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A seismic investigation of the eastern margin of the Galilee Basin, Queensland

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In 1976, four seismic reflection traverses were shot across, and close to, the eastern margin of the Galilee Basin to investigate the structure of the basin's northeast margin with relevance to the extent of the Permian coal measures, and to investigate the relationships and extent of the underlying Devonian Adavale Basin and Devonian-Carboniferous Drummond Basin.

The results show that the basin's northeast margin is steep and faulted, and that there is only a narrow strip in which coal is likely to be found at easily mineable depths. About 30 km southwest of this margin, the sediments are undisturbed, with a southerly dip of about half a degree; here 2000 m of Galilee Basin sedimentary rocks overlie 700 m of Drummond Basin sediments—which extend further to the northwest than was previously thought.

The eastern part of the Galilee Basin is underlain by the fluviatile sediments of the Drummond Basin. The more prospective Adavale Basin does not extend as far north as Jericho No. 1 exploration well.

The Koburra Trough, along the northeast margin of the Galilee Basin, contains a thick sequence of Permo-Carboniferous sediments; results from the 1976 survey indicate that it could be bounded by large anticlinal or monoclinal structures which might provide petroleum traps; it is on this area that exploration should concentrate.

Introduction

During 1976 the Bureau of Mineral Resources conducted a reconnaissance seismic survey over the eastern margin of the Galilee Basin. The survey was carried out to investigate the possibly steep northeast and northwest margins of the Koburra Trough, and the relative extent and relationships of the underlying Adavale and Drummond Basins.

The Galilee Basin is a broad sedimentary downwarp of Late Carboniferous to Triassic age and contains prospective Permian coal measures. The Koburra Trough is the deepest part of the basin and trends north-northwest near the eastern margin of the Galilee Basin. Sedimentary rocks within the trough attain a thickness of at least 6200 m, with 2800 m of these sediments belonging to the Galilee Basin, and the remainder unknown sediments of Carboniferous or possibly Devonian Age.

The eastern margin of the Galilee Basin overlies the western margin of the Devonian-Carboniferous Drummond Basin, and below the southern part of the Galilee Basin lies the Devonian Adavale Basin (Fig. 1). The northerly extent of the Adavale Basin and its relationship to the Drummond Basin is unknown, and information on these matters could be of economic importance, because of the occurrence of a small gas field within the Middle Devonian sequence of the Adavale Basin at Gilmore, and oil and gas shows in the Upper Carboniferous sequence in Lake Galilee No. 1 well.

Previous geophysical investigations

Most of the eastern part of the Galilee Basin has been extensively covered by seismic surveys subsidised under the Petroleum Subsidy Acts, and hence publicly available (Fig. 2), but there are few over the eastern margin. Most surveys obtained good reflections from the top of the Upper Permian coal measures, the 'P horizon', but only later surveys recorded any deeper reflections. The top Permian is, therefore, the deepest horizon that has been regionally mapped; structure contours on this horizon (Fig. 3) show a depth of at least 1400 m in the Koburra Trough, and the steep northeast margin of the Trough.

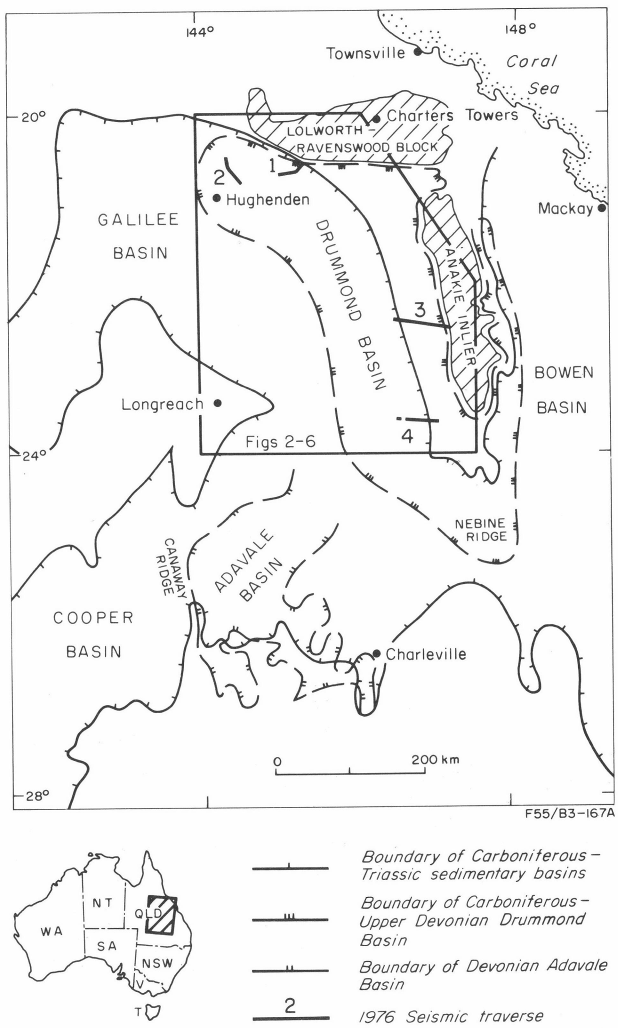

Figure 1. Regional tectonic setting. From Tectonic Map of Australia, 1971, and various BMR Explanatory Notes. Basin boundaries modified by recent seismic survey results.

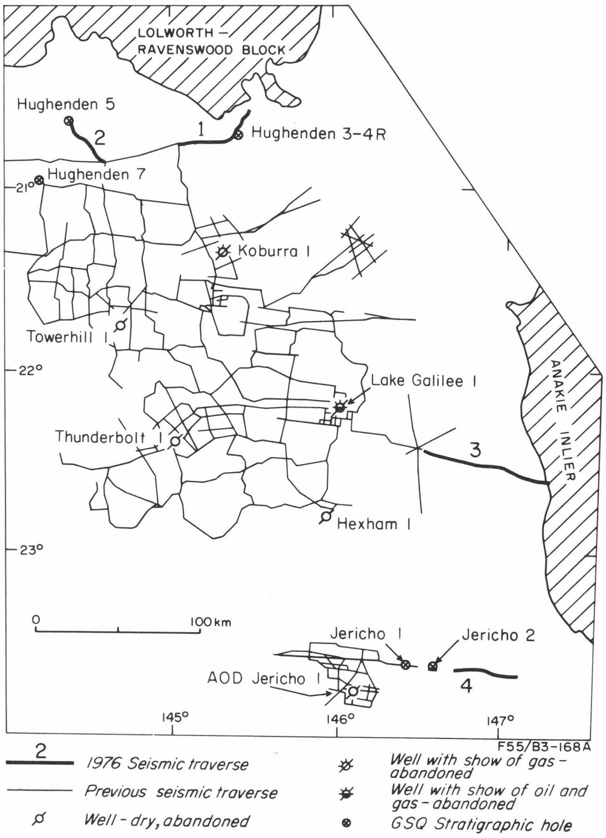

Figure 2. Seismic traverses and exploration wells.

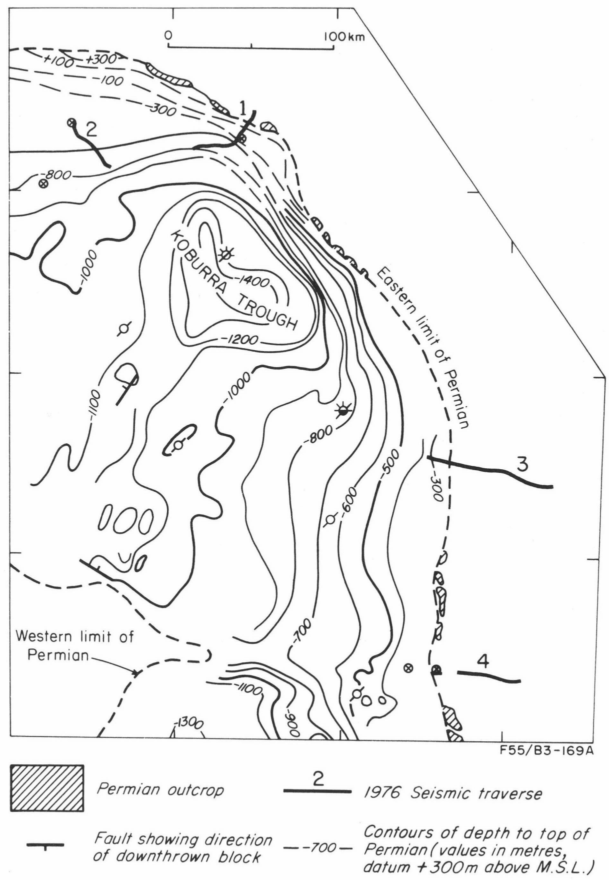

Figure 3. Depth contours to top of Permian.

In 1971, BMR recorded a seismic traverse east of Lake Galilee No. 1 well to investigate the structure of the eastern margin of the Galilee Basin and its relation to the Drummond Basin (Harrison, Anfiloff, & Moss, 1975); it was concluded that the eastern margin of the Galilee Basin is underlain by Middle to Upper Devonian sediments, possibly of the Adavale Basin. However this interpretation was based on scant palynological evidence for the age of these sediments at the bottom of Lake Galilee No. 1 (Playford, Appendix 1a *in* Pemberton, 1965). Recent examinations of the cores from this well, and from other wells in the Galilee Basin throws doubt on this identification (P. Hawkins, pers. comm.).

Regional total magnetic intensity contours are shown in Figure 4. A zone of relatively low amplitude magnetic anomalies coincides with the Koburra Trough, and Hsu (1974) has interpreted magnetic basement depths of 3000 m to 6000 m in this region. At the northwest end of the Koburra Trough, a northeast-trending magnetic lineation separates the low intensity magnetic anomalies over the Trough from higher magnetic intensity to the northwest; Hsu (1974) suggested that this lineation marked the northwest boundary of the Trough.

The Galilee Basin has also been covered by reconnaissance gravity surveys (Gibb, 1968); the Bouguer anomaly map and gravity provinces of Fraser, Darby & Vale (1977) are shown in Figure 5. The Bouguer anomaly values show a general increase in amplitude over the Lolworth-Ravenswood Block in the north and towards the Anakie Inlier in the east (both basement highs located on Fig. 2). The Tangorin Gravity Depression corresponds approximately with the Koburra Trough; but apart from these general observations there is little correlation between Bouguer anomalies and depth to sedimentary basement. One feature, investigated in detail was the Donnybrook Gravity High within the Drummond Gravity Shelf over which a detailed gravity traverse was recorded in 1971. Harrison & others (1975) considered that the anomaly was probably caused by basement uplift, but that a reverse density contrast at depth could alternatively be the cause.

Objectives and program

Four seismic reflection traverses were recorded. Traverses 1 and 2 were surveyed to investigate the possible steep northeast and northwest margins of the Koburra Trough, and to tie the existing seismic network to the stratigraphic bores GSQ Hughenden No. 3-4R and GSQ Hughenden No. 5.

Traverses 3 and 4 were designed to investigate the relationships and relative extents of the Adavale and Drummond Basins in the area east and south of Lake Galilee No. 1 well. There was considerable doubt as to whether the basal sediments in Lake Galilee No. 1 and Jericho No. 1 belong to the Adavale or Drummond Basins. The relative extent of these two basins is regarded as important, because gas has been discovered in the Adavale Basin, but neither gas nor oil has been found in the Drummond Basin. Traverse 3 was shot eastwards from the end of the 1971 BMR seismic traverse to the outcrop of the Anakie Metamorphics, thus providing continuous seismic coverage from Lake Galilee No. 1 across the Drummond Basin to basement outcrop. Traverse 4 provided a similar link between Jericho No. 2 and the Drummond Basin outcrops to the east.

Six-fold common depth point (CDP) seismic reflection techniques were used and gravity measurements at

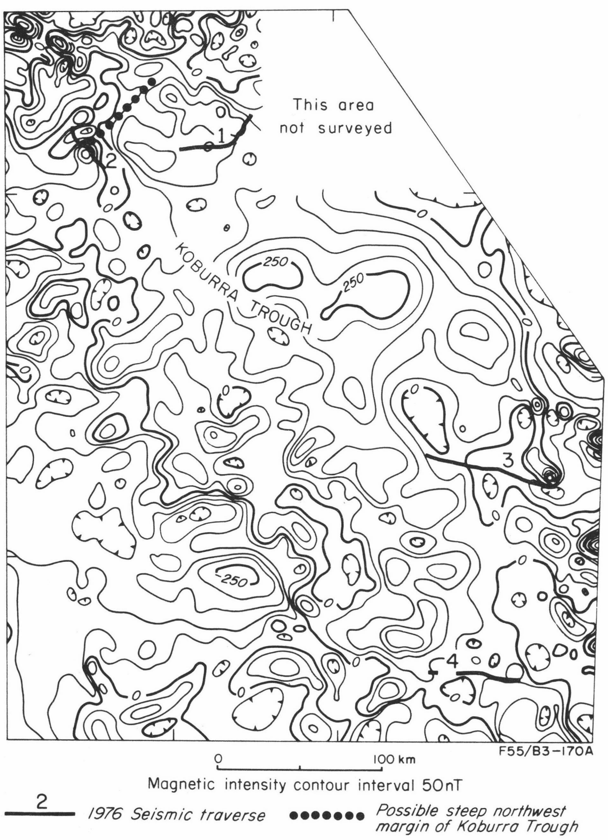

Figure 4. Regional total magnetic intensity.

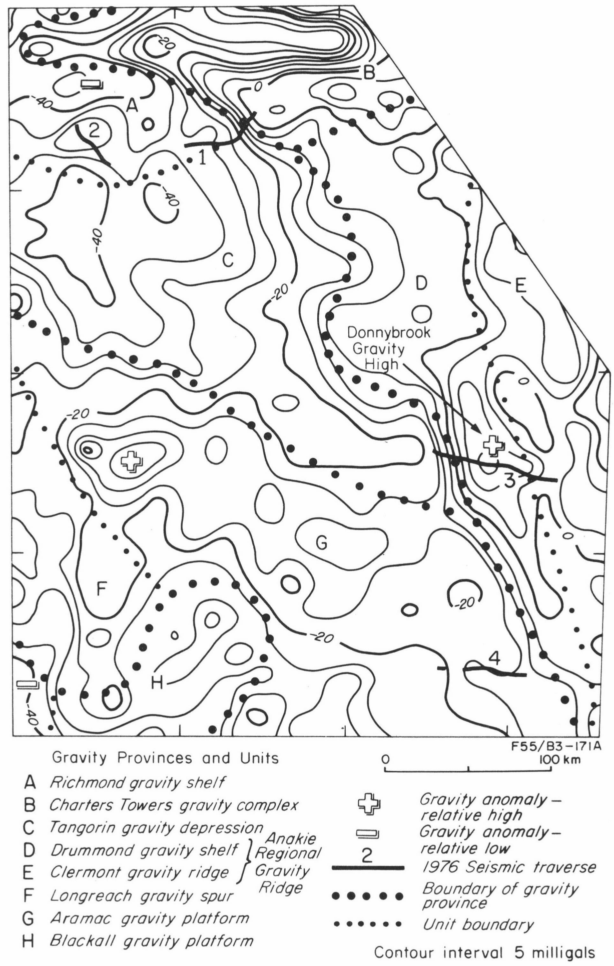

Figure 5. Regional Bouguer anomaly contours.

½ km intervals were taken along all four traverses; details of the field operations are given in Brassil & Anfiloff (1977), and Schmidt, Nelson, & Anfiloff (1977).

Geology

Regional setting

The regional tectonic setting of the area is shown in Figure 1, and details of the geology in Figure 6. The Lolworth-Ravenswood Block and Anakie Inlier are the main basement outcrops in the area. Sedimentary rocks belonging to sedimentary basins of four different ages, the Adavale, Drummond, Galilee, and Eromanga Basins, occupy the area to the south and west of these basement highs.

Rocks of the Early to Middle Devonian Adavale Basin do not crop out anywhere, and the basin is known only from drill-hole and seismic information.

The Late Devonian to mid-Carboniferous Drummond Basin lies south of the Lolworth-Ravenswood Block and mainly west of the Anakie Inlier. Outcrops within this basin are confined to a narrow belt immediately to the west and east of the Anakie Inlier.

Late Carboniferous to Triassic sedimentation in the area was widespread; the sediments were deposited in three separate neighbouring basins—the Galilee, Cooper, and Bowen Basins. Although the Canaway Ridge is taken as the boundary between the Galilee and Cooper Basins, and the Nebine Ridge is considered as the boundary between the Galilee and Bowen Basins, Permo-Triassic sedimentary rocks are continuous across both of these ridges (Mollan, 1969; Senior, 1971; and Vine, 1976).

The Early Jurassic to early Late Cretaceous Eromanga Basin overlies all earlier sedimentary basins in the west of the survey area, and the entire region is covered with patches of duricrust and areas of Cainozoic sands, gravels and scattered basalt flows.

Basement

The basement rocks which crop out in the Lolworth-Ravenswood Block and Anakie Inlier consist of Lower Palaeozoic low-grade metasediments, granites, and acid volcanics. Towerhill 1 and Thunderbolt 1 wells are the only exploration wells in the eastern Galilee Basin to reach basement (see Table 1 and Fig. 2); both wells bottomed in Palaeozoic volcanics, which can be correlated either with the pre-Devonian Mount Windsor Volcanics of the Anakie High or with the Devonian-Carboniferous Silver Hills Volcanics of the Drummond Basin (Olgers, 1972).

Well	*Total depth (m)*	*Deepest rock type*
Koburra No. 1	3260	pre-Upper Carboniferous sandstone, shale, siltstone
Towerhill No. 1	1481	pre-Upper Carboniferous acid volcanics
Thunderbolt No. 1	1608	pre-Upper Carboniferous acid volcanics
Lake Galilee No. 1	3406	Middle or Upper Devonian sandstone and shale
Jericho No. 1	2786	pre-Upper Carboniferous acid volcanics
Allandale No. 1 (Lat. 24°25′S Long 145°54′E)	3006	Lower Devonian acid volcanics, possibly Gumbardo Formation

Table 1. Deepest rocks in exploration wells.

Period	*Basin*	Group or Formation	*Lithology*	*Thickness (m)*	*Reference*
Quaternary			Alluvium; soil, sand; basalt; duricrust	50	
			UNCONFORMITY		
Cretaceous	EROMANGA	Rolling Downs Group	Sandstone; siltstone; limestone	1000	Exon & Senior, 1976
Jurassic	EROMANGA	Hooray Sandstone or Gilbert River Formation	Quartzose, sub-labile sandstone	150	Exon, 1966
		Injune Creek Group	Mudstone; siltstone; sandstone	220	
		Hutton Sandstone	Quartz sandstone	120	
			UNCONFORMITY		
Triassic	GALILEE	Moolayember Formation or Warang Sandstone	Mudstone; siltsone; sandstone	150	
		Clematis Sandstone	Quartzose sandstone; minor cgl	120	
		Rewan Formation	Mudstone and siltstone	160	Vine & Doutch, 1972
Permian	GALILEE	Betts Creek Beds and Boonderoo Beds	Sandstone; siltstone; coal	100	Vine, 1972
			DISCONFORMITY		
		Joe Joe Group	Sandstone; mudstone; coal	1000	Hawkins, 1977
			UNCONFORMITY (KANIMBLAN OROGENY)		
Carboniferous	DRUMMOND	Ducabrook and Natal Fms	Sandstone; siltstone; tuff	1500	Olgers, 1972
		Star of Hope Formation	Sandstone; tuff; pebble cgl		
		Raymond Formation	Quartz sandstone; mudstone	1000	
		Mt Hall Formation	Sandstone; pebbly conglomerate	600	
		Telemon Formation	Sandstone; mudstone; minor 1st	600	
		Silver Hills Volcanics	Rhyolite; welded tuff	1500	
			UNCONFORMITY (TABBERABBERAN OROGENY)		
Devonian	ADAVALE	Buckabie Formation	Red sandstone; siltstone; shale	1500	Vine, 1972
		Etonvale Formation	Siltstone; shale dolomite	500	Tanner, 1968
		Bury Limestone	Limestone; oolitic fossiliferous	400	Paten, 1977
		Log Creek Formation	Sandstone; dolomite limestone	450	
		Eastwood Beds	Interbedded shale and sandstone	500	
		Gumbardo Formation	Acid volcanics; arkose	400	Auchincloss, 1976
			UNCONFORMITY		
Silurian-Cambrian		Basement rocks including Anakie Metamorphics	Low-grade metamorphics; granites; acid volcanics		

Table 2. Generalised stratigraphy of the area along the eastern margin of the Galilee Basin.

Stratigraphy

The generalised stratigraphy of the area is given in Table 2.

The Adavale Basin mainly contains shallow marine sediments deposited over a platform region (Paten, 1977). Overlying the acid and andesitic volcanics of the Gumbardo Formation is a transgressive sequence of shallow marine sediments including salt and dolomite in the Log Creek and Etonvale Formations. A small gas field was discovered in the Middle Devonian Log Creek Formation at Gilmore, but because of the field's poor reservoir characteristics, size, and distance from market, it has not been brought into production.

The terrestrial sediments of the Drummond Basin were deposited from Late Devonian to Early Carboniferous times in an intermontane trough. Olgers (1972) reports that up to 12 000 m of fluviatile sediments were deposited by generally north-flowing rivers. The initial and final stages of deposition in the basin were accompanied by acid volcanism; the Silver Hills Volcanics form a 1500 m-thick sequence of tuffs and rhyolites at the base of the Drummond Basin, and both the Star of Hope and Ducabrook Formations near the top of the sequence contain numerous tuffs.

Sedimentation in the Galilee Basin was also mainly fluviatile, and continued with minor breaks from the Late Carboniferous until the Late Triassic. There is evidence of glacial conditions in the Late Carboniferous and again in the Early Permian.

During the Late Permian, several distributary river systems flowed southwards into swamps, producing the widespread coal measures. These deposits have the best source-rock potential within the Galilee Basin (Hawkins, 1977).

During the Jurassic and Cretaceous, the fluvial and shallow marine sediments of the Eromanga Basin were deposited in a broad, regional downwarp; covering the area with up to 1800 m of mudstones; sandstones and minor limestone.

Structure

The main geological structures are shown in Figure 6. The Upper Carboniferous and younger sediments are only gently folded and occupy broad downwarps in the

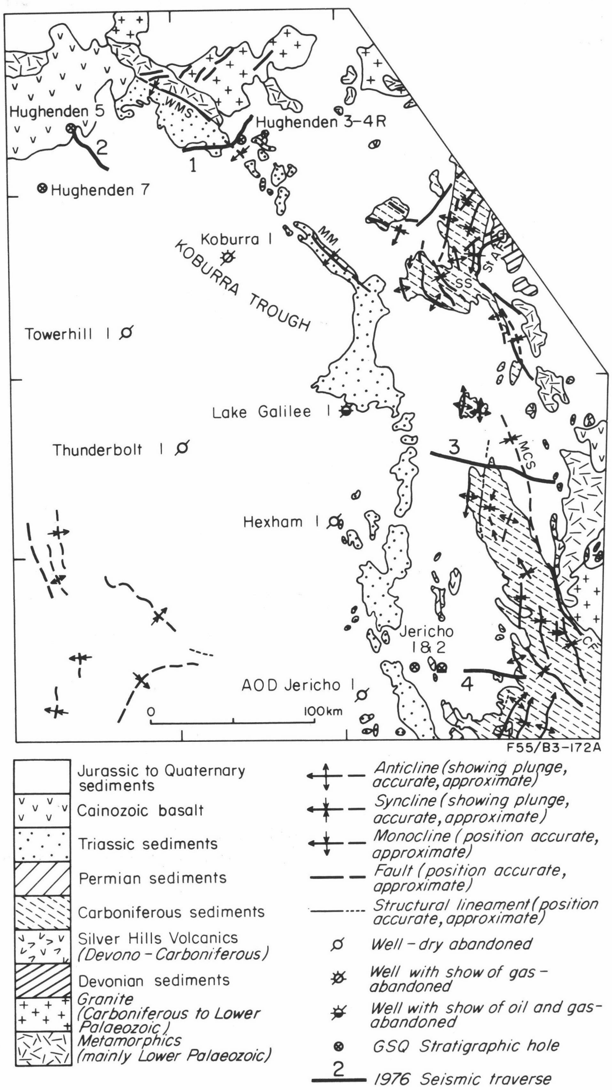

Figure 6. Geology, adapted after Olgers, 1973; Senior, 1974; and Senior & others, 1974.
WMS—White mountains structure; MM—Mingobar Monocline; SS—Scartwater Salient; St AF—Saint Ann's Fault; MCS—Mistake Creek Syncline; CF—Chinaman Fault.

underlying strata. However, the Devonian to Carboniferous sediments of the Adavale and Drummond Basins are folded into a series of generally north-northeast to north-northwest-trending folds, which become tighter towards the east. Olgers (1972) stated that structures in the Drummond Basin were formed during the mid-Carboniferous Kanimblan Orogeny as a result of compression from the east. He also considered that large-scale shearing occurred along northwest and northeast-trending fault zones. He postulated several megashears across the Drummond Basin and Anakie Inlier, and a décollement at the base of the Drummond Basin sequence. The St Anns and Chinaman Faults are high-angle reverse oblique-slip faults and form parts of the megashears.

The boundaries of the Koburra Trough (Fig. 3) have not been precisely defined, but the Trough is known to be about 300 km long along its northwest axis and 100 km across (Allen, 1974). It contains the greatest known thickness of Galilee Basin sediments, 2820 m in Koburra No. 1. The presence of a thick continuous sequence of shallow-water Permian sediments in the Trough indicates that subsidence occurred penecontemporaneously with deposition (Benstead, 1973).

The Mingobar Monocline forms part of the eastern margin of the Koburra Trough. This monocline in the outcropping Triassic and Permian sediments extends, in the subsurface, northwest and southeast of its mapped position (Fig. 6), and appears to be an anticline at depth on the several seismic sections that cross it.

Vine (1972) gave the name Belyando Feature to a lineament that included the White Mountains Structure, the Mingobar Monocline and part of the course of the Beylando River. He suggested that it was a major basement fracture zone and that it marked the western limit of the Drummond Basin. Harrison & others (1975) considered the Drummond Basin sediments to extend 20 km westwards of the Belyando Feature, which appeared to coincide with a shear zone as interpreted from seismic data. This shear zone was postulated to be an extension of the Chinaman Fault.

Results and interpretation

Figures 7 and 8 show a Bouguer anomaly profile, a near-surface seismic refraction profile produced by analysis of the first arrival times, and an interpretation of the seismic reflection section for the traverses. The seismic sections, together with more detailed gravity results will be published by Pinchin, Schmidt & Anfiloff (in prep.).

Traverse 1

The buried river channels interpreted from shallow refraction data (Fig. 7) may be filled with Tertiary sediments of middle-Pliocene age. R. Coventry (in prep.) has correlated the position of these river channels with deep, red soils formed on the lower slopes of the undissected undulating plains in the area during the late Pliocene. Deep, red loamy earths are found in the seismic shot-holes within these channels and the aerial photographs show traces of old river systems.

The shallow refraction data also shows that the youngest sediments at the east end of the line, a partly weathered layer that appears to infill the river channels, are much faulted. The faults were therefore active as recently as the Pliocene.

The three horizons shown in Figure 7 have been traced around the network of seismic lines (Fig. 2) to Koburra No. 1, Towerhill No. 1 and Lake Galilee No. 1 exploration wells. The horizon shown topping the Drummond Basin sequence also ties to the stratigraphic bore GSQ Hughenden No. 3-4R, where Gray (1977) tentatively correlates strata in the bottom of the hole with the Upper Carboniferous Natal Formation.

Faulting makes the basin margin crossed by Traverse 1 fairly steep. The basement rises, mainly by normal faulting, from 2500 m to the surface in a distance of 27 km, giving an average gradient of $5\frac{1}{2}°$; these depth figures are in agreement with Hsu's (1974) calculations of depth to magnetic basement.

The Lower Carboniferous strata do not pinch out, and the Permian sediments do not thin as they approach the basin margin, suggesting that the Drummond and Galilee Basins originally extended further in this direction, and that later uplift or rejuvenation of the Lolworth-Ravenswood Block produced the present margin. However, the Galilee Basin could not have extended much further northeast, because the Lolworth-Ravenswood Block was a source for sediments for the basin (Hawkins, 1977). The uplift of the margin occurred along a set of parallel monoclines and normal faults. The general structural trend in the area is northwest, so it is probable that the small horst-like block or faulted anticline, crossed by the traverse trends similarly northwest parallel to the White Mountains Structure.

The gravity results (Fig. 7) are consistent with the seismic data: the Bouguer anomaly values rise by about 30 mGal from west to east towards the Lolworth-Ravenswood Block, and the two local increases in gradient of the gravity profile coincide with shallow faults deduced from analysis of the seismic refraction data.

Traverse 2

The buried low-velocity layer interpreted from the shallow refraction data (Fig. 7) could be related to the deep weathering of the Late Cretaceous and Early Tertiary, in which case it would have been buried by later Tertiary terrestrial deposits. However, this is conjectural —the buried weathered zone may be Quaternary.

The shallowest seismic reflection is identified, from its extrapolation to GSQ Hughenden No. 5, as being from the top of the sandstone of the Lower Cretaceous Gilbert River Formation; such sandstones could be expected to yield a strong seismic reflection where they are overlain by mudstone of the Wallumbilla Formation at the base of the Rolling Downs Group. In GSQ Hughenden No. 7, drilled 35 km to the southwest of GSQ Hughenden No. 5 in 1977 (Balfe, in prep.), there is a sharp change in the electric and gamma-ray logs at the boundary between the Wallumbilla and Gilbert River Formations; one would expect a good seismic reflection from this boundary.

The other three reflections, the top Permian, the top of the Late Carboniferous Natal Formation, and basement, are tied to Traverse 1 and to the exploration wells in the area via the network of seismic lines shown in Figure 2.

Figure 7 shows the sediments are undisturbed and dip to the southeast at the slight gradient of $\frac{1}{2}°$. There is no evidence of a steep margin to the Galilee Basin here (cf. Vine & Paine, 1974) on the basis of Hsu's (1974) data. Drummond Basin sediments were not recognised so far northwest before (Fig. 1), and these sediments are believed to have been deposited over a shelf or plain to the west of the intermontane trough that Olgers (1972) considered to be the depositional limits of the basin.

The traverse straddles a broad, low-amplitude gravity high which, since the seismic reflectors are almost flat-lying, must be caused either by gradual density changes within the basement or by large deep structures beyond each end of the traverse (Anfiloff, pers. comm.).

Traverse 3

Interpretation of the shallow refraction data (Fig. 8) shows a weathered zone of fairly constant thickness (ca. 20 m), with a seismic velocity of 1000 m/s, underlain by a refractor with velocity about 2000 m/s. Below this, refractor velocities gradually increase from 3300 m/s in the west to 4500 m/s in the east.

The interpretation of the seismic data presented in Figure 8 is not definitive. However, it matches the known geology and conforms to many of Olgers' (1972) views of the structural development of the Drummond Basin. It does not provide a satisfactory model for the gravity profile, as is explained later. Interpretation is complicated by numerous diffractions and reflected refractions, especially in the more intensely faulted and folded zones. The possible faults at the extreme eastern end of the traverse do not show up on the seismic section, but strong diffraction patterns indicate major discontinuities within the basement rocks.

Olgers in his interpretation of the structure of the Drummond Basin postulated the existence of both thrust-faults and strike-slip faults. The thrust fault shown on this section is in rough alignment with the Chinaman Fault, which is a reverse oblique-slip fault. Olgers interprets a décollement at the base of the Scartwater Salient further north. On the other hand Olgers' Chinaman Megashear (which in places coincides with the Chinaman Fault) passes through this fault zone on Traverse 3, and it seems likely that both low-angle reverse movement and strike-slip movement has occurred here.

The thrust fault is interpreted here as forming during the mid-Carboniferous Kanimblan Orogeny; hence the Drummond Basin sediments, but not the Galilee Basin sediments were affected. This interpretation shows the younger Drummond Basin units to be restricted to the Mistake Creek Syncline, and the older Mount Hall and Telemon Formations to be thicker below the Beresford Upwarp, and to extend far to the west, as suggested by Vine & Doutch (1972). The Beresford Upwarp started to develop in Mount Hall time, and folding and normal faulting continued during deposition; the northern part of the Mistake Creek Syncline crossed by Traverse 3 started to develop after Star of Hope time, and therefore contains a thick Ducabrook Formation. The maximum thicknesses of each unit shown in Figure 8 are in general agreement with those mentioned by Olgers (1972)—except for the Silver Hills Volcanics, which here attains 3000 m, whereas 1500 m was suggested by surface mapping. The different thickness of Mount Hall and Telemon Formations across the thrust fault are due to erosion of the overthrust block prior to deposition of Galilee Basin sediments.

Traverse 3 crosses a Bouguer anomaly high of about 40 mGal, the Donnybrook Gravity High (see Fig. 8). To the east of this high, the Bouguer anomaly values drop steadily to the adjacent low; then, near the eastern end of the traverse, they rise abruptly by about 15 mGal. The seismic results rule out the possibility of a basement uplift as the cause of the Donnybrook Gravity High; in addition, an uplift large enough to produce this gravity high would cause the Silver Hills Volcanics to crop out over the uplift, and they do not. Admittedly, the Beresford Upwarp coincides fairly well with the Donnybrook Gravity High, but the 2 km amplitude of this upwarp could produce, at the most, a third of the observed gravity high, and the adjacent Mistake Creek Syncline, which is a geological structure of similar size, does not correlate well with the observed adjacent gravity low. The gravity profile itself provides evidence against large basement uplift beneath the Donnybrook Gravity High. The observed gravity values over the High are greater than the gravity values over the Anakie Metamorphics at the eastern end of the traverse; therefore, the Donnybrook Gravity High must be caused by a dense body, and not just represent uplifted Anakie Metamorphics. It is postulated here that a dense intrabasement block causes the gravity high; this interpretation is supported by the long wavelength of the high, which indicates a deep-seated origin.

An alternative interpretation based on the concept of low density Silver Hills Volcanics overlain by higher density Drummond Basin sediments is presented by Flavelle & Anfiloff (1976). However, this interpretation

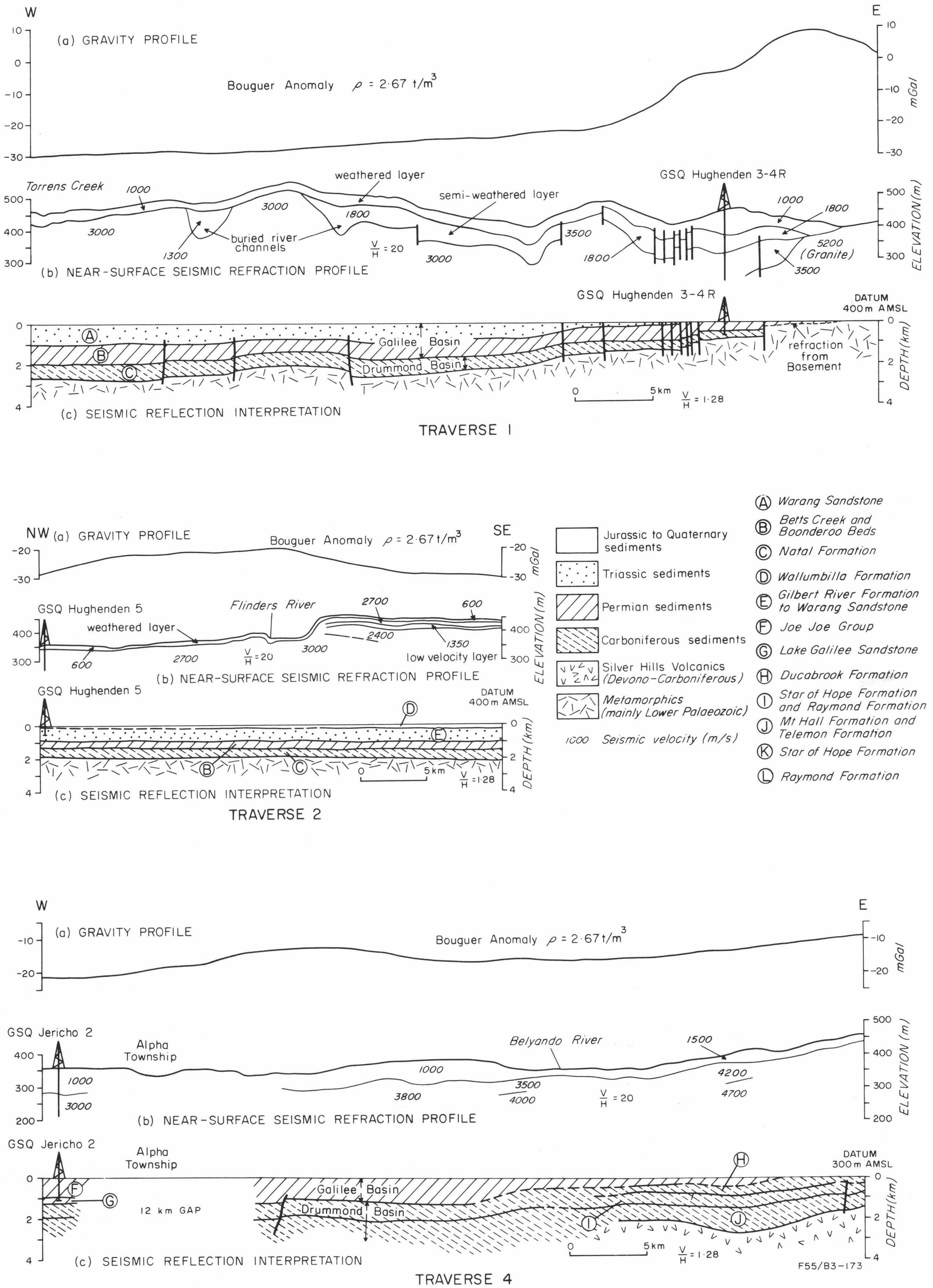

Figure 7. Seismic and gravity results, Traverses 1, 2, and 4.

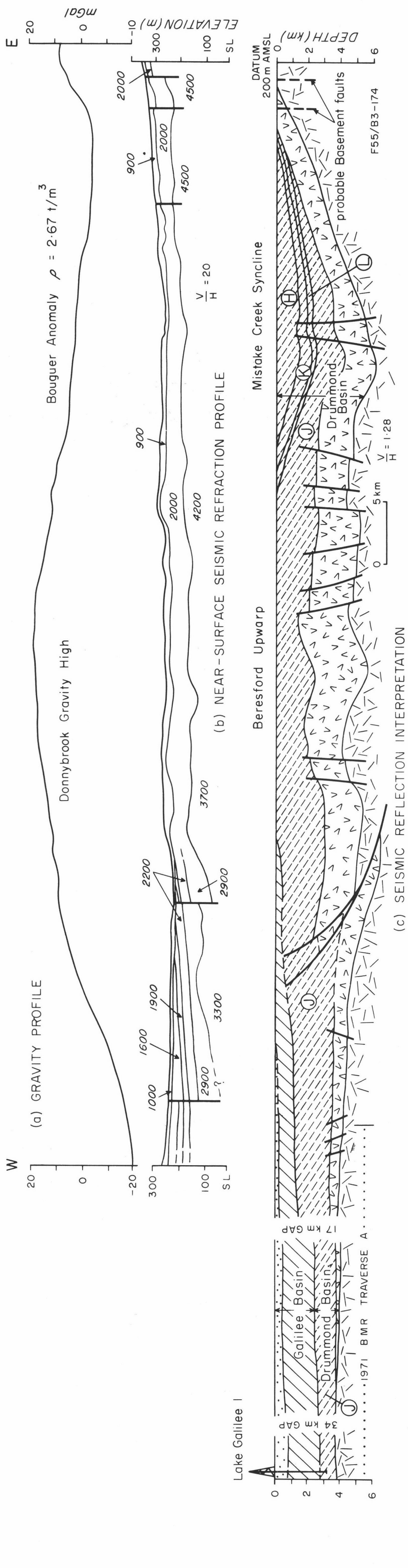

Figure 8. Seismic and gravity results, Traverse 3. For legend see Figure 7.

requires a complex geological history, in conflict with ideas expressed here. Both interpretations are discussed further by Pinchin & others (in prep.).

Traverse 4

Identification of the seismic reflections on this traverse (see Fig. 7) is based on the tie to the stratigraphic bore GSQ Jericho No. 2, the tie to the outcrops of the Drummond Basin in the east, and comparison of the seismic section character to that within the Mistake Creek Syncline on Traverse 3. The strongest reflection, as on Traverse 3, is from near the top of the Mount Hall Formation. No basement reflection has been identified.

The Drummond Basin rocks are not as tightly folded and faulted here as on Traverse 3, but more intense folding east of the traverse is indicated by the surface geology.

Because of the gap in seismic coverage between Traverse 4 and the nearest line of the Jericho Seismic Survey (Alliance, 1964) and because of the distance to be covered, correlation of the reflections on Traverse 4 with those at Jericho No. 1 well is difficult. However, the band of reflections arising from the Mount Hall and Telemon Formations can be followed westwards from Traverse 4 for a considerable distance towards Jericho 1 well. In this well, the Devonian strata consist of volcaniclastics and dacite which are probably related to the Silver Hills Volcanics. Olgers (1972) considered the Drummond Basin to extend to Jericho 1; these seismic results support his conclusions.

The Bouguer anomaly values rise gently from west to east along the traverse, and superimposed on this regional trend is a broad gravity high of only 7 mGal. The long wavelength of this gravity high indicates that it is probably caused by a structure deeper than 3000 m (W. Anfiloff, pers. comm.). Furthermore the seismic section shows no shallow structures that could be identified as possible sources of the gravity anomaly. The steady eastwards rise in Bouguer anomaly values is consistent with the eastwards shallowing of the Galilee Basin indicated by the seismic results.

Conclusions

The northeast margin of the Galilee Basin, adjacent to the Lolworth-Ravenswood Block, is formed by normal onlap onto basement, and is extensively modified by Tertiary faulting along previously existing northwesterly structural trends parallel to the White Mountains Structure and Mingobar Monocline. Traverse 1 crossed a gentle fault-bounded anticline, the amplitude of which increases with depth, indicating fault movement as far back as Early Carboniferous. Structures similar to this could occur further south in the Koburra Trough, where the sedimentary thickness is greater, and could provide the most attractive oil exploration targets in the area.

The steep, faulted nature of the northeast margin probably provides only a narrow strip where coal is likely to be found at shallow depths, and a detailed exploration program would be required to locate any commercial seams.

Rocks of the Drummond Basin are seen to extend further northwest than was previously thought. This raises the questions of the depositional environment west of the intermontane Drummond Basin trough, and the limits of deposition of these Upper Devonian and Lower Carboniferous strata. The Drummond Basin in the outcrop area is considered to be generally fluviatile and non-prospective for petroleum, but its extension to the west below the Galilee Basin could be of a different facies.

In the Mistake Creek Syncline and Beresford Upwarp (Traverse 3), the Drummond Basin rocks, including a thick sequence of Silver Hills Volcanics, are extensively folded and faulted. This folding ends in the east at a low-angle thrust fault below the Belyando River, west of which there is only gentle folding. The Silver Hills Volcanics are 3000 m thick below the Beresford Upwarp, and thin westwards to pinch out 30 km southeast of Lake Galilee No. 1.

It is thought unlikely that the Adavale Basin extends as far north as Jericho No. 1 well; seismic reflections from the Mount Hall and Telemon Formations can be followed westwards below the Galilee Basin from the Drummond Basin outcrop area to both Lake Galilee No. 1 and Jericho No. 1 exploration wells. Thus it seems likely that the volcaniclastics and dacite in the bottom of Jericho No. 1 are related to the Silver Hills Volcanics. Towerhill No. 1 and Thunderbolt No. 1 wells also bottomed in acid volcanics; if these are also equivalent to the Silver Hills Volcanics, then volcanics accumulated over a wide area, and it is possible that subsequent Drummond Basin sediments were similarly widespread. There is still not enough knowledge about the sediments that underlie the eastern margin of the Galilee Basin to determine the petroleum prospectivity of the area.

The Koburra Trough contains at least 2800 m of Galilee Basin sediments plus 3200 m of pre-Galilee strata, and it may be bounded by anticlinal structures similar to that crossed by Traverse 1. The Koburra Trough looks, at present, to be the most favourable place for petroleum exploration within the Galilee Basin, and its structural history and stratigraphy should be investigated in detail as the next step in the exploration of the basin.

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References

ALLEN, R. J., 1974—Hydrocarbon significance of Upper Palaeozoic sediments associated with the Koburra Trough, Galilee Basin. *Journal of the Australian Petroleum Exploration Association,* **14**, 59-65.

ALLIANCE OIL DEVELOPMENT, 1964—Seismic survey report, Jericho area, ATP81P, Queensland. *Bureau of Mineral Resources, Petroleum Search Subsidy Act Report* **63/1527** (unpubl.).

AUCHINCLOSS, G., 1976—Adavale Basin. *In* KNIGHT, C. L. (Editor), ECONOMIC GEOLOGY OF AUSTRALIA AND PAPUA NEW GUINEA, 3—Petroleum. *Australasian Institute of Mining and Metallurgy, Melbourne, Monograph* **7**, 309-15.

BALFE, P. E., in prep.—Stratigraphic drilling report—GSQ Hughenden 7. *Queensland Government Mining Journal.*

BENSTEAD, W. L., 1973—Galilee Basin. *Queensland Geological Survey Record* **1973/20** (unpublished).

BRASSIL, F., & ANFILOFF, W., 1977—Galilee Basin seismic and gravity survey, Queensland, 1976. Operational report —Clermont-Alpha area. *Bureau of Mineral Resources, Australia, Record* **1977/26** (unpubl.).

COVENTRY, R. J.—The surficial geology and geomorphic evolution of the Torrens Creek area, North Queensland. Submitted to the *Journal of the Geological Society of Australia.*

EXON, N. F., 1966—Revised Jurassic to Lower Cretaceous stratigraphy in the southeast Eromanga Basin, Queensland. *Queensland Government Mining Journal,* **67**, 775.

EXON, N. F., & SENIOR, B. R., 1976—The Cretaceous of the Eromanga and Surat Basins. *BMR Journal of Australian Geology and Geophysics,* **1**, 33-50.

FLAVELLE, A. J., & ANFILOFF, W., 1976—Non-standard gravity anomalies over sedimentary structures. *Journal of the Australian Petroleum Exploration Association,* **16**, 117-21.

FRASER, A. R., DARBY, F., & VALE, K. R., 1977—Reconnaissance gravity survey of Australia: a qualitative analysis of results. *Bureau of Mineral Resources, Australia, Report* **198**: *BMR Microform* **MF14**.

GIBB, R. A., 1968—North Eromanga and Drummond Basins gravity surveys, Queensland 1959-1963. *Bureau of Mineral Resources, Australia, Report* **131**.

GRAY, A. R. G., 1977—Stratigraphic drilling in the Hughenden 1:250 000 sheet area, 1974-75. *Queensland Government Mining Journal,* **78**, 382-92.

HARRISON, P. L., ANFILOFF, W., & MOSS, F. J., 1975—Galilee Basin seismic and gravity survey, Queensland 1971. *Bureau of Mineral Resources, Australia,* Report **175**.

HAWKINS, P. J., 1977—Galilee Basin—prospect review. *Petroleum Exploration Society of Australia, Queensland Branch, Symposium.* November 1977.

HSU, H. D., 1974—Aeromagnetic interpretation of northern Eromanga and Galilee Basins, Queensland. *Bureau of Mineral Resources, Australia, Record* **1974/42** (unpublished).

MOLLAN, G. M., 1969—Springsure, Queensland, 1:250 000 Geological Series. *Bureau of Mineral Resources, Australia, Explanatory Notes* **SG/55-4** (unpubl.).

OLGERS, F., 1972—Geology of the Drummond Basin, Queensland. *Bureau of Mineral Resources, Australia, Bulletin* **132**.

PATEN, R. J., 1977—The Adavale Basin, Queensland. *Petroleum Exploration Society of Australia, Queensland Branch. Symposium,* Nov. 1977.

PEMBERTON, R. L., 1965—Lake Galilee No. 1 well completion report. *Bureau of Mineral Resources, Australia, Petroleum Search Subsidy Act Report* **64/4076**.

PINCHIN, J., SCHMIDT, D. L., & ANFILOFF, W., in prep.—Eastern Galilee Basin seismic survey, Queensland, 1976. *Bureau of Mineral Resources, Australia, Record.*

SCHMIDT, D. L., NELSON, A., & ANFILOFF, W., 1977—Galilee Basin seismic and gravity survey, Queensland, 1976. Operational report—Pentland-Hughenden area. *Bureau of Mineral Resources, Australia, Record* **1977/27** (unpubl.).

SENIOR, B. R., 1971—Structural interpretation of the Southern Nebine Ridge area, Queensland. *Australasian Oil and Gas Review,* **17**(5).

SENIOR, B. R., 1974—Notes on the geology of the Central Eromanga Basin. *Bureau of Mineral Resources, Australia, Bulletin* **167B**.

SENIOR, B. R., HARRISON, P. L., & MOND, A., 1974—Notes on the Geology of the Northern Eromanga Basin. *Bureau of Mineral Resources, Australia, Bulletin* **167A**.

TANNER, J. J., 1968—Devonian of the Adavale Basin, Queensland, Australia. *International Symposium on Devonian Systems, Calgary, Alberta 1967,* 111-16.

VINE, R. R., & DOUTCH, H. F., 1972—Galilee, Queensland, 1:250 000 Geological Series. *Bureau of Mineral Resources, Australia, Explanatory Notes* **SF/55-10**.

VINE, R. R., & PAINE, A. G. L., 1974—Hughenden, Queensland, 1:250 000 Geological Series. *Bureau of Mineral Resources, Australia, Explanatory Notes* **SF/55-1**.

VINE, R. R., 1972—Relationships between the Adavale and Drummond Basins. *Journal of the Australian Petroleum Exploration Society,* **12**, 58-61.

VINE, R. R., 1976—Galilee Basin. *In* KNIGHT, C. L. (Editor), Economic Geology of Australia and Papua New Gninea, **3**—Petroleum. *Australasian Institute of Mining and Metallurgy, Melbourne, Monograph 7,* 392-5.