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GALILEE BASIN SEISMIC SURVEY, QUEENSLAND, 1975 - PRESURVEY REPORT

by

P.L. Harrison and J.A. Bauer

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SUMMARY

The Galilee Basin occupies a large area in central Queensland and contains up to 3000 m of mainly terrestrial Permo-Triassic sediments. Although a large number of seismic surveys have previously been made in the basin few of them have obtained reliable reflections below the "P" horizon, a strong reflector associated with widespread Upper Permian coal measures, so that the sediment thickness and the nature of the basin margins are not well known in some areas.

A seismic survey in the Galilee Basin is planned to operate during July to December 1975 in two areas in the western and northeastern parts of the basin near Brighton Downs and Hughenden respectively. The survey would commence near Brighton Downs (about 150 km southwest of Winton) to determine the southerly extent of the trough of Permo-Triassic sediments west of the Cork Fault. The survey would then move northeast to Hughenden to investigate possible steep margins to the basin in this area. The survey would use reflection techniques with a high proportion of multiple-coverage recording to obtain good deep reflections.

Presence of thick Permian sediments and possible steep margins to the basin in the above areas could enhance the possibility of stratigraphic and structural traps for hydrocarbons and could encourage further exploration by private companies.

1. INTRODUCTION

Seismic surveys in the western and northeastern parts of the Galilee Basin in central Queensland near Brighton Downs and Hughenden are planned during July to December 1975 to obtain information about the thickness and structure of the concealed Permo-Triassic sediments of the Galilee Basin and to determine the nature of the basin margins in these areas. Reflection recording will be made with about one half of the coverage being single-fold and one half at least six-fold, the latter to be made where previous work indicated that multiple coverage is necessary to obtain good reflections.

The proposal for the seismic work near Brighton Downs originated from a study of seismic and drilling results in the Northern Eromanga Basin by Harrison (in prep.). The seismic work near Hughenden was originally proposed by Vine & Paine (1974, p. 33), and the line east of Hughenden is proposed by the authors.

The Galilee Basin occupies a large area and has a maximum thickness of about 3000 metres of Upper Carboniferous(?), Permian and Triassic sediments. The basin is almost entirely concealed by the Cretaceous and Jurassic sediments of the Eromanga Basin which have a maximum thickness of about 1800 m, and the thickness and extent of the Galilee Basin sediments are known mainly from petroleum exploration wells and seismic surveys. About 38 seismic surveys have been made and about 40 wells have been drilled in the basin north of 24°S. However the 19 wells which drilled into the Permian sediments and much of the seismic work failed to provide reliable information about the thickness of the Permian section. Also, the basin margins have not been well-defined.

The possible presence of petroleum, shallow coal deposits and oil shale gives economic justification for the survey. The most prospective section for petroleum is the Lower Permian with potential stratigraphic and structural traps at the basin margins. A strong seismic reflector, the "P" horizon, is associated with widespread Upper Permian coal measures. Knowledge of the depth to this reflector near the basin margins would assist coal exploration programs. Oil shale is known to be associated with the Lower Cretaceous Toolebuc Limestone in parts of the basin but the only potentially commercial occurrence is at Julia Creek (Swarbrick, 1974).

In addition to the seismic work it is proposed to take gravity readings along the seismic lines to enable combined seismic and gravity modelling. The Queensland

Geological Survey propose to drill three or four coreholes to maximum depths of 1200 m during 1975 as part of their stratigraphic drilling program and they have proposed to cooperate with the geophysical work by BMR by locating some holes near the proposed survey areas so that the seismic lines may be tied to them and velocity logs obtained.

Access to both proposed survey areas is good. Access to the Brighton Downs area is by a graded and formed stockroute from Winton which follows the eastern side of the Diamantina River. There are also numerous station tracks but all roads are unsurfaced and impassable after rain. In the Hughenden area, the access is by a sealed highway from Charters Towers to the northeast. Both Winton and Hughenden are large towns with rail and air services.

The climate of the region is tropical-continental with a diurnal temperature range of about 17°C. The rainfall is about 400 to 600 mm, mainly during the summer. The summer is hot with an average of 80 days with temperatures above 40°C.

Good water supplies are available in both areas from artesian and sub-artesian bores. In the western area surface water may remain in pools in the Diamantina River and its larger tributaries.

In the Brighton Downs area the land surface consists mainly of duricrust surface with erosional residuals comprising mesas, buttes and plateaux often with steep scarps. The surface in places is rough and broken with numerous small creeks. The Diamantina River and its tributaries consist of braided channels with low steep scarps and thick vegetation. A bulldozer would be required in places to improve the access. About ten percent of the area consists of rolling downs, extensive undulating grassland with light scrub and fairly good access. In the Hughenden area the country adjacent to the sealed highway consists mainly of smoothly undulating hills and plains with extensive open forest. There should be few operational problems in this area.

2. GEOLOGY

General

The early geological work in the Galilee Basin was concerned with hydrological investigation of the Great Artesian Basin (Whitehouse, 1955). Following this, systematic surface mapping of the whole area was made at

1:250 000 scale by the BMR and the Geological Survey of Queensland and the results have been published as maps and explanatory notes.

The following notes about the geology of the Galilee Basin are largely drawn from reports by Casey (1970), Vine (1973), Benstead (1973) and Allen (1973, 74).

The Galilee Basin represents the northern lobe of a vast area of sedimentation which was formed by periodic downwarping during Upper Carboniferous/Lower Permian to Upper Triassic times; the Bowen and Cooper Basins form the eastern and western lobes (Allen, 1973). It is flanked to the northwest by the Georgina Basin and the Mt Isa Block and to the northeast by the Drummond Basin and the Lolworth-Ravenswood Block (Plate 1). The maximum known thickness of the Upper Carboniferous (?), Permian and Triassic Galilee Basin sediments is about 3000 m. Much of the basin area is covered by Jurassic-Cretaceous Eromanga Basin sediments. The Galilee Basin outcrops are confined to the basin's eastern margin where large areas are concealed by Cainozoic deposits.

Stratigraphy

The generalized stratigraphy of the overlapping Drummond, Galilee and Eromanga Basins is shown in Table 1. The stratigraphy of the Galilee Basin sediments is shown in more detail in Table 2.

Sedimentation in the Galilee Basin was mainly fluviatile continuing from the Upper Carboniferous/Lower Permian until the Upper Triassic. There is evidence of glacial conditions in the Upper Carboniferous/Lower Permian. Mild folding, uplift and some erosion occurred at the end of the Triassic.

The Galilee Basin sediments rest on a variety of older rocks including Lower Carboniferous Drummond Basin sediments and volcanics in the northeast, Devonian Adavale Basin sediments in the south with a possible northerly continuation (Vine, 1972), and a complex of older Palaeozoic and Precambrian crystalline rocks.

Basement Crystalline basement does not crop out within the Galilee Basin area, but has been intersected in some petroleum exploration wells (Plate 1). The basement rocks reached by wells consisted of Precambrian and Palaeozoic granites, Cambrian metamorphics and pre-Upper Carboniferous volcanics.

TABLE 1. GENERALIZED STRATIGRAPHY

BASIN	AGE	GROUP	FORMATION		APPROXIMATE THICKNESS (m)
	QUATERNARY TO TERTIARY ?		alluvium, soil, sandy deposits, duricrust, sandstone, mudstone		superficial up to 100
			UNCONFORMITY		
	CRETACEOUS	ROLLING DOWNS	Winton Formation	Labile sandstone; mudstone; coal	300+
			Mackunda Formation	Mudstone; siltstone; labile sandstone	240
			Allaru Formation	Mudstone; minor siltstone	240
			Toolebuc Limestone	Limestone; calcareous mudstone	25
			Wallumbilla Formation	Mudstone; siltstone; concretionary limestone	300
		HOORAY SANDSTONE		Quartzose-sublabile sandstone; pebbly in part; mudstone; siltstone	300
	JURASSIC	INJUNE CREEK	Westbourne Formation	Mudstone; siltstone; fine silty sandstone	30
			Adori Sandstone	Sandy mudstone; very fine quartzose sandstone	25
			Birkhead Formation	Mudstone; siltstone calcareous in part; labile sandstone	120
		HUTTON SANDSTONE		Quartzose-sublabile sandstone	120
			UNCONFORMITY		
	MIDDLE TO UPPER TRIASSIC		Moolayember Formation	Mudstone; siltstone; sandstone	up to 500
	LOWER TO MIDDLE TRIASSIC		Clematis Sandstone		200
	LOWER TRIASSIC		Dunda Beds	Sandstone; siltstone	60 to 100
			Rewan Formation	Mudstone; siltstone	200 to 330
	LOWER? - UPPER PERMIAN		Unnamed shale, coal, sandstone		160 to 200
			REGIONAL UNCONFORMITY		
	UPPER CARBONIFEROUS? TO LOWER PERMIAN		Unnamed shale, coal, sandstone, siltstone		600 to 1800
			UNCONFORMITY		
	LOWER CARBONIFEROUS	DRUMMOND	Ducabrook Formation	Mudstone; sandstone	over 1200
			Star of Hope Formation	Sandstone; tuff	1200 maximum
			LOCAL DISCONFORMITY		
			Mount Hall Formation	Pebble conglomerate; mudstone; sandstone	1000 maximum
			Telemon Formation	Sandstone; mudstone; tuff	Over 1500
			RELATIONSHIP OBSCURE		
	MIDDLE TO UPPER DEVONIAN		Sandstone, shale, siltstone		up to 2000
			UNCONFORMITY		
	LOWER PALAEOZOIC?		Basement, probably low grade metamorphics, acid intrusives, and related extrusives		

After Vine & Doutch (1972)

TABLE 2. GALILEE BASIN STRATIGRAPHY

AGE		FORMATION	LITHOLOGY	THICKNESS (max., m)	BMR PALYNOLOGICAL UNIT	EVANS (1967) PALYNOLOGICAL UNIT
Triassic	Middle and Lower	Moolayember Formation	Shale, siltstone and minor sandstone	277	Tr 3c-d	
		Clematis Sandstone	Sandstone; minor mudstone and conglomerate	238	Tr 3b Tr 3a	
		Dunda Beds	Sandstone		Tr 2a-b	
		Rewan Formation	Sandstone; minor siltstone and mudstone	310	Tr 1b Tr1a	
Permian	Upper	Bandanna Formation	Sandstone, coal and minor shale	201	P3-4	5
	Lower	Rodney Formation	Sandstone, coal and minor shale	82	P1c	3
		Marchmont Formation	Shale; minor sandstone and tuffaceous shale	247	P1b-c	2
		Glenaras Sandstone	Sandstone	306		
						-?-?-?-?-?-?-?-
		Yanburra Formation	Mudstone (silty and sandy)	219		
		Jabiru Formation	Sandstone, minor shale	506	C1-2/P1a	1
		Undifferentiated	Shale, sandstone and conglomerate	855		

After Benstead (1973)

Devonian to Lower Carboniferous The oldest sediments identified in the subsurface of the Galilee Basin area are Middle to Upper Devonian sediments in Lake Galilee No. 1 well in the interval 2840 m to 3406 m (total depth) (Exoil, 1965). Vine (1972) related these sediments to those of the Adavale Basin and proposed that the Lower Carboniferous Drummond Basin sediments do not extend west of a major lineament, the Belyando Feature (Plate 1). A BMR seismic survey in the Galilee Sheet area (Harrison, Anfiloff and Moss, 1973) showed that the Drummond Basin extends about 20 km west of the Belyando Feature and that a thick Devonian sequence extends from Lake Galilee No. 1 well eastwards beneath the Drummond Basin sediments. Private company seismic surveys (American Australian Energy, 1972, 1973) showed that the Devonian sequence thickens northward from the BMR traverse.

Upper Carboniferous/Lower Permian to Upper Permian The stratigraphy of the Galilee Basin is shown in Table 2. Permian outcrops are sparse and atypical so that the stratigraphy is based mainly on subsurface data from petroleum exploration wells. Approximately fifty wells have been drilled in the Galilee Basin but only nineteen of them drilled into the Permian. The Triassic nomenclature in Table 2 was defined by Exon (1970), the Upper Permian by Evans (1966) and the Lower Permian by Benstead (1973).

The nomenclature for the Upper Palaeozoic is not considered adequate by Allen (1974). There is uncertainty about the age of the oldest beds in the Galilee Basin sequence because palaeontologists disagree about the position of the Carboniferous-Permian boundary in Australia. Evans (1969) considers the oldest beds to be Late Carboniferous whereas Helby (1969) favours an Early Permian age. In Lake Galilee No. 1 well the basal Galilee Basin sediments were dated as Late Carboniferous by Evans (Exoil, 1965) but Benstead (1973) reported that Lower Permian microflora have been found in these sediments. Vine (1973) discussed the difficulties in making lithological correlations of the Upper Carboniferous(?) and Permian sediments. The most widespread lithological unit was a varved shale unit named the Marchmont Formation by Benstead (1973). For the rest of the sequence various alternative correlations can be made. Vine (1973) prepared isopach maps for four informal time-rock units based on gross lithological similarities and heavy dependence on palynological dating. His outline of the geological history for the area to the north of latitude 24°S is summarized below:

(1) Palynological stage 1. A deep trough (Koburra Trough, Benstead (1973)), developed in the northeast contemporaneously with Drummond Basin folding and uplift. Glaciation occurred mainly in the Drummond uplifted area.

(2) Palynological stage 2. The Koburra trough deepened, its southern end moved westward and a lobe of the main trough extended towards the Hulton-Rand Structure.

(3) Palynological Late stage 2 and 3. Sediments consisted of the varved shale unit, the Marchmont Formation (Benstead, 1973), overlying coal measures. Vine (1973) interpreted the top of this interval to be a basinwide unconformity because of the complete absence of any stage 4 microflora, but Allen (1974) considers that a time break may not have occurred. The marginal trough in the east disappeared and sub-basins developed on the downthrown side of the Hulton-Rand Structure and the Cork Fault. Sedimentation later became more widespread and extended to the upthrown sides of the faults. The highest areas were glaciated.

(4) Palynological Stage 5. The Colinlea Sandstone forms the basal unit with overlying Upper Permian coal measures. Deposition was more widespread than at any previous time though sediments were generally thin. Downwarping was greatest in the Koburra Trough and in the Lovelle Depression. The top of the Permian section forms a key marker horizon throughout the Galilee Basin because of the presence of Upper Permian coal seams which are easily recognizable on well logs and on seismic sections. The "P" horizon, a strong reflector associated with the coal measures, has been extensively mapped by seismic surveys in the Galilee Basin.

Triassic The Triassic sediments consist of a lower argillaceous unit (Rewan Formation), a middle arenaceous unit (Clematis Sandstone) and an upper argillaceous unit (Moolayember Formation). The latter formation is exposed along the eastern margin of the basin. The Clematis Sandstone has the highest porosity and permeability of the Triassic sediments and is one of the major aquifers of the Great Artesian (hydrological) Basin.

At the start of the Triassic, sedimentation (Rewan Formation) was restricted to the Lovelle Depression, the Koburra Trough and a sub-basin southeast of the Barcaldine Ridge. In later Triassic (Moolayember Formation) sediments thickened considerably towards the eastern margin and the Koburra Trough extended southeastward. Widespread late Triassic earth movements and local uplift ended the Galilee Basin development.

Jurassic - Cretaceous The stratigraphy of the Eromanga Basin sediments is described by Casey (1970) and by Senior, Harrison and Mond (in prep.). The Jurassic sequence is mainly terrestrial, the Lower Cretaceous is shallow marine and the Upper Cretaceous grades from paralic to fluvial and lacustrine. The Eromanga Basin sediments overlie most of the Galilee Basin except at the eastern margin, and their maximum thickness is about 1800 m.

Structure

The regional structural setting north of latitude 24°S is shown on Plate 1. The main structural features are the Barcaldine, Elderslie and Beryl ridges, the first two of which have flanking faults (Vine, 1973). The two main troughs in the area are the Lovelle Depression on the down-thrown side of the Cork Fault and the Koburra Trough in the northeast.

In the Lovelle Depression basement is at about 2300 m below M.S.L. and the Galilee sequence has a maximum thickness of about 700 m. The subsidence was probably controlled by faulting and the deposition of sediments does not appear to have been significant during the subsidence (Benstead, 1973). The Cork Fault has a displacement of about 240 m down to the west.

The Koburra Trough is a large feature measuring about 240 km by 130 km at basement level, with basement depths at 2550 m and 2790 m below M.S.L. in Koburra No. 1 well (Flinders, 1970) and Lake Galilee No. 1 well (Exoil, 1965) respectively. The Galilee sequence thickness in these wells is 2820 and 2790 m respectively.

The similarity of the structural maps of basement, top of Permian and top of Triassic suggest that folding of the Galilee sequence was caused by draping over existing basement structure (Benstead, 1973). The sediments are generally little-disturbed with dips less than 1°. The structure in the overlying Eromanga Basin sediments is basically a sheet of sediments dipping gradually southwest towards the middle of the basin. Dips are generally less than 1° (Casey, 1970). The structures are mainly of two types: drape folds over basement ridges and basement faults which may grade to monoclines at the surface.

Economic Geology

Hydrocarbons A number of oil and gas shows have been found within the Permian sediments of the Galilee Basin. The two most significant shows were from undifferentiated Lower Permian sediments in the Lake Galilee No. 1 well (Exoil, 1965) and the Koburra No. 1 well (Flinders, 1970) both of which lie within the Koburra Trough (Plate 1). In the Lake Galilee No. 1 well oil was recovered from the interval 2645 to 2668 m and in Koburra No. 1 well gas was recorded at 2949 m. Thick porous sandstones with good reservoir potential occur in the Jabiru Formation, Glenaras Sandstone and Bandanna Formation (Table 2). Formations in the Cooper Basin which correlate with the latter two have had significant gas discoveries (Benstead, 1973). Most wells in the Galilee Basin were drilled to test seismically-defined anticlines. According to Benstead (1973) there are twenty-two such structures shown on seismic maps of the "P" horizon (Upper Permian), only eight of which have been drilled. Stratigraphic traps probably occur where porous sandstones truncate against basement or tight sediments. The most prospective areas for such traps are probably along the eastern margin of the Towerhill-Thunderbolt High, the southwestern margin of the Koburra Trough and the northern flank of the Hulton-Rand Monocline (Plate 1). Structural and stratigraphic traps may also be present at the basin margins where the Lower Permian sequence truncates or thins markedly against the basement.

Coal A drilling program by the Geological Survey of Queensland and several seismic surveys (Plate 2) have defined where Upper Permian coal measures subcrop at the eastern margin of the Galilee Basin. The coal was found to be non-coking and sub-bituminous and the inferred reserves are "large" (Allen, 1974).

Oil Shale Oil shale has been found within the Lower Cretaceous Toolebuc Limestone in parts of the northern Eromanga Basin (Swarbrick, 1974). One potentially commercial occurrence has been found in the Julia Creek area where the thickness of the Toolebuc Limestone is about 15 m and that of the oil shale is about 5 m. The grade is reported to be about 100 litres/tonne.

3. PREVIOUS GEOPHYSICAL INVESTIGATIONS

Gravity Surveys

BMR reconnaissance gravity surveys from 1957 to 1963 covered most of the Galilee Basin north of 24°S and adjacent areas with readings at 11 km spacing (Gibb, 1967, 1968). Semi-detailed surveys were made by BMR in 1967 along seismic lines in the northeast Galilee Basin (Watts and Brown, in prep.), by Magellan Petroleum Corporation (1961) in north WINTON, by Australian Aquitaine Petroleum (1963) in MANEROO and by Farmout Drillers N.L. (1964) in LONGREACH.

Gibb (1968) divided the Bouguer anomaly map of the area into gravity provinces with further subdivisions into gravity units and sub-units (Plate 3). The gravity provinces and their possible causes are:

A. Cloncurry Regional Gravity High, related to dense Precambrian metamorphic rocks of the Cloncurry Fold Belt.

B. Anakie Regional Gravity High, which corresponds with Precambrian metamorphic and igneous rocks in the north and with Drummond Basin sediments in the south.

C. Muttaburra Gravity Ridge, related to a basement swell with thicker sediments to the north and south.

D. Flinders Regional Gravity Low, the main part of which, the Tangorin Gravity Depression, corresponds to thick Palaeozoic and Mesozoic sediments of the Koburra Trough.

E. Thomson Regional Gravity Low caused partly by a thick section of light Mesozoic sediments and partly by its Upper (?) Palaeozoic low-grade metamorphic basement having lower density than Precambrian metamorphic basement of the Cloncurry Fold Belt to the west.

Small gravity features relevant to the proposed surveys are discussed below.

The Brighton Downs Gravity Low (A2, Plate 3) is a north-northeast trending low which Gibb (1967, 1968) has interpreted as caused by either a shallow granite body or by a local sedimentary thickening of about 600 m. Gibb explained the anomaly by a rectangular granite body, about 16 km wide and about 2000 m thick, lying below Eromanga Basin sediments about 1070 m thick, using a density contrast between granite and Precambrian metamorphic basement of .15 gm/cm^3. Alternatively he could explain the anomaly by a local thickening of Eromanga sediments by 600 m, using a density contrast of 0.4 gm/cm^3 between sediments and basement. Evidence for granite comes from the facts that the anomaly is joined to the Williams Gravity Low (A1) which extends from the outcrop areas of the Williams Granite, and that granitic basement was penetrated in Ooroonoo No. 1 well (Conorada, 1962) about 16 km north of the anomaly. The anomaly however has a northeast trend in contrast to the predominant north-northwest trends of the granites of the Cloncurry Fold Belt. The granite in Ooroonoo No. 1 well is different in composition and is younger than the Williams granite.

The Diamantina Gravity Gradient (A4), which has northeast trend and Bouguer anomaly values increasing to the northwest, was interpreted by Gibb (1967) to be caused by a major change in basement density (.15 to .2 gm/cm^3) between Precambrian metamorphics in the northwest and Lower (?) Palaeozoic low-grade metamorphics in the southeast. Modelling indicated a gently sloping contact about 30 km long with a dip of about 8.5 degrees to the southeast.

The Cork Gravity Gradient (C4) trends northeast with Bouguer anomaly values increasing to the southeast and forms the southern boundary of a linear gravity low C3; these features indicate a fault with a sedimentary trough on the northwest side. Other gravity lows C1 and C2 northwest of C3 are probably related to lower density basement.

In the Richmond Gravity Complex the anomalies trend northeast. They are mainly small and irregular with steep gradients, suggesting they are caused by basement lithology variations. Inliers of Precambrian metamorphics, mapped in northeast RICHMOND and north HUGHENDEN with mainly northeast trend, support that interpretation. The Dumbano Gravity Low (D8) corresponds to out-cropping Dumbano Granite and the gravity high D6 corresponds to outcropping Precambrian metamorphics. By analogy the gravity low D9 may be related to a southerly extension of the Dumbano Granite and the gravity high D10 may be related to shallow metamorphic basement.

The White Mountains Gravity Gradient (B1) corresponds to the White Mountains Structure (Vine et al. 1965), a zone of monoclinal folding adjacent to basement outcrops which forms part of the northeastern margin of the Galilee Basin. The gravity interpretation suggests that thick sediments are faulted against the Precambrian (Cape River) Metamorphics.

Magnetic Surveys

The area has been covered by airborne magnetic surveys by BMR (Jewell, 1960, Waller, 1968 and Hsu 1974), and by private companies (Exoil, 1962 and Magellan, 1963a). Surveying by Central Queensland Petroleum Pty Ltd and the Catawba Corporation mainly in WINTON and MANUKA, was not reported by the companies but the results are presented by GIBB (1968). Hsu (1974) independently interpreted the survey results, except for the latter two, in a comprehensive study of magnetic data in the northern Eromanga Basin. The total magnetic intensity contours are shown in Plate 4 and the magnetic basement depth contours by Hsu (1974) in Plate 5.

Hsu (1974) divided the total magnetic intensity map (Plate 4) into provinces on the basis of anomaly shape and intensity and his provinces broadly correspond with the gravity provinces of Gibb (1968). The most marked feature is the change in magnetic anomaly pattern parallel to the Diamantina Gravity Gradient but displaced some 30 km northwest of that feature in BRIGHTON DOWNS. The magnetic intensity increases in value to the northwest and the anomalies in the northwest are smaller and more intense than in the southeast. At first sight this may suggest shallower basement in the northwest but in fact the reverse is true and the change in pattern is caused by the change in basement lithology discussed above. The steep magnetic gradient continues to the northeast and coincides broadly with the Cork Gravity Gradient. Magellan (1961) interpreted this gradient to be caused by a fault with downthrow to the southeast but the gravity interpretation and the seismic work show a fault with downthrow to the northwest. It is possible, as discussed by Gibb (1968), that the magnetic gradient is caused by a contact between Precambrian and Lower (?) Palaeozoic basement whereas the gravity gradient is caused by a different fault further southeast which forms the southeast flank of a deep sedimentary trough.

Waller (1968) interpreted the gravity and magnetic features near the Brighton Downs Gravity Low to indicate a basic body underlying granite at about 3000 m below mean sea level, but this seems geologically improbable. Hsu (1974) separated basement depths into upper and intra magnetic basements identifying the former by comparison with depths to crystalline basement determined from petroleum exploration wells. The contours shown in Plate 5 are his upper magnetic basement depths. The main structural features of the depth map are as follows: There is a deep trough up to 4000 m deep in the northeast, corresponding to the Koburra Trough, with a steep margin trending northeast through Hughenden. There is a major fault, the Cork Fault, in the southwest with downthrow to the northwest. The 'basement' depths from exploration wells are in many cases somewhat different from the magnetic basement depths of Hsu (1974). For Newlands 1, Fermoy 1, Penrith 1 (metamorphic basement), bore R4375 (granite) and Thunderbolt 1 (Volcanics) the magnetic basement was deeper indicating 'basement' met in the wells has relatively low magnetic susceptibility and overlies rocks with higher magnetic susceptibility. For Ooroonoo 1 (granite), Lovelle Downs 1 and Weston 1 wells (meta-quartzite) the magnetic basement is much shallower than the 'basement' in the wells. There are no volcanics in the well sequences and the sediments do not appear to have high magnetic susceptibilities so it appears the magnetic basement depths are not reliable in the area west of the Cork Fault on MACKUNDA and BRIGHTON DOWNS sheets.

Seismic Surveys

Thirty-eight seismic surveys have been made in the Galilee Basin area north of 24°S and their locations are shown in Plate 2. The recording parameters used in the reflection surveys near the western and northeastern margins have been summarized in Tables 3 and 4. Seismic surveys in the Galilee Basin using single-coverage recording have generally experienced difficulty in recording good reflection seismic data from below the "P" horizon, many of the problems being caused by the low energy penetration through this horizon and the strong surface multiples of the horizon which interfered with deeper reflections. The few surveys which used six- and twelve-fold coverage were generally successful in obtaining deeper data. In the Lovelle Depression west of the Cork Fault, however, single coverage has generally been successful and this appears to be related to the fact that the "P" horizon is a weaker reflector than in other parts of the basin.

Seismic work in the Cork Fault area near the western margin of the basin commenced with a survey by BMR in 1960 (Robertson, 1964) followed by a number of company surveys:

1961	Mayne Seismic Survey
1964	Binburie Seismic Survey
1966	Collingwood Seismic Survey
1967-68	Western River Seismic Survey
1971	Williams Creek Seismic Survey
1973	Wokingham Creek Seismic Survey

Stratigraphic control in the area is provided by the Ooroonoo 1, Newlands 1, Goleburra 1 and Lovelle Downs 1 wells. The Surveys from 1966 to 1973 investigated the trough of Permo-Triassic sediments west of the Cork Fault (Lovelle Depression, Plate 1).

Mayne Seismic Survey 1961 (Conorada, 1962). This reconnaissance survey by Austral Geo Prospectors Pty Ltd for Conorada Petroleum Corporation recorded about 200 km of continuous single coverage and six reversed refraction profiles ranging from 8 km to 15 km long. Three reflection horizons were mapped and interpreted as: Unidentified Cretaceous, Unidentified Jurassic and Near Top Permian. Up to seven refractors were recorded with velocities increasing from 1070 m/s to 5900 m/s. The company interpreted a possible 1000 m thick Permian section on the easternmost profile. Later drilling of Newlands No. 1 well near the profile showed that Permian sediments were absent and that 1700

TABLE 3. Summary of recording parameters used in seismic reflection surveys near western margin of Galilee Basin

Survey	Coverage	Shot Pattern	Shot Depth	Charge Size	Geophone Pattern	Geophone Type	Station Interval	Offset	Record Section Quality
WESTERN RIVER (Phillips-Sunray, 1967)	(i) Single-fold (ii) 12-fold	(i) 3 in line, spacing 21 m (ii) single	(i) 44 m (average) (ii) 42 m (average)	(i) 27 kg (average) (ii) 18 kg (average)	24 in two parallel rows, 9 m apart, oblique to traverse, spacing between geophones 14 m	HS - 20Hz	(i) 46 m (ii) 91 m	(i) Split-spread 549-0-549 m (ii) Split-spread 1097-0-1097 m	Fair
WILLIAMS CREEK (U.S. National Resources, 1971)	(i) Single-fold (ii) 6-fold	(i) 3 in line, spacing 21 m (ii) single	32 m "	22 kg "	12, spacing 4.5 m in line "	HS - 14Hz	67 m	(i) Split-spread 805-0-805 m (ii) Split-spread 771-0-771 m	Fair
[illegible] (Marathon, 1964)	Single-fold	Up to 5 in line, or two rows of 5, 4.5 m apart, spacing between holes 4.5 m	Up to 60 m	7-68 kg	12, spacing 4.5 m in line	S32 - 27Hz	34 m	Split-spread 402-0-402 m	Fair

TABLE 4. Summary of recording parameters used in seismic reflection surveys near northeastern margin of Galilee Basin

Survey	Coverage	Shot Pattern	Shot Depth	Charge Size	Geophone Pattern	Geophone Type	Station Interval	Offset	Below "P" horizon Record Section Quality
BOWEN DOWNS (Amerada, 1967a)	Spot-correlation; some continuous single-fold	1 to 7 holes, in line or patterns, spacing 10 to 45 m	18-40 m	7-34 kg	8, 12, or 16 in line or in 2 rows, 3 to 4.5 m between geophones	HS - 30Hz; EVS - 20 Hz	34 or 45 m	Split-spread, 400-0-400 m or 540-0-540 m	Poor
TOWERHILL (Amerada, 1967b)	5 to 12-fold	32 drops on two parallel 90 m lines	0	Weight-dropping	144 (6 strings in 120 x 180 m half-feather array	EVS - 3A	90 m	685-2800 m (usual)	Good
YARROWGLEN (Amerada, 1967c)	Spot-correlation	4 holes in line, spacing 15 m	24-35 m	2-2.5 kg	8 or 12, spacing 10 m in line, or 16, spacing 4.3 m in line	HS - 20Hz, HS - 30Hz, EVS - 20Hz	34 m	Split-spread 400-0-400 m	Poor
TORRENS CREEK (Exoil, 1963)	Single-fold	Single; some 3-hole patterns	27 m (average)	9 kg	8 or 12, spacing 9 m in line	Electro-Tech-30Hz	34 m	Split-spread 400-0-400 m	Poor
KOBURRA (Flinders, 1970)	Single-fold	Single	30-50 m	10-70 kg	12, spacing 4 or 4.5 m in line	HS - 14Hz	45 m	Split-spread 540-0-540 m	Poor
FLINDERS RIVER (Jones, 1970)	Single-fold	3 to 7 holes in line, spacing 10 to 15 m	30-37 m	4-13 kg	16, spacing 3 m in line; 24, spacing 6 m in line; 32, spacing 3-6 m in two lines 9 m apart	HS - 14Hz	46 m	Split-spread 549-0-549 m	Not applicable

m of Cretaceous and Jurassic sediments directly overlay metamorphic basement. The company refractor velocities and depths are compared to the stratigraphy in Newlands 1 and Ooroonoo 1 wells and to the interval velocities in Newlands 1 well. (Plate 8). The interval and refractor velocities at Newlands No. 1 have similar values for the same formations. Equivalent formations in the two well sequences also have associated refractor velocities which are similar. The 5200 m/s refractor, interpreted by the company as corresponding to the top of the Permian is now considered to correspond to the top of a metamorphic sequence about 1000 m thick near Newlands No. 1 well, overlying granite of refractor velocity 5900 m/s, at a depth of about 3000 m. A weak reflection at about 1.9 s near the profile could originate from the metamorphic/granite contact.

The reinterpreted refraction profiles south of Ooroonoo No. 1 well, indicate Cretaceous and Jurassic sediments to be about 1200 m thick overlying a thin layer of metamorphics then granite. On the southernmost profile the metamorphics appear to thicken by about 500 m. The profiles show no evidence of Pre-Mesozoic sediments.

<u>Binburie Seismic Survey 1964</u> (Marathon, 1964)

This reconnaissance survey by Geophysical Service Inc. for Marathon Petroleum Australia Ltd., recorded about 170 km of continuous single coverage consisting mainly of two long lines, one line south from Ooroonoo No. 1 well and the other joining the southern end of the first line and extending east to about longitude 142°30'E. Two reflectors were mapped and, based on the tie with Ooroonoo No. 1 well, they were interpreted to originate from near the top of the Jurassic and from near the base of the Jurassic. Near the centre of the line 5B, south of the well (Plate 13) reflections were recorded down to 3.0s (about 6000 m), which were angularly unconformable with the two shallow reflectors. These deep reflections appear to originate from Pre-Mesozoic sediments. The maximum thickness of these older sediments is about 4000 m (see cross-section DEF Plate 13). These sediments are too far south to be associated with the Brighton Downs Gravity Low. Druce (pers. comm.) has suggested that Lower Palaeozoic carbonate rocks may exist in the "Diamantina Basin" west of the Lovelle Depression and east of the Lucknow ridge. The deeper sediments south of Ooroonoo No. 1 well could be an extension of these Lower Palaeozoic sediments. No major faulting of the shallow reflectors can be seen on the Binburie Survey lines which indicates either that the Holberton Structure (Plate 2) was not active in this area during the Mesozoic or that it does not extend as far south as the area surveyed.

Western River Seismic Survey, 1967 (Phillips-Sunray, 1968)

This survey by United Geophysical Corporation for Phillips Australian Oil Co. and Sunray DX Oil Company aimed at further defining the Permo-Triassic section on the downthrown (west) side of the Cork Fault indicated by the previous Collingwood survey (Plate 2) (Phillips, 1966). The survey recorded about 260 km continuous single coverage and 30 km of 12- fold CDP, and indicated a maximum 600 m of Permo-Triassic sediments west of the fault. Three horizons were mapped: the Blythesdale (Cretaceous/Jurassic boundary), Basal Jurassic (?) and Basal Permian (?). The two shallower horizons are based on fair quality reflections and are fairly reliable whereas the Basal Permian (?) is based on poorer, discontinuous data and hence is less reliable. The survey showed that the Cork Fault is a major fault at both Permian and basement level over the survey area although the fault was complex and did not always affect the two shallower horizons. The three structure maps are similar showing increase of structural relief with depth. The isochron map of the Permo-Triassic section indicates gradual thinning of the sequence to the west and south; overall the thickness of the sequence varies from about 600 m to 1100 m. The seismic section from Line 16 is shown in Plate 9 and the line position is shown in Plate 13.

Williams Creek Seismic Survey 1971 (U.S. Natural Resources, 1971)

This survey by Geophysical Services Inc. for U.S. National Resources Australia Ltd recorded about 160 km of continuous single coverage and 20 km of 6-fold CDP coverage. The survey was made on the eastern, upthrown side of the Cork Fault and its interpretation incorporated the previous Collingwood and Western River surveys. The aim of the survey was to investigate structural highs suggested by previous seismic and water-bore data. Three horizons were mapped, as for the Western River survey discussed above. The Blythesdale horizon was uniformly continuous and reliable, the Basal Jurassic (?) was variable in character and reliability possibly because of erosion of the pre-Jurassic surface, and the Basal Permian (?) horizon was variable in character but was a strong and reliable horizon over most of the area. The horizon maps indicated a broad anticlinal feature with thinning of the Permo-Triassic sequence over the high areas. The sediment thickness over the highs was about 100-150 m. In 1972, following the above seismic surveys, two wells were drilled one on either side of the Cork Fault. The Lovelle Downs No. 1 on the downthrown side of the fault drilled through 630 m and the Goleburra No. 1 on the upthrown side drilled through 280 m of Permo-Triassic sediments.

The horizons mapped by the Williams Creek survey were named before well control was available. Using the velocity shoot in Lovelle Downs No. 1 well the expected reflection times were calculated for the top and the base of the Permian. The top of the Permian in the well agreed closely with the basal Jurassic (Top of Triassic) in the seismic report, but the basal Permian in the well was found to be about 100 milliseconds two-way-time (150 m) deeper than in the seismic report. A new structure contour map of the basal Permian was therefore obtained by adding a constant 150 m to the company contours. Similarly a new Permian isopach map was prepared by adding 150 m to the values on the company isopach map. The velocity and time-depth information for this area is shown on Plate 6.

Seismic surveys in the northeastern part of the Galilee Basin have been made by the BMR and private companies since 1962. The surveys most relevant to the proposed survey are as follows. (References given below).

1962-63	Torrens Creek Seismic Survey
1966	Flinders River (BMR) Seismic Survey
1965-66	Bowen Downs Seismic Survey
1966-67	Towerhill Seismic Survey
1966-67	Yarrowglen Seismic Survey
1969	Koburra Seismic Survey

The Towerhill No. 1 well (Amerada, 1967d) and Koburra No. 1 well (Flinders, 1970), drilled in 1967 and 1970 respectively, provide stratigraphic control in the area (Plate 1).

Torrens Creek Seismic survey 1962-63 (Exoil, 1963). This survey by Austral Geo Prospectors Pty Ltd for Exoil N.L. recorded about 400 km of continuous single coverage and a reversed refraction profile of length 20 km. Two reflection horizons were mapped. The shallower, an outstanding reflector ("P" horizon), can be correlated with Upper Permian coal measures. The deeper horizon, picked down to 1.7s (about 3400 m), was not reliable as it was based on poor and discontinuous reflections. The refraction profile recorded five nearly horizontal refractors with velocities of 2320, 3080, 3850, 5000 and 6020 m/s. The deepest refractor, at a depth of about 3660 m, has a velocity which would be likely for the crystalline basement. The two reflection horizons did not correlate with any of the refractors. The reflection sections were re-examined and there was partial evidence for a reflection at about 1.8-1.9s, at depths similar to that of the deepest refractor.

Flinders River Seismic Survey 1966 (Jones, 1970). This survey by the BMR recorded 70 km of continuous single coverage reflection and nine refraction lines with maximum offset 19 km. Most work was recorded in the Richmond area west of Hughenden but some refraction work was done between Lake Galilee No. 1 and Thunderbolt No. 1 wells (Plate 2). The survey demonstrated that in the area between Julia Creek and Richmond, corresponding to the Nonda Gravity Depression and the northern part of the Tangorin Gravity Depression (Plate 3) there was only a thin Palaeozoic section. At water bore 15530 (Plate 1) only 50 m of Upper Permian overlay the "basement rock" according to the drillers report (Vine, 1970). The reflection work showed that sedimentary thickness variations had little relation to gravity anomalies in the area, indicating that the gravity pattern is caused mainly by density changes within the basement.

The refraction work between the Lake Galilee and Thunderbolt wells recorded refractors of velocity 2750, 3440, 4650 and 5750 m/s. The last was interpreted to be the basement with depths of about 2600 m on the easternmost refraction profile and about 2000 m on the western profile. This refraction information contributes to the definition of the southwest margin of the Koburra Trough in the area (Plate 1).

Bowen Downs Seismic Survey, 1965-66 (Amerada, 1967a). This survey was made by Petty Geophysical Engineering Co. and Namco Geophysical Co. for Amerada Petroleum Corporation. The survey covered a very large area and recorded about 2460 km of traverse nearly all of which was spot correlation traversing. With this method, shots were fired at every third shot-point giving a subsurface coverage of 400 m per shot and an 800 m gap between each shot coverage. The survey was successful in mapping the strong "P" reflector but multiples of this event, low record quality and the large subsurface gaps made it difficult to pick and correlate deeper events and the company did not interpret the deeper sections. Many of the Bowen Downs lines were reprocessed in the BMR playback centre and an attempt was made to pick a basement reflector. The results showing the basement depth contours are presented in Plate 12, and an isopach map of the Upper Permian-basement interval is shown in Plate 13.

Towerhill Seismic Survey (Amerada, 1967b). This survey was made by Ray Geophysics Pty Ltd for Amerada Petroleum Corporation. The survey used a surface source, the Geograph "Thumper", and 6-12 fold CDP reflection profiling. This was one of the few seismic surveys in the Galilee

Basin which obtained good reflection data from below the "P" horizon. Two horizons, I and II, were mapped, and interpreted as the "P" horizon (Upper Permian) and the crystalline basement respectively; and occasionally an intermediate horizon III was mapped. In the area of the Koburra No. 1 well, the survey recorded basement down to 3.5s, (about 7000 m). The seismic lines near the Koburra No. 1 and Towerhill No. 1 wells provided valuable data for the contour maps of the basement and of the Upper Permian-basement isopachs which are shown in Plates 12 and 13.

The results along line R-57 which passes through Koburra No. 1 well and extends east on BUCHANAN sheet nearly as far as Drummond basin outcrops, give a clear picture of the relationship of Drummond Basin and Galilee Basin sediments in that area. The Permian and Triassic sediments (see cross-section ABC on Plate 13) thin steadily eastwards and near the eastern end of the seismic line they are draped over a monocline which corresponds to the Mingobar Monocline mapped at the surface by Vine et al. (1965). West of the monocline the Permian sediments are underlain by a sedimentary sequence about 5000 m thick, of presumably Drummond Basin sediments which thin steadily westward to about 1000 m at the western end of the line R-57.

Vine (1972) considered the Mingobar moncline to form part of the Belyando Feature (Plate 1) which he suggested to be a major basement fracture zone forming the western limit of the Drummond Basin deposition. The seismic evidence from line R-57 shows that the thick Drummond sediments extend at least 70 km west of the monocline and that this feature while causing a displacement of 500-1000 m at basement level does not mark the western limit of the Drummond Basin. Similarly line R-58 of the survey which lies further south on the same sheet, BUCHANAN, shows that thick Drummond Basin sediments extend at least 100 km west of the proposed Belyando Feature. Hence it appears on BUCHANAN as on GALILEE that the feature does not mark the Drummond Basin's western margin. But the feature in fact marks the eastern margin of the Galilee Basin. Further south, on the GALILEE sheet, the structure at the eastern margin of the Galilee Basin appears to be different. Here about 1500 m of Middle Devonian (Adavale Basin age) sediments are present beneath the Drummond Basin sequence and extend with uniform thickness eastwards from Lake Galilee No. 1 well, and the Drummond Basin sediments wedge out about 20 km west of the Belyando River, (Harrison, et al., 1971). The possibility that part of the thick "Drummond" sequences on line R-57 and R-58 may be of "Adavale" age cannot be excluded, but this seems unlikely because of the apparent conformity of the entire sequence on those lines.

Yarrowglen Seismic Survey 1966-67 (Amerada, 1967c). This reconnaissance seismic survey by Namco Geophysical Co. & Petty Engineering Geophysical Co. for Amerada Petroleum Corporation recorded about 610 km of spot-correlation single coverage similar to that in the Bowen Downs survey above. The results, apart from the "P" horizon, were poor and little reliable deep data were recorded.

Koburra Seismic Survey 1969 (Flinders, 1970). This survey by United Geophysical Corporation for Flinders Petroleum N.L. recorded about 230 km of continuous single coverage mainly to detail structural highs partly defined by previous surveys. The survey did not record reliable data below the "P" horizon. A poorly-defined train of reflections which might contain a multiple of the "P" horizon occurred at 1.6 to 2.0 seconds. Record quality was very low over areas of Cretaceous outcrop.

The seismic sections from the above surveys were re-examined and an attempt was made to pick a basement reflector in the northeast Galilee Basin, using the Towerhill No. 1 well as the geological control. A reliable basement reflector could be picked on the good quality Towerhill seismic lines near the Towerhill No. 1 and Koburra No. 1 wells but it was difficult to follow on any of the spot-correlation single coverage lines of the Bowen Downs and Yarrowglen surveys, which provide most of the coverage, and the basement depths are of low reliability on these survey lines. The seismic section from line N16 of the Bowen Downs survey is shown in Plate 11. A basement structure contour map was drawn (Plate 12) and an isopach map of the Upper Permian-basement interval was drawn (Plate 13). It was not possible to pick a reflection from the base of the Permian on most of the sections so this isopach map includes a thick sequence of Drummond Basin sediments beneath the Permian in the east. West of Towerhill No. 1 well there are probably little or no Drummond Basin sediments so the contours represent Permian thickness there. The velocity and time versus depth information for this area is shown on Plate 7.

Summary

Three interpretative cross-sections have been drawn, two in the western part and one in the northeastern part of the Galilee Basin, summarizing the drilling and seismic information (Plate 13).

Western area. A northeast trending trough of Permo-Triassic sediments about 600 m thick (Lovelle Depression) exists on the western downthrown side of the Cork Fault which is a major regional structure. Southwest of the trough Permian and Triassic sediments are absent in the Ooroonoo No. 1 well which drilled into granite beneath Eromanga Basin sediments. The Holberton Structure is a prominent surface feature about 60 km east of the well and is probably a southerly extension of the Cork Fault. On a single seismic line (5B) south of Ooroonoo No. 1 well deep reflections indicate a sedimentary sequence about 4000 m thick beneath about 1200 m of Eromanga sediments. These sediments may possibly be related to a suspected "Diamantina Basin" west of the Lovelle Depression (E. Druce, pers. comm.). Seismic work is necessary to determine the southerly extent of Permo-Triassic sediments in the Lovelle Depression, whether they are present west of the Holberton Structure and whether they extend south of Ooroonoo No. 1 well, possibly forming part of the 4000 m thick sequence shown there by previous seismic work. Another area requiring further seismic surveys is the western margin of the Permo-Triassic Lovelle Depression between latitudes 22° - 23°S.

Northeastern area. In the northeastern part of the Galilee Basin a north-northwest trending deep trough of Permo-Triassic sediments, the Koburra Trough, has been suggested to have steep margins near Hughenden and about 120 km east of Hughenden. Evidence for a steep margin near Hughenden comes from magnetic interpretation by Hsu (1974), who shows a steep rise in basement trending northeast through Hughenden (Plate 5). Basement depths interpreted from previous seismic work (Plate 12) however show a gentle rise in basement in contrast to the magnetic interpretation, although the basement reflection was difficult to pick because of multiples of the strong "P" reflector, poor record quality and large gaps in subsurface coverage arising from the spot-correlation recording method (Plate 11). The magnetic basement may of course be a different geological horizon than the seismically-defined basement. The magnetic intensity map (Plate 4) shows a distinction between broad anomalies in the east and smaller anomalies on the west of a northeast line through Hughenden, and there is a corresponding linear gravity trend (Plate 3). Gravity interpretation by Gibb (1968) however suggests the gravity anomalies are caused by intra-basement density variations. Seismic work is needed to obtain reliable basement depths and to determine the nature and structure of the steep margin suggested near Hughenden.

About 120 km east of Hughenden there is a strong northwest-trending gravity gradient corresponding to the White Mountains Structure, (Plate 1), a monocline at the surface but probably a major basement fault at depth. Precambrian metamorphics outcrop to the northeast. Magnetic basement depths (Plate 5) and gravity interpretation (Gibb, 1968) both suggest that sediments truncate against a steeply dipping or faulted basement. No seismic work has been done in the area. It is probable that a thick Drummond Basin sequence is present beneath the Permo-Triassic sediments as on the seismic lines to the south on BUCHANAN. The thickness of Permo-Triassic sediments in the area is unknown. Seismic work is needed to determine the thickness of these sediments and the structure at the basin margin.

4. OBJECTIVES AND PROGRAM

The objectives of the proposed seismic survey in the Galilee Basin are to obtain information about the thickness and structure of the Permo-Triassic sediments in two areas near the western and northeastern margins of the basin. Presence of thick Permian sediments and possible steep margins to the basin in the above areas could enhance the possibility of stratigraphic and structural traps for hydrocarbons and could encourage further exploration by private companies.

Two reflection traverses at right angles (Plate 2) are proposed initially to investigate the western margin of the basin southwest of the Cork Fault. The southwesterly-trending traverse is to join the earlier company lines and obtain information about the southern extent of the Lovelle Depression. The southeasterly-trending traverse is to investigate the sediments west of the Holberton Structure. The total length of line in this area initially would be about 110 km. If the objectives in this area were achieved in less than the programmed time an additional east-west line would be surveyed south of Ooroonoo No. 1 well to further investigate the 4000 m thick trough of possible Lower Palaeozoic sediments which was suggested on the earlier seismic line south of the well.

In the northeastern part of the basin it is proposed to record two reflection lines, each about 30 km long, (Plate 2), to investigate the margins of the Koburra Trough which contains a thick sequence of Permian and Triassic rocks. The objective is to record reflections from the sediments below the "P" horizon and determine the structure of the margins of the trough. Short six-fold C.D.P. probes will be recorded to check the depth to basement before deciding the exact placement of the reflection profiles.

As single-coverage recording has been successful near the western margin during the earlier surveys, it is proposed that the single coverage technique be generally used except in sections where 6-fold coverage may be necessary to obtain better reflections from the deeper sediments. In the northeastern area, six-fold coverage would be necessary to obtain reliable information.

Near the western margin of the basin the south-westerly-trending seismic line will be placed adjacent to a graded stock route parallel to the Diamantina River so as to provide good access for the operations. The line perpendicular to that would be placed along station tracks where possible but its exact location will be decided following a vehicle reconnaissance of the area to avoid heavy scrub and difficult creek crossings. A bulldozer would be hired to improve the access and increase operational efficiency where necessary.

In the northeastern area of the basin it is proposed to record the lines adjacent to the bitumen Flinders Highway which links Hughenden with Charters Towers so that operations in that area should be facilitated.

The seismic survey party will leave Canberra about 16 June, operate for about five months giving about 100 operating days and return to Canberra about 15 December 1975.

The proposed program is as follows:-

Western Margin:

Experimentation	Uphole shoot Noise test
Production recording	Single coverage for 75 km Six-fold CDP for 37.5 km
Total	110 km

Northeast Margin:

Experimentation	Uphole shoots (2) Noise test
Production recording	Two lines of six-fold CDP each 30 km
Total	60 km

The proposed coverage is 170 km. Further recording will be made as required during the survey.

Expanded spreads (two days recording each) have not been included in the above program because good velocity information is available in the western area from several well velocity shoots, and in the northeastern area there is adequate velocity information from company expanded spreads and the sonic log in Towerhill No. 1 well. An expanded spread may be recorded if considered necessary during the field work to help in identifying multiple reflections.

The reflection method has been proposed because in both areas it is necessary to obtain precise information about the thickness of the Permian and Triassic sediments. Sedimentary boundaries which are effective seismic reflectors do not necessarily produce refractions. The strongly reflecting "P" horizon associated with Upper Permian coal measures, for instance does not appear from refraction work in the basin to be associated with a refractor. The main potential value of refraction work lies in defining the structure of the basement surface. In the event that reflection techniques are found to be unsuccessful in mapping the basement, consideration will need to be given to using refraction depth probes to obtain the refractor velocities and depths down to basement, and continuous refraction profiles to map basement. The refraction technique has been used successfully in several areas of the basin.

It is proposed also to take gravity measurements at 1 km intervals along the seismic lines to allow combined gravity and seismic modelling.

It is expected that the Geological Survey of Qld will be drilling 1200 m deep stratigraphic holes in the areas of the proposed seismic surveys and the seismic traverses can be tied to the holes so that the seismic results may be correlated with well stratigraphic and velocity logs.

A list of the proposed personnel and equipment for the Seismic Survey Party is given in Appendix 1.

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APPENDIX 1: Proposed Staff and Equipment

STAFF

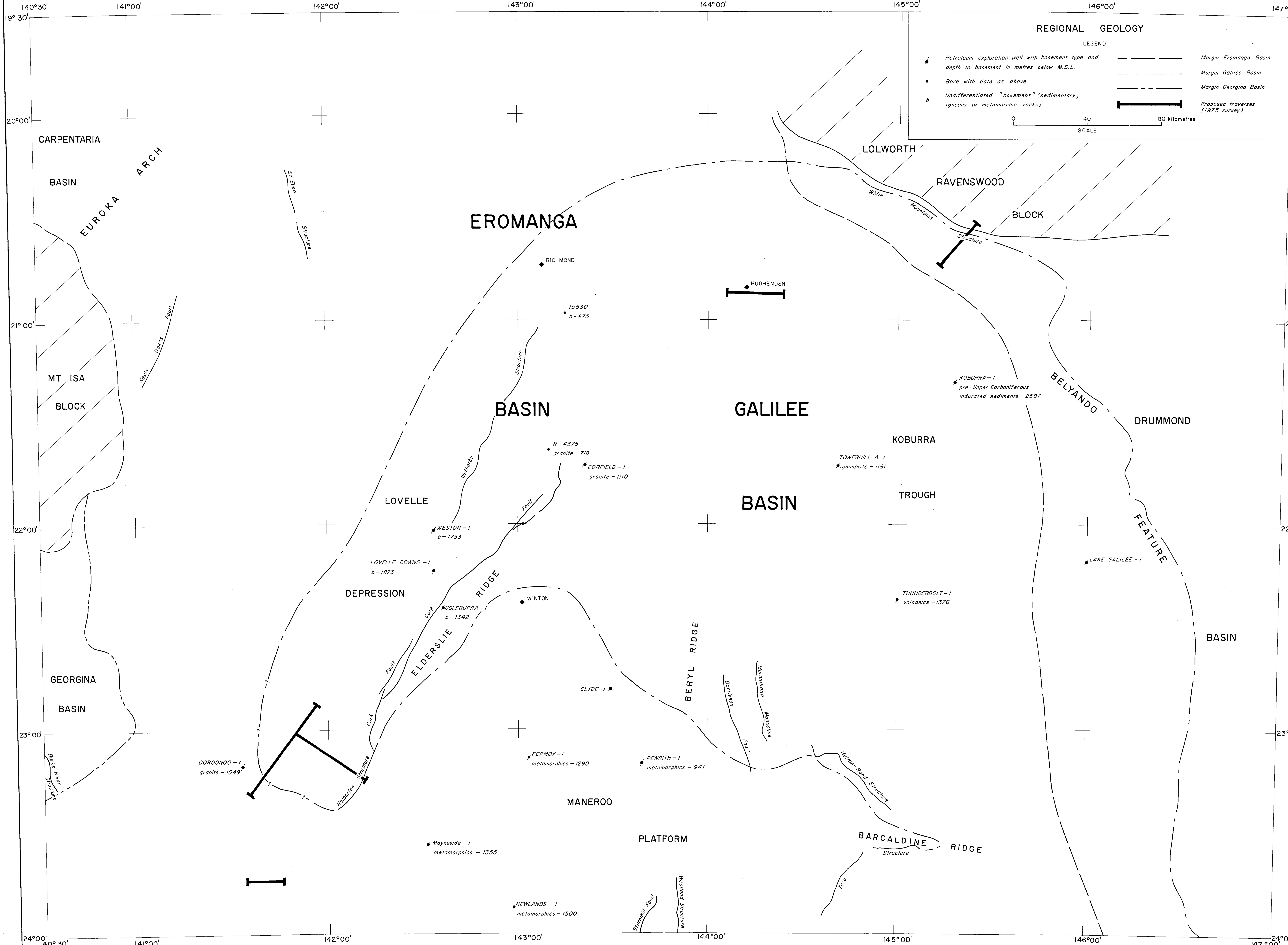
Party Leader	P.L. Harrison
Geophysicists	J.A. Bauer (part-time) Others to be decided
Surveyor	1 (under contract from department of Services and Property)
Observer	L.E. Hemphill
Assistant Observer	To be decided
Party Clerk	P. Swan
Shooters	R.D.E. Cherry L. Rickardsson
Mechanic	D.J. McIntyre
Wages Hands	1 Cook 1 Cook's Offsider 1 Wages Mechanic 9 Field Hands
(ex-Petroleum Technology Section)	
Toolpusher	A. Zoska
Drillers	L. Keast T. Shanahan J. Kearney
Drill Assistant	1
Field Hands	3

EQUIPMENT

Seismic Amplifiers	SIE PT-700
Magnetic Recorder	SIE PMR-20
Camera	SIA TRO-6

Geophones	GSC 20D 8Hz (total 1280) for reflection and refraction
Cables	12 x 610 m, 2 x 146 m weathering cables
Recording Truck	Bedford 5 tonne 4 x 4
Shooting Truck	Bedford 5 tonne 4 x 4 Water Tanker
Workshop Truck	International D1610 5 tonne 4 x 4
Flat Top Trucks	Bedford 5 tonne 4 x 4 2
Water Tankers	International 5 tonne 4 x 4 3
Personnel Carriers	Toyota Landcruisers 4
Geophone Carriers	Land Rover Ute, L.W.B. 3
Stores Runs	International C1300, 1 tonne 4 x 4
Office Caravan	4 wheel trailer
Kitchen Caravan	" " "
Ablutions Caravan	" " "
Explosives Magazine	" " "
Workshop Trailer	" " "
Generator Trailer	" " " Special
General Purpose Trailer	" " " 2
Drill Trailer	" " " 1
Drilling Rigs	Mayhew 1000 3
Drill Tankers	Chieftain 1

PLATE I

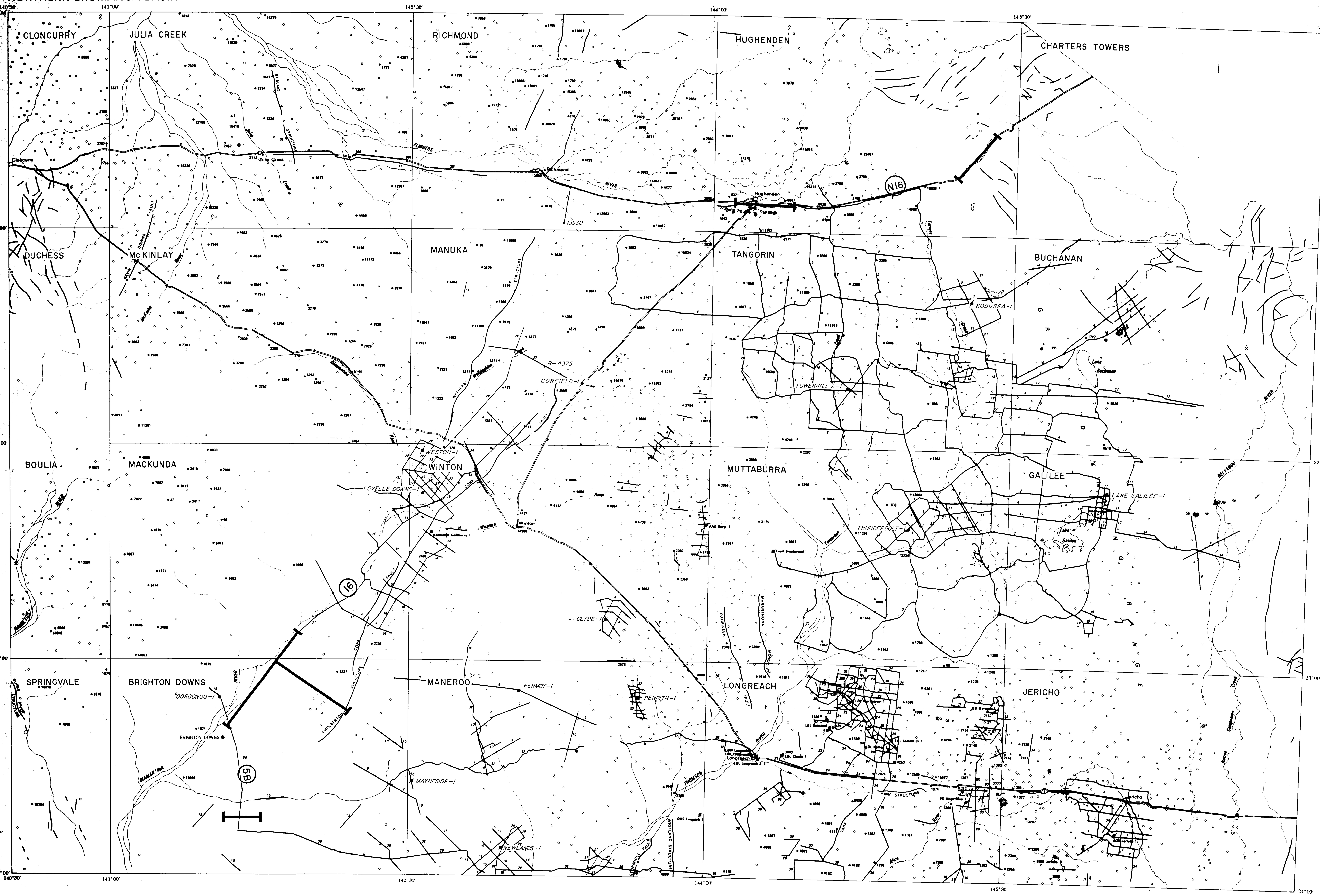


Record No. 1975/131

F54/B3-221

PLATE 2

NORTHERN EROMANGA BASIN



SEISMIC TRAVERSE LOCATION MAP

Scale 1 : 1 000 000

20 10 0 20 40 60 80 100 KILOMETRES

SEISMIC SURVEYS (to December 1973)

REF NO	DATE OF SURVEY	ABBREVIATED NAME	REFERENCE	DATE OF REPORT
1	1963	Jericho	AOD	1964
2	1965–66	Bowen Downs	AMERADA	1967a
3	1966–67	Thunderbolt	AMERADA	1967b
4	1966–67	Towerhill	AMERADA	1967c
5	1966–67	Yarrowglen	AMERADA	1967d
6	1972	Belyando	American Australian Energy	1972
7	1962–63	Blackall–Mitchell	Petty	1963
8	1963	Cairnhope–Rimbanda	AAO	1963
9	1963	Fermoy	Aquitaine	1963
10	1964	Vergemont	Aquitaine	1964
11	1969	Windeyer	Beaver	1969
12	1960	Winton	Robertson C S	1964
13	1966	Flinders River	Jones P and Brown A R	1966
14	1971	Galilee Basin	Harrison P L, Anfiloff W and Moss J	1973
15	1961	Mayne	Conorada	1962
16	1960	Longreach–Silsoe	Cree Oil	1962
17	1962	Lake Galilee & Lake Buchanan	Exoil	1963a
18	1962–63	Torrens Creek	Exoil	1963b
19	1972	Hexham	Exoil	1972
20	1962	Lagoon Creek	Farmout Drillers	1963
21	1969	Koburra	Haematite	1969
22	1973	Wokingham Creek	LOL	1973
23	1961–62	Balmoral	LOL	1962
24	1962–63	Rodney Downs	LOL	1963
25	1963	Brixton	LOL	1964
26	1965	Wellshot Creek	LOL	1966
27	1969	Thomson River	LOL	1969
28	1963	Ruthven	Marathon	1964
29	1964	Binburie	Marathon	1964
30	1965	Barcoo	Marathon	1965
31	1966–67	West Blackall	Marathon	1966
32	1962	Maneroo	Minad	1962
33	1961	Coreena	Oil Development	1962
34	1962	Alpha	Oil Development	1963
35	1965	Rodney Creek	Phillips–Sunray	1966
36	1966	Collingwood	Phillips—Sunray	1966
37	1967–68	Western River	Phillips—Sunray	1967
38	1971	Williams Creek	U S Natural Resources	1971

Note: 35 surveys were subsidized by the Australian Government and 3 were made by the BMR

• 2981 — *Wireline logged water bore (mainly gamma-ray) with registered number. QIWSC records*

AAO Penrith 1 — *Petroleum exploration well*

BMR Jericho 9 — *BMR shallow stratigraphic hole*

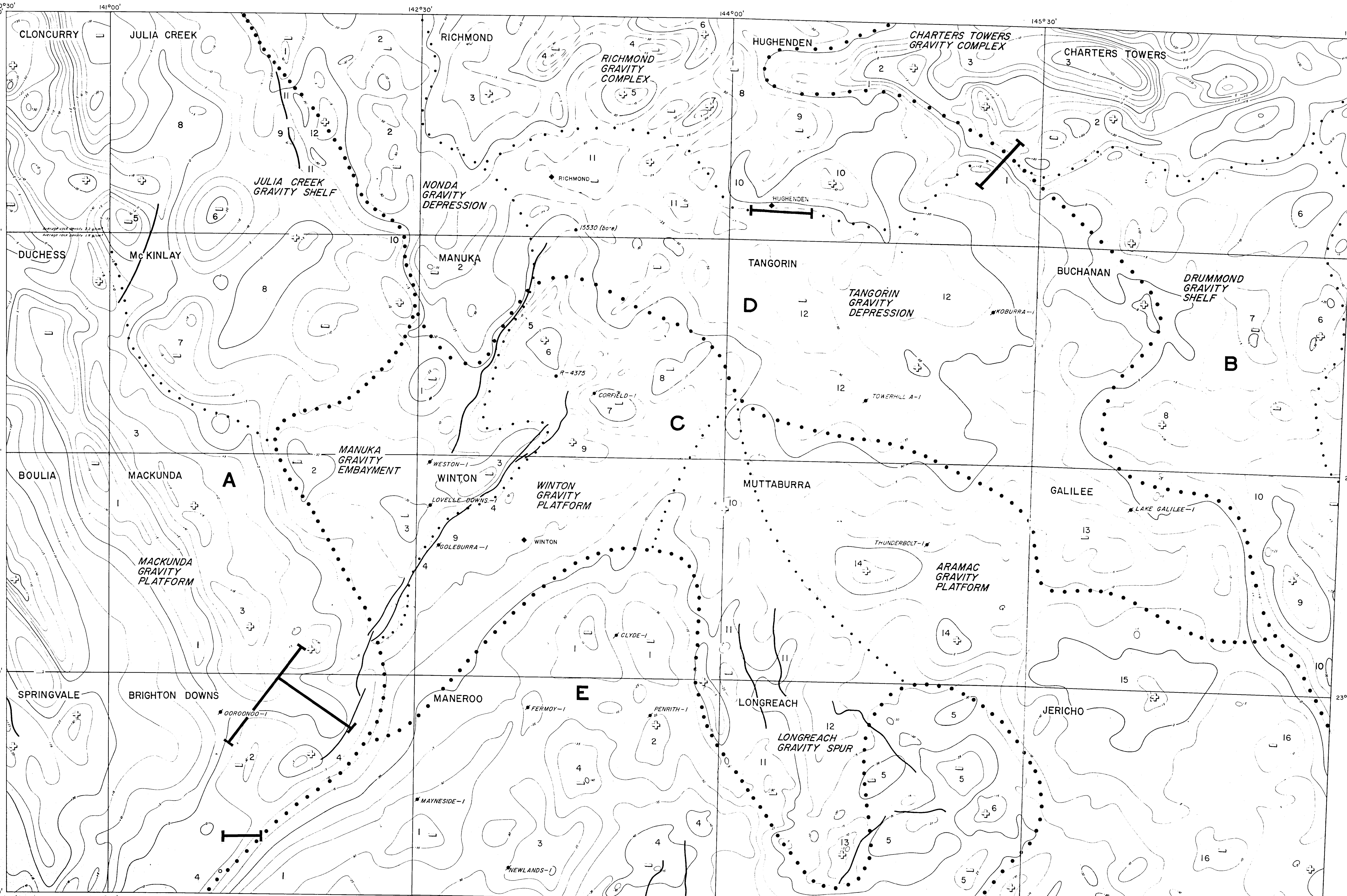
Seismic lines with reference number

Proposed traverses (1975 survey)

16 — *Previous seismic line number*

Record No. 1975/131

F54/B3—222-1



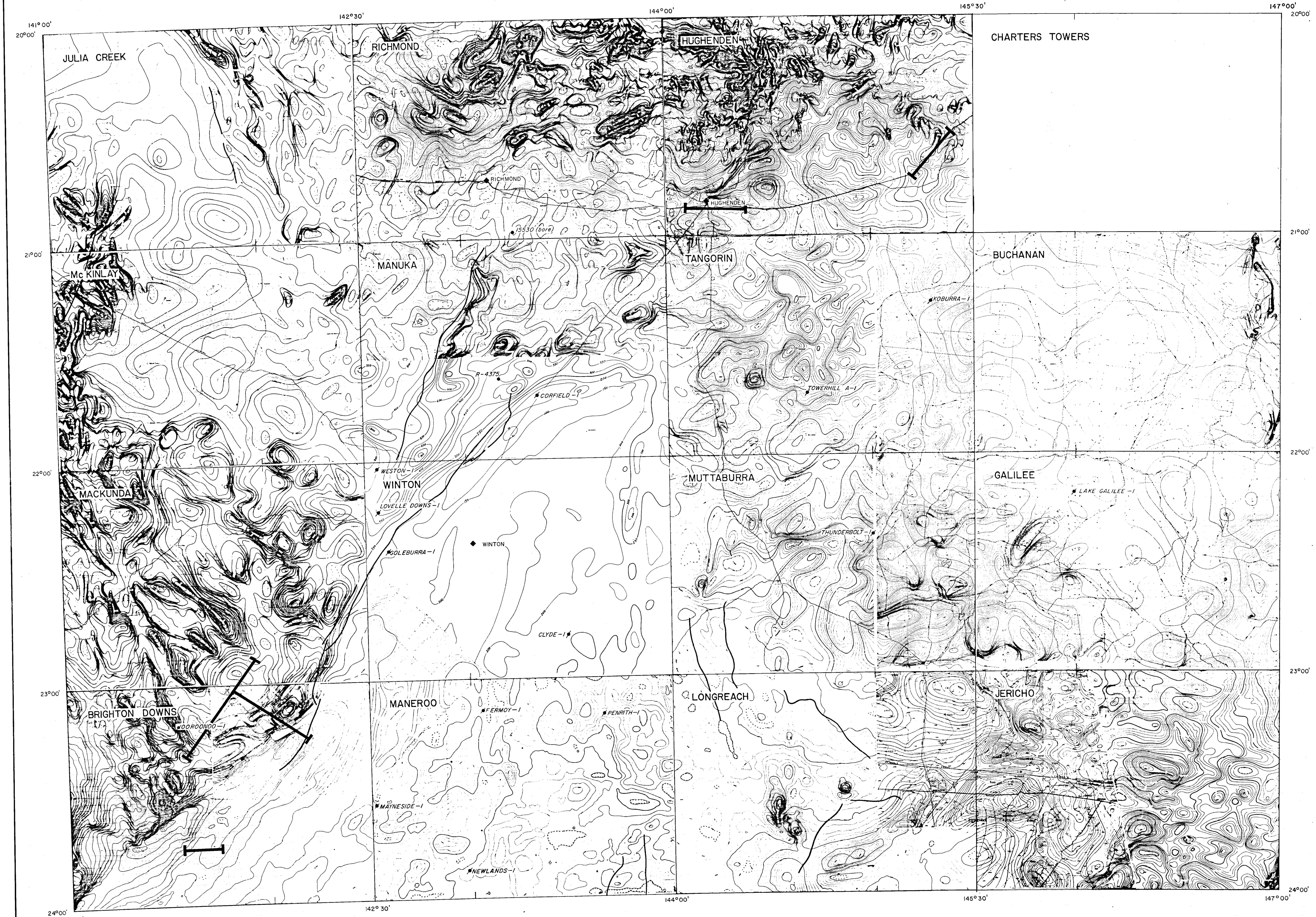
Proposed traverses (1975 survey)
Isogals values in milligals
Bouguer anomaly 'high'
Bouguer anomaly 'low'
12 Gravity sub-unit
Gravity province boundary
Gravity unit boundary
B Gravity province (see text)
MANEROO 1:250000 map area
Petroleum exploration well
Water bore

BOUGUER ANOMALY CONTOURS

Adapted from Gibb (1968, Plate 3)

20 0 20 40 60 80 100 KILOMETRES

(Based on F54/B2-43-2)



TOTAL MAGNETIC INTENSITY CONTOURS

20 0 20 40 60 80 100 KILOMETRES

Petroleum exploration well

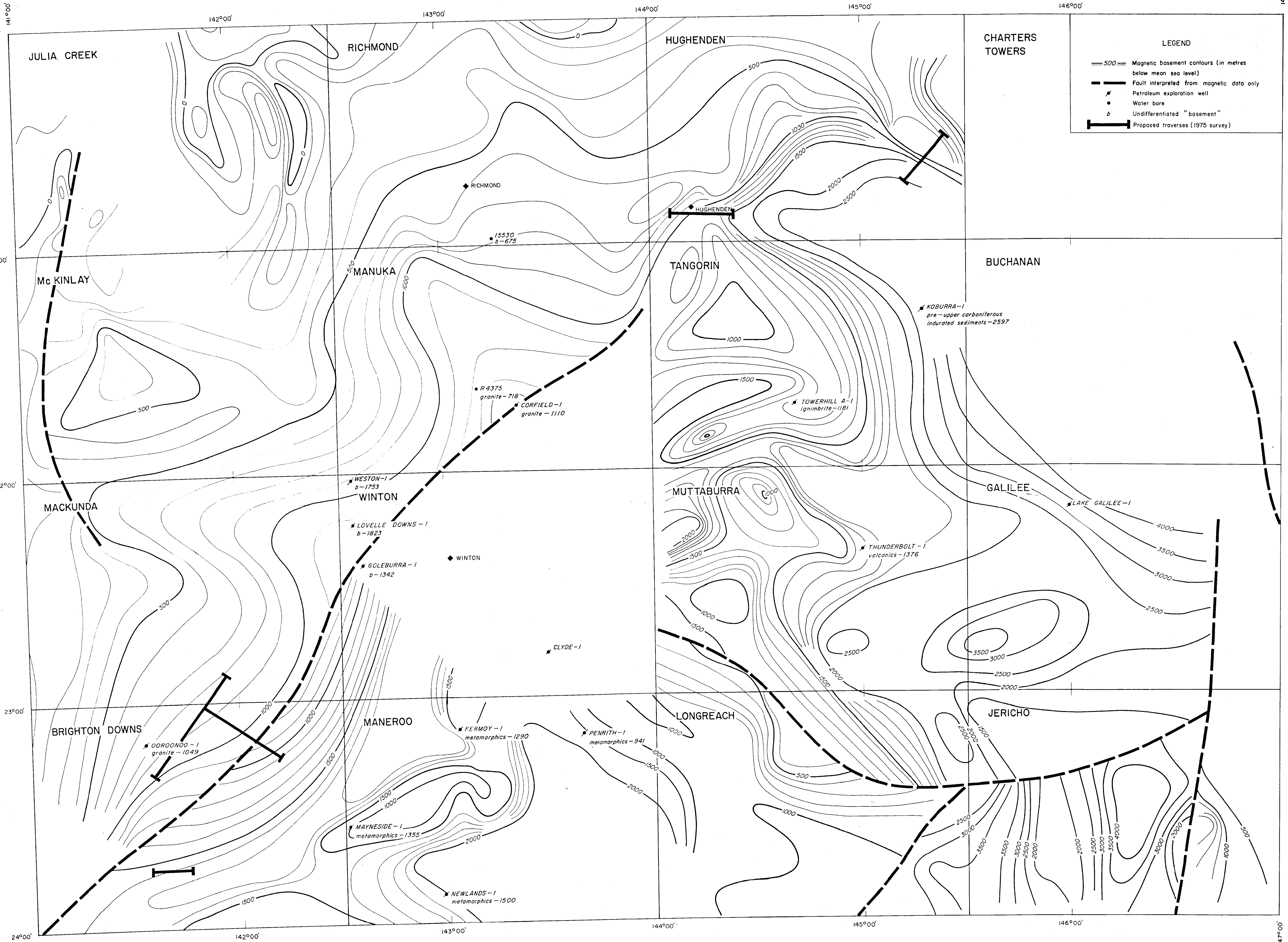
Water bore

Proposed traverses (1975 survey)

(Based on F54/B1-87)

Record No. 1975/131

F54/B3-224-1



CONTOURS OF UPPER MAGNETIC BASEMENT

20 0 20 40 60 80 KILOMETRES

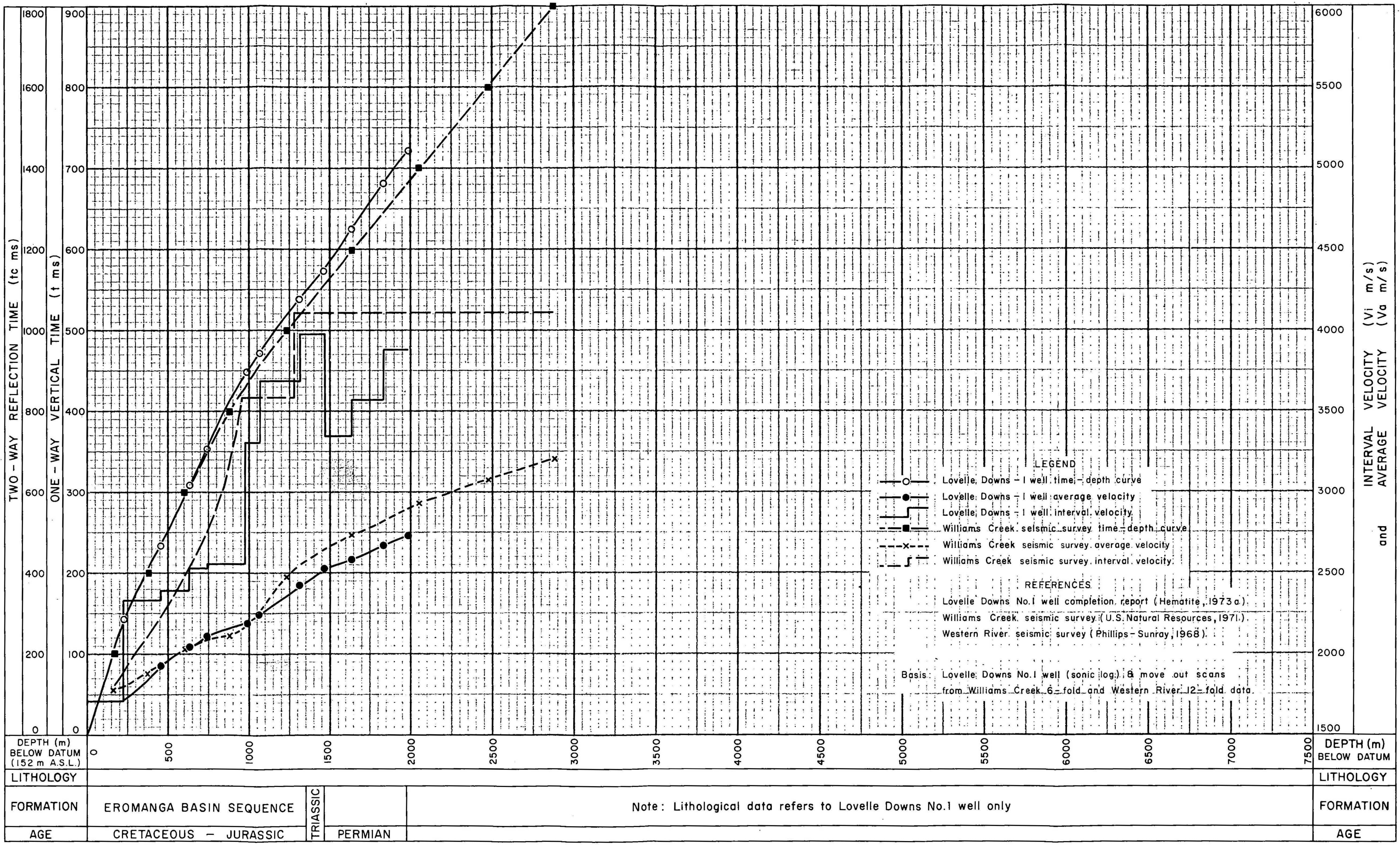
Depth contours after Hsu (1974)

Record No. 1975/131

F54/B3-225-1

(Based on F54/B1-83)

PLATE 6

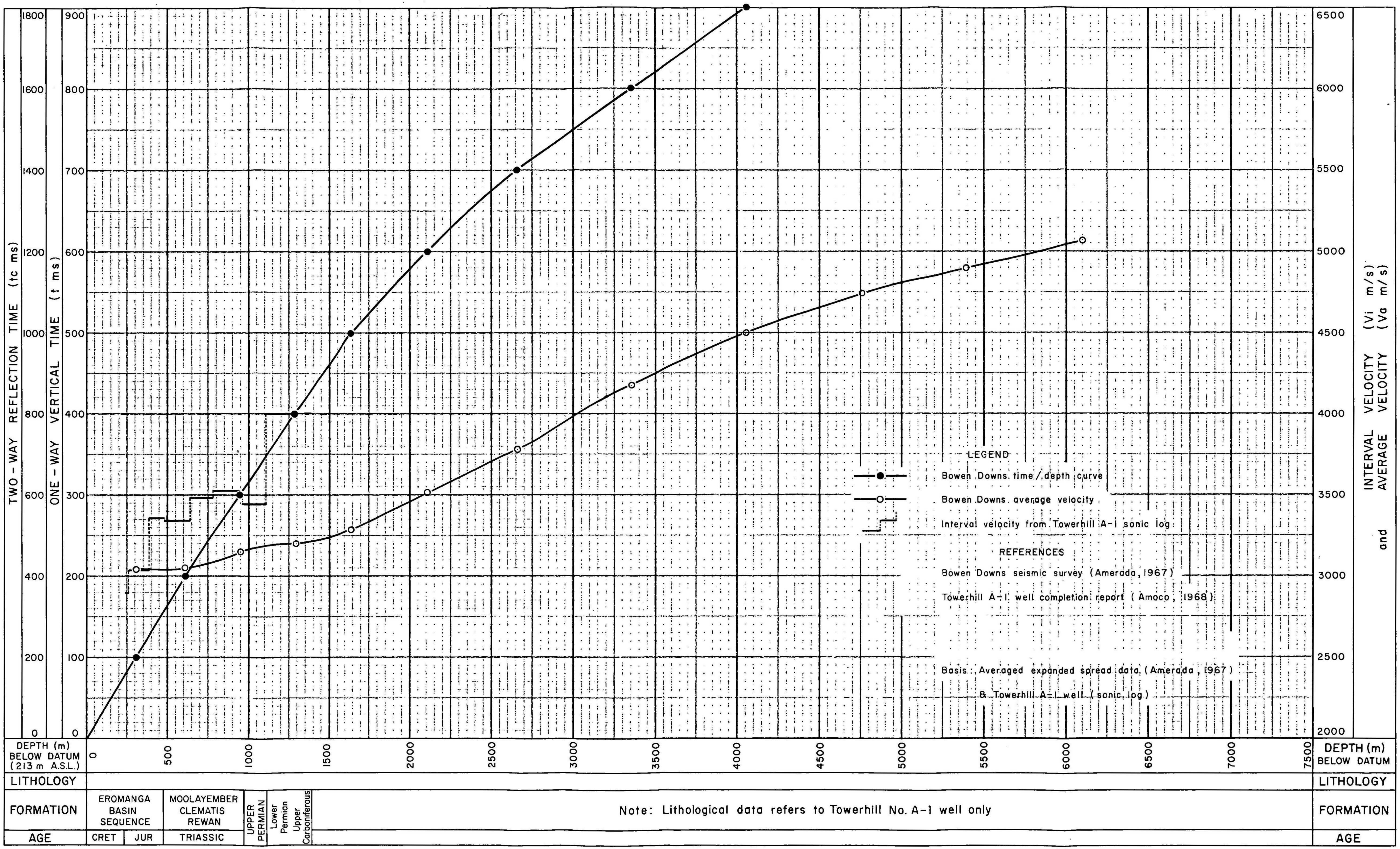


(Based on G85/3-21-1)

WESTERN MARGIN AREA

VELOCITY AND TIME VERSUS DEPTH

F54/B3-226



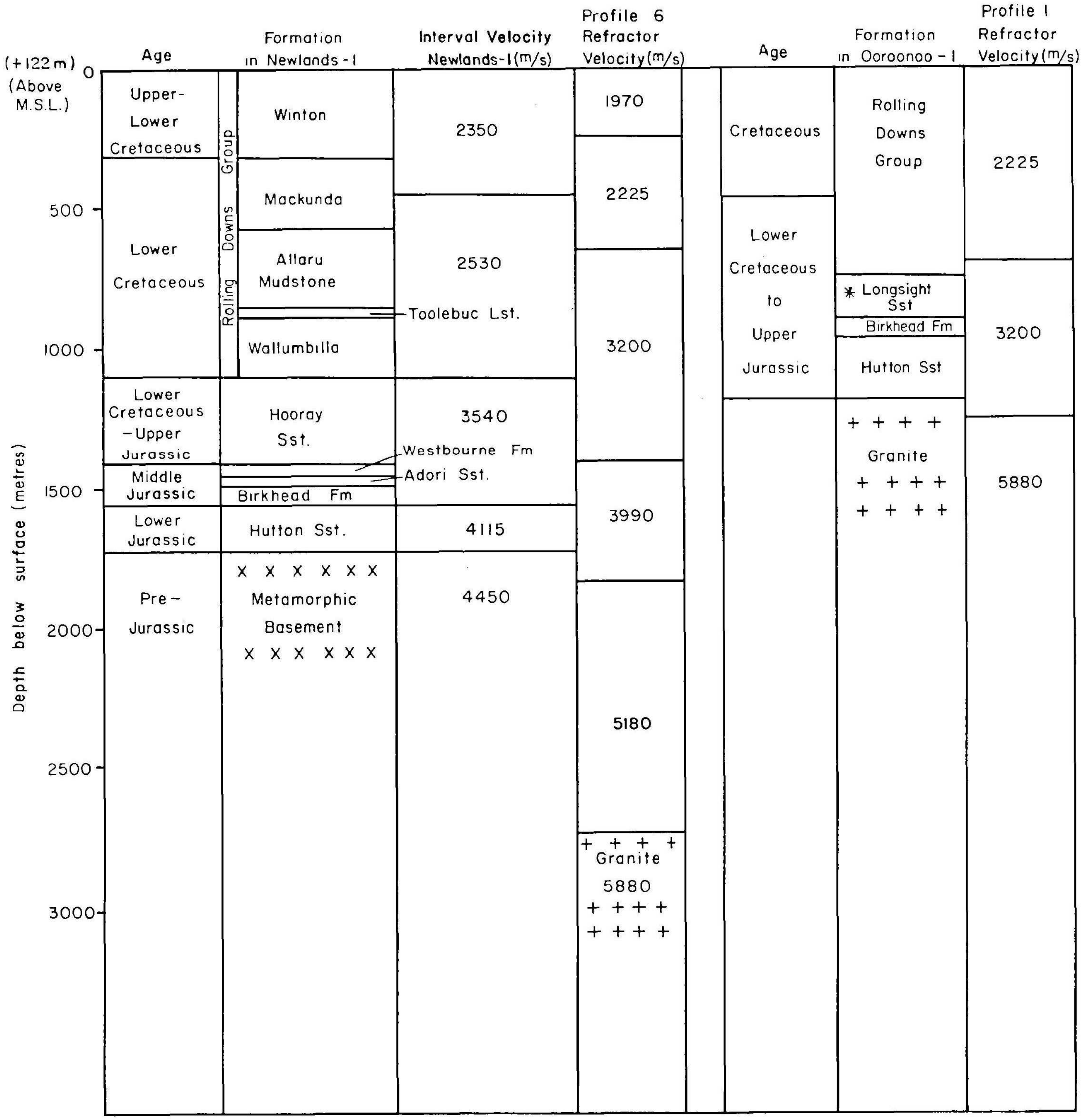
(Based on G85/3-21-1)

NORTHEAST MARGIN AREA

VELOCITY AND TIME VERSUS DEPTH

Record No. 1975/131

F55/B3-105



COMPARISON OF REFRACTION DATA FROM MAYNE SEISMIC SURVEY WITH INTERVAL VELOCITIES AND STRATIGRAPHY IN OOROONOO No. I AND NEWLANDS No. I WELLS

* The Longsight Sandstone is the western equivalent of the Hooray Sandstone – Westbourne Formation – Adori Sandstone sequence

NOTE: The recording parameters are shown in Table 3. The section was processed in the BMR playback centre applying company statics and NMO corrections, and playback filter, LL16 – KK78.

0·5 0 0·5 1·0 1·5 2·0 km
0 0·549 km

SEISMIC SECTION FROM LINE 16
WESTERN RIVER SEISMIC SURVEY
(PHILLIPS – SUNRAY, 1968)

Record No. 1975/131

F54/B3-228

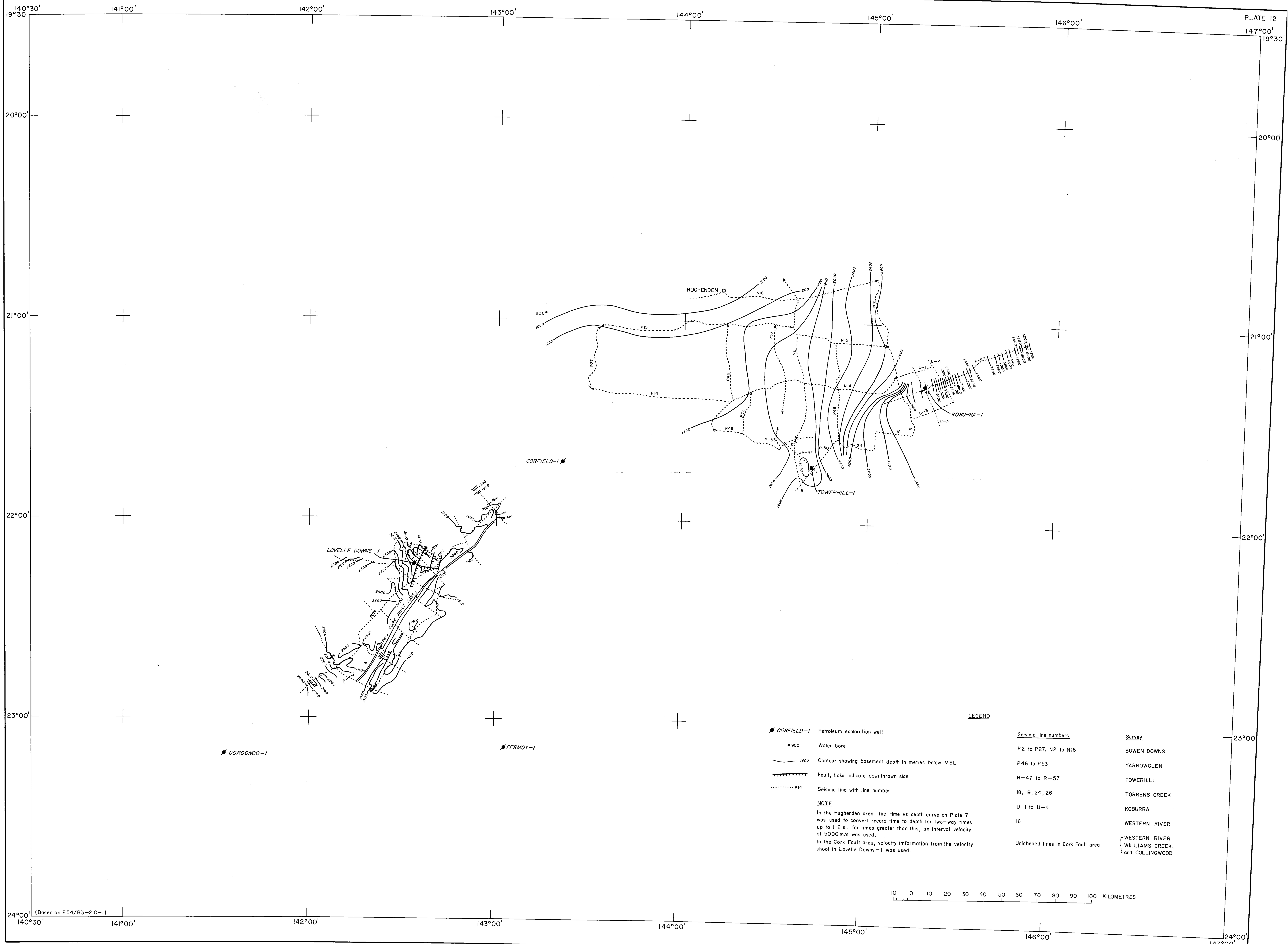
Record No. 1975/131

F54/B3-229

SEISMIC SECTION FROM LINE N16
BOWEN DOWNS SURVEY
(Amerada, 1967a)

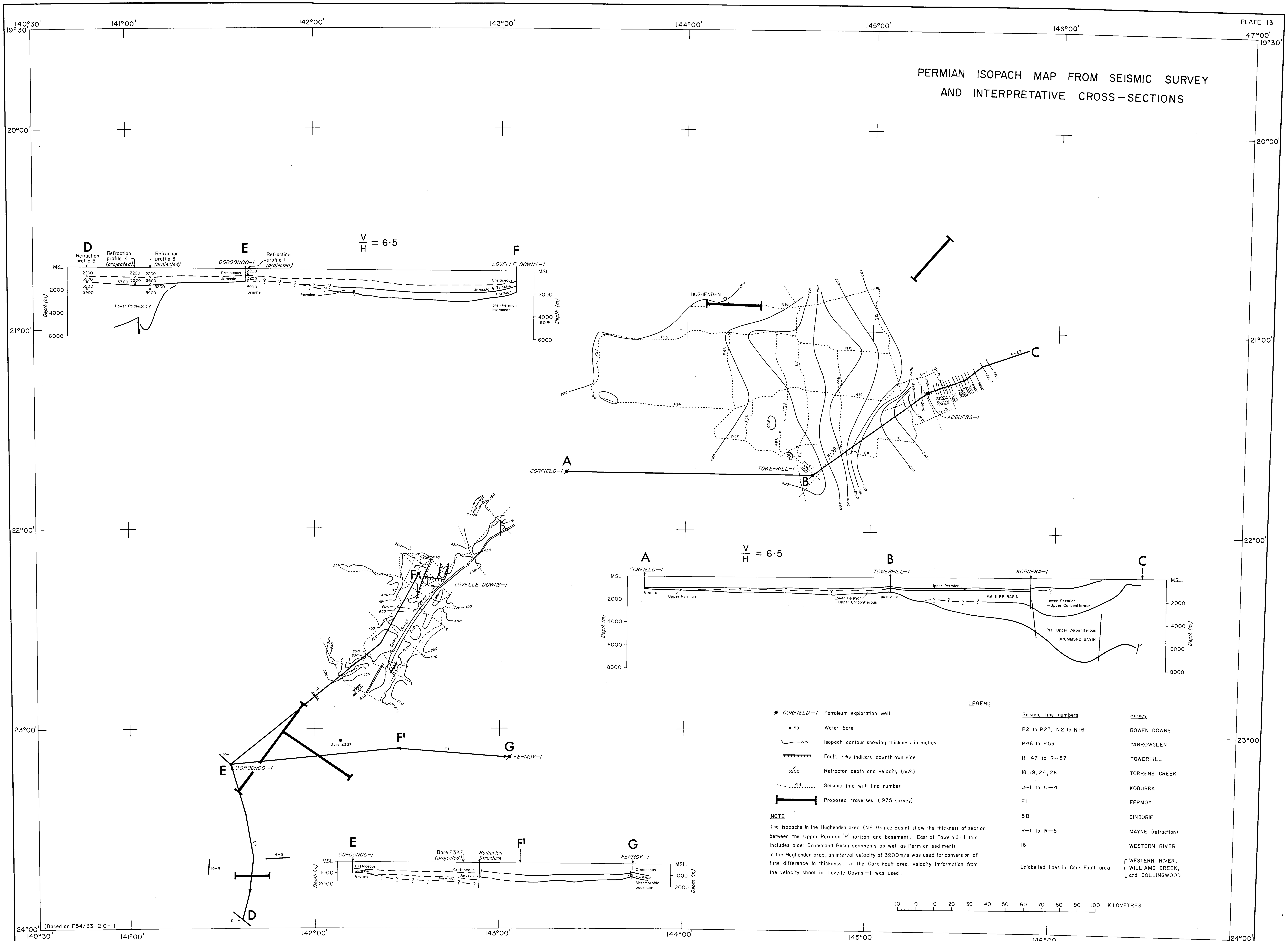
NOTE: Recording coverage was not continuous and there is a subsurface gap of 806m between each record coverage of 403m. These and other gaps are not shown to scale. The recording parameters are shown in Table 4. The section was processed in the BMR playback centre applying NMO corrections from velocity information on Plate 8 and playback filters of LL16-KK78

PLATE 12



Record No. 1975/131

F54/B3-232



Record No. 1975/131

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