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SOUTHEASTERN GEORGINA BASIN SEISMIC SURVEY, QUEENSLAND & NORTHERN TERRITORY, 1977

PREVIEW REPORT

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S.P. MATHUR and J.A. BAUER

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SUMMARY

Previous geological and geophysical studies in the southeastern Georgina Basin have provided information on the general nature and structure of the Toko Syncline area. The structure is indicated to be a deep, southeast-plunging, asymmetric synclinal depression filled with up to 7000 m of Late Adelaidean to Devonian sediments. The southwestern flank of the syncline shows steep dips and is bounded on the southwest by the Craigie Fault/Toomba Fault system. The northeastern flank shows gentler dips and gradual thinning of the sediments to the northeast. Two deep exploration wells, Netting Fence No. 1 and Ethabuka No. 1, supplied information on the stratigraphy and lithology of the sediments and suggest thickening towards southeast, the deeper part of the syncline, and possibilities of stratigraphic pinchouts along the axis as well as across the northeastern flank of the syncline. The wells also indicated the presence of source rocks and reservoir facies within the Middle Cambrian section, caprocks in the Lower Ordovician, and significant amount of petroleum (gas) in the Coolibah Formation (Lower Ordovician).

Although the seismic surveys provided useful information on the shallow sediments, down to Ordovician, and mapped the anticlinal structure on which the Ethabuka No. 1 well was drilled, the seismic coverage in the syncline area is limited, ties to the wells and outcrops are unsatisfactory, and the quality of the data from the deeper sediments and the faulted zones along the southwestern and southern margins is poor.

A seismic and associated gravity survey by BMR is therefore planned for between June and November 1977 to investigate the nature and structure of the Cambrian and deeper sediments and of the southwestern faulted margin of the syncline, and to provide ties between the exploration wells, the previous seismic traverses and rock outcrops. It is expected that the proposed survey, consisting of about 250 km of reflection traverses, and using 6-fold coverage and digital recording and processing techniques, will provide the information that will assist in the evaluation of the true potential of the area and in the regional study of the Georgina Basin currently being carried out by the BMR.

INTRODUCTION

A seismic survey in the southeastern Georgina Basin is planned for the period June to November 1977 to investigate the nature and structure of the sediments of the Toko Syncline. The purpose of the survey is to provide additional information on the sedimentary section in the syncline and on its southwestern boundary, the Toomba Fault. This information is required to evaluate more fully the petroleum potential of the Toko Syncline area, and to assist in the regional study of the Georgina Basin currently being carried out by the Geological Branch.

Previous geological and geophysical work has indicated that the sediments of the Toko Syncline are mainly of Lower Palaeozoic age and up to 4000 m thick. The work has also demonstrated that petroleum source rocks, reservoir facies, caprocks, and structural and possibly stratigraphic traps are present in the syncline area. Two of the three exploration wells drilled in the area have indicated the presence of significant amounts of hydrocarbon, mainly gas, and the petroleum potential of the area is considered to be high. However, the previous seismic work, by BMR and private companies during 1960-70, did not succeed in providing definitive information on the nature of the deep sediments, or on the structure of the Toomba Fault that was needed to evaluate the true petroleum potential of the area, and also to understand the geological and tectonic history of this part of the Georgina Basin. The proposed survey is expected to provide this information by obtaining better quality seismic data along ties between previous seismic traverses and exploration wells, and across the Toomba Fault. It will use the digital recording and processing techniques now available. In addition to the seismic work it is proposed to take gravity readings along the seismic lines to enable a combined seismic and gravity interpretation to be made. A few relatively shallow (up to 914 m deep) stratigraphic wells are also proposed to be drilled by BMR and the Geological Survey of Queensland (GSQ) in areas chosen to provide lithological cross sections through the complete sedimentary section and aid in the identification of key seismic horizons.

The survey area is generally arid. Most of it is covered by the sands of the Simpson Desert; the sands form longitudinal dunes trending north-northwest. The climate is characteristic of central Australia, with a

hot summer, mild winter, marked daily temperature variations and sparse rainfall. From June to August the maximum temperatures are less than 27°C, with cool to cold nights. From October the days become hotter. The average rainfall is 15 cm a year - most of it falls between November and March occasionally accompanied by tropical storms. Much of the area is covered by spinifex; eucalypts are found mainly along the banks of major streams.

Access to the survey area from Brisbane is mostly by sealed roads as far as Boulia, and thence by graded tracks to Bedourie town and Carlo and Sandringham Stations. The sandy desert areas further west can be reached by 4-wheel-drive vehicles, but a bulldozer will be required to pull heavier vehicles, and cut seismic traverses across the dunes. The nearest town where supplies are available, and which has regular flight connections to Brisbane, is Mount Isa, about 450 km north of Bedourie.

During the most recnet seismic survey in the area (Alliance, 1970), Mayhew 1000 air/water combination drills were used successfully to drill shot-holes in most areas, but a hammer tool was required when drilling through dolomites and limestones. Good water supplies are available in the south around Sandringham Station. In other parts, water should be available from waterholes, soaks and springs.

GEOLOGY

The Georgina Basin extends northwest from about 25°S latitude in northwestern Queensland, to approximately 18°S in the Northern Territory (Pl. 1). It contains predominantly Cambrian and Ordovician marine sediments, and Devonian and Siluro (?)-Devonian freshwater sequences. It is bounded on the southwest, west, northeast and east by Precambrian rocks of the Arunta Block, Tennant Creek Block, South Nicholson Basin and Mount Isa-Cloncurry Block respectively, and is probably connected with the Wiso Basin (Lander Trough) to the west, and with the Daly River Basin to the north, under a cover of Mesozoic and Quaternary sediments. The southern margin of the basin is concealed under Mesozoic sediments of the Eromanga Basin. In the southwest and southeast about two thousand metres of unmetamorphosed sedimentary rocks of Late Adelaidean to Lower Cambrian age is developed. The stratigraphy and geological history of the basin are discussed by Smith (1972) and Shergold & Druce (in prep.).

Most of the northern half of the basin contains a thin, gently undulating sequence of Middle Cambrian marine sediments less than 400 m thick. In the southern half, thick and complete basin sequences are preserved in major synclinal areas, the Dulcie and Toko Synclines, where outcrops show maximum thicknesses of about 2000 m for the Late Adelaidean-Early Cambrian, 1800 m for the Middle Cambrian-Middle Ordovician sediments, and of 640 m for the overlying Devonian freshwater sediments.

The Dulcie and Toko Synclines were formed along the western and southwestern margin of the Georgina Basin during post-Devonian tectonism equivalent to the Alice Springs Orogeny in the Ngalia and Amadeus Basins to the west. Several major faults, including the Tarlton, Craigie and Toomba Faults, and some minor faults and folds between the Dulcie and Toko Synclines, were also formed at this time. The faulting along the southwestern margin of the basin is expressed as an en echelon series of northwest-trending faults with throws of as much as 1000 m down to the northeast.

The Toko Syncline is bounded on the southwest by the Craigie/Toomba Fault system. The surface geology (Pl. 2) indicates that the syncline trends northwest, plunges to the southeast, and is asymmetric - with steep dips on the southwestern flank flattening out rapidly to the northeast, and gentle dips on the northeastern flank. Complementary to the major fault system, a secondary set of east-northeast trending faults are seen in the northern part of the Toko Syncline. They are normal faults, with blocks downthrown to the southeast and throws of less than 60 m.

The maximum thickness of the Palaeozoic sediments in the Toko Syncline is estimated to be about 4000 m under the cover of Eromanga Basin (Mesozoic) sediments in the south. The stratigraphy of the sedimentary section in the syncline, and the depths to the geological formations encountered in the three exploration wells and two boreholes, are shown in Table 1.

The Netting Fence No. 1 Well (PAP, 1965) was drilled through about 2000 m of the complete sequence of Cambrian-Ordovician sediments in the northern part of the Toko Syncline, and encountered several hydrocarbon shows from the earliest Middle Cambrian to the Middle Ordovician sediments. The Ethabuka No. 1 Well (Alliance, 1975) was drilled to the south to a total depth of about 2000 m and encountered a small gas flow in a sand reservoir within the Coolibah Formation. Because of drilling problems, this well was

TABLE 1. Stratigraphy and lithology in Toko Syncline based on exploration well and bore hole data

AGE	FORMATION NAME	LITHOLOGY	DEPTH (METRES) BELOW K.B.* Netting Fence No. 1 K.B. = 245 m	Ethabuka No. 1 K.B. = 127 m	Bedourie Scout Hole No. 1 K.B. = 105 m	Ine Brothers No. 1 K.B. = 94 m	Kamaran Downs No. 3 K.B. = 80 m (?)
Quaternary		Sand, alluvium		0	0	0	0
		UNCONFORMITY					
	Lower Wilgunya Form	Gypsiferous shales		31			
Cretaceous	Longsight Sandstone	Quartz sandstone carrying artesian water		529			
		UNCONFORMITY					
Siluro-Devonian	Cravens Peak Beds	Red brown quartz Sandstone with some boulder conglomerate		640	Absent		
		UNCONFORMITY					
Ordovician	Toko Group: Ethabuka Beds	Siltstone, sandstone		1024	Absent		
	Toko Group: Mithaka Formation	Gypsiferous shale and siltstone glauconitic quartz sandstone coquinite		1202	132		
	Toko Group: Carlo Sandstone	Quartz sandstone				Absent	
	Toko Group: Nora Formation	Siltstone with minor dolomitic sandstone and coquinite	125	1503			Absent
	Toko Group: Coolibah Formation	Limestone and marl with chert lenses	239	1734			
	Kelly Creek Formation	Sandstone dolomite coquinite with chert lenses	274	1814			
	Ninmaroo Formation	Dolomite and marl	384				

TABLE 1 (Continued)

AGE	FORMATION NAME	LITHOLOGY	DEPTH (METRES) BELOW K.B.* Netting Fence No. 1 K.B. = 245 m	Ethabuka No. 1 K.B. = 127 m	Bedourie Scout Hole No. 1 K.B. = 105 m	The Brothers No. 1 K.B. = 94 m	Kamaran Downs No. 3 K.B. = 60 m (?)
Upper Cambrian	Georgina Limestone	Limestone and marl	726			351	
Middle Cambrian	Marqua Group: Mungerebar Limestone	Clastic and crystalline limestone	1247			Equivalent Present	Absent
	Steamboat Sandstone	Arenaceous, calcareous sandstone and silt limestone	1327				
	Netting Fence Formation	Quartzose, calcareous sandstone, silty, sandy limestone, siltstone, shale	1548				
	Thorntonia Limestone	Dolomitic limestone siltstone. Calcareous sandstone, breccia	1959				
	UNCONFORMITY						
Late Adelaidean/ Lower Cambrian	Sylvester Sandstone	Silicified sandstone and green siltstone	Absent				
	Sun Hill Arkose	Arkose, sandstone, conglomerate	Absent				
? ? ?							
Adelaidean	Field River Beds	Siltstone, arkose, dolomite sandstone, boulder conglomerate	Absent				
	UNCONFORMITY						
Precambrian?		Granite	2009				
	TOTAL DEPTH		2032	1961	251	1267	461

* K.B. elevation is above sea level

terminated in the Kelly Creek Formation (Lower Ordovician), and failed to test the deeper sediments. The thicknesses of the four common formations in the two wells (Table 1) indicate that the sediments in the Ethabuka No. 1 Well area are about twice as thick as in the Netting Fence No. 1 Well area, implying that the southeast thickening of the sediments and part of the plunge of the syncline to be a depositional feature.

In the southern part of the syncline area, in The Brothers No. 1 Well (FPC, 1965a) the Upper Cambrian sediments were overlain by 351 m of Mesozoic sediments. No hydrocarbon shows were detected. Seismic data (FPC, 1965b) indicate that this area is an upthrown block, separated from the deepest part of the syncline in the west by a zone bounded by two faults. The Bedourie Scout Hole No. 1 drilled by FPC (1965b) in this deepest part of the syncline bottomed in Ordovician Mithaka Formation underlying Mesozoic sediments. In the Kamaran Downs No. 3 Bore (Reynolds, 1968) to the southwest granite was intersected below the Mesozoic, which suggests that the hole was drilled on the upthrown side of the Toomba Fault.

Alliance (1974) considers the petroleum potential of the Toko Syncline area north of 24°S to be high: the investigations to date have indicated the presence of source rocks in the Netting Fence Formation and suitable reservoir facies within the Middle Cambrian section at Netting Fence No. 1 Well, with caprocks in the Nora and Mithaka Formations, and a small overpressured gas reservoir within the Coolibah Formation at Ethabuka No. 1. Suitable structural traps have been outlined along the southwestern faulted margin of the syncline and the possibility of stratigraphic traps exists both on the northeastern flank, and along the axis of the syncline where considerable thinning of the sedimentary section occurs. The potential of the deeper southern part of the syncline is further upgraded by the water salinity measurements, which suggest that the sediments at Ethabunka No. 1 Well have not been subjected to the fresh water flushing that is evident in the shallower northern part at Netting Fence No. 1 Well.

PREVIOUS GEOPHYSICAL STUDIES

AEROMAGNETIC SURVEYS

The magnetic surveys over the syncline area were carried out by BMR north of 24°S, (Wells, Milson & Tipper, 1966), and by FPC (1963) south of 24°S. The magnetic pattern is dominated by a zone of relatively undisturbed

field, which trends southeast and is associated with Toko Syncline. On the map of interpreted depth to the magnetic basement, the syncline is represented as a broad asymmetric feature, dipping steeply on the southwestern side and more gradually on the northeastern side (Pl. 3). North of 24°S maximum depths of over 7000 m are estimated in two small areas within a large depression bounded by the 5000 m contour. The steep southwestern flank of the syncline is faulted.

West of the syncline, a magnetically disturbed zone fringes a region of near-surface magnetic basement. The anomalies, up to 1500 nT in amplitude, are considered to be associated with basic rocks at shallow depths.

East of the syncline, two regions (A & B) of shallow magnetic basement with north-south trends are evident at longitudes 139°00' and 139°25'. The western region (A) corresponds to the outcrop of Late Adelaidean/Lower Cambrian Sylvester Sandstone or the Sun Hill Arkose; magnetic basement is shallow, estimated at about 500 m below sea level. The eastern region of shallow basement (B) has no surface expression, and Cretaceous sediments are seen in outcrop. Between these two regions a magnetic basement trough has a maximum depth of about 3000 m. The southeast-trending trough coincides with the southward extension of the Glenormiston Gravity Shelf (Pl. 4). These magnetic and gravity features could indicate a thickening of sediments, or may be caused by low density (granitic) basement. The presence of Upper Cambrian Georgina Limestone east of Sun Hill Arkose in outcrops separated by a fault and located about 10 km southeast of Glenormiston (Pl. 2) supports the former interpretation.

GRAVITY SURVEYS

Reconnaissance gravity surveys in the area have been made by BMR on a 11-km grid. The resulting Bouguer anomalies are shown in Plate 4. The anomalies have been studied by Gibb (1967), and Fraser et al. (in press). On the basis of the correlation of the anomalies with geology, several gravity features have been recognised (Pl. 4). The most predominant feature, the Toko Gravity Trough, trends southeast and shows anomalies ranging from 0 to -35 mGal. It corresponds at its northern end with the outcropping rocks of the Toko Syncline. Further north it disappears where the older and denser rocks of the syncline crop out. In the south, the anomalies suggest that the Toko Syncline plunges southeast under the Mesozoic cover. The steep

gradient at the southwestern edge of the trough coincides with the Toomba Fault in the north, and suggests that the fault also extends under the Mesozoic cover in the south.

The Bedourie Gravity Ridge on the west and south of the Toko Gravity Trough shows small gravity features, with trends between northeast and northwest and anomalies between 0 and +25 mGal. It has been proposed by Fraser et al. (in press) that this area is underlain by dense metamorphic rocks of the Mount Isa Geosyncline. The Glenormiston Gravity Shelf is located where the Georgina Basin sediments lap on to the Mount Isa Geosyncline. The gravity features here probably reflect both intra-basement density contrasts and the local thickening of sediments. The elongate northwesterly trending features on the southwest of the Toko Gravity Trough, viz., the Field Gravity Spur, Hay Gravity Low and Caroline Gravity Ridge are considered to represent intra-basement density variations within the Arunta Block.

SEISMIC SURVEYS

Several reconnaissance and detailed seismic surveys were made during 1960-70 by private companies and BMR, mostly in the southern part of the syncline. However, the seismic coverage of the syncline is not uniform (Plate 2). There are almost no data available in the Netting Fence No. 1 Well area; the northern traverses of the Toko Range Survey (Alliance, 1970) are not interconnected; and there are no direct ties across 24°S latitude between the Toko Range Survey and the Bedourie and Sandringham Surveys (FPC, 1965b, 1965d). Most surveys used reflection methods. The techniques used, and the quality of data and results obtained in individual surveys, are summarised in Table 2. A more detailed description of the results from each survey is given below:

Boulia-Springvale-Marion Downs-Glenormiston areas seismic survey, 1960 (Phillips - Sunray, 1962)

Only a small part of this survey extended into the area relevant to this report; the remainder lay further east and will not be considered here.

TABLE 2. Summary of recording parameters and results from previous seismic surveys

SURVEY	TYPE	SHOT PATTERN	CHARGE SIZE AND DEPTH	GEOPHONE TYPE	GEOPHONE PATTERN
Boulia-Springvale Marion Downs and Glenormiston areas Seismic Survey, 1960 (Phillips-Sunray, 1962)	Reflection (split-spread, spot correlation and single-fold)	1 to 5 holes/shot in line or X-pattern with holes 20 m apart	5 kg at 30 m	Electro-Tech EVS-28 30 cps	4 to 32/litres, in line, X-pattern, or pallelogram
Seismic Survey, 1960, Great Artesian Basin, SA & QLD (Milton & Seedsman, 1961)	Refraction (probes) Reflection (split-spread, spot-correlation)	Single hole	10 kg at 20 m	-	10/trace, 3 m apart
Annandale Seismic Survey, 1963 (FPC, 1964)	Reflection (split-spread) Refraction (probes) Offset spreads	24/shot in two groups of 3x4 either side of traverse	27 to 55 kg/ shot at 5 m	HSJ model K 20 cps (reflection) HS 4.5 cps (refraction)	36/trace in 3 lines
Bedourie Seismic and Gravity Survey 1964 (FPC, 1965b)	Reflection (Split-spread) Refraction (probes and continuous profiling) Offset spreads	24/shot in two groups of 3 x 4 either side of traverse	27 kg/shot at 5 m	HSJ	36/trace, in 3 lines 10 m apart, geophones 5 m apart
Sandringham Seismic and Gravity Survey, 1965 (FPC, 1965d)	Reflection (split-spread) Offset-spreads	36/shot in two groups of 3 x 6 either side of traverse	20 kg/shot at 5 m	HSJ 20 cps	36/trace, in 3 lines 20 m apart, geophones 5 m apart
South-Eastern Georgina Basin Seismic Survey, QLD 1963-1964 (Jones & Robertson, 1967)	Reflection (split-spread, some 6-fold CDP) Refraction (probes and continuous profiling)	Variable up to 12 holes/shot	1 to 23 kg/ shot at 14 to 27 m	HSJ (reflection) Electro-tech 4.5 cps (refraction)	16 to 32/trace spacing and configuration variable
Toko Range Seismic Survey, QLD, 1970 (Alliance, 1970)	Reflection (split-spread)	Mainly single holes; some 3 and 5 hole patterns	15 kg/shot at 36 m for single holes 23 m for 3 holes 14 m for 5 holes	HSJ - 420 Hz	12/trace, 4-5 m apart

GEOPHONE STATION	SPREAD	DATA QUALITY	DATA PRESENTATION	REMARKS
15 to 45 m	Split-spreads; 200-0-200 m 500-0-500 m; spot correlation: gaps of up to 3 km between shots	Poor to fair (difficult to correlate)	Wiggly-trace record sections, Time cross-sections	Limited usefulness due to difficulty in correlating between shotpoints
30m(reflection) 60m(refraction)	730-0-730 m (reflection) 0-1460 m (refraction)	Poor to fair	Time cross-sections	'Z' (base of Mesozoic) horizon mapped by reflection and refraction. Possibility of Cambro-Ordovician sediments in Breadalbane area indicated
50 to 60 m	600-0-600 m 720-0-720 m	Fair	Depth cross-sections all lines, VA sections all lines, Depth contour map on Horizon 'C'	SW of Toko Syncline only Horizons 'C' (top Blythesdale/Transition Beds) and 'Z' (base Mesozoic) picked. (Hor. Z refraction velocity 5700 to 6050 m/s) In Toko Syncline 8 reflections picked down to 2.5 sec. 'Ninmaroo' refractor velocity 5900 m/s, depth 4600 m.
50 or 60 m	600-0-600 m 720-0-720 m	Fair	Depth cross-sections all lines, VA sections some lines, Depth, contour maps on 'Z', 'N', 'X' horizons	'C', 'Z', and 'N' (?Ninmaroo) picked in Toko Syncline, 'C', 'Z', and 'X' (?base of Cambrian seds) picked on Bedourie Block
50 m	600-0-600 m	Fair (better than previous Bedourie survey)	Depth cross-sections all lines, VA sections all lines, Time contour maps on 'Z', 'MC', 'T_1', 'T_2' Pr 'horizons'	'Z' and 'MC' (middle Cambrian) horizons picked over most of Bedourie Block, 'T_1' and 'T_2' (Marqua Beds) and 'Pr' (?Upper Proterozoic) picked only in small area east of Brothers No. 1 well, 'X' horizon (?top of ?Tillite series) picked on most lines
15 or 45 m	183-0-183 m or 549-0-549 m	Fair to good	VA sections all lines	'Ninmaroo' reflection picked in Toko Syncline, reflections conformable with Ninmaroo indicate Palaeozoic sediments down to 4500 m Possible Proterozoic Sediments underlie Palaeozoic, Overthrust faulting from south-west indicated at southwestern margin
34 or 67 m	402-0-402 m or 805-0-805 m	Poor to good	VA sections all lines, Time contour maps on Horizon "A" (? Ninmaroo) and Horizon "C" (? top Lower Cambrian or Proterozoic), "A-C" Isochron	Useful reconnaissance of central Toko Syncline. One closed structure detailed and another indicated. Showed considerable fault-disturbance near south-western margin.

A line (G11 in Pl. 2) recorded from the Netting Fence area east towards Glenormiston, using spot-correlation shots up to 3 km apart, yielded fair record quality on the western end, but this rapidly deteriorated eastwards. Near the western end of the line a very doubtful seismic structure corresponding closely with a definite surface feature (the Netting Fence Structure) was noted. Correlation between shotpoints on this line was very difficult.

A similar traverse (G9) from Marion Downs southwest towards the Toko Syncline generally yielded very poor data.

Seismic survey, 1960, Great Artesian Basin, S.A. & Qld (Milton & Seedsman, 1961)

This survey, conducted by the South Australian Department of Mines (SADM), consisted of a series of short refraction depth probes and some spot-correlation reflection profiling using 3 km spacing between shotpoints. The results from only the Bedourie and Kamaran Downs No. 3 bore areas are relevant to the study of the syncline.

In the area to the north of Bedourie a refractor with velocity of 5450 m/s was recorded at a depth of 600 m. It was believed to be associated with early Palaeozoic limestone. Deep reflections down to a depth of 1500 m below this refractor were also recorded.

On the refraction line at Kamaran Downs Bore No. 3, a velocity of 5640 m/s was recorded at a depth of 450 m. This refractor must correspond to the granite met in the bore at 461 m.

Annandale seismic survey, 1963 (FPC, 1964)

This survey, carried out by Compagnie Generale de Geophysique, recorded 420 km of reflection and 110 km of refraction profiles. Much of the survey lay to the southwest of the Toko Syncline where only two horizons, 'C' (Transition Beds) and 'Z' (base of Mesozoic), were mapped. Refraction velocities of 5700 - 6050 m/s were found for the 'Z' horizon; below this horizon only very scattered and steeply dipping reflections were recorded.

However on line AQ (Pl. 2), the northernmost line of the survey, reflections down to 2.5 s on the northern side of a major fault showed the existence of a deep syncline. Eight reflection horizons were followed to a total depth of about 6000 m. The deepest refractor had a velocity of 5900 m/s and a maximum depth of 4600 m, and was thought to originate from the Ninmaroo Formation.

Bedourie seismic and gravity survey, 1964 (FPC, 1965b)

This survey, also conducted by Compagnie Generale de Geophysique, followed the Annandale survey and was carried out mainly in the southern Toko Syncline (Pl. 2). It recorded 1360 km of reflection and 57 km of refraction profiles.

In the Toko Syncline good results were obtained and reflections could be picked down to about 2.5 - 3.0 seconds. The shallow 'C' horizon (Transition Beds) was identified in the southern part of the area, but was too shallow to be followed further north. The 'Z' horizon (base of Mesozoic) is almost horizontal, and has a refraction velocity ranging from 3500 to 4550 m/s. Below the 'Z' horizon, several other horizons were picked, all dipping regularly to the southwest. The strongest of these is the 'N' horizon, thought at the time to correspond to the Ninmaroo Formation, but now tied to the Coolibah Formation.

The syncline is cut-off to the southwest by a major fault, which was mapped by the Annandale survey, and which has a displacement of over 4000 metres. The eastern margin of the syncline is also faulted, with the throw of the fault increasing from 1000 m in the northern part of the survey area to 2700 m in the south. This fault separates the main Toko Syncline from the eastern Border Zone (Pl. 6), this zone is characterised by stronger southwesterly dips (up to 20^{o}) on all horizons below 'Z'. It was possible to correlate the 'N' horizon across the fault; the 'N' and all horizons beneath it disappear in succession eastwards by truncation beneath the near-horizontal 'Z' horizon. It appears that much of the sequence overlying 'N' has been removed by erosion.

In the area immediately east of the Toko Syncline the 'N' horizon is not recognisable, but a horizon 'X' can be picked at reflection times ranging from 0.9 to 1.5 secs. It is not persistent over the whole area and is often hidden by multiples, possibly originating from the 'Z' horizon.

The relationship of this area to the Toko Syncline edge is not known because a zone of poor quality reflections - possibly due to faulting - precludes any chance of relating the 'X' horizon directly to the 'N' horizon. The Brothers No. 1 Well, about 15 km northwest of Bedourie, indicated that the Mesozoic sediments were underlain by Upper to Middle Cambrian limestone. It is therefore possible that the 'X' horizon, which might be near the base of the Cambrian sediments, provides an indication of the extent of the Bedourie Block. The 'X' horizon also corresponds to the deepest refractor recorded in this area. The 'Z' horizon is a very strong reflector, and has a refraction velocity of 4500 to 5650 m/s, much higher than in the Toko Syncline.

With two exceptions, no continuous reflections were picked below the 'Z' horizon east of the Bedourie Block. The refraction velocity of the 'Z' horizon in this area is generally greater than 5800 m/s and is in agreement with the results from Marduroo Well No. 1 (FPC, 1965c) namely that this is an area where Mesozoic sediments rest directly on the Proterozoic.

Sandringham seismic and gravity survey, 1965 (FPC, 1965d)

The Sandringham survey was also conducted by Compagnie Generale de Geophysique, and recorded 182 km of reflection profiles (Pl. 2). It was carried out as a follow-up to the Bedourie survey to investigate in more detail the eastern margin of the Toko Syncline and the adjacent Bedourie Block. The French Petroleum Company considered that though the Toko Syncline contained potential source rock, the most likely place for suitable trap structures was in these areas.

Improved record quality over the Bedourie survey results allowed the mapping of additional reflection horizons. Apart from the 'Z' (base of Mesozoic) horizon, the survey mapped MC_1, MC_2, T_1, T_2 and Pr horizons. By tying to The Brothers No. 1 Well (EPF, 1965a), MC_1 could be correlated with the top of the Pomegranate LImestone; MC_2, which is parallel to MC_1, with a layer in the Pomegranate Limestone; and T_2 tentatively with the lower Marqua Beds. T_1 is a marker picked east of The Brothers No. 1 Well which is truncated before the well. Pr was thought to originate in the Upper Proterozoic, and lHorizon X, which was plotted on depth cross-sections but not contoured, was thought by FPC to originate from the top of the ?Tillite Series.

Horizon MC_1 or the horizon MC_2 was mapped over the central and southern parts of the Bedourie Block. In the east of this area only MC_2 exists, MC_1 is absent. Record quality was too poor in the northern part of the Block to allow mapping of any horizons below 'Z'; however weak reflections suggest that the top of the middle Cambrian series is eroded, the lower Cambrian still being present.

Horizons T_1, T_2 and Pr were picked only in a small area immediately east of The Brothers No. 1 Well. A small high with closures of 10 to 15 ms on the T_2 and Pr horizons was mapped.

Southeastern Georgina Basin seismic survey, Qld 1963-1964 (Jones & Robertson, 1967)

This BMR survey was a reconnaissance of the southern Toko Syncline to investigate the possible extension of a thick Lower Palaeozoic sequence from the outcrop area in the northwest part of the syncline southeastwards, as was suggested by a large southeasterly trending negative gravity anomaly. The survey also explored the area to the east to determine whether areas of low gravity could be related to thickened Lower Palaeozoic sediments.

The survey, conducted over two seasons, comprised 290 km mainly of single-fold reflection traverses (Pl. 2), and about 100 km of refraction, both as depth probes and continuous profiling. Some experimentation was carried out to determine optimum shooting parameters. Fair to good reflection results were obtained in the Toko Syncline, except near the disturbed south-western margin, but east of the syncline results were generally poorer. The refraction method was useful in identifying the 'Ninmaroo' reflection in the Toko Syncline, and the unconformity at the base of the Mesozoic to the east of the syncline; however there were few other persistent refractors and it was considered that the reflection method was more suited to the area.

The survey was successful in showing that the Toko Syncline extends southeast from the outcrop to 24°S latitude and beyond. The most persistent reflection recorded was thought to originate in the Lower Ordovician Ninmaroo Formation, but was later tied to the Coolibah Formation in Ethabuka No. 1 Well. This horizon reaches a maximum depth of over 3000 m on traverse BF, (Pl. 5), the main line across the syncline, but Lower Palaeozoic sediments

conformable with this horizon probably extend to about 4500 m. Beneath the 'Coolibah' reflection near the deepest part of the Palaeozoic syncline there occurs a group of northeasterly dipping reflections in the 3-4 second range. These may correspond to the top of a probable Proterozoic sequence, which is unconformably overlain by the Palaeozoic sequence. Examination of the Bouguer anomalies along traverse BF shows that the Toko Gravity Trough minimum lies about 13 km northeast of the Palaeozoic structural low, as indicated by the Coolibah Formation reflection. This, together with the fact that the ?Proterozoic sequence appears to dip northeastwards towards the gravity minimum, suggests that the gravity results may reflect the ?Proterozoic structure rather than the Palaeozoic syncline.

On the seismic section (Pl. 5) there is an indication between SP 169 and 174, of a weak southwest-dipping reflection at times 1.0 to 1.4 s which is believed to be from the plane of the overthrust Toomba Fault. The seismic section shows considerable similarity with that recorded at the northern overthrust margin of the Ngalia Basin (Wells, Moss & Sabitay, 1972). Additional evidence for the overthrust fault comes from the presence of a residual gravity high between SP 168 and 178 which has been interpreted by Jones & Robertson (1967) as a southwesterly dipping high-density slab, presumably brought up from the southwest by reverse faulting. This high-density, and so high-velocity, slab is also considered to account for steep northeasterly dips seen on reflections between SP 173 and 176.

Toko Range Seismic Survey, AP160P, Queensland, 1970
(Alliance, 1970)

The Toko Range survey was carried out in the central part of the syncline. It consisted of 140 km of single-fold reflection profiles recorded by United Geophysical Corporation (Pl. 2).

The quality of the data which were recorded in analogue form and processed digitally varies from good to very poor. The main reflections, which can be followed over most of the surveyed area, were mapped, though jump correlations over large distances were required because of the absence of tie lines in the northern part. The shallower of the two horizons was believed to represent Ninmaroo Formation through ties to the BMR work (Jones & Robertson, 1967). The deeper horizon, the data for which are not very reliable, was thought to represent the erosional surface of either the Lower Cambrian or

Proterozoic sequence. But on the basis of ties to Ethabuka Well No. 1, which was drilled subsequently and penetrated only the shallower horizon, this horizon was identified as the Coolibah Formation, and the deeper horizon re-interpreted as the Georgina Limestone (Alliance, 1974).

The two mapped horizons, which appear generally conformable to each other, show three structures which could form important traps for petroleum: A high with closure of more than 60 ms (230 m) where Ethabuka No. 1 Well was drilled and gas was encountered, and another two highs in which there is a possibility of closure greater than 250 ms (750 m) but, presently, insufficient seismic control - one to the southwest and the other against the Toomba Fault to the northwest of Ethabuka No. 1 Well.

Most of the seismic traverses ended some distance away from the Toomba Fault and therefore show little effects of the faulted margin. Only traverse AK crossed this margin, and shows overturning and complex faulting of the sediments with the suggestion of overthrusting at the southwestern margin similar to that seen on the BMR traverse BF.

SUMMATION

Geological, magnetic, and gravity data indicate the Toko Syncline to be a deep, southeast plunging, asymmetric synclinal sedimentary trough with significant faulting along its southwestern margin and gradual shallowing on its northeastern flank. These data also provide evidence for the presence of a small, partly faulted, relatively shallow trough of Lower Palaeozoic sediments southeast of Glenormiston (Plate 2) lying at the northeastern margin and separated by a ridge from the main part of the syncline.

In the northern part of the syncline the Netting Fence No. 1 Well was drilled through about 760 m of Middle Cambrian (Marqua Group) sediments, most of which are absent from the outcrops on the northeastern flank, whereas the Late Adelaidean/Lower Cambrian (Sylvester Sandstone & Sun Hill Arkose) sediments which are absent in the well, are present in the outcrops (23^{o} 30' S, 139^{o} 00' E; Pl. 2) below a thinner Middle Cambrian sequence. The relative thickness of the common formations (Carlo Sandstone, Nora Formation, Coolibah Formation & Kelly Creek Formation) penetrated both in the Netting Fence No. 1 and Ethabuka No. 1 Wells indicate a thickening of these formations to the southeast by a factor of at least 1.33 between the two wells. These data therefore suggest possibilities of stratigraphic pinchouts within the Middle and Lower

Cambrian sequences along the axis, as well as across the northeastern flank of the syncline.

Although the seismic surveys provide useful information on the shallow sediments in the synclinal trough, the available seismic coverage in the area, and ties between the seismic traverses and with the wells and outcrops, are limited. The quality of the seismic data varies from fair to poor, and is poorer in the deeper sediments, and in the structurally disturbed fault zones on the southwestern margin and the southern part of the southeastern margin of the syncline.

A number of significant reflectors are present within the sediments, and several horizons have been mapped over different parts of the area. North of 24° S, Alliance (1974) has mapped two horizons, the Lower Ordovician Coolibah Formation and Upper Cambrian Georgina Limestone. South of 24° S, FPC (1965b, 1965d) mapped several horizons which are believed to correspond to the base of Mesozoic cover, the Coolibah Formation, and boundaries within and at the base of the Cambrian sequence.

The general nature of the syncline is illustrated by the structure contour map of the Coolibah Formation (Pl. 6), a NW-SE section (Pl. 7) along the axis of the syncline connecting Netting Fence No. 1 Well, Ethabuka No. 1 Well, Bedourie Scout Hole No. 1, and The Brothers No. 1 Well, and three SW-NE sections (Pls. 5, 8 & 9) across the northern, central and southern parts of the seismically surveyed area of the syncline. The structural map is a compilation of reflection - time contours from Alliance (1974) north of 24° S, and depth contours from FPC (1965b) south of 24° S. In the northern part the reflection is tied to the Coolibah Formation in the Ethabuka No. 1 Well. The reflection in the southern part has no direct ties with that farther north, but is believed to be the same on the basis of jump correlation across the 8 km gap. The sections in Plates 7, 8 and 9 are based on seismic reflection and well information.

The structural map and sections confirm the general finding of the earlier studies, that north of 24° S the syncline is asymmetric, plunging to the southeast, faulted on its southwestern margin, and gradually shallows on its northeastern flank. Although no faults have been shown on the structural map (Pl. 6) (Alliance, 1974), the seismic sections (e.g., Pl. 5) do show evidence of complex faulting accompanied by underthrusting, overturning and folding of sediments along the southwestern margin, which seem to have been caused by compression from the southwest.

South of 24° S, the structural map (Pl. 6) shows that under the Mesozoic cover, the syncline becomes a monoclinal feature. It is bounded on the southwest presumably by a southeast extension of the Toomba Fault, and faulted on the northeast by two northerly trending faults (French and Pippagitta Faults) which divide the feature into three structural parts: (1) the main Monocline, in which the sediments become shallow to the northeast, (2) the Border Zone, consisting of a narrow horst block where the Coolibah Formation rises steeply to the northeast and is truncated by the overlying Mesozoic sediments, and (3) the Bedourie Block where Upper Cambrian Chatsworth Limestone (presumably the equivalent of Georgina Limestone) was intersected below the Mesozoic cover in The Brothers No. 1 Well (Pls. 7 & 9).

The map also shows three closed anticlinal structures north of 24° S; these could form important traps for petroleum: one was drilled by Ethabuka No. 1 Well in which gas was encountered, the other two, showing much larger closures, are based on insufficient and poor data.

The seismic sections show several reflection events shallower and deeper than, and most conformable with the Coolibah Formation reflection, and suggest that the structure on the map (Pl. 6) is representative of that of most of the Palaeozoic sequence.

Only one of the deeper reflections, which is the strongest and most widespread in the surveyed area, can be followed along the traverse TA (Pl. 8) on to the northeastern flank of the syncline. Though it has been suggested by Alliance (1974) that it corresponds with the Ninmaroo Formation it was not penetrated by Ethabuka No. 1 Well, nor tied to the outcrops to the northeast. The interpretation of still deeper events is complicated by the presence of multiples that Jones & Robertson (1967) showed can be attenuated by the use of multiple-fold recording techniques. The steeply northeast-dipping events seen at times greater than 3.2 s on traverse BF, and at times greater than 2.0 s on traverses AX and AK, have been suggested as representing a horizon within the Proterozoic sequence, but the seismic data are not sufficient for a reliable interpretation.

The seismic reflectors plotted in Plate 7 do not support the south-eastern thickening of sediments indicated by the information from the Netting Fence No. 1 and Ethabuka No. 1 Wells. This, however, may be because the seismic data are available only for the Ethabuka No. 1 Well area, the lower reflector (? Georgina Limestone) is based on poorer quality data, and the same velocity function (curve B in Plate 10) was used to obtain depths over the mapped area.

As most of the seismic traverses on the southwestern flank of the syncline ended before the faulted margin was reached, the available seismic data are not adequate for studying the nature and structure of the Toomba Fault and the adjacent sediments.

It is apparent from the foregoing review that the following additional information is required:

- The nature and structure of the Lower Palaeozoic sediments and the underlying basement,
- The variation in thickness and character of the Palaeozoic sediments and the basement along the axis as well as across the flanks of the syncline,
- The nature and structure of the Toomba Fault along the southwestern margin, and of the adjacent sediments,
- Ties between the previous seismic work, wells and outcrops for correlation of seismic reflections with lithological horizons.

It is considered that further seismic work using multiple-fold coverage and digital recording and processing techniques would help provide the additional information.

OBJECTIVE AND PROGRAM

The overall objective of the proposed seismic and gravity survey in the southeastern part of the Georgina Basin is to obtain more definite information (than was provided by the earlier surveys) on the thickness and structure of the Lower Palaeozoic sediments in the Toko Syncline, and the nature of its southwestern margin, (the Toomba Fault.)

In particular, the objectives of the proposed survey are

- to obtain good quality reflections, free from multiples, from the Cambrian section and the deeper horizons in the syncline,
- to obtain good quality data in the vicinity of the Toomba Fault zone,
- to provide ties between the exploration wells, the previous seismic traverses and rock outcrops on the flanks of the syncline.

In order to achieve these objectives, the following field work is planned:

- Some experimentation to determine optimum seismic recording parameters.
- Six-fold reflection recording along traverses shown in Plate 2; the rough order of recording is indicated by numbers on the traverses, the lower priority traverses (broken lines) will be recorded only if the results warrant it and if the time permits. This is to obtain good quality data in key areas where no seismic data exists, and where the quality of the data from previous seismic surveys is poor.
- Expanded spread recording to obtain velocity information in two areas, one on the eastern flank of the syncline where the total Palaeozoic section is thin and shallow, and the other in the Ethabuka No. 1 area where the section is thick and deep. This will also help in identifying the multiple reflections and their removal during the processing of the data.
- Gravity observations at 1 km intervals along the seismic traverses to allow combined seismic and gravity interpretation.

Seismic data recording in the field will be done using multiple coverage and digital recording techniques. The proposed personnel and equipment are listed in Appendix 1. The data will be processed by Geophysical Service International on contract.

The shot and geophone patterns will be generally the same as those used by previous seismic surveys in the area (see Table 2 for details). In poor reflection areas, however, some experimentation will be required to determine the optimum patterns. The geophone spacing is planned to be 41 m or 82 m; the smaller spacing in areas where the key reflections are shallow and in the fault zone, and the larger where the key reflections are deep. It is expected that suitable cables will be available during the survey to record 48 channels of seismic data.

The field party is expected to leave Canberra in early June, carry out the field operations from late June to early November, and return to headquarters in early December. The proposed program which includes about 250 km of reflection traverses, two expanded spreads and some experimentation, is

considered reasonable for the time available in the field, considering the remoteness of the survey area, the difficulties expected in traversing across the sand dunes, and the possibility of rains hampering the operations from October and November.

The GSQ propose to drill a fully cored, 914 m deep stratigraphic hole on the northeastern flank of the syncline to investigate the Lower Palaeozoic sequence and the basement, and to provide lithological identification of deeper reflections. The hole (No. 1, Pl. 2) is to be drilled in an area where it is estimated to penetrate through about 40 m of Cretaceous and about 840 m of Cambrian sediments into the Proterozoic basement rocks. Seismic work on the northeast extension of traverse TA will precede the drilling in order to locate a site which is free from structural complications, and where good reflections are present.

Geological Branch BMR propose to drill a few shallow (300 m) stratigraphic bores in the syncline area; one of which (No. 2, Pl. 2) may be connected by seismic traverse if it is considered to be helpful in the lithological identification of the reflecting horizons.

It is expected that the proposed survey using multiple-fold coverage and digital recording and processing techniques should help provide the information required to evaluate the true petroleum potential of the Toko Syncline area. Presence of suitable structural and stratigraphic traps, if revealed by the survey, would greatly enhance the prospects of finding commercial quantities of petroleum, as significant amounts of gas have already been discovered in the area.

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APPENDIX 1: PROPOSED PERSONNEL AND EQUIPMENT

Personnel

Party Leader	P.L. Harrison
Geophysicists	J.A. Bauer
	D. Schmidt
	P. Symonds (part-time)
	W. Anfiloff (part-time)
	A. Nelson (GSQ)
Observer	J.C. Grace (part-time)
	G. Jennings (part-time)
Asst. Observer	C. Allen
Party Clerk	S. D'Arcy
Shooters	R. Cherry
	L. Rickardsson
Mechanic	D. McIntyre
Cook	1
Cook's Assistant	1
Wages Hands	11
Drillers	A. Zoska)
	E. Lodwick)
	K. Reine) Technology
	K. Huth) Section
Wages Mechanic	J. Keyte)
Surveyor	Australian Survey Office,
Surveyor's Assistants	Dept. of Administrative Services.

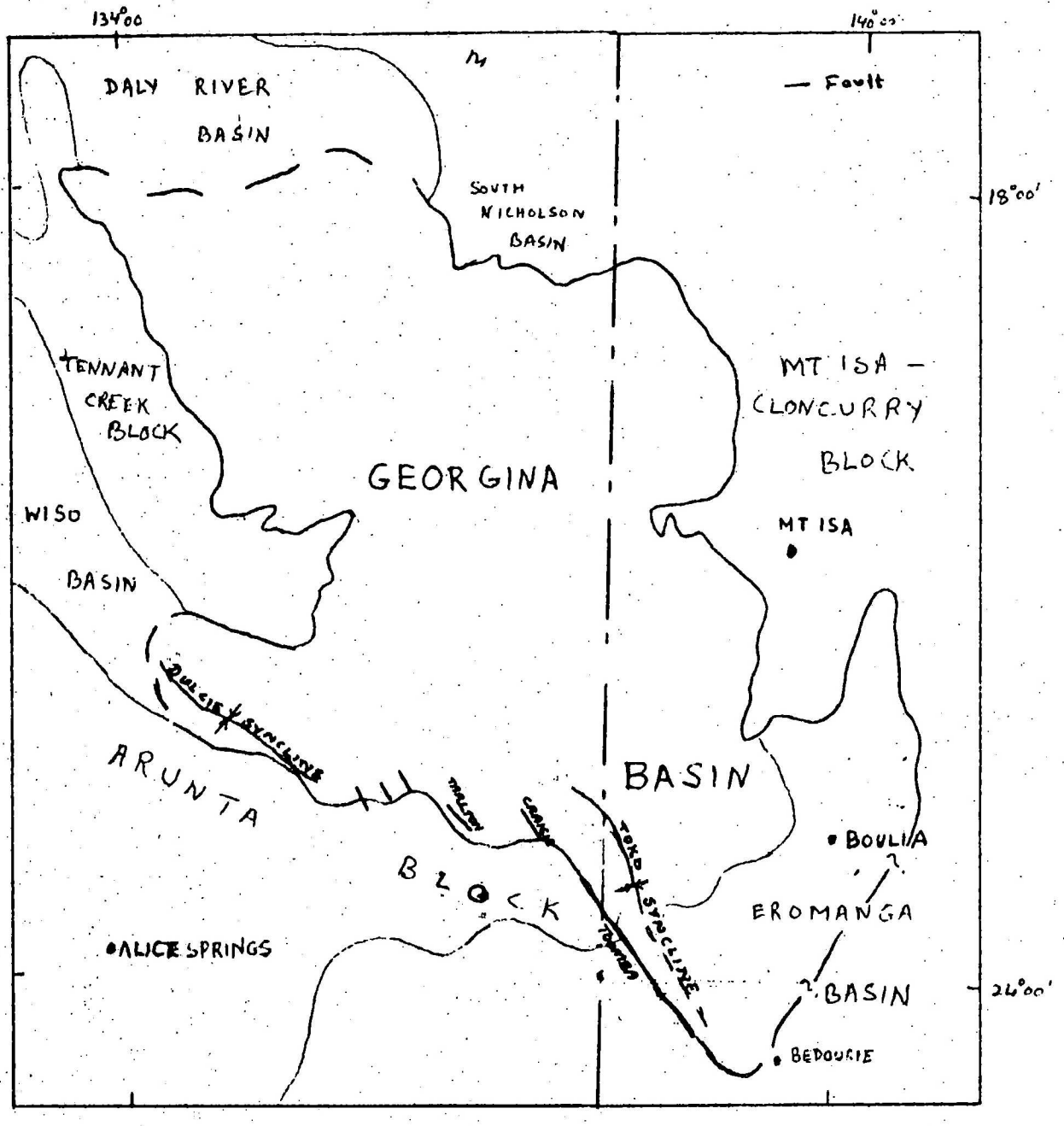
Equipment

Recording system	TI DFS-IV
Cameras	SIE TRO-6 Geospace 1801
Switch Gear	I/O Rota-Long
Radio Firing Unit	I/O R.F.U.
Cables - 24 channel	SCG-5, 18x265 m
- 48 channel	3x530 m (on order)
- extender, 48 channel	2x2100 m (on order)
- weathering	2x146 m
Geophones	GSC 20D 8 Hz (1280)
Transceivers	CODAN 6424 SSB (4) PYE CAMBRIDGE FM 100 (8) or equivalent
Gravity Meter	1 Worden
Micro Barometers	2
Recording Truck	International 3 tonne 4x4
Shooting Truck	International 3 tonne 4x4
Workshop Truck	International D1610, 3 tonne 4x4
Flat Top Trucks	International D1610, 3 tonne 4x4(2)
Water Tankers	International D1610 (3)
Stores Truck	International D1310, 30 cwt. 4x4
Geophone Carriers	Land Rover, L.W.B. (3)
Personnel Carriers	Land Rover, S.W.B. (3)
Drilling Rigs	Mayhew 1000/Mac Trucks (3)
Drill Tankers	A.E.C. Militant (3)
Office Caravan	1 4-wheel
Kitchen Caravan	1 4-wheel
Ablutions Caravan	1 4-wheel
Explosives Magazine	1 4-wheel

Equipment (Continued)

Workshop Trailer	1 4-wheel
Generator Trailer	1 2-wheel
General Purpose Trailers	2 4-wheel
Drill Trailer	1 4-wheel, 6 tonne
Drill Mechanics Trailer	1 2-wheel

PLATE 1



STRUCTURAL SETTING OF GEORGINA BASIN

Record No.1977/25

* Drawn by Author

F54/B3-269A

PLATE 2

DETAILED GEOLOGY AND TRAVERSE LOCATION MAP + TOKO SYNCLINE AREA

SYNCLINE
ANTICLINE
FAULT
PETROLEUM EXPLORATION WELL
SEISMIC TRAVERSE (PREVIOUSLY SHOT)
SEISMIC TRAVERSE (PROPOSED) — FIRST PRIORITY } NUMBERS INDICATE ROUGH ORDER OF RECORDING
" " " — SECOND PRIORITY }
G 10 SURVEY NUMBER, LINE NUMBER
STRATIGRAPHIC HOLE (PROPOSED)

SURVEY NAME SYMBOLS

G	Glenormiston Area
T	Toko Syncline
B	B.M.R.
A	Amaudale
L	Bedourie
M	Sandringham.

— — Approximate western edge of Toko Syncline

Cainozoic
Mesozoic
Permian
Silurian to Devonian
Ordovician
Cambrian to Ordovician
Upper Cambrian
Middle Cambrian
Late Adelaidean/ Lower Cambrian
Adelaidean
Archaean

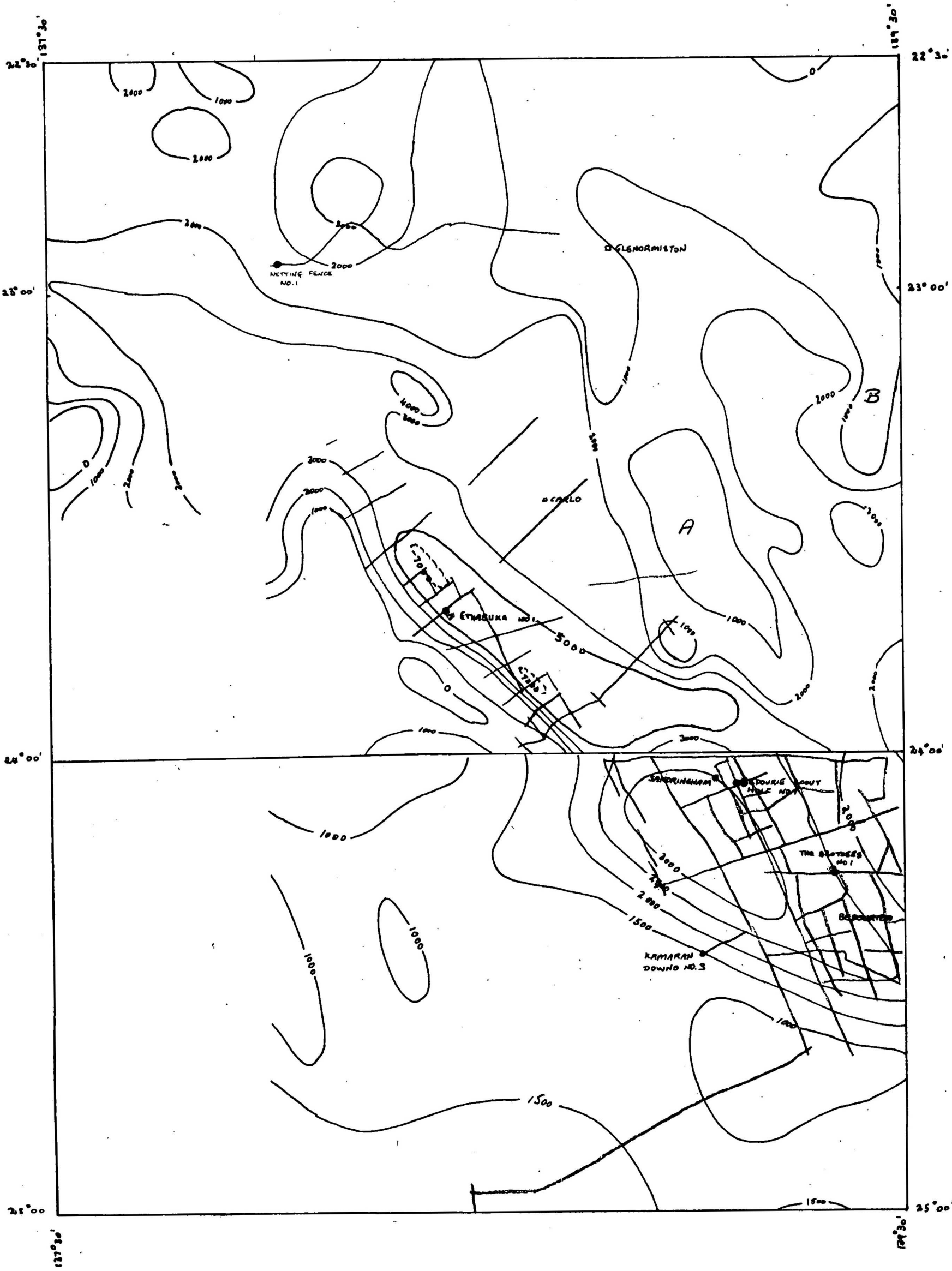
SCALE 1:500,000

10 5 0 10 20 km

Record No.1977/25 & 1978/10

F54/B3-270

PLATE 3



MAGNETIC BASEMENT CONTOURS

0 to 7000

SCALE 1:1000 000

10 5 0 10 20 30 KM

CONTOURS NORTH OF 24° 00' FROM WELLS, ET AL., (1966)

CONTOURS SOUTH OF 24° 00' FROM F.P.C. (1965c)

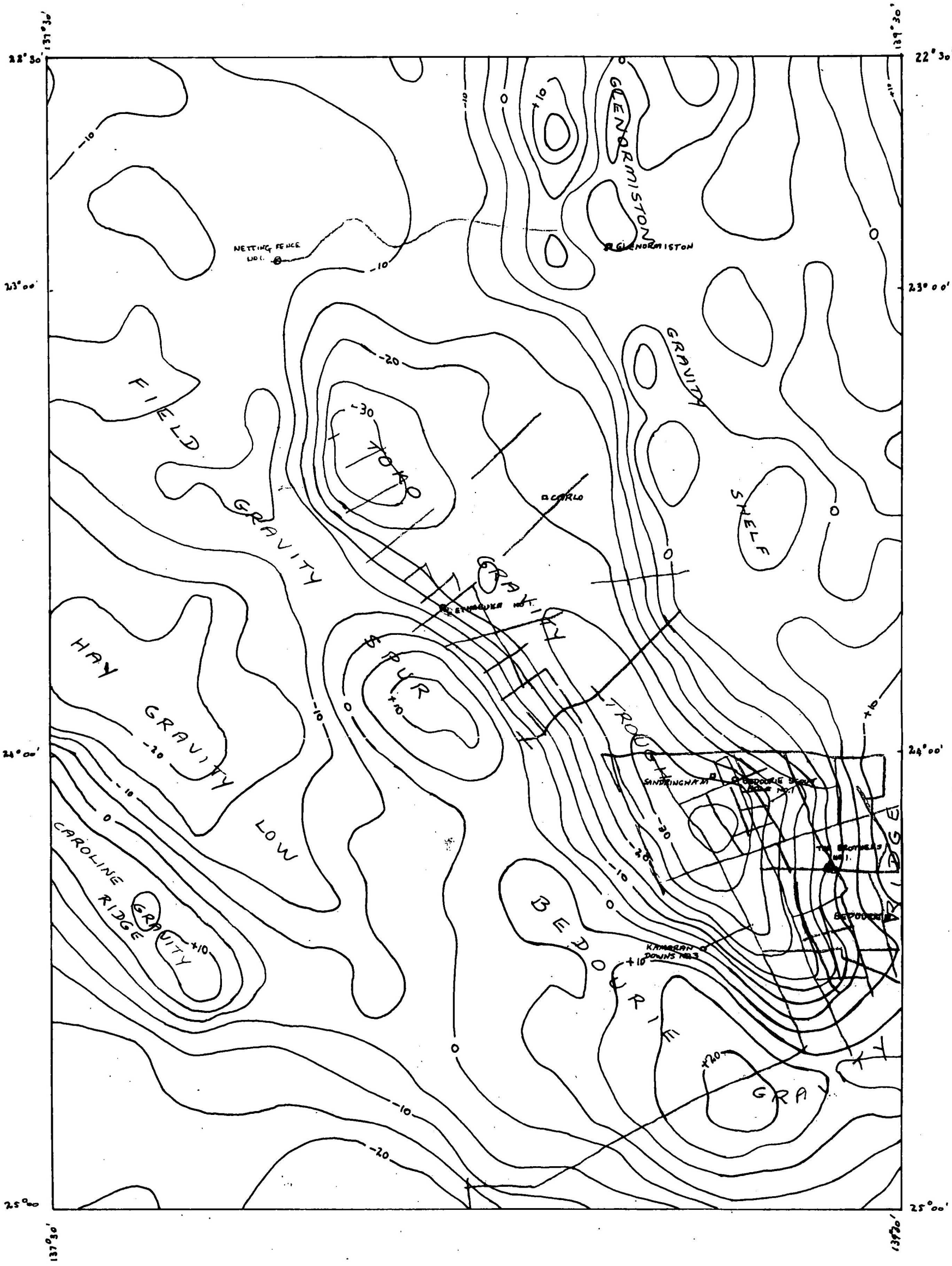
— 1500 — Magnetic basement depth (metres below msl)

——— Seismic line

0 — 1000

1000 — 2000

PLATE 4



BOUGUER ANOMALIES

SCALE 1:1000000

10 5 0 10 20 30km

DENSITY 2.67 GM/CC

-20 Bouguer anomaly contours (mgals)

Seismic line

Record No.1977/25

* Drawn by Author

F54/B3-272

CORRECTED RECORD SECTION

PLATE 5

RECORDING INFORMATION

Magnetic Recorder: DS7-7

Amplifiers: 7000B

Filters: K18-K160

A.G.C.: W.B.

Gain Initial: -55

Final: -10

Geophones: HSJ-14c/s

Geophone pattern:

16/trace, 20' apart in line

Station interval 150'

Shot-hole pattern:

25' 50' or 25' 50'

Depth 45'

Charge 2½ to 5 lb/hole

PLAYBACK INFORMATION

Filters: 1/20-1/60

A.G.C.: S.S.

Gain Initial: -40

Final: -20

Trip delay: 0

Compositing: Nil

VELOCITY INFORMATION

t;Δt analysis and

Expanded Spread Velocity Shoot

Traverses E,U,W,T.H

HORIZONTAL SCALE

FEET

0 1000 2000 3000 4000 5000

0 1800 3600

SOUTH-EASTERN GEORGINA BASIN

SEISMIC SURVEY 1963

TRAVERSE BF

RECORDED BY: *Seismic Party No.1*

SECTION BY: *Bureau of Mineral Resources Playback Centre SIE MS 42*

TO ACCOMPANY RECORD No.1977/25
& Record No. 1978/10

F54/B3-136-1

PLATE 6

137°30'
138°00'
139°00'
139°30'
22°30'
23°00'
24°00'
25°00'

TOKO SYNCLINE

NETTING FENCE NO. 1

CRAIGIE FAULT

TOOMBA FAULT

GLENORMISTON

CARLO 9

ETHADUKA NO 1

TOOMBA FAULT

STANDRINGHAM

MONOCLINAL FLEXURE

PIPPAGATTA FAULT

BEDOURIE

THE BROTHERS NO 1

BLOCK

BEDOURIE D

KAMARAN DOWNS NO. 3

TOOMBA FAULT

BORDER ZONE

TOKO SYNCLINE AREA

SCALE 1:500,000

10 5 0 10 20KM

STRUCTURE AT COOLIBAH FORMATION

NORTH OF 24° 00' CONTOURS IN MILLISECONDS (Alliance, 1974)

SOUTH OF 24° 00' CONTOURS IN METRES (N Horizon) (EPC, 1965d)

Record No.1977/25 & 1978/10

NORTHWEST

SOUTHEAST

Netting Fence No. 1

Ethabuka No.1

Bedourie Scout Hole No. 1

The Brothers No.1

Datum (91m above msl)

Depth (metres below datum)

200
400
600
800
1000
1200
1400
1600
1800
2000
2200
2400
2600
2800
3000
3200
3400
3600
3800
4000
4200
4400
4600
4800
5000

Nora
Coolibah
Kelly Ck
Ninmaroo
Georgina
Mungeranie
Steamboat
Netting Fence
Thorntonia Granite

Top Nora (from well correlation)
Top Coolibah (from well correlation)
Z (Base Mesozoic)
Coolibah
? Georgina
?
?

Wilgunya
Longsight
Cravens Peak
Ethabuka
Mithaka
Carlo
Nora
Coolibah
Kelly Creek
(Fair)
Coolibah
(Poor)
?
?

Unconformity

2405

Mesozoic
Z
Mithaka
Coolibah
MC (Pomegranate)
FRENCH FAULT
PIPPAGITTA FAULT
X (? Proterozoic)

Mesozoic
Chatsworth
O'hara
MC
Pomegranate
Thorntonia

V/H = 25

0 10 miles
16 km

Horizontal scale 1: 500,000

seismic reflection event

* Drawn by Author

STRUCTURAL SECTION BETWEEN NETTING FENCE NO.1, ETHABUKA NO.1, BEDOURIE SCOUT HOLE NO.1 AND THE BROTHERS NO.1

Record No.1977/25

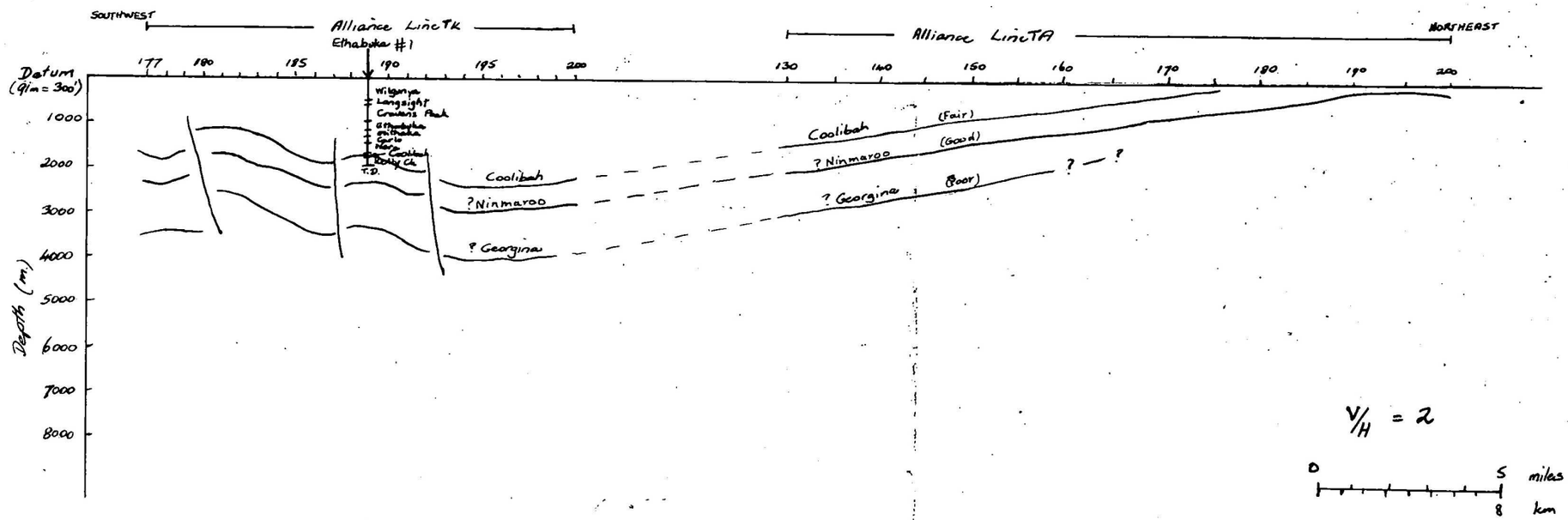


PLATE 8 STRUCTURAL SECTION ALONG TRAVERSES TK AND TA

$V/H = 2$

0 5 miles
8 km

Horizontal scale 1:250,000

——— seismic reflection event

Record No.1977/25

*Drawn by Author

F 54/B3-275

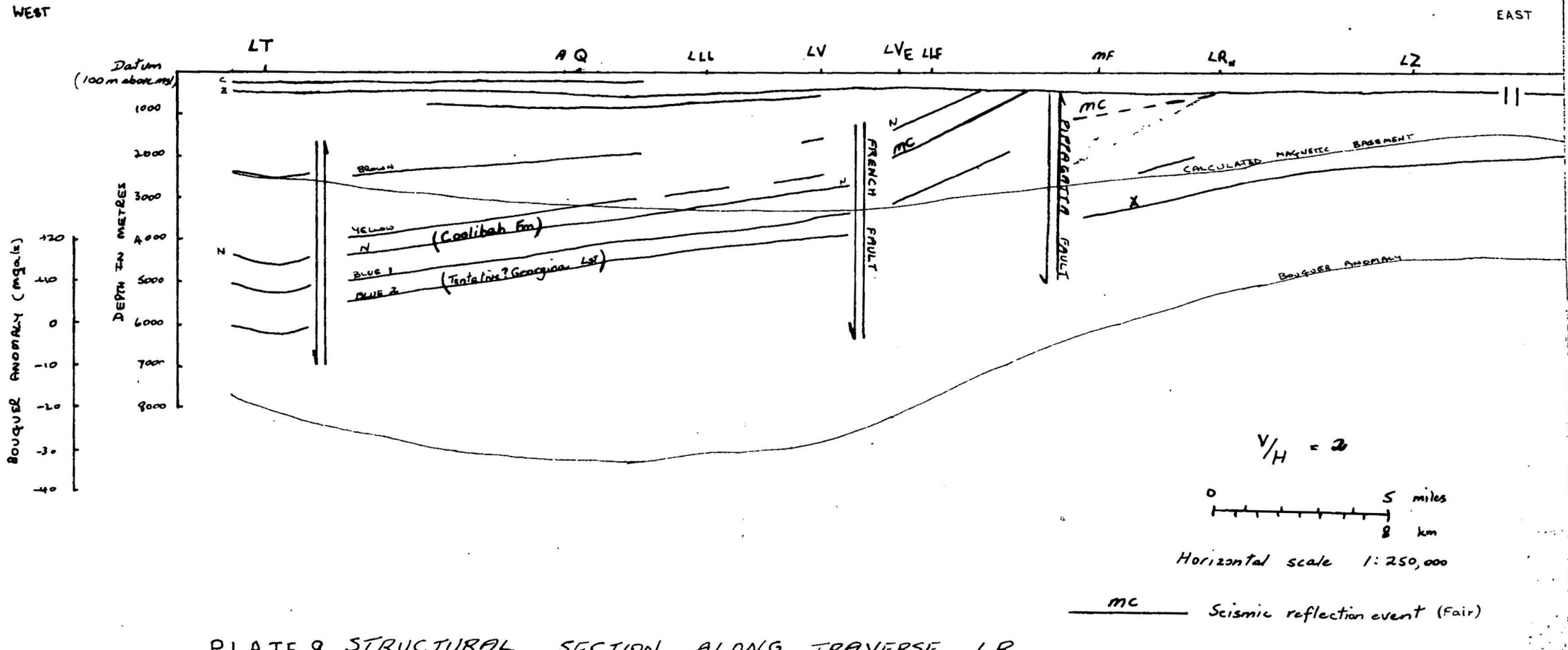


PLATE 9 STRUCTURAL SECTION ALONG TRAVERSE LR

Record No.1977/25 * Drawn by Author

F54/B3-276

PLATE 10

TIME - DEPTH CURVES

Reflection Time (Milliseconds)

0 500 1000 1500 2000

Depth (metres below surface)

500 1000 1500 2000 2500 3000 3500 4000 4500

After BMR ($T-\Delta T$)

A B C

Netting Fence Nº 1
Extrapolated.

Data Corrected to
Sea Level + 400 metres
(G.L. at Ethabuka)

Ethabuka Nº 1
Extrapolated.