DEPARTMENT OF ~~NATIONAL RESOURCES~~ NATIONAL DEVELOPMENT

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A PROPOSAL FOR A SEISMIC SURVEY IN THE

WESTERN DARLING BASIN, N.S.W.

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CONTENTS

PLATES

SUMMARY

Information from surface geology, well, gravity and seismic data from the western part of the Darling Basin has been reviewed to assess the requirements for further seismic work in the area. Structural and stratigraphic information has been examined and an attempt made to relate this to potential hydrocarbon generation and entrapment.

The only group of rocks considered to have source potential is the Lower Devonian marine sequence. This sequence will be most prospective where marginal marine conditions of deposition prevailed, resulting in suitable sand/shale relationships, and where suitable structures might be found. It is considered that the best chance of finding these structures is at the margins of the sub-basins.

The areas regarded as being most likely to have the necessary combination of source, reservoir, seal, and structure in the study area are the Blantyre Trough and the northern part of the Menindee Trough, in particular the northern, western, and eastern margins. Seismic coverage to date in these areas has been insufficient and not of good enough quality to adequately determine the nature of these margins.

A 3-month long program of multiple-coverage reflection seismic recording over 200 km of traverses is recommended to provide more information in these areas, thereby allowing a more complete evaluation of the hydrocarbon potential of the region. Although the odds against the occurrence of petroleum are high, further exploration is warranted in view of the basin's proximity to the markets and the Moomba-Sydney pipeline.

INTRODUCTION

The Darling Basin is an intracratonic fault-bounded basin in western New South Wales, with up to 7000 metres of upper Palaeozoic, mainly Devonian sediments. It consists of a number of horsts and grabens which formed during Late Devonian and Middle Carboniferous times. Only the western part of the basin - consisting of the Menindee, Blantyre, and Bancannia Troughs - is reviewed here as the geological and geophysical evidence suggests that this area is more prospective for petroleum than the rest of the basin.

Surface exposure of the Darling Basin sequence in the western part of the basin is confined mainly to the flanks of the Bancannia Trough, with small outcrops elsewhere. The sediments of the Menindee Trough do not crop out.

Two wells in the Blantyre Trough and three in the Bancannia Trough provide subsurface information in the area reviewed here. The only show of petroleum was encountered in Bancannia South 1, where indications of gas and traces of bitumen were found in the Middle-Upper Devonian section. Potential source rock was encountered in the Lower Devonian marine Amphitheatre Formation in the Blantyre Trough in the Mount Emu 1 well.

Reconnaissance gravity coverage of the area was made by a BMR helicopter gravity survey. Gravity, which provides the most systematic geophysical coverage of the western Darling Basin, has been used to delineate the trough boundaries and other structural features. The basin configuration as inferred from gravity exhibits generally good correspondence with the configuration inferred from surface geology, drilling, and seismic information.

Four aeromagnetic surveys give partial magnetic coverage of the area reviewed here. The magnetic basement depths interpreted from these surveys are, however, shallower than the metamorphic basement depths estimated from the seismic data.

There have been ten subsidised seismic surveys, conducted mainly in the 1960s ~~but~~ with the most recent in 1973, covering parts of the Menindee, Blantyre, and Bancannia Troughs. These have produced fair to good results in the trough areas but very poor results around the margins of the troughs and on the intervening highs. Well ties and outcrop information have enabled identification of reflections down to basement in the Bancannia Trough. The correlations are not good in the Blantyre Trough, where neither of the two wells reached basement and where the seismic data, near Mount Emu 1 in particular, were of poor quality. Identification of reflections in the Menindee Trough is based solely on reflection character correlation. It is the uncertainty of reflector identification and the lack of good quality seismic data in key areas which led to this review to determine if further seismic work is necessary.

GEOLOGY

The following is a summary of geology based mainly on studies made by Evans (1976, 1977). The surface geology is shown in Plate 1, the subsurface geology from exploration wells in Plate 2, and the structural elements in Plate 4.

Rocks in the area range in age from Proterozoic to Cainozoic. Proterozoic and Lower Palaeozoic rocks make up the economic basement, Upper Silurian to Lower Carboniferous sediments constitute the Darling Basin sequence, and Upper Carboniferous-?Lower Permian, Cretaceous, and Cainozoic sediments form a veneer which overlies many of the older rocks. The complete stratigraphy is shown in Table 1.

TABLE 1. Stratigraphy (adapted from Evans, 1976)

	AGE	GROUP OR FORMATION		LITHOLOGY	
POST-DARLING VENEER	CAINOZOIC	Undifferentiated		Alluvial and aeolian sands, clay gypsum	
		UNCONFORMITY			
	EARLY CRETACEOUS - LATE JURASSIC	Undifferentiated		Shale, sandstone, siltstone, impure limestone	
		UNCONFORMITY E			
	(?) EARLY PERMIAN-LATE CARBONIFEROUS	Undifferentiated		Glacigene conglomerates, shales	
		UNCONFORMITY D			
DARLING BASIN SEQUENCE		(WEST)	(EAST)	(WEST)	(EAST)
	EARLY CARBONIFEROUS-LATE DEVONIAN	Nundooka Sandstone and Coco Range Beds or Ravensdale Formation	Mulga Downs Group	Quartzose sandstone Qtzse sandst., conglom. Quartzose sandstone	Massive sandstone, quartzite, some shale
		UNCONFORMITY C			
	MIDDLE DEVONIAN	and Snake Cave Sandstone	(undifferentiated)		
		UNCONFORMITY B			
	EARLY DEVONIAN -LATE SILURIAN	Un-named	Cobar Group (includes Amphitheatre Fmn/Barrow Range Beds, Mallee Tank Fmn)	Purple-red sandstone	Sandstone, siltstone, claystone, quartzite, conglomerate, limestone
		UNCONFORMITY A			
BASEMENT ROCKS	LATE SILURIAN-ORDOVICIAN	Mootwingee Group	Tinderra Granite	Shale, limestone, sandstone	
	CAMBRIAN	Gnalta Group (includes Mt Wright Volcanics)	Ballast Beds Giralambone Beds	Lavas, tuffs, limestones, sandstone, shale	
		UNCONFORMITY			
	LATE PROTEROZOIC	Torrowangee Group		Quartzite, tillites, laminated shales, limestone lenses	
		UNCONFORMITY			
	(?) EARLY PROTEROZOIC	Willyama Complex		Gneisses, schists, phyllites, pegmatite, granite, amphibolite	

Note: See Plate 2 for thicknesses of stratigraphic units met in wells in Bancannia and Blantyre Troughs, and Plate 7 for thicknesses estimated from seismic data.

Basement Rocks

Proterozoic. The major Proterozoic sequence in the area is the strongly metamorphosed and mineralised Willyama Complex of the Broken Hill Block. The Willyama Complex is overlain with pronounced unconformity by the upper Proterozoic Torrowangee Group. Precambrian low-grade metamorphics, possibly equivalents of the Torrowangee Group, crop out in the Wonominta Block to the east of the Bancannia Trough.

Cambrian-Ordovician. Lower Cambrian to Lower Ordovician sediments are present in the Wonominta Block, in the Scopes Range High, and in an outlier on the Broken Hill Block. The Lower Cambrian rocks consist of lavas, tuffs, limestone, sandstone, and shale (Mount Wright Volcanics). These beds appear to have been deposited under shallow marine conditions in a reducing environment and can therefore be considered a possible source of hydrocarbons, but their potential must be reduced because of deep burial. Middle Cambrian rocks, predominantly limestone, are found in a north-plunging syncline between Mount Wright and the hills near Mootwingee. Upper Cambrian and Ordovician shales and limestones of the Mootwingee Group crop out in the Mootwingee and Dolo Hills. Fossiliferous Cambrian sandstones and shales are preserved in the Caloola Syncline on the eastern edge of the Broken Hill Block.

Darling Basin sequence

Up to 7000 metres of Upper Palaeozoic sediments, mainly Devonian in age but probably including some Silurian and certainly including Lower Carboniferous rocks, were deposited in the Darling Basin. The basin-fill has been divided into two main sequences, the Upper Silurian to Lower Devonian and the Middle Devonian to Lower Carboniferous. These sequences are separated by an unconformity which represents a widespread reorganisation of depositional regimes throughout the basin. In the west, a gentler unconformity separates the Middle Devonian from the Upper Devonian-Lower Carboniferous sequence.

<u>Upper Silurian-Lower Devonian</u>. This sequence includes terrigenous clastic sediments representing shallow marine, deltaic, and fluvial facies. In the east, the Upper Silurian-Lower Devonian period is represented by: the Cobar Group, which consists of the Mallee Tank Formation, a sequence of quartz sandstone, fossiliferous limestone, siltstone, and claystone outcropping from Cobar west to about $143^{o}30'$ longitude; the Amphitheatre Formation, a marine sequence of claystone and siltstone interbedded with sandstone; or the Barrow Range Beds, a probable littoral facies equivalent of the Amphitheatre Formation.

In the west, purple-red sandstones outcropping in the Gnalta-Mount Daubeny region on the flanks of the Wonominta Block are considered to be Late Silurian-Early Devonian in age. This un-named sequence, which is confined between the Gap and Koonenberry Faults, appears to be mainly continental in origin but exhibits some evidence of marine or marginal marine facies.

The only wells considered by Evans (1976) to have encountered sediments of Late Silurian-Early Devonian age are Mount Emu 1 and Bancannia South 1. Mount Emu 1 encountered about 670 metres of marine siltstone and shale with minor limestone which Haskell (Haskell & Wiltshire, 1970) thought range in age from Early to Middle Devonian, grading upwards into continental red sandstone and minor siltstone regarded by Haskell as late Middle Devonian in age. As these ages are based on the presence or absence of a few key spores which are not characteristic in the northern hemisphere, Evans (1976) considers it possible that the entire sequence is Early Devonian. Despite the poor quality of the seismic data on the line which ties to Mount Emu 1, the seismic reflections interpreted as coming from the unconformity surfaces A and B suggest that the sedimentary sequence in Mount Emu 1 is conformable Lower Devonian rocks.

Bancannia South 1 (Baarda, 1968a) intersected 3000 metres of Devonian sandstone, shale, and siltstone, which was originally interpreted as being entirely Middle-Late Devonian in age, before bottoming in volcanics similar to the outcropping Lower Cambrian Mount Wright volcanics. On palaeontological and seismic evidence, however, Evans (1976) now considers the lowermost 400 metres of the supposed Middle-Upper Devonian sequence to be Late Silurian-Early Devonian.

The seismic data, in conjunction with well and outcrop information, indicate that the Upper Silurian-Lower Devonian sequence in the Blantyre Trough may attain a thickness of 4500 metres, a significant part of which can be expected to be of marine origin. In the Bancannia Trough, the sequence consists of a sediment wedge, up to 2000 metres thick in the east, which laps westwards onto basement. The available evidence suggests that this sequence is mainly continental in origin. In the Menindee Trough, the existence of up to 3000 metres of Upper Silurian-Lower Devonian sediments is inferred from comparison of the character of seismic records there with those in the Bancannia and Blantyre Troughs.

Middle Devonian-Lower Carboniferous. Sediments of this age are widespread, extending from the flanks of the Broken Hill Block to the Cobar region east of 145°E, and are almost entirely of an alluvial facies. In the Cobar region these sediments are grouped into the Mulga Downs Group which generally consists of massive sandstone, quartzite, and subordinate shale; west of the Koonenberry Fault the Middle Devonian-Lower Carboniferous has been divided into formations. Outcrops around the Wonominta Block are divided into the Snake Cave Sandstone and the Ravensdale Formation, the two being separated by a gentle unconformity. Sequences of equivalent age which crop out along the western flank of the Bancannia Trough have been named the Coco Range Beds and the Nundooka Sandstone, neither of which is adequately dated.

Thick sequences of Middle Devonian-Lower Carboniferous sediments were intersected in the Bancannia North 1 (Baarda, 1968b), Bancannia South 1, (Baarda, 1968a), and Jupiter 1 (Wiltshire, 1969) wells in the Bancannia Trough, and in Blantyre 1 (Campe & Cundill, 1964) in the Blantyre Trough.

Seismic data indicate that the Middle Devonian-Lower Carboniferous sequence may reach a thickness of 6000 metres in the eastern part of the Bancannia Trough, 4000 metres in the Blantyre Trough, and ?4000 metres in the Menindee Trough.

Post-Darling Veneer

Upper Carboniferous-?Lower Permian. Glacigene conglomerates and marginal marine shales were encountered in Blantyre 1 well and in Ivanhoe 1 well to the southeast; they contained microfloras which date the beds as Late Carboniferous. Thick sequences have also been encountered in the south of the area reviewed in wells drilled in the Wentworth and Tararra Troughs. Seismic data indicate that the Upper Carboniferous sediments infill lows surrounding eroded highs which were formed during intra-Carboniferous orogenies.

Mesozoic-Cainozoic. Cretaceous sediments of the Eromanga Basin crop out in the north around White Cliffs and have been encountered in wells drilled in the Bancannia Trough. In the south, Cretaceous sediments of the Murray Basin were intersected by wells drilled in the Tararra and Wentworth Troughs. A thin (up to 400 m) veneer of alluvial Cainozoic sediments blankets most of the region.

PREVIOUS GEOPHYSICAL INVESTIGATIONS

GRAVITY

The following gravity surveys have been made in the western Darling Basin:

East Darling Helicopter Gravity Survey (Planet, 1963)

Nucha Gravity Survey (Planet, 1965)

Scopes Gravity Survey (Alliance, 1967)

Four Corners Gravity Survey (Alliance, 1968a)

Blantyre Basin Detailed Gravity Survey (NSW, 1969)

BMR Reconnaissance Gravity Survey (Zadoroznyj, 1975).

The most comprehensive gravity coverage of the area was by the BMR survey, a reconnaissance survey with gravity stations occupied by helicopter on an 11-km grid. Plate 3 shows the Bouguer anomaly contours resulting from the compilation of all the gravity data, and the main gravity features.

Most gravity features can be related to structural elements in the area; the structural elements are shown in Plate 4.

G1 is the gravity expression of the Bancannia Trough. Between 30°30'S and 31°30'S the steep gravity gradients on either side of the trough indicate probable faulting. Gradients on the eastern side of the trough are steeper than those to the west, suggesting that the faulting in the east is at a higher angle. Very shallow gradients in the north and in the southwest corner suggest either the absence of faulting or the presence of very low angle faults in these areas. The trough contains two distinct structural lows with Bouguer anomalies below -25 mGal; the presence of this double low is supported by the results of the Bancannia and Mootwingee aeromagnetic survey (Planet Oil-Geosurveys, 1964) (see later). Interpretation of the results of the Nucha Survey indicate a thickness of some 3650 m of sediments.

G5 is the gravity effect of the Menindee Trough. This trough also appears to be faulted against the Willyama Complex to the west, the Scopes Range to the north, and the Lake Wintlow High to the east. To the south basement appears to rise gradually with a saddle ridge at about $32^{o}50'S$, before deepening again into the Tararra Trough.

G8 is the expression of the Blantyre Trough. This trough seems to be a more irregularly-shaped depression than the Bancannia and Menindee Troughs and is possibly only faulted on the western side against the Lake Wintlow High. The trough appears to trend northerly and is interrupted on its eastern side by the easterly-trending Snake Flat Feature (G9) - a probable basement ridge. South of this feature is a narrow easterly-trending syncline which can probably be considered part of the Blantyre Trough. Separation of the Blantyre Trough and the Wentworth Trough to the south does not appear to be as pronounced as that between the Menindee and Tararra Troughs. The reconnaissance nature of the survey in this area makes it difficult to deduce an exact relationship.

G2, G3, and G4 are the gravity expressions of the Willyama Complex, Scopes Range High, and Wonominta Block, respectively.

G6 is the Lake Wintlow basement high which separates the Menindee and Blantyre Troughs. Bouguer gravity values here are not as strongly positive as in the Scopes Range and Wonominta Block, indicating greater depth of burial of basement. To the south and south-southwest this feature continues as G7.

AEROMAGNETIC

Four aeromagnetic surveys have been made in the western Darling Basin. The magnetic basement depths interpreted from these surveys are compiled in Plate 5. The depth contours in the trough areas generally agree in form with the trough configuration interpreted from the gravity and seismic data, but the depths are shallower than those estimated for the metamorphic basement from the seismic data. A brief description of the four surveys and their results follows.

Menindee (NAP, 1962)

This survey was flown in November 1962 for the North Australian Petroleum Company by Aero Service Ltd, in Petroleum Exploration Licence 48 (PEL 48). It consisted of four parallel traverses one mile apart. The survey area lies immediately to the south (north?) of Menindee and covers the northern ends of both the Menindee and Blantyre Troughs.

Magnetic basement was interpreted at a depth of 3800 m below sea level in the Blantyre Trough and 3600-4100 m below sea level in the Menindee Trough. Over the Lake Wintlow High basement was computed at a depth of about 550 m below sea level and the source was attributed to metasediments. Over the Willyama Complex, basement was calculated at 450 m to near surface. These magnetic basement depths were, however, revised when results from the later (Darnick Range) survey became available.

Darling area (Planet Oil, 1962)

This survey was flown in early 1963 for a consortium of companies by Aero Service Ltd in PELs 32, 35, 38-41, 52, 54-56, and 72. Of these areas, only PEL 52 and the western extremities of PELs 38 and 56 are in the area of interest. These areas cover much of the Menindee Trough, the northern area of the Blantyre Trough, and the area immediately to the northeast.

Magnetic contours in the area show intense northeast-trending anomalies interrupted in the east by a similar-trending magnetic maximum. The field east of here flattens (Lake Wintlow High) and is interpreted as being caused by a shallow metamorphic horizon overlying deeper, extremely acidic basement. The western anomaly pattern arises from strongly faulted Proterozoic rocks. The elongation of anomalies is parallel to one of the major fold directions in the Willyama Complex.

Calculations of depth to magnetic basement yield a central trough depth of 2400 m as compared with the depth of 3600-4100 m below sea level calculated from the results of the Menindee Survey. The character of the magnetic intensity suggests that the trough does not contain any of the high-grade metamorphics found to the east. The magnetic pattern suggests that the eastern side of the trough is fault controlled. A change in strike of the trough was interpreted 6.5 km north of Menindee, suggesting the possibility of east-west faulting.

Darnick Range (NAP, 1963)

The Darnick Range Survey was flown in June 1963 by Aero Service Ltd for North Australian Petroleum Company, in PEL 48 (same survey area as for Menindee Survey). Flight-lines were flown along the same headings as the former survey; four bands of traverses consisting of four lines each with a spacing of one mile between lines and eight miles between bands were flown, together with five tie-lines.

Interpretation of the new data showed the existence of a complex trough at an average depth of 1800 m below sea level except for the eastern edge, where a wedge of sediments extends to a depth of 3000 m below sea level. A strong persistent magnetic negative again suggests the eastern margin is fault bounded. East of this, the magnetic pattern suggests shallow, fairly acidic sources at about 760 m below sea level. The 25% difference in maximum computed depth of basement between that computed from this survey and from the Menindee Survey is probably a result of insufficient magnetic data in the earlier. The magnetic basement depths shown in Plate 5 were interpreted from this survey data.

Bancannia and Mootwingee (Planet Oil-Geosurveys, 1964)

This survey was flown in October 1964 by Aero Service Ltd for

Planet Oil Company (PEL 114) and Geosurveys of Australia (PEL 78); these leases encompass most of the Bancannia Trough and the area immediately to the east. Traverses were flown northeast-southwest in bands of 3 traverses 1.6 km apart, with 16 km between bands.

Interpretation of data from this survey concluded that horst and graben features which trend north-northwest are present in the Bancannia area. Horsts are represented by the Precambrian and Lower Palaeozoic of the Barrier Ranges and the Mootwingee Hills. The western side of the Bancannia Trough appears to be faulted at a shallow angle, whereas the eastern side appears to be steeply faulted. Two basement lows are interpreted within the graben (both below 3600 m below sea level) separated by a saddle rising to 2750 m below sea level. A small re-entrant appeared to be present in the southwest corner of the trough, connected to the trough proper above the 2100 m contour. Neither the southern nor the northern ends of the trough were covered by this survey. There is an implied thickness of about 3000 m of sediments in the northeast of the survey area (east of the Mootwingee Hills). This could indicate another graben structure.

SEISMIC

To the end of 1973, ten subsidised seismic surveys had been completed in the Menindee, Blantyre, and Bancannia Troughs and on the Lake Wintlow High. The traverse locations are shown in Plate 4. The following summary of surveys has been compiled chronologically.

Stephens Creek Refraction Survey (Oil Development, 1962)

This survey, conducted by the General Geophysical Company, consisted of 67 km of refraction shooting on five traverses on the Lake Wintlow High and in the Menindee Trough and its western flank with the object of determining depth to basement and the regional gradient of the basement rocks. In addition to refraction shooting, one split-spread profile was shot within each refraction profile. Reflection data were of no value.

Refraction profiles on the eastern side of the Menindee Trough showed considerable thickness of section, and indicated minor anticlinal features. Other profiles showed little section, being in areas of high basement.

Lake Pamamaroo Seismic Survey (Alliance, 1963)

Eight single-fold coverage lines were shot in this survey by Geophysical Associates Pty Ltd over the Lake Wintlow High to investigate a structural reversal found in the Stephens Creek Refraction Survey. Two horizons were mapped, one of Tertiary age and a second deeper horizon of unknown age. The shallower horizon showed regional westerly dip into the Menindee Trough and, in the extreme east, easterly dip into the Blantyre Trough. The second horizon was the deepest continuous reflection mapped. On this, steeper westerly dip was observed, but no terracing was seen as on shallower horizons. The isopach between the two horizons showed eastward convergence of the section, with local areas of thinning related to terracing on the upper horizon.

Tandou Seismic Survey (NAP, 1966)

The Tandou reflection/refraction survey was shot on seven lines in the southern end of the Menindee Trough by Petty Geophysical with the objectives of determining the thickness of the sedimentary section and defining any structural closures. Two horizons were mapped. The upper one probably originated from Permo-Carboniferous coal measures, and the lower one was a phantom horizon at approximately 0.9 s probably originating in the Upper Devonian. It was concluded that the area was underlain by a sedimentary section of low structural relief and of a synclinal nature. A refraction probe indicated a possible 3000 m of sediments.

Bancannia Seismic Survey (Planet, 1966)

This survey, conducted by Namco Geophysical Company, recorded five lines totalling 80 km of reflection profiles in the northern part of the Bancannia Trough. Fair-quality reflection data were obtained which indicated the presence of a thick (up to 7000 m) sedimentary section, thickening from west to east.

Lake Wintlow Seismic Survey (Alliance, 1968b)

This survey was conducted by Geophysical Associates Pty Ltd over the western flank of the Blantyre Trough, the Lake Wintlow High, and part of the Menindee Trough. 112 km of single-fold reflection and 45 km of refraction traverses were recorded with the objectives of further defining the Palaeozoic section within the Blantyre Trough and investigating gravity anomalies found in earlier surveys. Refraction recording indicated the presence of about 150 m of Palaeozoic section overlying Proterozoic basement (refractor velocity 5800 m/s) on the Scopes Range High, and about 4000 m of sediment overlying basement at Blantyre 1 well. These sediments thin rapidly onto the Lake Wintlow High.

Three horizons (?Upper Devonian, ?base Devonian, and ?Cambro-Ordovician) were mapped. Two lines were recorded from the deeper part of the Blantyre Trough onto the Lake Wintlow High. On these, reflection quality deteriorated rapidly up dip and the nature of the margin was unclear. A north-south line in the Blantyre Trough showed north dip with wedging out to the south. A line in the Menindee Trough indicated a faulted western margin.

Nucha Seismic Survey (Planet, 1968)

This survey was conducted by Planet Management and Research Pty Ltd over much of the Bancannia Trough. 200 kilometres of 6-fold coverage reflection data were recorded on 7 lines. The objectives were to extend knowledge of subsurface structural and depositional conditions in the southern Bancannia Trough and to locate any structural closures within the Devonian sequence.

Fair-quality data enabled three horizons (?top of Snake Cave Sandstone, within the Snake Cave Sandstone, ?top Mootwingee Group) to be mapped, and structural cross-sections were compiled. All the structure maps show the presence of a northerly trending anticline in the western part of the trough. This structure is characterised by gentle dips on the eastern flank and extreme west dips with possible thrust faulting on the western flank. The crest of the anticline appears to have been eroded. Shallower beds deposited since the erosion exhibit only slight closure over the pre-erosional fold.

Poor correlations carried from Bancannia South 1 suggest that the gas-bearing interval in the well may have been eroded from the anticlinal crest. A deeper gas-bearing interval at Bancannia South 1 lies below the eroded surface of the structure, but erosion may have affected the upper-most part of the interval.

Tandou-Coombah Seismic Survey (NAP, 1968)

The survey was conducted by Ray Geophysical in the same area as the 1965 Tandou Seismic Survey (southern Menindee Trough). Five lines totalling 142 km of 5-fold CDP reflection coverage were recorded using weight-dropping techniques. In addition, one-way refraction data were recorded over the same traverses. The objectives of the survey were to improve previous seismic control over the area, to confirm the reliability of a drill prospect, and to obtain data from the Lower Devonian and pre-Devonian sequences.

Record quality ranged from poor to good, and three horizons were mapped. The shallowest, of uncertain age, showed regional south-westerly dip. The second, believed to originate from the top of the Amphitheatre Formation, showed a regional northeast dip. An event slightly higher than this horizon may originate from the top of the Devonian sequence as it is associated with a large unconformity. The deepest horizon was thought to be basement, and refraction analysis supported this with velocities measured at 5650 and 6100 m/s, which are about those expected of Precambrian basement. Minimum and maximum recorded refraction basement depths were 2750 and 3230 m. A possible fracture with downthrown side to the west was mapped on one line.

<u>Tandou (Redbank) Seismic Survey</u> (NAP, 1969)

The Redbank survey was conducted by Ray Geophysical in the same area as the two previous Tandou surveys. 37 kilometres of 5-fold weight-drop seismic data were recorded with the aims of defining the limits of a structure indicated by the Tandou-Coombah survey, and obtaining additional information on sedimentary dips to the north and northeast of the prospect area.

Data quality was fair to good and three horizons were mapped. The shallowest, ?Tertiary horizon showed regional southwesterly dip. The intermediate (top Amphitheatre Formation) horizon, showed dip to the northwest or north-northwest.

A major fault zone and large uplift to the east were mapped. Varying dip directions on the upthrown block indicate a structure with likely closure against the fault.

Mount Emu Seismic Survey (NSW, 1970)

The Mount Emu Seismic Survey was carried out by Petty Geophysical in the Blantyre Trough. Three lines totalling 51 kilometres were recorded using 3- and 6-fold CDP techniques. The aims of the survey were to investigate the sources of gravity anomalies and attempt to identify reflections with lithological boundaries at the Mount Emu 1 well.

One line was recorded from the deeper part of the Blantyre Trough southeast of Mount Emu 1. Six horizons were mapped. The three shallowest horizons are probably within the Upper Devonian redbeds, and the other three are possibly at the top of, within, and at the base of the marine Devonian sequence. All reflections deteriorate up dip and it is not possible to correlate reflectors reliably with lithological boundaries at Mount Emu 1.

A cross-spread was recorded over the Snake Flat Gravity Feature (G9), a gravity high showing about 4 mGal of closure. It was anticipated that the corss-spread might show closure and pinching out of sediments against the high. Two horizons, both probably originating in the Upper Devonian sequence, were mapped, and these indicated that anticlinal closure does exist.

Menindee Regional Seismic Survey (Beaver, 1973)

The Menindee Seismic Survey was conducted by G.E.S. Pty Ltd in the Blantyre, Menindee, and southern Bancannia Troughs. Eleven lines of 6-fold CDP reflection coverage totalling 228 km were shot for the purpose of further defining the limits and structural configuration of the sub-basins within the area and to indicate areas of interest for future detailed work.

Data quality was good, except in areas of shallow basement where few or no reflected events were recorded. Up to five horizons, probably originating from the base of and within the Devonian section, can be traced in basin areas.

A fault-controlled closure, the Snake Flat anticlinal feature, was mapped west of Mount Emu 1, and structural growth continuing from early deposition to the present was indicated. Correlation of events across the feature was, however, dubious.

Four traverses in the northern Menindee Trough located the structural reversal first mapped by the Stephens Creek Refraction Survey. East and west dips were established, but seismic control is at present insufficient to determine structural relations to the north and south.

Four traverses were shot in the southern Bancannia Trough between Jupiter 1 well and the Scopes Range High. The syncline was shown to continue south from Jupiter 1 and to partly terminate against bounding faults. It could not be established whether the trough extended further to the south. In the west of the survey area an under-thrust fault which had been indicated by the Nucha Survey, was mapped. A closed high was interpreted on the upthrown eastern side of the fault, but closure to the south could not be established because of insufficient control.

General

Recording parameters and data quality and presentation for the above surveys have been summarised in Table 2. In general, single-fold coverage has succeeded in obtaining reflections only down to about 1.5 s two-way time. To obtain good quality section below this, it has been necessary to go to 6-fold CDP coverage. In the later surveys, penetration of up to 3.2 s two-way time has been achieved in the deeper basin sections (Plate 6). Reflection quality which is good in deeper parts of the troughs, however, deteriorates rapidly up dip, and in the areas of basement highs

TABLE 2. SUMMARY OF RECORDING PARAMETERS, DATA QUALITY AND RESULTS FROM PREVIOUS SEISMIC SURVEYS

SURVEY	AREA	METHOD	COVERAGE	RECORDING MODE	DATA QUALITY	HORIZONS MAPPED	DATA PRESENTATION
Stephens Creek (Oil Development, 1962)	Menindee Trough	Refraction Single reflection shots		Analogue	Fair to poor		Profiles
Lake Pamamarco (Alliance, 1963)	Lake Wintlow High	Reflection, explosive	single-fold	Analogue	Fair to poor	A - Upper Tertiary B - ?	? Structure maps and Isochron.
Tandou (MAP, 1966)	Menindee Trough	Reflection, explosive Refraction	single-fold	Analogue FM	Shallow, good to fair Deep, poor	A - ? Permo-Carb. B - Phantom, ? Upper Devonian	Structure contours (time)
Bancannia (Planet, 1966)	Bancannia Trough	Reflection, explosive	single-fold	Analogue	Fair	Nil	Depth profile map
Lake Wintlow (Alliance, 1968b)	Lake Wintlow High	Reflection, explosive Refraction	single-fold	Analogue FM	Good to poor	A - ? Upper Devonian B - ? Base Devonian C - ? Cambro-Ord.	Structure contour (time)
Mucha (Planet, 1968)	Bancannia Trough	Reflection, explosive	6-fold	Analogue, SIE GA22	Fair	A - ? Top Snake Cave B - ? In Snake Cave C - ? Top Mootwingee	Structure contour (time) and Isochron maps, Geological X-sections
Tandou-Coombah (MAP, 1968)	Menindee Trough	Reflection, weight-dropping Refraction	5-fold	Analogue FM	Mainly good to fair	A - ? B1 - Upper Devonian B - ? Top Amphitheatre Group C - ? Basement	Structure contours (time) and Isochron maps
Tandou (Redbank) (MAP, 1969)	Menindee Trough	Reflection, "Thumper" weight-dropping	5-fold	Analogue FM	Good to fair	A - ? Tertiary B - ? Upper Devonian C - ? Basement	Structure contour (time) and Isochron maps
Mount Eau (NSW, 1970)	Blantyre Trough	Reflection, explosive	3-6 fold	Digital, DFS III	Good to very poor	A - ? Upper Devonian B - ? Lower Devonian	Structure contour (time) and Isochron maps
Menindee Regional (Beaver, 1973)	Bancannia, Menindee, Blantyre Troughs	Reflection, explosive	6-fold	Analogue	Fair, provided not shooting on high velocity layer	A - ? Upper Devonian C - ? Mid-Lower Devonian D - ? Cambro-Ordovician E - ? Basement	Structure contour (time) and Isochron maps

it is practically impossible to follow the reflections. The poor quality is possibly due to the basement in these areas being structurally complex with steep dips. Surveys have utilised analogue recording, with the exception of the Mount Emu Reflection survey, which was digitally recorded.

SUMMATION OF GEOLOGICAL/GEOPHYSICAL INFORMATION

STRUCTURE AND BASIN EVOLUTION

The Darling Basin is an intracratonic feature, bounded by the Broken Hill Block to the west, the Wonominta and Paroo Blocks to the north, the Ivanhoe Block to the south, and the Cobar "massif" to the east. Outcrops of the Darling Basin sequence are sparse, but gravity data suggest that the basin consists of a number of grabens separated by basement uplifts, and drilling and seismic information where available have supported this interpretation. The structural configuration of the Darling Basin and its environs is illustrated in Plate 4 and geological interpretation of key seismic sections by Evans (1976) is presented in Plate 7.

Of the grabens, the Bancannia, Blantyre, and Menindee Troughs in the western part of the basin are considered to have the highest potential for hydrocarbons. Only these three troughs are discussed further here; the material is drawn largely from Evans (1977).

The Bancannia Trough, a northwesterly-trending graben lying between the Broken Hill and Wonominta Blocks and containing up to 7000 metres of mainly Devonian sediments, is the best known of these troughs. It has been investigated by three reflection seismic surveys and three petroleum exploration wells. The trough is bounded to the southwest and northeast by faults running parallel to the Corunna Fault in the Broken Hill Block and the Koonenberry Fault in the Wonominta Block, and to the south by faulting against the Scopes Range High. The graben is thought to have resulted from the action of a left lateral, slightly divergent, shear couple between the Broken Hill and Wonominta Blocks (Evans, 1976).

Cambro-Ordovician rocks crop out to the north, east, and south of the present day Bancannia Trough. Rose & Brunker (1969) consider that sedimentation during the Cambro-Ordovician period was controlled by the Koonenberry Fault Complex in the east and the Corunna Fault in the west, and that an ancestral Bancannia Trough received sediments during that time. Thus it is likely that a Lower Palaeozoic sequence underlies the Darling Basin sequence in the Bancannia Trough.

The deepest horizon to be reliably mapped by seismic surveying in the Bancannia Trough is the unconformable Horizon A (Plate 7), identified at Bancannia South 1 as the base of the Lower Devonian sequence. A second unconformity, Horizon B, dated as the Lower/Middle Devonian boundary, is present throughout the trough. It represents a period of mild but significant readjustment of depositional systems during which, for example, greater subsidence occurred along the northeastern boundary of the Bancannia Trough, resulting in onlapping westwards of the Middle Devonian sequence. A major period of deformation in the early Late Devonian, during which the Scopes Range High was uplifted, is marked by Horizon C. Minor movements of the northeast and southwest boundary faults also occurred at this time. Major movements occurred on the boundary faults in the Carboniferous. The Bancannia South and Jupiter structures are anticlinal features, underthrust at depth, which formed during this tectonic phase.

The Blantyre Trough, which is less well known than the Bancannia Trough, has been investigated by three reflection seismic surveys and two wells. Sediments of the trough crop out only in the extreme southeast. The Blantyre Trough is separated from the Menindee Trough to the west by the Lake Wintlow High, and from the Pondie Range Trough to the north by a high corresponding to the Wilcannia Gravity High. Its southern margin and its relationship with the Wentworth Trough are poorly known. About 6000 metres of sediments are believed to be present in the trough.

Seismic surveys in the Blantyre Trough mapped the two unconformities, Horizons A and B, which were mapped in the Bancannia Trough, but no unconformity corresponding to Horizon C could be identified. The seismic data indicate that the Blantyre Trough was created mainly by margin uplift in the early Late Devonian; there is some evidence, however, that the eastern flank of the Lake Wintlow High may have been topographically high in the Early Devonian.

Two features in the Blantyre Trough, the Mount Emu and Snake Flat structures, are suggested by gravity and seismic data to be basement-involved anticlines, with minor faulting which formed during the mid-Carboniferous tectonic activity.

The Menindee Trough, lying between the Scopes Range and Lake Wintlow Highs, is the least well known of the grabens of the western Darling Basin. No wells have been drilled into it, and it is completely obscured by younger sediments. The six seismic surveys which have been conducted in the trough indicate the presence of approximately 6000 metres of sediments. The trough is fault-bounded in the west, north, and east, and extends southwestwards into the Tararra Trough, in which Upper Carboniferous and younger sediments are preserved.

Seismic surveys in the Menindee Trough have mapped three unconformity horizons, which have been correlated with Horizons A, B, and C mapped in the Bancannia Trough. Like the Blantyre Trough, the Menindee Trough appears to have been formed by uplift of the Scopes Range and Lake Wintlow Highs in the early Late Devonian, when the Bancannia, Blantyre, and Menindee Troughs became separate entities. A basement uplift in the northeastern part of the trough probably formed at this time. A fourth unconformity, Horizon D, represents the mid-Carboniferous tectonic phase which produced flexuring of sediments in the Menindee Trough.

In summary, the tectonic history of the western Darling Basin can be depicted in terms of the unconformities mapped by seismic surveys. Deposition began in the Late Silurian to Early Devonian on a peneplained surface of Precambrian and probably Lower Palaeozoic rocks, in a broad, fault-bounded basin, the limits of which were controlled by pre-existing fractures such as the Koonenberry and Corunna Faults in the northwest, and possibly the Darling River Lineament in the southeast. The beginning of deposition is marked by Horizon A. During the Early Devonian, marine sediments, grading to continental in the west, were laid down. At about the end of the Early Devonian, regional readjustments gave rise to a widespread unconformity, Horizon B. This marked the end of the marine influence in the area. At the beginning of the Late Devonian, major tectonic forces caused uplift of the Scopes Range and Lake Wintlow Highs, and minor movements on the bounding faults of the Bancannia Trough; the effects of these forces did not appear to extend east of the Lake Wintlow High. This phase is correlated with Horizon C. Further movements in the Carboniferous resulted in further upwarp and faulting on previously formed highs, renewed movements on the bounding faults of the Bancannia Trough, and widespread flexuring. This phase is correlated with Horizon D.

Minor adjustments and final infilling of topographic lows took place during the Late Carboniferous and Early Permian, mainly in the southwest. Except for crustal sagging associated with the formation of the Eromanga and Murray Basins, the area has been stable since the Permian.

HYDROCARBON POTENTIAL

Source rocks. The only group of rocks considered to have hydrocarbon source potential is the Lower Devonian marine sequence. All other groups have been completely metamorphosed (Proterozoic rocks) or partly metamorphosed by deep burial (Cambro-Ordovician rocks), or consist mainly of redbeds containing little organic matter (Middle Devonian-Lower Carboniferous sequence). Although the Lower Devonian sequence shows evidence of low-grade metamorphism in Poopelloe Lake 1, it has not been affected by metamorphism in the west as indicated in Mount Emu 1 and Bancannia South 1.

The Lower Devonian sequence in Mount Emu 1 in the Blantyre Trough consists largely of marine siltstones and shales. The organic content is not high, but the presence of identifiable remains of land and marine microfloras gives reason to expect that sediments with sufficient organic content to constitute a source of hydrocarbons may exist in the trough.

It is not known if a marine Lower Devonian sequence exists in the Menindee Trough, but evidence for its existence would certainly upgrade the prospectivity of the trough. Clarification of the Lower Devonian aspect of the Lake Wintlow High, which may have influenced the distribution and extent of marine sediments, would assist in this regard.

The prospects for good source rocks in the Bancannia Trough are thought to be poor. Both on the eastern flank of the trough and at Bancannia South 1 the Lower Devonian sequence consists mainly of continental redbeds with a very low organic content.

The generally great depth of burial of the Lower Devonian sequence will have induced excessive maturation of any hydrocarbons in many parts of the western Darling Basin. However, elevated sequences, such as could occur on the flanks of the major highs, may be favourable for hydrocarbon generation.

Cambro-Ordovician sediments which have been mapped around the Bancannia Trough may form possible source rocks, but the extent and nature of these sediments below the Darling Basin sequence in the Bancannia, Menindee, and Blantyre Troughs is unknown, and their potential is considered low because of their deep burial.

Reservoir rocks. Sandstones with fair porosity were encountered in wells in the Bancannia Trough. On a seismic section in the trough, Evans (1976) has identified a Middle Devonian event, Horizon Bg (Plate 7), which he interprets as being of deltaic origin and implying a sediment source from the northeast. If this is the case, sands may be expected throughout much of the Bancannia Trough and possibly into the northern Menindee Trough.

Sandstones at Mount Emu 1 in the Blantyre Trough were hard and tight. It is considered that porosity would be preserved only where sands were deposited at relatively shallow depths such as on the flanks of the major highs, or where they were sufficiently uplifted by post-depositional tectonics as not to have suffered the prolonged effects of deep burial.

Seal. The distribution of suitable seal horizons is largely unknown, but the chances of their occurring are thought to be fair.

Structure. Three types of structures capable of trapping hydrocarbons were recognised by Evans (1977). These are:

1. Basement uplifts associated with compressive phases of shear along deep crustal fracture systems, e.g. the Menindee Structure.

2. Plastic deformation structures associated with strike-slip movement along major fault lines, e.g. the Bancannia South and Jupiter Structures.

3. Basement-involved flexures, e.g. the Mount Emu Structure.

The timing of structuring in the Darling Basin is critical. The basin was largely undisturbed during deposition of several thousand metres of Lower and Middle Devonian sediments. Assuming that an overburden of 1500 m is required before major hydrocarbon generation occurs (Evans, 1976), generation within the Lower Devonian sequence is likely to have been well advanced prior to the major tectonic period in early Late Devonian time, with the result that hydrocarbons would probably have been dissipated. Evidence of earlier structuring such as onlap of the Lower Devonian sequence against the eastern flank of the Lake Wintlow high, as interpreted in Plate 7, is very desirable to upgrade the prospectivity of the area.

CONCLUSIONS

An understanding of the broad structure of the western Darling Basin has been achieved, mainly from the gravity data which clearly reflect the configuration of the Proterozoic basement rocks, and from seismic data which have indicated the thickness of sediments in each trough and to some extent depicted the nature of the graben boundaries. The seismic information has also shown the presence of several structures in the sedimentary sequence.

In order to assess the hydrocarbon potential, the following questions require consideration and further investigation:

1. Do source rocks exist?
2. Did conditions exist during the Lower Devonian under which source rocks could have been deposited in close proximity to reservoir rocks?
3. Do there exist sequences that were either not deeply buried after deposition, or which have been elevated by post-depositional tectonics, such that they have not suffered from the adverse effects, in terms of maturation and porosity, of deep burial?

4. Are there traps, structural or stratigraphic, which were in existence at the time of hydrocarbon migration?

The potential for hydrocarbon source rocks has been demonstrated in the Blantyre Trough. In the Menindee Trough, the presence of source rocks can, at present, only be inferred by comparison with the Blantyre Trough. In the Bancannia Trough, present evidence indicates that the chances of suitable source rocks occurring are not good.

The most likely place for source and reservoir rocks to have been deposited in close proximity is around the basin margins or other elevated landmasses. Present meagre evidence suggests that such an elevated area may have existed at the northwestern margin of the present Blantyre Trough in the Early Devonian. Similar circumstances associated with the major basement uplifts could exist elsewhere.

Similarly, the more prospective shallow sequences are most likely to occur on the flanks of the major highs, either because they were originally deposited there and have been preserved since, or because deformation associated with uplift of these highs during the major tectonic phases resulted in the elevation of nearby sediments, and some of these would have escaped erosion.

The most likely kinds of traps are considered to be stratigraphic, associated with the lapping of sequences onto basement highs, and structural, associated with deformation during the early Late Devonian tectonic period.

From the preceding discussion it can be seen that an assessment of the hydrocarbon potential of the western Darling Basin hinges on the clarification of relations between the grabens, in particular the Blantyre and Menindee Troughs, and their bounding highs. The existing seismic coverage at the margins of the Blantyre Trough consists of two poor-quality lines across the western margin, and one across the southeastern margin.

Similarly the Menindee Trough has one poor-quality line crossing its western margin, and two across its complex northeastern margin. Though these lines have shown where the graben boundaries lie, and defined their gross configuration, the data are not of good enough quality to show the more detailed stratigraphic and structural relations needed for the complete appraisal of the various factors affecting hydrocarbon potential. Moreover, there are large areas around the graben margins that are completely unexplored.

Although the odds are about 50 to 1 against the presence of petroleum in the Darling Basin according to Smith (1977), further seismic work is warranted to tie the existing seismic coverage and investigate the prospective Lower Devonian sediments.

OBJECTIVES AND PROGRAM

The main objective of a new seismic survey should be to investigate the presence and structure of Lower Devonian sediments on the eastern, northern, and western flanks of the Blantyre and Menindee Troughs. To do this, the reflections corresponding to the top and bottom of the Lower Devonian sequence must be identified with as much certainty as possible in both troughs. In the Blantyre Trough, a better seismic tie to Mount Emu 1, the only well to intersect the Lower Devonian sequence, is needed to identify the reflections from the top of the sequence. Ties to the outcrop of Middle Devonian sediments on the southeast margin of the trough, and to Blantyre 1 in its centre, would place upper limits on the top of the Lower Devonian sequence elsewhere in the trough. The base of the sequence can be identified on character only, as this boundary does not crop out and has not been reached by wells. The only means of identification of these reflections in the Menindee Trough is by ties into the Bancannia Trough, in which the top and base of the Lower Devonian sequence are identified at Bancannia South 1, and into the Blantyre Trough, in which the top of the sequence is tentatively identified at Mount Emu 1.

In order to investigate the Lower Devonian sequence on the flanks of the Blantyre and Menindee Troughs where the hydrocarbon potential is considered to be the greatest, and to identify the main reflections, a program of four seismic reflection traverses to be supplemented with shallow stratigraphic drilling is proposed.

The seismic traverses 1, 2, and 3 are designed to provide ties between the exploration wells in the Blantyre Trough and the outcrops at the southeast margin of the trough, and to investigate the sediments on the eastern, northern, and western flanks of the trough. Traverses 3 and 4 are designed to provide ties between the seismic surveys in the Menindee Trough, where no exploration wells have been drilled, and the surveys in the Blantyre and Bancannia Troughs, where the wells have indicated the presence of Lower Devonian sediments. The traverse 4 would also investigate the northern flank of the Menindee Trough.

High multiplicity, 6 to 12-fold CDP, seismic coverage would be required, particularly across the basement highs where the quality of exsiting seismic data deteriorates very markedly. Digital recording and processing techniques should be used.

The proposed program consists of approximately 200 kilometres of reflection traverse, which would require a period of three months to record. The personnel, vehicles, and equipment necessary for the survey are listed in Appendix 1.

It is not known whether even better-quality reflections if recorded could be followed from the trough areas through the structurally complex flanks to the highs, and whether the correlation of the reflections from one trough to the other would be definitive. Hence it is considered necessary for lithological identification of reflections that shallow stratigraphic drilling be carried out along the margins of the Menindee and Blantyre Troughs where the presence of Lower Devonian rocks at 1000-

2000 m depths has been suggested by the previous seismic data. Such drilling would also provide samples for systematic reservoir and cap rock studies for a better determination of the hydrocarbon potential of the area.

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APPENDIX 1. PROPOSED PERSONNEL, VEHICLES AND EQUIPMENT - BMR

Party Leader	1	
Party Manager	1	
Geophysicist	1	
Technical officer (Science)	1	
Technical officer (Engineering)	1	
Field Assistant (Shooter)	2	
Field Assistant	2	
Mechanic	1	
Toolpusher	1)	
Drillers	3)	Petroleum Technology Section
Asst. Driller	1)	
Wages Mechanic	1	
Cook	1	
Cook's Offsider	1	
Wages Hands	12	
Surveyor	1)	
Technical Officer (Surveying)	1)	Australian Survey Office
Chainman	2)	

VEHICLES

Recording truck	International D1610 3-tonne, 4 x 4	1
Shooting truck	" " " "	1
Workshop truck	" " " "	1
Flat-top trucks	" " " "	2
Water tankers	" " " "	2
Stores truck	International D1310 30 cwt, 4 x 4	1
Geophone carriers	" " " "	3
Personnel carriers	Landrover S.W.B., S.W., L.W.B.	3
Drilling rigs	Mayhew 1000/Mack 6 x 8 trucks	4

VEHICLES (cont'd)

Drill tankers	A.E.C. Militant	4
Office caravan	4-wheel	1
Kitchen caravan	4-wheel	1
Ablutions caravan	"	1
General purpose trailers	"	3
Workshop trailer	"	1
Drill trailer	4-wheel, 6-tonne	1
Drill mechanics trailer	2-wheel	1

EQUIPMENT

Recording system	TI DFS-IV	1
Camera	ERC 10	1
C.D.P. roll-along switch	I/O Rota-long	1
Radio firing unit	I/O R.F.U.	1
Cables	539 m, 48-channel	17
	140 m, weathering cables	2
Geophones	Geospace GSC 20D, 8 Hz in groups of 8 at 5 m intervals	2000
Tranceivers	Codan 6924	2
	Phillips FM 828	8
Gravity meter	Worden	1

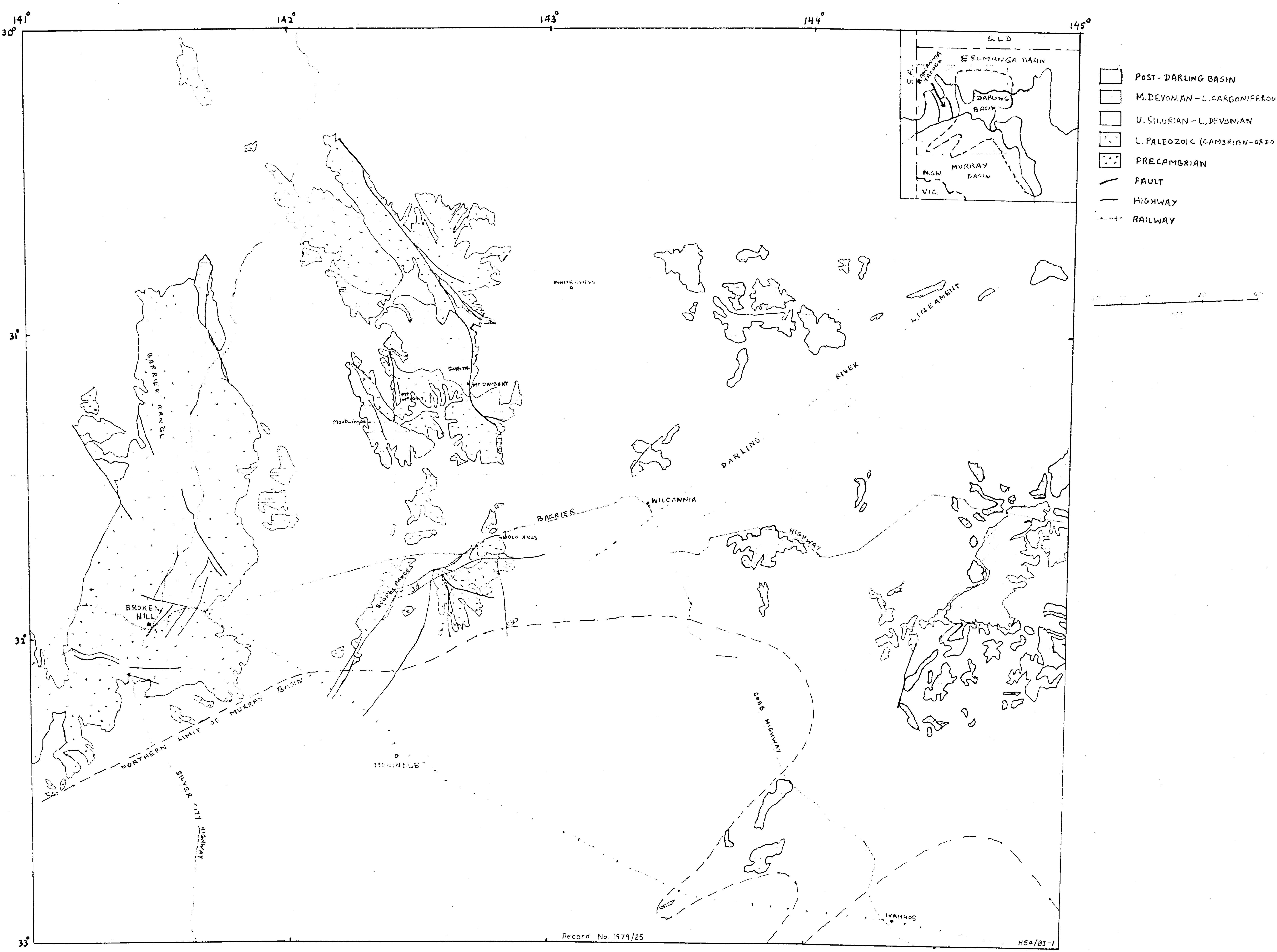


PLATE 1. SURFACE GEOLOGY AND LOCALITY MAP

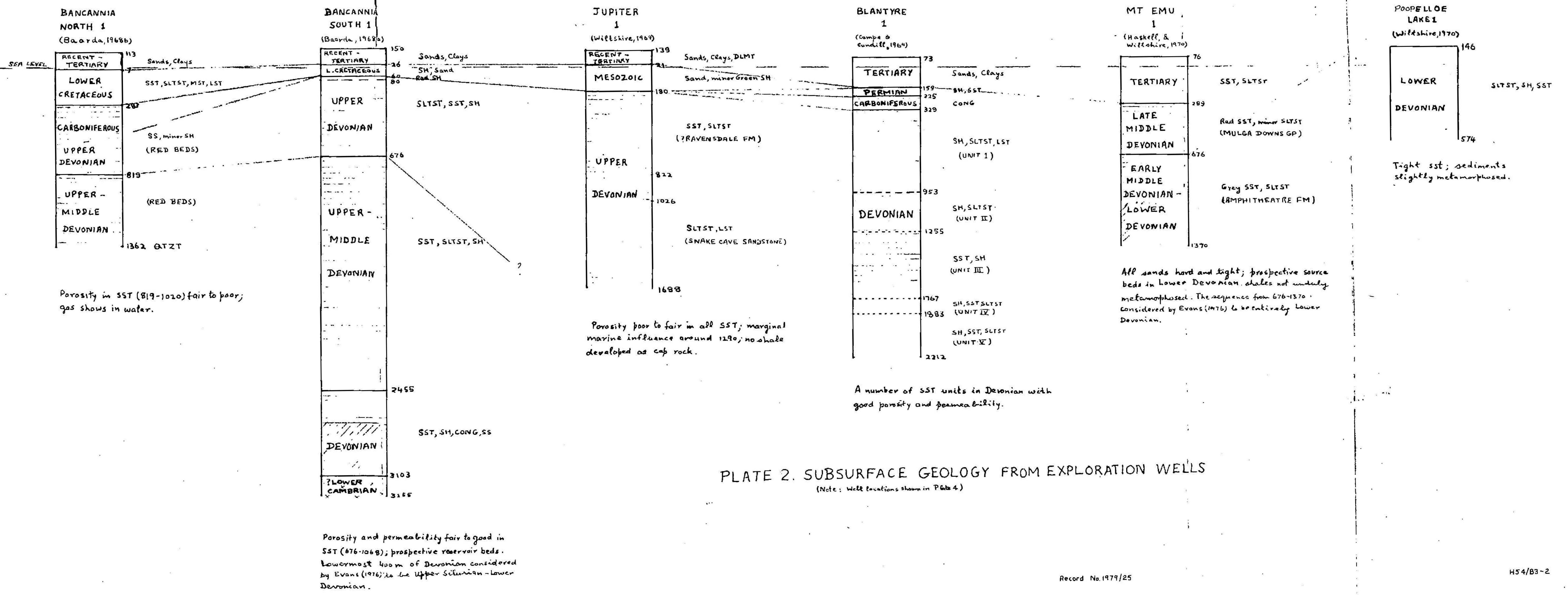


PLATE 2. SUBSURFACE GEOLOGY FROM EXPLORATION WELLS

(Note: Well locations shown in Plate 4)

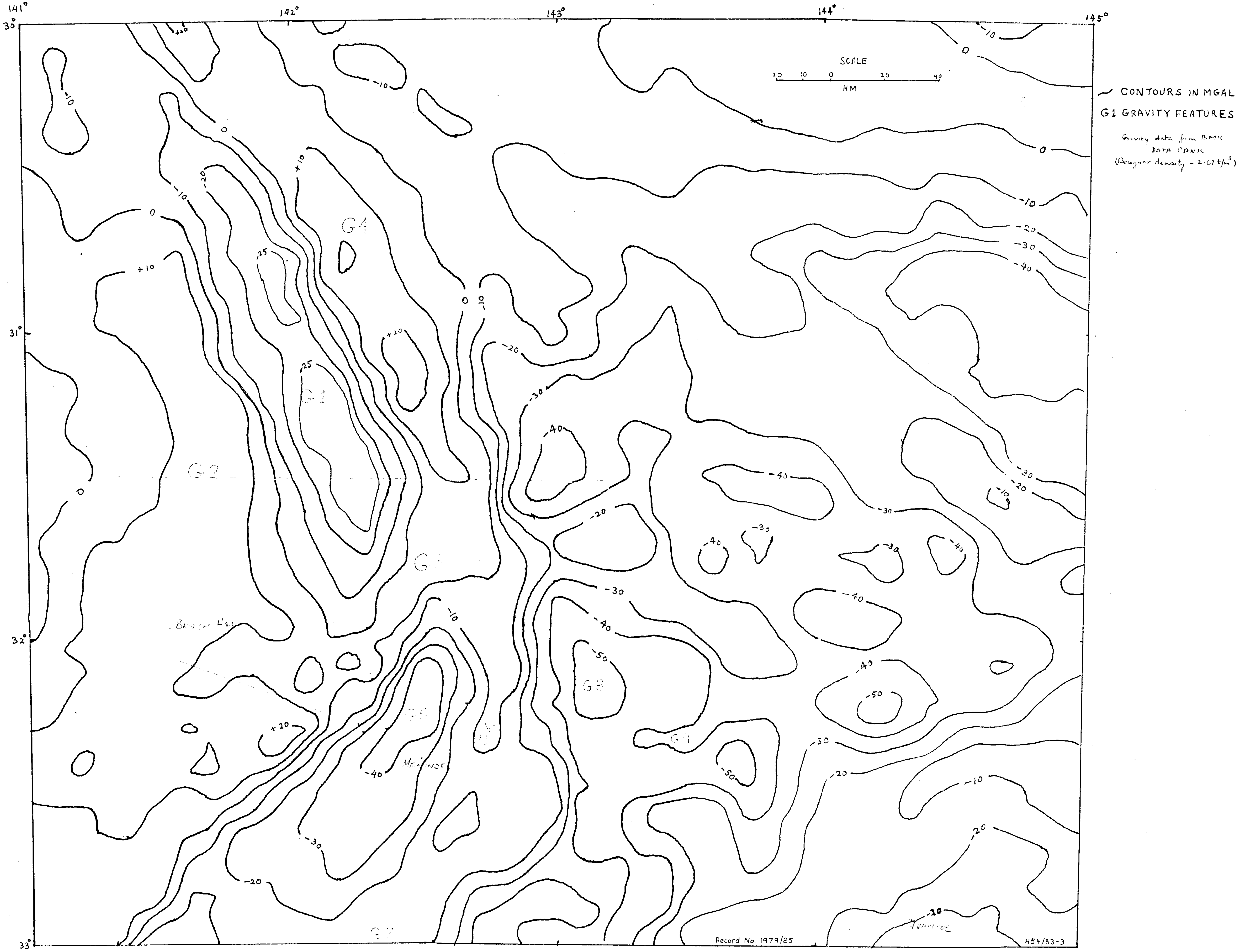


PLATE 3. BOUGUER ANOMALIES AND GRAVITY FEATURES

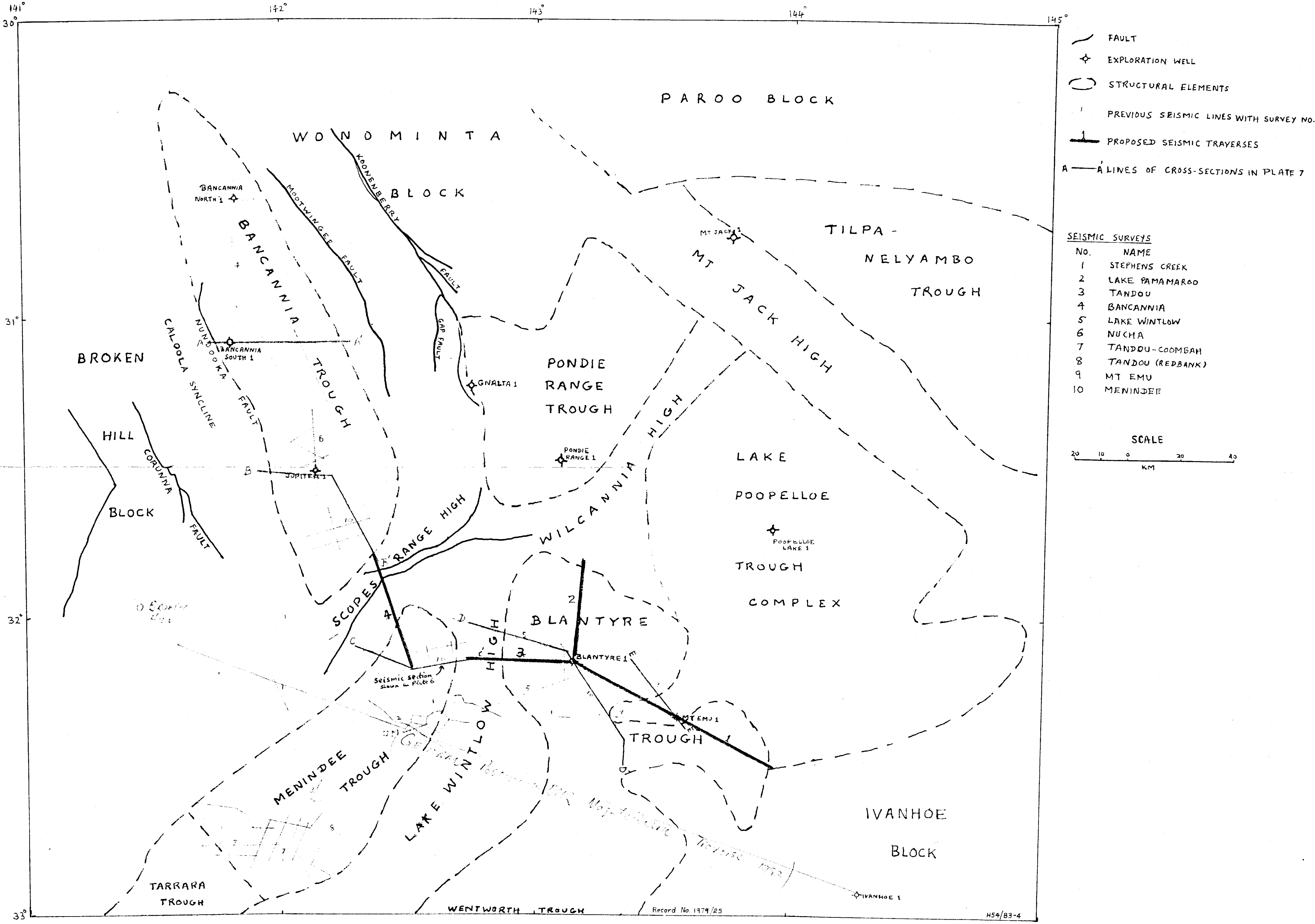


PLATE 4. SEISMIC TRAVERSES, WELL LOCATIONS AND STRUCTURAL ELEMENTS

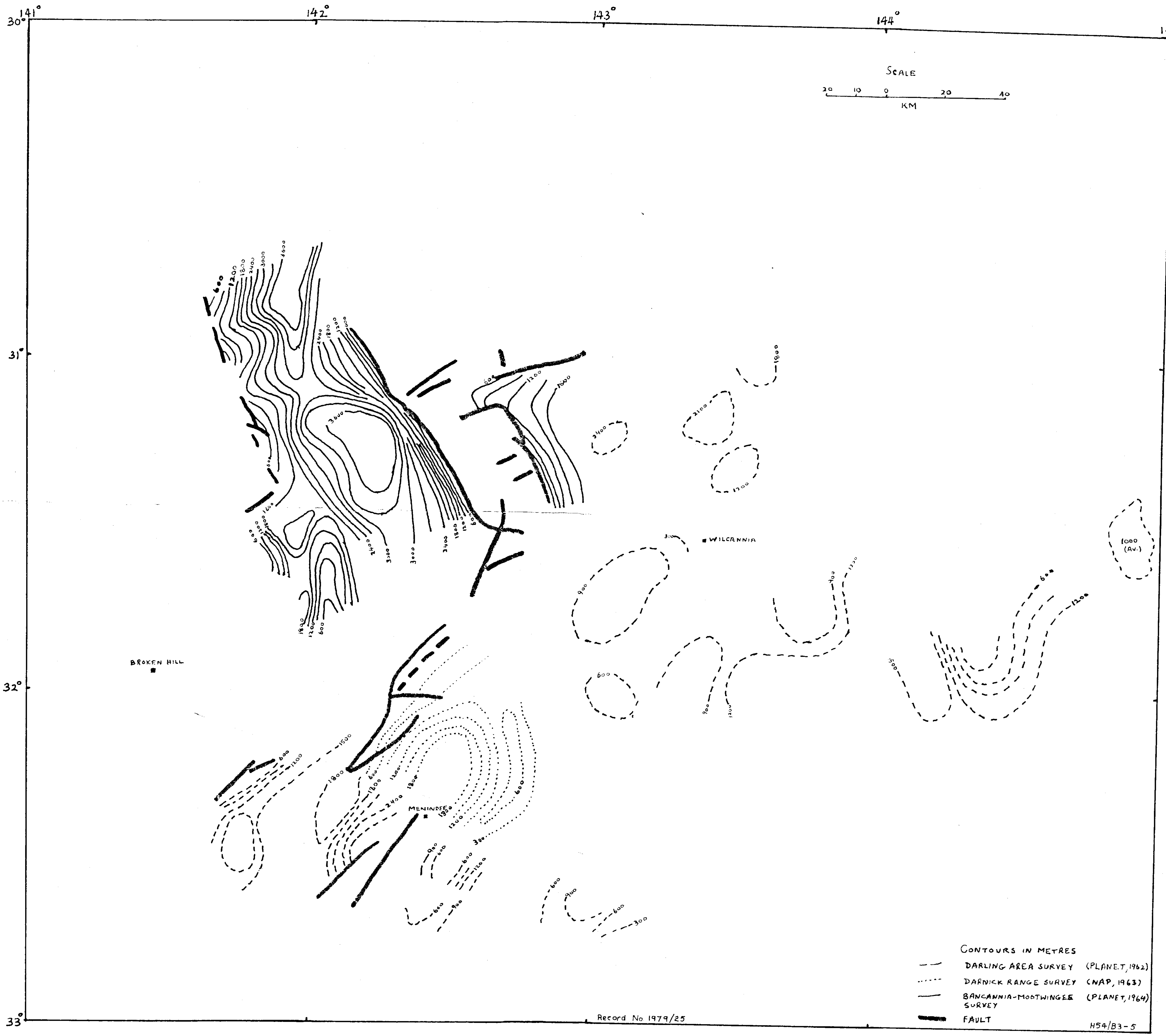


PLATE 5. MAGNETIC BASEMENT DEPTHS

PLATE 6

SECTION OBTAINED UNDER PETROLEUM SEARCH SUBSIDY ACTS

FINAL STACK

E

10 SHOTPOINTS

1041 m

GEOPHYSICAL SERVICE INTERNATIONAL

DIGITAL PROCESSING CENTRE SYDNEY, N.S.W. AUSTRALIA

FOR

BEAVER EXPLORATION AUSTRALIA N.L.

AREA MENINDEE REGIONAL S.S.

LINE MR-2

SHOTPOINTS 106-283 DIRECTION EAST

FIELD RECORDING DATA:

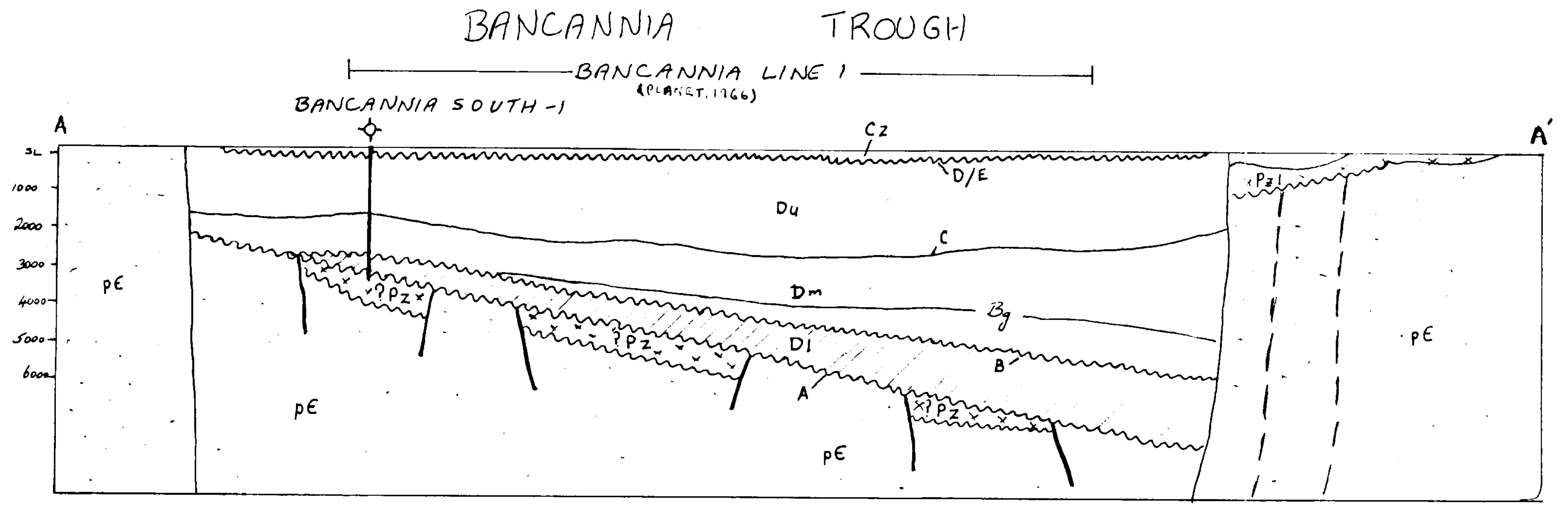
Recorded by G.E.S. Pty Ltd — Date September 1973

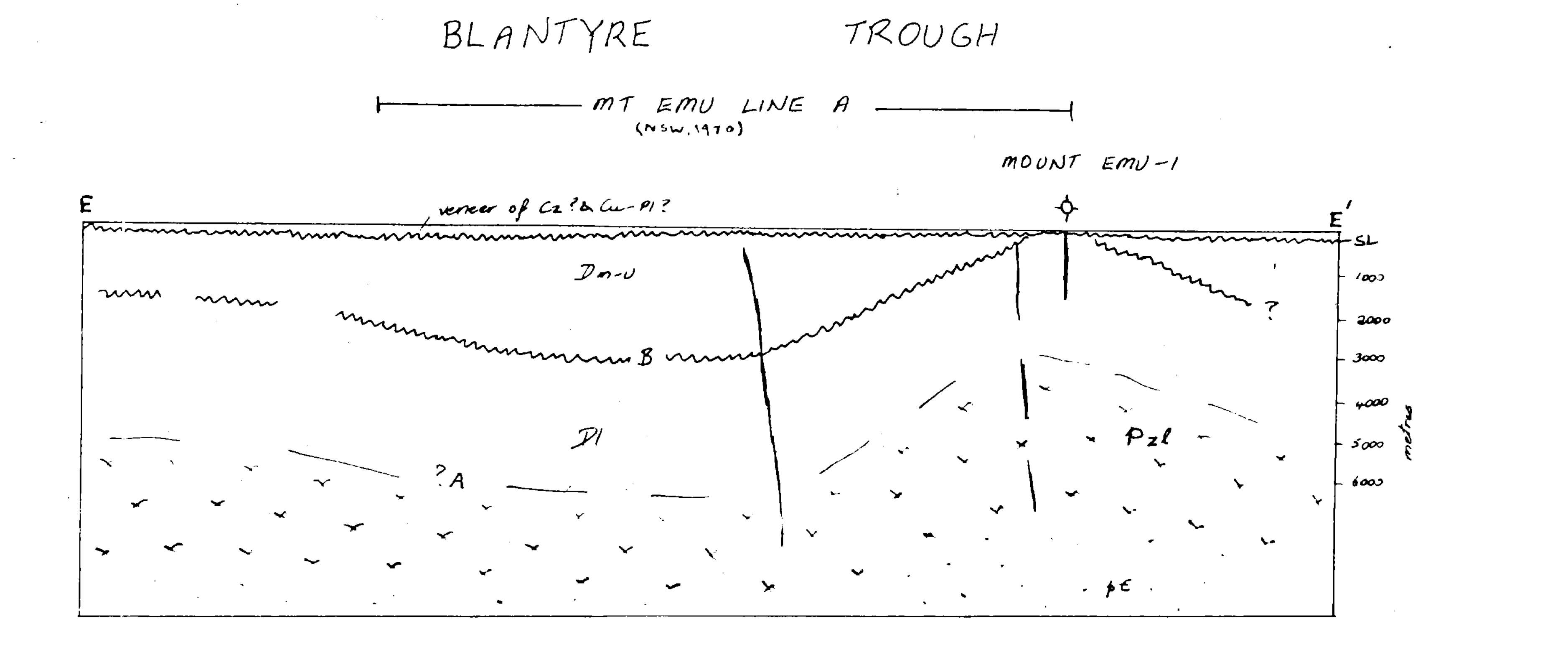
Recording System GA 33 — Filter OUT + V65

Mode Analog — Record Length 5.0 secs.

PROCESSING SEQUENCE:

PLATE 7. INTERPRETATIVE CROSS-SECTIONS ACROSS THE TROUGHS (AFTER EVANS (1976)).





NOTE: SEE LOCATION OF SECTIONS IN PLATE 4

Mz/Cz	Cenozoic and/or Mesozoic undifferentiated
Cu-Pl	Upper Carboniferous - Lower Permian
Du	Upper Devonian incl. [illegible]
Dm	Middle Devonian incl. [illegible] of Snake Cave Fm (Ds)
Dm-u	Middle-upper Devonian undiff. incl. Mulga Downs Gp.
Dl	Lower Devonian (and possibly uppermost Silurian) incl. Cobar Group
Pzl	Cambro-Ordovician undiff. incl. Gnalta & Mootwingee Groups
pЄ	Precambrian (largely Proterozoic) undiff.
A (wavy line)	Unconformity

HORIZONTAL SCALE: 5 0 5 10 KM

V/H = 3.5