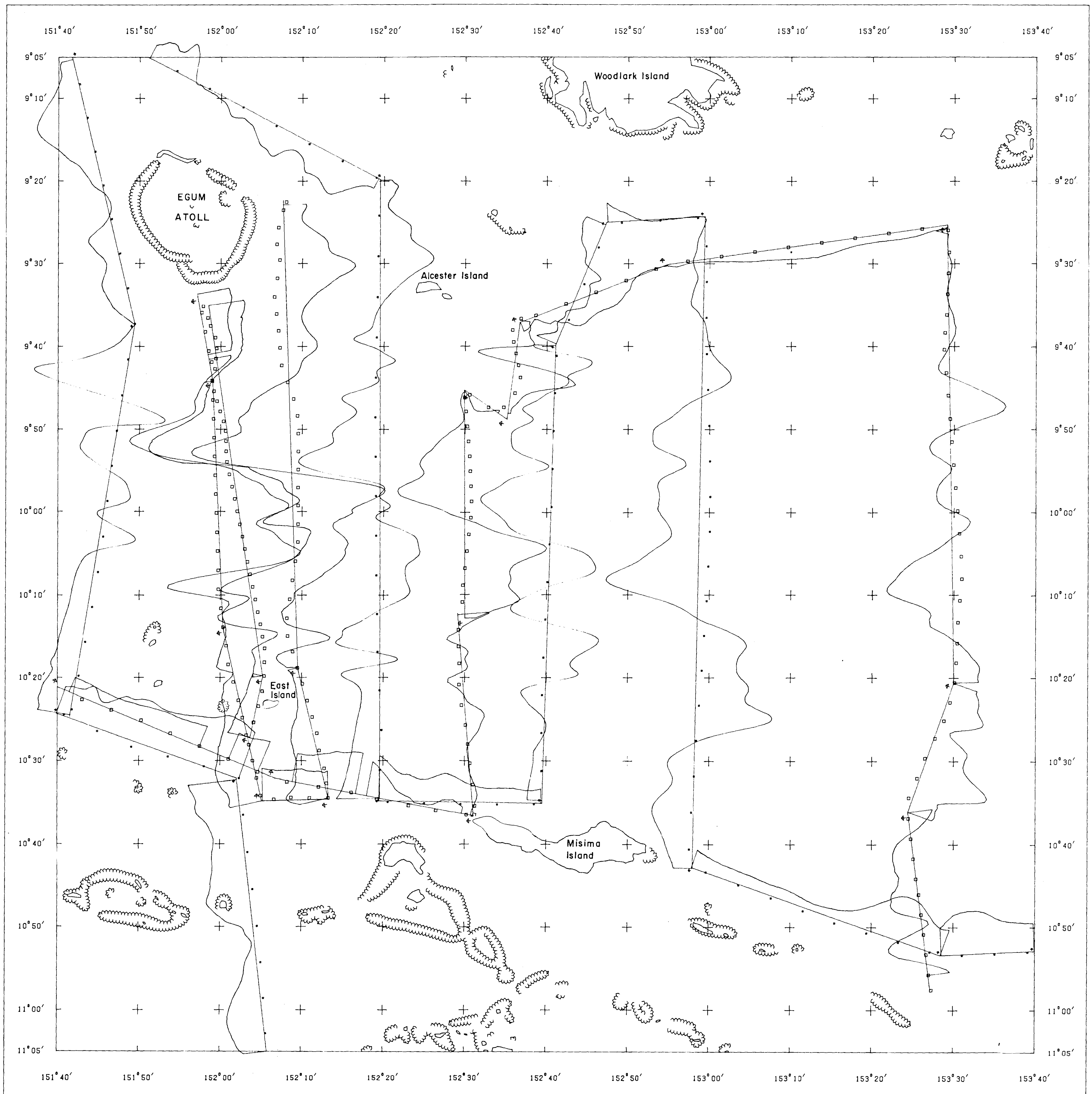
Figure II: BATHYMETRY PROFILES
WEST WOODLARK BASIN

MAGNETIC ANOMALY PROFILES

WEST WOODLARK BASIN

SCALE 1:600000

EDITION OF 1984/10/03



Record 1984/32

23/C56 -12

▫ *Survey 45 (1984) half-hourly positions*
▫ *Survey 05 (1970) half-hourly positions*

Profile scale 200nT
Profile baseline value: 0nT
Positive direction of profile

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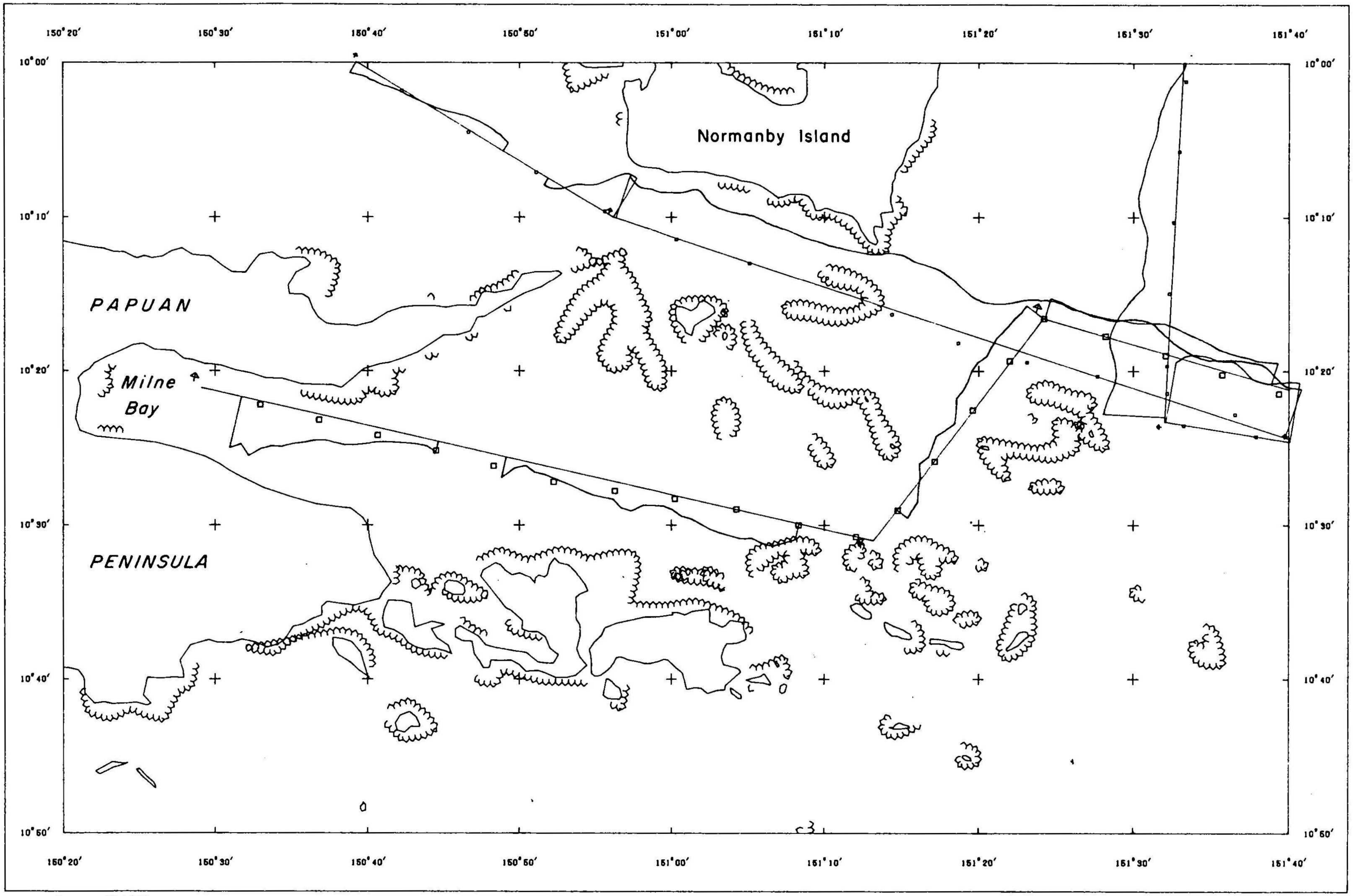
Figure 12: MAGNETIC ANOMALY PROFILES
WEST WOODLARK BASIN

MAGNETIC ANOMALY PROFILES

SCALE 1:600000

MILNE BAY AREA

EDITION OF 1984/10/03



Record 1984/32

23/C56 - 13

□ Survey 45 (1984) half-hourly positions
▫ Survey 05 (1970) half-hourly positions

Profile scale 200nT
Profile baseline value: 0nT
Positive direction of profile

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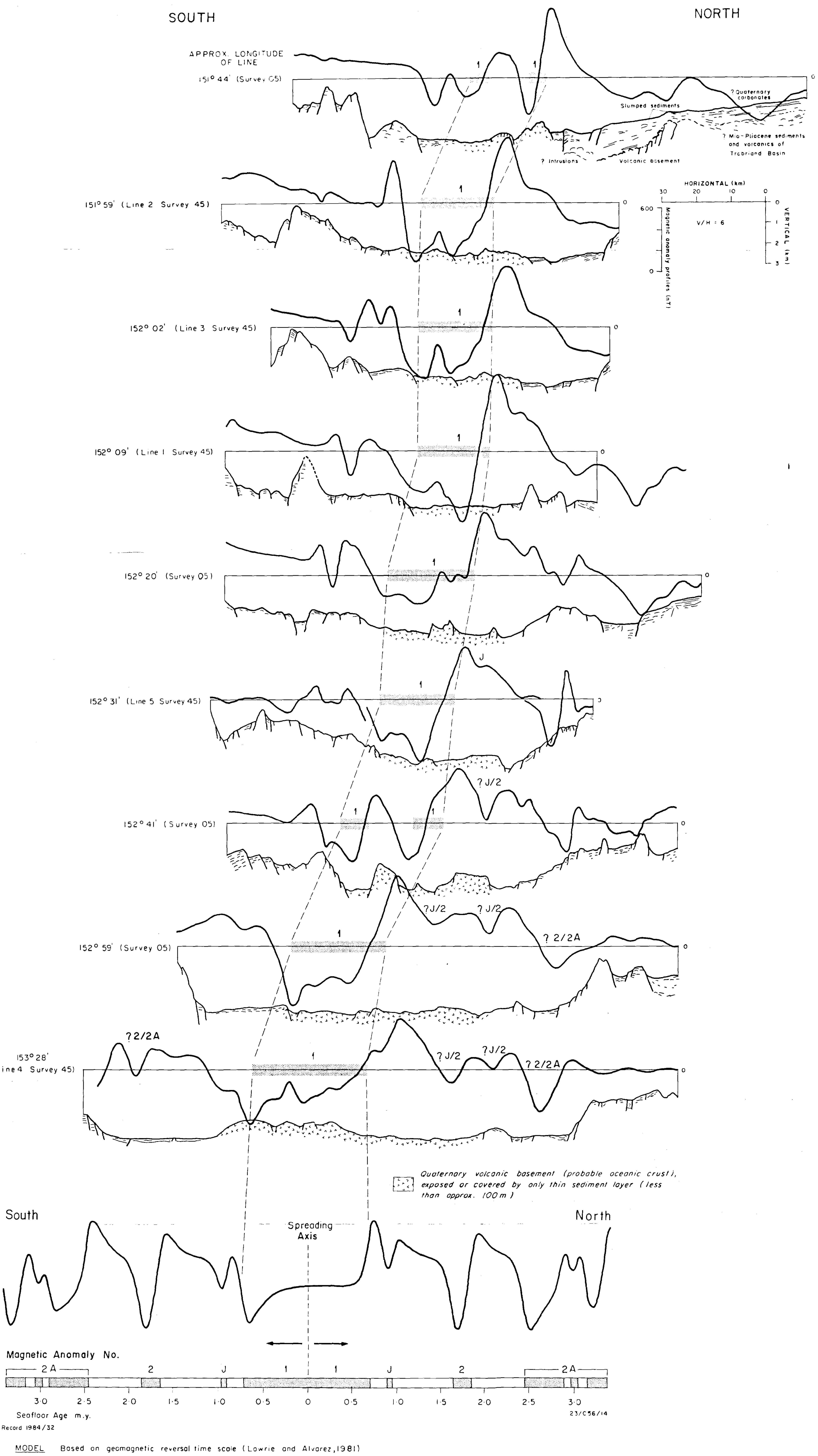
WITH NATURAL SCALE CORRECT
AT LATITUDE 8 30

Figure 13:
MAGNETIC ANOMALY PROFILES
MILNE BAY AREA

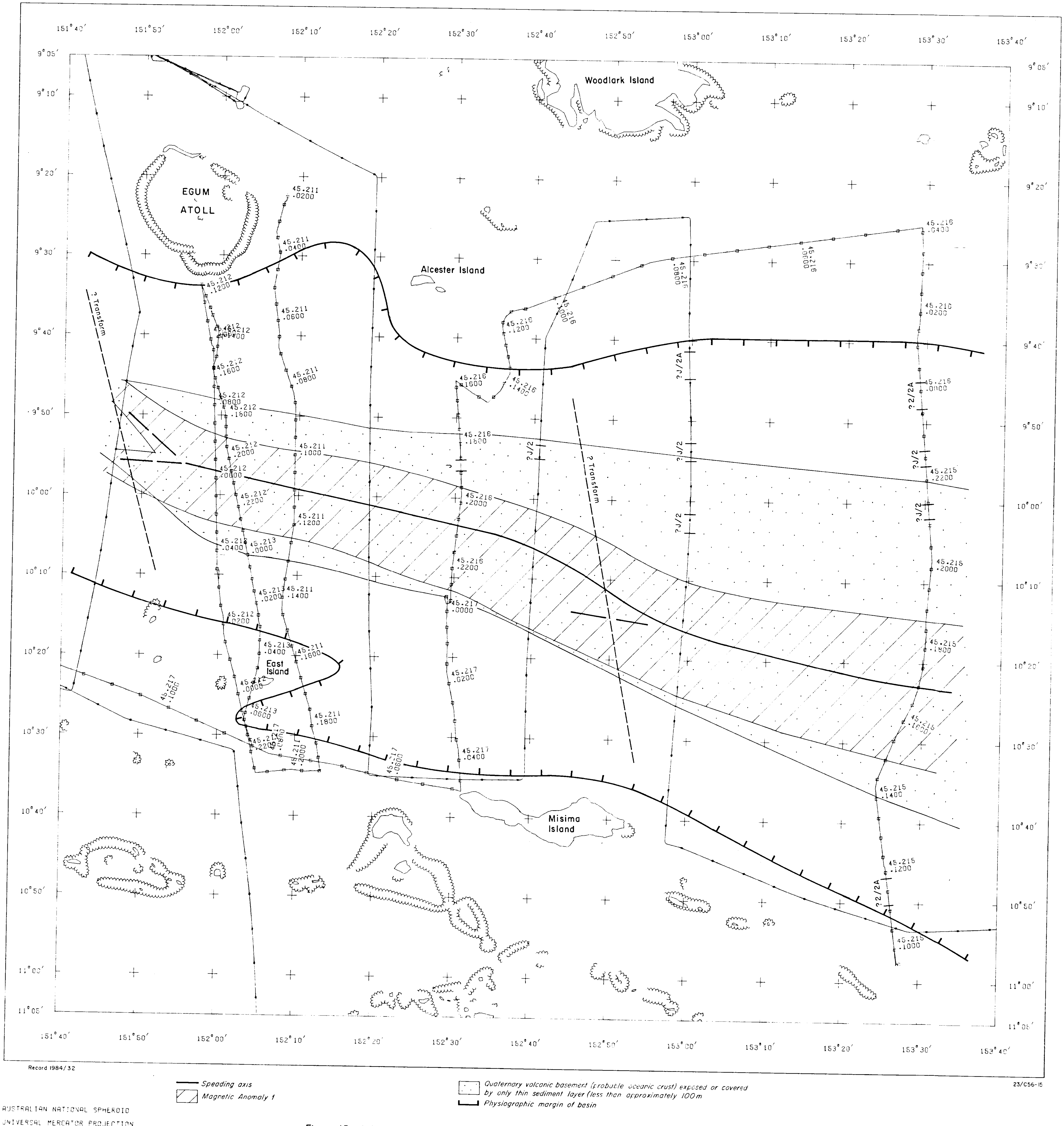


MODEL Based on geomagnetic reversal time scale (Lowrie and Alvarez, 1981)
Depth to top of magnetic layer 2·8 km; thickness 0·5 km; intensity of magnetization 0·010 e.m.u.; profile azimuth is north across E-W spreading axis; symmetric spreading rate (total) of 5·2 cm/year.

Figure 14: Preliminary interpretation of West Woodlark Basin seismic section and magnetic anomaly profiles

SCALE 1:600000

EDITION OF 1984/09/14



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WITH NATURAL SCALE CORRECT
AT LATITUDE 8 30

Figure 15: Principal structural features of West Woodlark Basin