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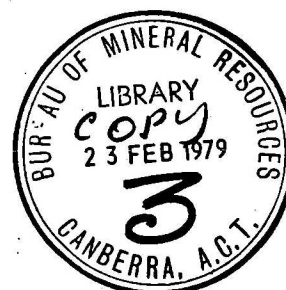
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A REVIEW OF PETROLEUM EXPLORATION AND PROSPECTS IN THE CARNARVON BASIN

by

C.S. Robertson, D.K. Cronk, K.L. Lockwood and S.J. Mayne

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1. INTRODUCTION

This Report is a summary of petroleum exploration and prospects in the Carnarvon Basin, an epicontinental sedimentary sequence extending along the central Western Australian coastal region and consisting of sediments ranging in age from Silurian to Recent. The northern and southern extremities of the basin coincide approximately with latitudes 19°S and 28°S. The eastern basin boundary is formed by sedimentary onlap onto the Precambrian shield and the western boundary is arbitrarily defined as the continental shelf edge.

The summary is based on information available up to the end of 1975, including confidential information supplied to the Bureau of Mineral Resources, Geology and Geophysics (BMR) under the Petroleum (Submerged Lands) Act 1967-1974. It is intended that it should be useful in the formation of future exploration programs by BMR, and in the evaluation of exploration proposed and carried out by petroleum companies.

2. GEOLOGY

2.1 Extent of Carnarvon Basin

The term 'Carnarvon Basin' has been used in the literature to refer to various Phanerozoic sediments draping the northwestern periphery of the Western Australian Shield and presumably occupying an elongate crustal depression or 'basin'. The word 'basin', which generally implies a structural unit, is rather inappropriate when applied to the sediments in the region currently under review. In this review the traditional term 'Carnarvon Basin' is retained for convenience, but the Carnarvon Basin is defined as a sedimentary sequence, without structural connotations. The sediments range from Silurian to Recent and are believed to have a maximum thickness of up to 12 000 m. Pre-Permian sediments are known only from the southern part of the region.

The basin is limited on the eastern side by Precambrian outcrops of the Pilbara and Gascoyne Blocks. On the western side sediments generally extend beyond the edge of the continental shelf, but the sediments in deep water beyond the 200-m bathymetric contour are largely beyond the scope of this review. Since sedimentary sequences similar to those of the Carnarvon Basin, particularly the Mesozoic and Cainozoic parts, extend around the periphery of the Australian continent well beyond the Carnarvon Basin region, definition of the limits of the Carnarvon Basin in the axial direction is somewhat arbitrary. The boundaries are here taken to be the North Turtle Arch in the north and the Precambrian Northampton Block and adjoining ridges in the south (Fig. 1). The basin covers an area of about 300 000 km², of which about two-thirds is beneath the sea.

2.2 Exploration history

The earliest known geological investigations carried out in the basin were by F.T. Gregory in 1861. The Geological Survey of Western Australia (GSWA) surveyed the northern Carnarvon Basin between 1900 and 1920, and Maitland (1898, 1907), Woolnough (1928), Talbot (1929), Feldtman (1930), and Forman (1937) worked with the Survey in the southern part of the basin. In 1925 Clapp made the first attempt at assessing the basin's petroleum possibilities. Geologists of Oil Search Limited conducted a comprehensive survey in the basin; Dee & Rudd (1932) made a private investigation of part of the Byro Sub-basin for that company. Following this, Condit (1935) presented the earliest published report indicating the possibility of a thick Permo-Carboniferous marine section in the basin. Raggat in 1937 defined a major part of the Permian stratigraphy and noted the presence of Cretaceous and Eocene rocks but failed to recognise any Carboniferous or Devonian sediments. These were later recognised by Teichert (1949) who reported the discovery of Devonian and Carboniferous sediments, based on palaeontological evidence, in the Minilya district. Together, Clarke & Teichert (1948) investigated the Cretaceous rocks in the area along the lower reaches of the Murchison River. Since 1948 the Bureau of Mineral Resources (BMR) has conducted extensive field mapping in the Southern Carnarvon Basin and a partial list of its publications includes Condon (1954, 1955, 1956, 1962, 1965, 1967, 1968) Condon et al., (1956), Konicki, Dickins, & Quinlan (1958), and Perry & Dickins (1960). In 1968 Marathon Petroleum conducted a reconnaissance sur-

face geological survey primarily to investigate the Lower Palaeozoic stratigraphy in the basin. West Australian Petroleum Pty Ltd (WAPET) has carried out geological investigations in the basin since 1954, and Burmah Oil Company of Australia (BOCAL) since 1964, and as a result of these companies' widespread drilling programs a large amount of subsurface stratigraphic information has become available. A comprehensive summary of previous work carried out in the Carnarvon basin is given by Condon (1965, pp. 7-10).

Nearly the entire onshore area of the basin has been mapped geologically at a scale of 1:500 000 (two maps) during a large-scale mapping project carried out by BMR between 1948 and 1956. A major part of the onshore area has been mapped at a scale of 1:250 000 by the Geological Survey of Western Australia and BMR, and eight first-edition maps with explanatory notes (not including those for the Winning Pool Sheet area) have been published. Memoir 2 of GSWA, 'The Geology of Western Australia', has a useful chapter on the Carnarvon Basin.

The Carnarvon Basin has received a lot of attention in oil exploration in recent years and up until the end of 1975 a total of 212 petroleum exploration wells, plus 5 BMR stratigraphic well, had been drilled. Most of the drilling has been concentrated in the onshore Cape Range area (Exmouth Sub-basin), on Barrow Island, and in the Dampier Sub-basin. Few wells have been drilled in the southern onshore part of the basin, where prospectivity is considered to be low. The oil companies WAPET and BOCAL currently hold petroleum exploration title areas for much of the basin. Well completion and geophysical survey reports on many petroleum exploration company operations are available on open file at BMR under the terms of the Petroleum Search Subsidy Act 1959-73 (PSSA). Copies of final reports on subsidised operations can be bought from the Australian Government Publishing Service and some private copying firms. Basic data from these operations, such as seismic record sections, cannot be copied but can be viewed at BMR in Canberra. The Western Australian Mines Department has released to the public exploration information from some areas relinquished by exploration companies.

Plate 1 shows simplified geology of the Carnarvon Basin and the location of petroleum exploration wells and BMR stratigraphic holes. The drilling operations carried out by private oil companies (with the exclusion of development wells) and BMR are listed in Appendix 1. The bibliography offers a selection of the more important references and is not intended to

be comprehensive. A bibliography of the Carnarvon Basin containing all known available information current to 31-12-69 has been produced by Ozimic (1970).

2.3 Basin subdivision

A regional structural subdivision of the Carnarvon Basin region is illustrated in Figure 1 (mainly after interpretations by WAPET and BOCAL). Onshore, and particularly in the south, the Carnarvon Basin consists largely of a number of meridionally-trending Palaeozoic structural sub-basins. The most extensive of these is the Gascoyne Sub-basin occupying a large coastal area extending both onshore and offshore and centred around Shark Bay. The Gascoyne Sub-basin is bounded on the east by a north-south line of basement ridges extending from the Northampton Block (a Precambrian inlier separating the Carnarvon and Perth Basins) in the south at least as far north as Exmouth Gulf. On the eastern side of this line of ridges there is a zone of down-to-the-east normal faults (displacement is reversed in the Cretaceous sequence) known as the Wandagee-Yandi-Kennedy Fault System.

In the narrow region between the Wandagee-Yandi-Kennedy Fault System and the outcropping Precambrian rocks of the Gascoyne Block to the east lie, from north to south, Ashburton, Merlinleigh, Byro, and Coolcalalaya Sub-basins. These are a series of narrow asymmetrical troughs, elongated north-south, containing mainly Permian sediments. With the exception of the Coolcalalaya Sub-basin, these sub-basins are bounded to the east where the sediments onlap Precambrian rocks. In the south the Coolcalalaya Sub-basin abuts the craton along the major Darling Fault System.

West of the offshore portion of the Gascoyne Sub-basin sediments extend into deep water on the Carnarvon terrace (Fig. 1) and in the Houtman Sub-basin, which lies on the continental slope southwest of Shark Bay. These deep-water areas are currently the subject of a separate study within BMR. For further information the reader is referred to Symonds & Cameron (1977).

The Ashburton and Merlinleigh Sub-basins (Condon, 1954a) contain about 5000 m of Palaeozoic (Silurian to Permian) and? Lower Mesozoic sediments overlain by a veneer of Cretaceous and younger rocks. They are separated by a cross-basin feature (the Marrilla High) which shows evidence of growth during Early Palaeozoic time (Thomas & Smith, 1974). In GSWA

Memoir No. 2 no distinction is made between these two sub-basins and the whole area is referred to as the Merlinleigh Sub-basin. The Geological Survey recognises the Bidgemia Sub-basin (Condon, 1954a) as a narrow feature paralleling the southeastern margin of the Merlinleigh Sub-basin, being restricted on either side by basement ridges and containing about 900 m of Devonian to Permian sediments.

A small Precambrian block, the Carrandibby Inlier, divides the Merlinleigh Sub-basin from the shallower Byro and Coolcalclaya Sub-basins (Condon, 1954) to the south. There has been some disagreement on whether the Coolcalalaya and Byro Sub-basins should be regarded as part of the Perth or the Carnarvon Basin. Reconnaissance gravity surveys carried out in the area suggest that the Coolcalalaya Sub-basin is structurally continuous with the Perth Basin (Fraser, 1973), which it resembles in form more than it does sub-units of the Carnarvon Basin (Konecki, 1958). The Byro Sub-basin contains up to 1500 m of Permian sediments which are faulted against the Carrandibby Inlier to the north. To the east the Sub-basin is bordered by the Precambrian Shield and to the southwest it adjoins the Coolcalalaya Sub-basin. Available stratigraphic evidence suggests there are no stratigraphic grounds for separating the Byro and Coolcalalaya Sub-basins, although separation on structural grounds has been suggested by Konecki et al. (1958) and Condon (1968). It is evident that the definition of a boundary between the eastern sub-basins of the Carnarvon Basin and the Perth Basin must be rather arbitrary. In this review we follow the Geological Survey of Western Australia (1975) in regarding the Coolcalalaya Sub-basin as part of the Perth Basin, and the Byro Sub-basin as part of the Carnarvon Basin.

The Gascoyne Sub-basin (Condon, 1954a) contains generally northward-dipping Palaeozoic sediments of Silurian age in the south overlain by a veneer of Cretaceous and younger sediments. At the Early Cretaceous unconformity, subcropping rocks become younger towards the north, ranging from Silurian to Late Triassic (Thomas & Smith, 1974). As already indicated, the Gascoyne Sub-basin lies to the west of an extensive basement ridge and fault system. The sediments of the sub-basin have been uplifted some 2500 to 3000 m relative to the Permian troughs to the east, along the Wandagee-Yandi-Kennedy Fault System. The Gascoyne Sub-basin is bounded on the north and northwest by the Long Island and Rough Range Faults (Fig. 1).

The southern extent of the onshore part of the sub-basin is limited by the Northampton Block. Offshore, the results of a reconnaissance aeromagnetic survey conducted by BMR (Spence, 1962) near the Abrolhos Islands suggest that an offshore basement ridge trends in a northwesterly direction from the Northampton Block. The Geelvink Channel seismic and magnetic survey, carried out in the area by BP Petroleum Development Australia, confirmed the existence of a basement ridge in the area and further defined the position of what is described as a basement 'hinge-line' which may involve normal faulting. The Zuytdorp seismic survey (Continental Oil Company of Australia, 1973) also indicated the existence of a 'westward plunging nose coming off the Northampton Block' which Continental named the 'Easter Ridge'. Gun Island No. 1 well (BP Petroleum Development Australia, 1969) was drilled in the Abrolhos Islands south of the basement ridge. The nature of the succession penetrated established the vigorous development of the Perth Basin south of the ridge in the Jurassic and Triassic. Since the Triassic, sedimentation has been continuous across this ridge, but the ridge nevertheless serves as a convenient boundary between the offshore Carnarvon and Perth Basins.

In the offshore part of the Gascoyne Sub-basin, west of the town of Carnarvon, aeromagnetic data, supported by results of the Geelvink Channel seismic and magnetic survey, indicate an area of relatively shallow basement referred to as the Bernier Platform (Fig. 1). This basement 'platform' has a general north-south trend, but there are indications of an east-northeast-trending spur off the main platform, which possibly continues onshore (Geary, 1970).

In the northern half of the Gascoyne Sub-basin there has been extensive block-faulting with a dominant north-south trend during post-Triassic, pre-Aptian time. The overall synclinal form of the sub-basin has been modified in the central area by horsts and grabens and destroyed in the north, particularly under the Exmouth Gulf, by east-dipping blocks separated by down-to-the-west normal faults. Along some of the major faults minor reverse movements of 50-300 m, which occurred during the Late Tertiary, have produced asymmetrical anticlines in the overlying Tertiary and Cretaceous sediments.

To the north of the Gascoyne Sub-basin are the Exmouth, Barrow, and Dampier structural sub-basins which appear to have formed a continuous depositional trough during the Jurassic, following block-faulting of the region in Early Jurassic times. The faulting occurred in a dominantly tensional

regime at the time of a postulated collapse of the western side of the Carnarvon Basin (Veevers, 1971) and may be related to the northwesterly 'pull-apart' associated with the break up of Gondwanaland (See Chapter 4).

The Exmouth Sub-basin is the most southerly of these three sub-basins and forms an elongate Mesozoic trough containing some 5000-7000 m of mainly Jurassic marine and fluviatile sediments. It is bounded to the south-east by the Rough Range Fault, a normal fault with a down-to-the-basin throw of up to 3000 m in the pre-Cretaceous, and plunges northeast into the Barrow Sub-basin, the southern limit of which is arbitrarily defined as the southern edge of the Neocomian Barrow Group. The position of the western boundary of the Exmouth Sub-basin is not accurately known but is for convenience taken as the edge of the Continental Shelf.

The Barrow and Dampier Sub-basins (Mollan et al, 1969) lie entirely offshore from the Pilbara Block and form a northeast-trending elongated trough dominated by Mesozoic downwarps. The sub-basins are bounded to the east by the down-to-the-west Enderby, Flinders, and Long Island Fault System, separating them from the Peedamulla, Cape Preston, and Pilbara Shelves. They are flanked to the west by the Rankin Platform and its southern extension a high regional trend comprising block-faulted Triassic and Early Jurassic sediments unconformably overlain by a sequence (over 3000 m thick in the West Tryal area) of Cretaceous, Tertiary, and Quaternary sediments. In the Mesozoic downwarps, the sedimentary sequence is at least 5000 m thick and consists of Middle Jurassic to Early Cretaceous marine, deltaic, and fluvial sediments. Recent seismic data have indicated sedimentary sections of over 15 000 m in some areas of the Barrow Sub-basin with the possibility of a thick Palaeozoic sequence at depth. Complexly faulted Permian, Triassic, and Early Jurassic sediments are considered to underlie the downwarps but to date have only been penetrated on the high eastern and western flanks of the trough.

Despite some differences in structural style there appears to be no tectonic or depositional break between the Barrow and Dampier Sub-basins, with the Dampier Sub-basin being continuous with, and forming the northeast extension of, the Barrow Sub-basin (Kaye et al., 1972).

The Dampier Sub-basin covers an area of about 52 000 km². It is limited to the north by a faulted north-trending basement extension, the De Grey Nose; to the southeast the Pilbara Shelf, an area of thin sedimentary cover, forms a hinge feature separating the deep basin centre from the Pilbara Block (Fig. 1). The Rankin Platform flanks the western side of the sub-basin and is one of the four main positive trends differentiated in this area, the other three being, from west to east, the Madeline-Dampier Trend, the Legendre-Rosemary Trend, and the Enderby Trend. The main sediment source for the sub-basin is the Pilbara Block. A northwesterly source of clastic material is believed to have existed at least in the Early Mesozoic and possibly through to the Late Cretaceous (Kaye et al., 1972). A wedge of basinward-thickening Tertiary sediments onlaps the entire Mesozoic substructure.

The Beagle Sub-basin lies to the northeast of the Dampier Sub-basin and is partly separated from it by the De Grey Nose. It is bounded to the north by an outer platform area considered to be similar to the Rankin Platform and to the south by the Pilbara Shelf, and is restricted in the northeast by the block-faulted south-trending Turtle Arch (BOCAL, 1974). Other features within the sub-basin include the Beagle Trough and the Picard Trend. The Beagle Trough is a major Mesozoic depositional downwarp which appears to form the northeastern extension of the Lewis Trough of the Dampier Sub-basin. Immediately north of the trough is a series of structurally positive features referred to as the Picard Trend, on which the first exploratory well in the sub-basin, Picard No. 1, was drilled.

The Exmouth Plateau (Fig. 1) lies adjacent to the continental shelf to the northwest of the Exmouth, Barrow, and Dampier Sub-basins. As defined by Wilcox & Exon (1976), the plateau is restricted by the 200 and 2000 m bathymetric contours and is limited to the northeast by a subsea canyon (Swan Canyon) debouching northward at around 117°30'E. The physiography of the plateau is described by Falvey & Veevers (1974).

The regional geology of the area has been interpreted from 12 000 km of gravity, magnetic, and reflection seismic data from the BMR Continental Margin Survey; from 6000 km of reflection seismic profiles recorded by Esso Australia, Australian Gulf Oil, and Shell Development (Australia); and from ties with exploration wells in the Carnarvon and Canning Basins. The Exmouth Plateau trends in a predominantly northeasterly direction and is characterised by gentle warping and extensive normal faulting of pre-Cretaceous sediments.

A major arch (Exmouth Plateau Arch) and syncline (Kangaroo Syncline) on the plateau lie parallel to the Rankin Platform at distances of about 200 km and 80 km to the northwest, respectively. For an interpretation of existing information on the Exmouth Plateau the reader is referred to Wilcox & Exon (1976).

2.4 Structure

The structure of the southern part of the Carnarvon Basin has been described in detail by Condon (1968). This part of the basin is subdivided into a number of minor sub-basins (Condon, 1965b) separated by ridges of Precambrian basement which mostly appear to have been structural 'highs' for most of the time since the basin's inception. During the Palaeozoic and the greater part of the Triassic, an age when tectonically stable conditions generally prevailed, the sub-basins sagged as sediments were laid down and the original structural relief of these ridges increased. The most prominent ridge is the Wandagee Ridge, a south-trending feature which is located west of the Wandagee Fault and which forms the boundary between the Merlinleigh and Gascoyne Sub-basins.

In the Late Triassic-Early Jurassic extensive block-faulting occurred throughout the Carnarvon Basin region. It is thought to have developed in a taphrogenic regime linked with continental rifting, a phase marking the beginning of a process which led finally to the rupture of this part of the Gondwanaland continental block (Veevers, 1971 - see Chapter 4). Block faulting developed around the continental margin, trending from almost north-south in the southern sub-basins to north-northeast in the Exmouth and Barrow Sub-basins and to northeast in the Dampier and Beagle Sub-basins. Most of the faults of this phase are normal with blocks downthrown towards the west or northwest. The majority of faults were active during the Jurassic but movement along some continued into the Late Cretaceous. Evidence in support of pre-Neocomian fault movement is found along the Flinders and Enderby fault zones and along the Rankin Trend (Fig. 1) where thick Jurassic sections have been intersected in the downthrown blocks but are generally lacking on the upthrown blocks. In the Enderby fault zone, syndepositional faulting about the horsts has induced supratenuous folds in adjacent Jurassic and Cretaceous sediments (WAPET, 1973).

The normal down-to-the-west Enderby and Flinders fault zones separate the shelf area from the western basinal area referred to as the Dampier Sub-basin in the north and the Barrow Sub-basin in the south. The faulted shelf area borders the present-day coastline and comprises Precambrian to Early Triassic rocks unconformably overlain by a thin cover of Cretaceous and Tertiary sediments. The shelf area is divided from north to south into the Pilbara Shelf, the Cape Preston Shelf, and Peedamulla shelf, which resemble fault-segmented, en echelon repetitions of a western shelf area in the Gascoyne Sub-basin further to the south.

As indicated previously, the Barrow and Dampier Sub-basins contain a great thickness of Jurassic and Cretaceous sediments. In the centre of the basin, the thickness has been estimated at up to 6000 m from seismic and gravity data. Madeleine No. 1 well, drilled on the structurally positive Madeleine-Dampier Trend in the Dampier Sub-basin, intersected over 1800 m of Neocomian and Jurassic sediments before reaching total depth in the Middle Jurassic.

The Dampier Sub-Basin is restricted to the north by a south-trending basement ridge, the De Grey Nose. The northwestern margins of the Barrow and Dampier Sub-basins are marked by upfaulted horst blocks which coincide with positive gravity anomalies. In BOCAL'S area to the north, the Rankin Platform comprises a pre-Cretaceous (Triassic/Jurassic) horst block complexly segmented into a series of en echelon blocks draped by Cretaceous and thick Tertiary sediments. Farther to the south and offset to the northwest from the Rankin Platform the northwestern margin of the Barrow Sub-basin is marked by a central graben bounded by horsts on either side. This northeast horst trend has been indicated by seismic and gravity data to extend as far south as the Exmouth area and the term 'Yardie-North Rankin Trend' is used to describe the overall feature.

On the seaward side of the Rankin Platform but still within the limits of the Dampier Sub-basin, BOCAL recognise a structurally high area of up-thrown fault blocks which they refer to as the Deep Water Trend. Since there is no well control on or near the trend, the ages and lithologies of rocks present are extrapolated from wells to the southeast. Between the Deep Water Trend and the Rankin Platform lies a well defined trough first recognized from the Montebello-Turtle Marine seismic survey (BMR File no. 72/509) in 1972 and since named the Victoria Trough. It is thought to contain in its deepest parts over 2250 m of Jurassic sediments. These are probably claystones and

sandstones similar to those in the Kendrew Trough southeast of the Rankin Platform (see below) and should therefore have a similar hydrocarbon potential (BOCAL, 1975).

The Mesozoic structure in the Dampier Sub-Basin is characterised by a relatively complex system of fault-blocks which probably gave rise to palaeotopography of fault scarps and basins during the Jurassic. Most of the blocks in the sub-basin would have been covered with sediments by the latest Jurassic. Exceptions were the Rankin Platform blocks, the highest of which remained emergent until the Aptian. Conditions were favourable for the formation of drape closures in the overlying Late Jurassic and Cretaceous sediments in association with the fault-blocks. Shoreward from the Rankin Platform several major structural features trending roughly northeast have been recognised in the Dampier Sub-basin by BOCAL and these converge in a northerly direction towards the De Grey Nose. From northwest to southeast they are: The Kendrew Terrace: a sedimentary downwarp which narrows towards the De Grey Nose and is probably Late Jurassic to Cretaceous.

The Madeleine-Dampier Trend: an anticlinal feature in Jurassic and Early Cretaceous sediments which is possibly due to drape over pre-Jurassic fault-blocks.

The Lewis Trough: a relatively narrow, deep, structurally uncomplicated depression with a thick Jurassic and Cretaceous section ranging to over 3000 m thick in the axial zone.

The Lengendre-Rosemary Trend: a complex, elongate horst-like structure related to two independent fault zones initiated in the Jurassic, the first being downthrown to the southeast and the second to the northwest.

The Enderby Fault Zone: a fault complex with associated horsts, grabens, and half-grabens. Syndepositional movements along the faults are characteristic of this zone which was originally considered as part of the Pilbara Shelf but is now included in the Dampier Sub-basin (Powell, 1973).

These trends do not appear to extend south into the Barrow Sub-basin, however seismic evidence there is generally poor below the base Muderong reflector (Early Cretaceous). A major flexure on the base Muderong, which is thought to be related to deep seated horst blocks, passes through Barrow Island but appears to die out northward before reaching the Dampier Sub-basin (WAPET, 1972).

After the initiation of the main positive trends in the basin, probably in the Early Jurassic, uplift in the early Middle Jurassic resulted in some minor erosion along the basin edges and on the De Grey Nose. During the Late Jurassic and Neocomian, uplift and erosion occurred over most of the southern Carnarvon Basin with sedimentation apparently continuous throughout the Neocomian only to the north and possibly to the west of Barrow Island. Uplift caused rejuvenation along some north-south trending faults which fragmented the earlier horst blocks. Because there have been several erosional periods in the Late Jurassic - Early Cretaceous, preservation of lithology and stratigraphy across faults is variable.

In the northwestern part of the Carnarvon Basin there is widespread evidence for the existence of a mild tectonic phase during the Tertiary.

A series of broad north-northeast-trending anticlinal folds developed in Tertiary and Cretaceous rocks in the Gascoyne, Exmouth and Barrow Sub-basins and were probably folded in the Late Miocene (Playford and Johnstone, 1959). The Cape Range Anticline on North West Cape, formed in Miocene limestone, is the largest of these structures, being 100 km long with a structural relief of 450 m. The Rough Range Anticline runs parallel to the Cape Range Anticline to the southeast of the latter and is 70 km long with a structural relief of 90 m. The Giralia Anticline south of Exmouth Gulf is another large structure with a length of 130 km and a structural relief of 210 m. There is evidence that this structure was initiated in the Cretaceous. Smaller structures belonging to this series onshore in the northern Gascoyne Sub-basin include the Marrilla, Warroora, Chargoo, Gerardi, Chirrita, Minilya, Grierson, Boolan, Yankie Tank and Cape Cuvier Anticlines. Further north, the Barrow Island Anticline shows evidence of growth in the Lower Cretaceous where the structure appears to be a broad north-plunging nose fault bounded to the west, south and east (WAPET, 1973). However, the anticlinal structure which developed at the base of the Miocene Trealla limestone and which has at least 25 m vertical closure and 10 000 hectares of areal closure provides evidence that significant arching also occurred in the Tertiary.

The Rough Range and Giralia Anticlines are associated with high angle reverse faults on their eastern flanks where movement appears to have been localized by older, normal faults. A Rough Range the normal fault was last active in the Late Jurassic or Early Cretaceous. Rough Range South No. 5 well intersected an interval along the reverse fault in which 126 m of Lower Cretaceous sediment was repeated. Further evidence of reversal of movement along

old normal faults is found along the Wandagee Fault which has a normal down-to-the-east throw of 2500-3000 m in Pre-Cretaceous sediments and a reverse throw of up to 200 m in Cretaceous sediments at different points along its length. The reverse movement along this fault dies out in the incompetent shales of the Early Cretaceous Winning Group and has surface expression in broad asymmetrical anticlines in Late Cretaceous and Tertiary rocks. There is some controversy as to whether these features are a result of a post-Middle Miocene compressional phase or whether equilibrium adjustment (rebound) or inverted basin movement may be responsible. In the Barrow and Dampier Sub-basins and their adjacent borderland blocks there is no evidence of any compressional features, at least in the Mesozoic and Tertiary, and structural forces operating in these areas appear to have been entirely tensional.

The Cretaceous and Tertiary sequences at various localities throughout the basin are locally effected by minor faulting and rejuvenation of older fault systems.

2.5 Stratigraphy and basin development

A generalised stratigraphic table of the Carnarvon Basin is presented in Table 1. Stratigraphic tables for individual wells in various parts of the basin are presented in Appendix 3 and well correlation charts across the main sub-basins are shown in Plates 7 to 11. These latter were prepared by A. Mond of BMR in 1975 for the ESCAP Stratigraphic Atlas. They are based on company interpretations.

The present stratigraphic subdivision of the Carnarvon Basin has evolved since the turn of the century and many of the Palaeozoic, Cretaceous and Tertiary units, which were first recognised in the southern part of the basin but which have since been identified in the northern and offshore parts of the basin, are described in detail by Condon (1954, 1965, 1967 and 1968).

A number of published papers deal with the stratigraphy of particular areas. The Jurassic and Neocomian units of the Exmouth Sub-basin are described by McWhae and others (1958). Parry (1967) and Crank (1973) discuss the geology of Barrow Island. The following publications by BOCAL personnel cover the Dampier Sub-basin and Rankin Platform; Kaye and others (1972), Martison and others (1972), Powell (1973) and Dewhurst (1973). A recent account of the stratigraphy of the Northwest Shelf is given by Powell (1976).

TABLE 1

GENERALISED STRATIGRAPHY OF THE CARNARVON BASIN

(after Thomas and Smith, 1974)

AGE		UNIT	DEPOSITIONAL ENVIRONMENT	
TERTIARY	Pliocene	Unnamed unit	Marine	
	Miocene	Pilgramunna Formation		
		Trealla Limestone		
		Cape Range Group		
		Giralia Calcarenite		
		Cardabia Group		
	Late	Miria Marl		
		Toolonga Calcilutite		
		Gearle Siltstone		
		Windalia Radiolarite		
Muderong Shale				
Early	Birdrong Sandstone			
	Barrow Formation			
	or			
	Wogatti Sandstone			
JURASSIC	Late	Dupuy Member	Marginal to Nonmarine	Marine to Deltaic
	Mid	Learmonth Fm. or Dingo Claystone		
	Early	Legendre Fm.		
TRIASSIC	Late	Mungaroo Formation	Fluvial to marginal marine	
	Mid			
	Early	Locker Shale	Marine to marginal marine	
PERMIAN	Artinskian	Kennedy Group	Marine and marginal marine	
	Tatarian	Byro Group		
		Wooramel Group	Marine	
		Callytharra Formation	Glacials	
	Sakmarian		marine to lacustrine	
		Lyons Group	"Deltaic" to marine	
CARBONIFEROUS		Yindagindy Formation	Marine	
		Williambury Formation		
		Moogooree Limestone	Near shore marine	
DEVONIAN		Willaraddie Formation	Shelf to Basinal	
		Munabia Sandstone		
		Gneudna Formation	Continental	
SILURIAN		Nannyarra Gwacke	Shelf	
		Dirk Hartog Formation		
		Tumblagooda Sandstone	Continental	
PRECAMBRIAN				

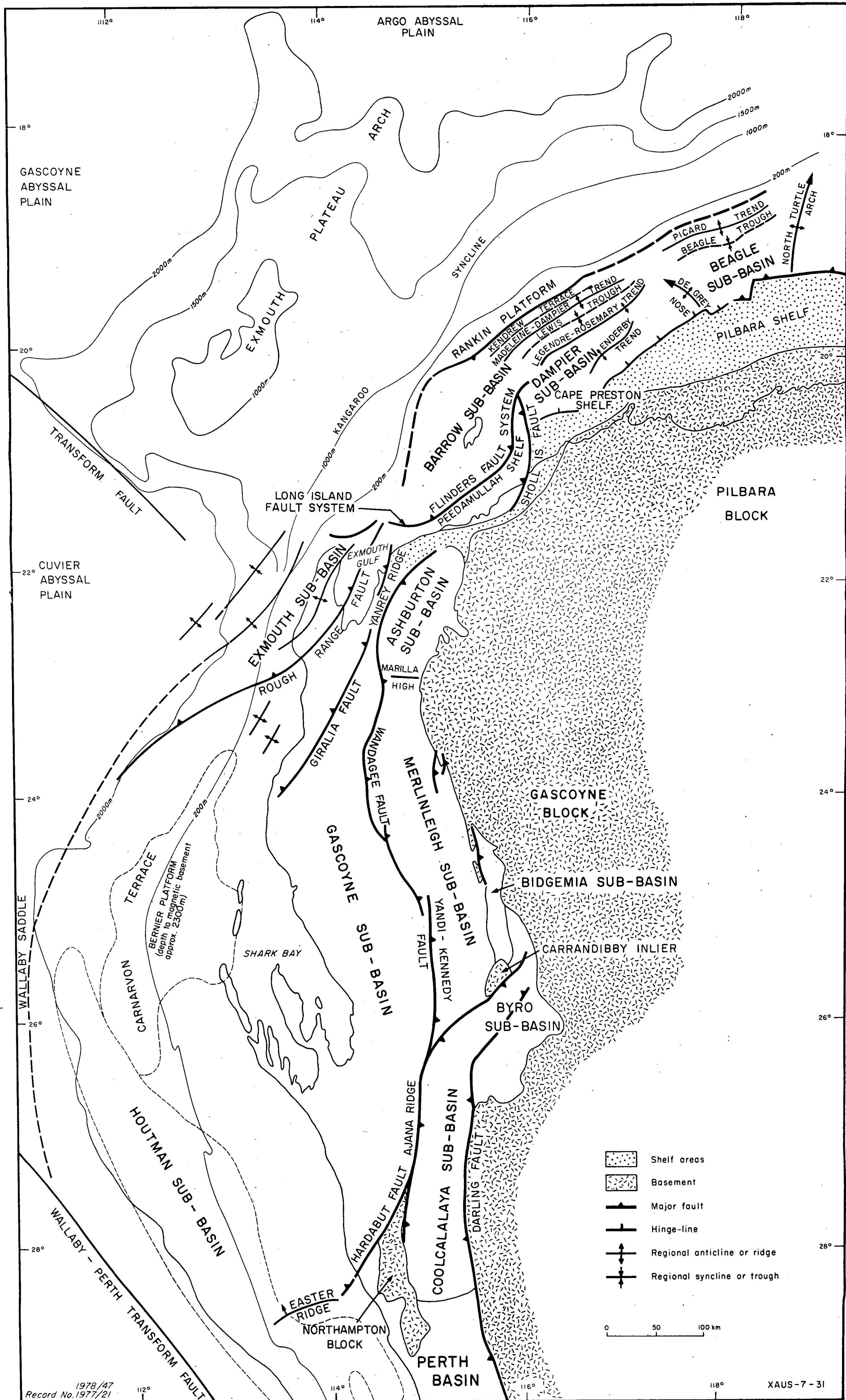


FIG.1 STRUCTURAL SUBDIVISIONS CARNARVON BASIN

A comprehensive and detailed description of the stratigraphy of the whole of the Carnarvon Basin is given by GSWA (1975). Thomas and Smith (1974) have also described the stratigraphy and development of the basin. Their description has provided the basis for the following summary.

Silurian

Silurian sediments subcrop extensively in the Gascoyne Sub-basin and probably extend as far north as the Exmouth Gulf area. The Early Silurian (and possibly Ordovician) Tumblagooda Sandstone (Clarke and Teichert, 1948) is a thick sequence of fluviatile red-bed sediments deposited under continental to estuarine conditions. Up to 1200 m of continuous exposure of this formation crops out in river valleys on either side of the Northampton Block, in the Gascoyne and Coolcalalaya Sub-basins. The type section extends for some 70 km along the Murchison River Gorge from near Hardabut Pool to Second Gully Point. In the Coolcalalaya Sub-basin the unit has an estimated maximum thickness of up to 2100 m. It has been penetrated in the wells Kalbarri No. 1, Tamala No. 1, Marrilla No. 1, Wandagee No. 1, Quail No. 1, Dirk Hartog 17B, Yaringa No. 1, and in a number of water bores near the Carnarvon township. The formation comprises a sequence of coarse, red, crossbedded sandstones with associated lenticles of fine, silty sandstone considered to have been deposited in the downthrown area, following the relative uplift of the Precambrian hinterland along the Darling Fault. The upthrown Precambrian rocks provided a prolific source of sand during the Silurian, and with continued sedimentation and subsidence of basinal areas, activity along the Darling Fault continued.

Planation of the eastern land mass gradually exhausted the terrigenous supply of material and in the later part of the Silurian relatively quiescent shallow marine and tidal flat conditions prevailed. The sequence deposited during this time consists of a red-bed succession of chocolate mudstones, purple dolomites, limestones, anhydrite and thin salt beds and is called the Dirk Hartog Formation (McWhae et al., 1958 p. 31). It does not crop out but has been intersected in a number of wells in the Gascoyne Sub-basin. The type section for this formation is between 665 m and 1404 m in Dirk Hartog 17B well.

Late Devonian-Early Carboniferous

No sediments were deposited in the Early Devonian but following this a series of well-bedded, uniform, shallow marine shelf sediments were deposited over a wide area of the basin. The sequence largely comprises interbedded limestones (possibly associated with reef complexes) and shallow marine sandstones with some localized development of thick deltaic sandstones and boulder conglomerates along the eastern basin margin. In the Merlinleigh Sub-basin an outcropping sequence, 2200 m thick, of poorly-sorted, shallow marine, terrigenous clastics and shelf carbonates onlaps the Precambrian basement.

The Devonian units from the base upwards are as follows:

the Nannyarra Greywacke (Condon, 1954a; type section at southern end of Gneudna paddock on Williambury Station, 23°58'S, 115°13'E) a continental conglomeratic deposit; The Gneudna Formation (named Teichert, 1949, defined Condon, 1954a, p. 13, revised Condon 1965; type section same as before) or richly fossiliferous calcarenites, limestones and sandstones; the Munabia Sandstone (Teichert, 1949, amended Condon 1954a; type section in Gneudna paddock on Williambury Station), a mainly clean "sparkling" quartz sandstone, often cross-bedded; the Willaraddie Formation (Condon, 1954: type section 2.8 km northwest of Gneudna Well), of poorly sorted conglomeratic sandstones and siltstones.

In the early Carboniferous succession the basal unit, the Moogooree Limestone (Teichert 1949, Condon 1954a: type section is 4 km northwest of Gneudna Well), consists of interbedded calcarenite and calcilutite. The overlying interbedded poorly sorted sandstone and cross bedded torrential conglomerates of the Williambury Formation ("Williambury Sandstone" of Teichert, 1949, amended Condon, 1954a: type section in Gneudna paddock, 4 km southeast of Williambury homestead) are in turn overlain by the Yindagindy Formation ("Yindagindi Limestone" of Teichert, 1950, amended Condon 1954a: type section is 4 km west of Williambury homestead). This uppermost Carboniferous unit dominantly comprises thin beds of sandstone with minor layers of fossiliferous, oolitic calcilutite.

Sediments in this time sequence have been recognised in wells drilled as far north as Rough Range (Gascoyne Sub-basin) and the Robe River area (Peedamullah Shelf).

Permian

Towards the end of the Carboniferous, the eastern basin margin was uplifted and this provided a new source of material for the area. Glaciers formed in the eastern highlands and during the Early Permian deposited the Lyons Group "tillites" into the marine trough of the Carnarvon Basin. The Lyons Group ("Lyons Conglomerate" of Maitland 1912, amended Teichert, 1950) is the basal Permian (Sakmarian) unit which unconformably overlies the Lower Carboniferous rocks where present. It comprises marine siltstone and lithic sandstone, containing a number of boulder beds (tillites) which are believed to have originated as a result of ice rafting in the uplifted Pilbara Block. Over 2300 m of this unit was penetrated in the Remarkable Hill No. 1 well and the outcrop thickness of the sequence is over 1500 m. The type section of the Lyons Group is along the north side of the Wyndham River (Condon, 1967).

The Carnarvon Basin had regained tectonic stability by the Artinskian, during which time a widespread sequence of largely black shales and fine sandstones was deposited in the basin, which was possibly silled at the time. The Sakmarian-Artinskian Callytharra Formation ("Cathythara Limestone" of Condit, 1935, amended Condon, 1954a: type section 1 km west of Cathytharra Spring) overlies the Lyons Group and comprises a fossiliferous siltstone and shale unit with minor beds of limestone. Disconformably overlying this formation is the Artinskian Wooramel Group ("Wooramel Sandstone" by Condit, 1935, amended by McWhae et al., 1958 & Konecki et al., 1958), a sequence consisting of mainly quartz sandstone and greywacke with minor siltstone and shale.

The type locality for the Wooramel Group is in the Byro Sub-basin from Gap Pool to One Gum Creek junction on the Wooramel River. This unit is succeeded by the siltstones, black fossiliferous shales and fine sandstones of the Byro Group ("Byro Limestone Group" of Dee and Rudd, 1932, "Byro Formation" of Condit, 1935, redefined Condon, 1954a). A 1250 m thick complete sequence of this unit was penetrated in Kennedy Range No. 1 well. The uppermost Permian Kennedy Group ("Kennedy Sandstone" of Condit, 1935, "Kennedy Stage" of Raggatt, 1936, amended Condon, 1954a) a marine sandstone unit, represents the closing regressive stages of Permian sedimentation in the southern part of the basin, prior to a long period of non-deposition. In the northern Carnarvon Basin sedimentation continued from the Late Permian into the Early Triassic without any major tectonic break. No formal names have been given to these sequences.

Permian sediments only outcrop along the eastern edge of the Merlingleigh Sub-basin, with the thickest surface sections being in the Kennedy Range area and measuring in excess of 4000 m. The strata, from well control, are known to underlie a large area of the northern Gascoyne Sub-basin and have been penetrated on the Peedamulla Shelf. They are probably present at considerable depth in the Exmouth, Barrow and Dampier Sub-basins.

Triassic

The Triassic sequence is a regressive sequence which has only been preserved in the northern part of the basin, in the Exmouth, Barrow and Dampier Sub-basins and on the bordering Peedamullah Shelf and Rankin Platform. Scattered outcrops of Triassic sediments occur in the southern Gascoyne Sub-basin adjacent to the Hardabut Fault but these are correlated with the Kockatea Shale and Wittecarra Sandstone of the Perth Basin.

In the north two formations, the Locker Shale and the overlying Mungaroo Formation, are distinguished. The Early Triassic Locker Shale is a widespread unit which overlies the Kennedy Group with probable disconformity. It is a fine grained marine unit which passes upwards and regresses into the Middle Triassic sandy deltaic to fluvial sediments of the Mungaroo Formation. The wells Onslow No. 1 and Long Island No. 1 are the type wells for the Locker Shale and Mungaroo Formation respectively.

In the Onslow-Long Island area the Mungaroo Formation ("Mungaroo Beds" of Parry, in WAPET, 1967, amended GSWA, 1975) consist of interbeds of fine to coarse grained, clean sandstones alternating with red to brown claystone and rare coal. However, the likely equivalents penetrated in the North Tryal Rocks-North Rankin Trend area are fluviodeltaic claystones and thick porous sands which are generally coarser and contain higher percentages of porous sand.

A near-shore marine influence is evident in the Late Triassic sections penetrated by Enderby No. 1 and De Grey No. 1.

The age range of the Mungaroo Beds is from Middle to Late Triassic on the Peedamulla Shelf but on the Rankin Platform and in the Exmouth Sub-basin it extends into the Early Jurassic without evidence of any major break in deposition or change in lithology. No complete Triassic sections have been intersected in the basin to date.

Jurassic

The regressive conditions of Late Triassic sedimentation continued into the Early Jurassic except in the inner parts of the Dampier and Beagle Sub-basins where there is evidence of an unconformity between the Carnian and the Toarcian (Powell, 1976). Faulting probably began around the end of the Early Jurassic and lead to the formation of the Exmouth-Barrow-Dampier trough, flanked by structurally high remnants of the older basin (Peedamulla, Cape Preston and Pilbara Shelves, Gascoyne Sub-basin and Rankin Platform). The horst blocks initiated during this period contain the hydrocarbon accumulations of the Rankin Platform.

During the Middle to Late Jurassic, subsidence and rapid sedimentation continued in the basin with up to 5000 m of marine sediments (Dingo Claystone and equivalents) being deposited in some of the deepest areas. Along the shallower eastern margins where paralic conditions predominated, the sandy equivalents of the Learmonth (approximately 1600 m thick in Sandy Point No. 1) and Legendre Formations were deposited.

The Dingo Claystone (McWhae et al., 1958) was first described in the Cape Range area and the type section, consisting of 3494 m of massive marine claystone with minor interbeds of dolomite, limestone and silty sandstone, was intersected in Cape Range No. 2 well between 1130 m and 4624 m (T.D.). The probable equivalent formation intersected in Barrow Deep No. 1 contains significant sandstone intervals.

The Dupuy Member of the Dingo Claystone was deposited in the northeastern area of the Barrow Sub-basin during the Tithonian. It is considered to have been deposited in a nearshore marine environment and consists of very fine to fine-grained, variably argillaceous sandstone, interbedded with dark grey and brownish grey shales (type section in Barrow No. 25 well).

The Learmonth Formation (McWhae et al., 1958) is the lateral equivalent of the Dingo Claystone along the southern and eastern margins of the Exmouth Sub-basin. The transition between these two formations is rapid and this can probably be attributed to relative fault block movement in association with basin subsidence during their time of deposition. The formation was deposited under paralic conditions and mainly comprises kaolinitic sandstone and siltstone with interbedded coal. The type section is in Rough Range No. 1 well between 1216 m and 1890 m.

In the northeastern Dampier Sub-basin for much of the Middle and Upper Jurassic fluvial and deltaic sedimentation, with brief marine incursions, prevailed, resulting in the deposition of the Legendre Formation of Kaye and others (1972).

There appears to have been no Jurassic sedimentation on the Peedamulla and Cape Preston Shelves, but in the Barrow and Exmouth Sub-basins the total thickness of the sequence has been estimated at over 7000 m. Deposition in the Middle to Late Jurassic period was probably continuous in the deeper parts of the basin but a period of faulting and erosion (Powell, 1973) has been recognised in the Dampier and the southern Barrow Sub-basins. During the same period the southern Carnarvon Palaeozoic Sub-basins were subjected to uplift, extensive block-faulting and deep erosion.

Early Cretaceous (Neocomian)

The cycle of deltaic and fluvial sedimentation, which was initiated in the Jurassic (represented by the Dupuy Member) continued into the Neocomian in the Barrow and Dampier Sub-basins where it reached maximum development in the Barrow Formation ("Barrow Group" of BOCAL, 1968, amended G.S.W.A., 1975). As a result, more than 1400 m of coarse clastic sediments accumulated in the Barrow Sub-basin. The Barrow Formation is a sequence (first intersected in Barrow No. 1, type section between 909 m and 2181 m) consisting mainly of medium to coarse grained and often conglomeritic sandstone with thin interbeds of shale and claystone. These interbeds are indicative of the occasional brief marine incursions in what is considered to be a broadly deltaic sequence which generally becomes progressively less marine upwards in the section. The uppermost sediments in the Barrow Formation are probably entirely fluvial.

The thickest known section (1240 m) of Barrow Formation was penetrated at Pasco Island. Oil Sands occur within the Barrow Formation in the Barrow Sub-basin at Pasco and Barrow Islands and have also been penetrated by Legendre No. 1 well in the Dampier Sub-basin but are non-commercial.

The Barrow Formation is restricted to the Barrow and Dampier Sub-basins. It is absent on the marginal shelf areas of these sub-basins and is represented by time equivalent marine shales on the Rankin Platform. In the Exmouth Sub-basin where Neocomian sedimentation was not extensive, the Wogatti Sandstone (McWhae et al., 1958) is the time equivalent of the Barrow

Formation. This unit has a maximum thickness of 107 m and consists of coarse-grained, argillaceous, continental sandstone occurring in a belt along the downthrown side of the Rough Range Fault. The type section is in Rough Range No. 1 well between 1109 m and 1216 m.

During the late Neocomian times there was considerable uplift and erosion involving the truncation of the Palaeozoic Sub-basins to the south of the Long Island Fault.

Early-Late Cretaceous (Aptian-Cenomanian)

A period of marine transgression associated with continental break-up commenced in the northern part of the basin (Beagle and Dampier Sub-basins) in the Neocomian but did not reach the Barrow Sub-basin or further south until the early Aptian (as represented by the unconformity in Table 1.). The transgression covered most of the Carnarvon Basin with a relatively uniform veneer of mainly argillaceous sediments, referred to as the Winning Group ("Winning Series" of Raggatt, 1936, Fairbridge, 1953; and Johnstone et al., 1958). These sediments transgressed the previously emergent Peedamulla and Cape Preston Shelves and provided a cap seal for the faulted Upper Triassic-Lower Jurassic reservoir rocks of the Rankin Platform, and also covered most of the southern Palaeozoic Sub-basins.

The Winning Group is thickest (1500 m) to the northwest of Barrow Island but thins to less than 100 m in the southern part of the basin. The basal unit in the group, the Birdrong Sandstone ("Birdrong Formation" of Condon, 1954a, amended GSWA, 1975), comprises weakly lithified quartz sandstone, commonly glauconitic, with lesser amounts of interbedded siltstone and quartz greywacke. This unit has an average thickness of 15-30 m and its type section is located 1 km west of Birdrong Spring in the Kennedy Range. The overlying Muderong Shale (Condon, 1954a) was deposited to the end of the Aptian under more established marine conditions. This unit consists of shale, claystone and siltstone and contains an upper member, the Windalia Sand, which represents the last major influx of sand into the basin during the Cretaceous. This member is the main producing horizon in the Barrow Island Field and comprises a very fine to fine grained, shaly, glauconitic sandstone with a high porosity and low permeability. the type section for the Muderong Shale is 2.1 km west-southwest of the Muderong Bore on Middalya Station (24°08'03"S, 114°45'49"E). The Windalia Radiolarite

(Condon, 1954a, Condon et al., 1956) rests conformably on the Muderong Shale and consists of a sequence of highly siliceous, organic sediments of mainly radiolarian tests. The type locality is at Windalia Hill near the Lyndon River. This unit is indicative of a period of high organic activity in the basin. The Gearle Siltstone (Condon, 1954a, Condon et al., 1956) is a thick marine sequence of siltstone and claystone (in part bentonitic) and is the youngest formation of the Winning Group.

Late Cretaceous (Senonian-Maestrichtian)

Tectonically stable conditions continued throughout this period, marked by a decline in the supply of terrigenous material and the establishment of shelf carbonate sedimentation. Due to the almost complete peneplanation of the eastern source area, sediments deposited after the Gearle Siltstone are almost entirely carbonates. The Toolonga Calcilutite unit ("Toolonga Chalk" of Clarke and Teichert, 1948, amended Johnstone et al., 1958) unconformably overlies the Gearle Siltstone and comprises an argillaceous calcilutite which grades into siltstone and is characterised by fragments of *Inoceramus* (a large pelecypod). The type section for this unit is in the Toolonga Hills, 3 km north of Yalthoo Well on Murchison House station. On the Rankin Platform a marl or shaly calcilutite, the Miria Marl (Condon, 1954a, Condon et al., 1956) overlies this unit and in part is probably its lateral equivalent. It has a type section 1.2 km thick located on Toothawarra Creek on Cardabia Station.

Tertiary

A regional unconformity separates the Late Cretaceous from the Palaeocene. Thomas and Smith (1974) envisage three main episodes of Tertiary sedimentation in the Carnarvon Basin, each being bounded by major disconformities. These episodes are represented by the Palaeocene-Early Eocene Cardabia Group ("Cardabia Series" of Raggatt, 1936, amended Condon, 1954a, Condon et al., 1956, Condon, 1968), the Eocene Giralia Calcarenite ("Giralian Stage" of Singleton, 1941, amended Condon et al., 1956) and its equivalents, and post-Eocene sediments including the Cape Range Group (Condon et al., 1953, amended Condon, 1968), the Trealla Limestone (Condon et al., 1953) and the Pilgrammuna Formation (Condon et al., 1955).

Most Tertiary sediments are carbonates. Marine Tertiary sediments crop out in the northern part of the basin from Barrow Island to just north of the Carnarvon township and also in a small area to the east of Hamelin Pool. The estimated total thickness of Tertiary sediments in the basin is around 700 m. For a more detailed account of the Tertiary stratigraphy see GSWA (1975, pp299-303), Quilty (1974, pp309-12) and Condon (1968).

Quaternary

The Quaternary deposits in the basin cover quite a large surface area but are usually thin, not often exceeding 30 m. The total maximum thickness of these sediments is estimated at about 300 m. They have not been studied in detail except in the Shark Bay area where research has been conducted by the University of Western Australia since 1965 (Logan, Davies, Read, and Cebulski, 1970).

Laterite deposits are widespread in the Carnarvon basin and are described in detail by Condon (1954a).

The Exmouth Sandstone (Craig, 1950, Condon, 1954a) unconformably overlies the Trealla Limestone or the Pilgramunna Formation. It consists of reddish quartz sandstone, partly calcareous, and has a type section 12 m thick on Cape Range at 22°21'00"S, 114°00'00"E. This unit is now taken to include the "Vlaming Sandstone" of Condon et al., 1955 (Condon, 1968). The Exmouth Sandstone is a shoreline deposit with marine affinities and although its age is uncertain it is generally regarded as Pleistocene.

The Joolabroo Conglomerate (Teichert, in Condon, 1954a) is a conglomerate, pebbly sand and sandy clay unit in the Minilya River Valley. The type section is 8 km west-northwest of the Wandagee Station homestead at 23°44'30"S, 114°28'30"E.

Other Quaternary units recognised in the basin include the Coastal Limestone, commonly developed in coastal areas of the basin, and the Tamala Eolianite, its equivalent in the Shark Bay area; the Bundera Calcarenite and Mowbowra Conglomerate of the Exmouth Gulf area; the Walatharra Formation of Giralia Range; and the Nadarra Formation of the area between the William-bury and Coordewandy Stations. Recent deposits are described by Condon (1954a).

Since the Late Cretaceous, the accumulation of up to 3000 m of carbonate sediments along the shelf edge has brought about the northwesterly tilt of the entire northern region of the Carnarvon Basin.

3. GEOPHYSICS

The geophysical exploration of the onshore Carnarvon Basin was initiated by BMR with gravity surveys in 1950 and a seismic survey in 1951. BMR carried out a variety of geophysical surveys throughout the 1950s. WAPET employed the first contract seismic crew in Australia in the Carnarvon Basin in 1952. This crew worked during most of 1952 and 1953 on various surface structures in the northern part of the Carnarvon Basin (including Rough Range) and in the Kimberleys further north. From that time onwards much of the geophysical exploration onshore in the Carnarvon Basin has been done for WAPET. The results of WAPET's surveys in the 1950s, prior to the introduction of PSSA, are generally not available.

Apart from a few submarine gravity observations by Vening Meinesz (1941) in the 1930s WAPET initiated offshore geophysical exploration of the basin in 1961 with a marine seismic survey in the waters around North West Cape. Its first seismic survey on Barrow Island was done in 1963. BOCAL commenced marine geophysical operations in 1964. Since that time WAPET and BOCAL have been responsible for most of the numerous offshore surveys in the Barrow and Dampier Sub-basins respectively, while a lesser amount of exploration has been done for other companies in the southern Carnarvon Basin.

3.1 Magnetic Surveys

Plates 3A and 3B show the extent of magnetic surveys, both airborne and shipborne, in the Carnarvon Basin.

Airborne geophysical surveys covering the entire onshore part of the Carnarvon Basin were conducted by BMR during the years 1956 (Parkinson, 1957), 1957 (Forsyth, 1960), 1959 and 1961 (Spence, 1961 and 1962). Magnetic and radiometric measurements were made. Observations extended eastward across the margins of the shield type rocks of the Gascoyne and Yilgarn Blocks. Contoured maps of total magnetic intensity have since been published by BMR at a scale of 1:250,000.

No comprehensive interpretation of the data has been published but unpublished work by J. Quilty (personal communication, 1975) of BMR gives estimates of basement depth over much of the onshore basin, and has been used as the basis of Plate 4.

Airborne surveys were flown over offshore areas in 1965 for Tasman Oil, and in 1967 and 1969 for WAPET. Magnetometer recordings were made on a number of marine geophysical surveys which are listed in Appendix 2. The ship's tracks for these surveys are shown in Plates 3A & 3B. For most of the marine magnetometer surveys, magnetic intensity data are available only in the form of profiles, often displayed as an interpretative aid on seismic record cross-sections.

Magnetic intensity contour maps are available for the aeromagnetic surveys, but datum differences between surveys mitigate against the preparation of an integrated magnetic intensity map covering the whole of the basin.

Results The onshore Carnarvon Basin magnetic coverage is of high quality, being derived from a single data acquisition technique at constant altitude with firm control over diurnal variations. The offshore regional results are very fragmentary and in general of lower reliability. Conflicting interpretations exist and these will not prove simple to resolve. Complications arise from the existence of two or more magnetic horizons.

Whitworth (1969) has divided the Northwest Shelf into geophysical provinces on the basis of magnetic, gravity, and seismic data. His province VIII, a magnetically featureless gravity 'high' corresponds to the Rankin structural trend (Fig. 1), while the adjacent province IX, corresponding to the Barrow and Dampier Sub-basins, contains recognisable magnetic features and is a region of low gravity. Several interpretations are possible, in the absence of deep crustal refraction data, and they include:

1. A basement having no magnetic expression in either province (the anomalies being generated within the sedimentary section):
2. A basement having magnetic character spatially varying between the two provinces, giving rise to magnetic anomalies in the low gravity province and none in the high gravity province, but shallowing from one to the other;

3. A very deep crustal source for the gravity anomaly, (see gravity section);

Magnetic features in Whitworth's province XIII, the offshore extension of the Pilbara Block, tend to correlate with gravity 'highs'. The magnetic amplitudes and wavelengths are consistent with a shallow magnetic basement.

About 15-20 km west of North West Cape, a large amplitude north-south-oriented dipole pattern has been mapped by the BMR Continental Margin survey. It was also recognized from data near the boundaries of three airborne surveys. This magnetic feature is probably associated with the continuous belt of strongly positive gravity anomalies following the continental margin northwards from North West Cape. The magnetic and gravity anomalies possibly originate from a deep-seated horst block on basement associated with rifting at the continental margin. Magnetic basement is indicated to lie at depths in excess of 9km in this area, although the base of prospective sediments is likely to be considerably shallower than this.

Other magnetic features of large extent outlined by the BMR Continental Margin survey include:

1. A region of low intensity northwest of Bernier Island (Pl. 3B) which may be continuous with an aeromagnetic 'low' near the north end of Shark Bay;

2. A long wavelength magnetic 'high', possibly associated with the Bernier Platform, (Section 2.3 of this review, and Geary, 1970), which was indicated by the results of the West Carnarvon aeromagnetic survey.

3. A magnetic 'high' 35 km northwest of Geraldton, perhaps the same anomaly previously interpreted from the Bernier seismic and magnetic survey as arising from a basement ridge near the Easter Islands which forms the northern edge of the Abrolhos Sub-basin.

A great many anomalies of the Bernier marine magnetic survey are believed to be caused by the presence of shallow magnetic material in the depth range 200-1000 m, and have been interpreted by the operating company as arising from igneous dykes and flows of a similar age. This interpretation was supported to some extent by seismic results, since there was some correlation between seismic and magnetic anomalies, and it was confirmed by the drilling of Edel No. 1 well.

Plate 4 shows interpreted depths to magnetic basement. Of the magnetic surveys for which basement depth estimates were available, not all were suitable for inclusion in Plate 4. Some were excluded for reasons of poor reliability or redundancy, e.g, the Bernier marine seismic and magnetic survey for Ocean Ventures was excluded because it was in an area covered by the more extensive West Carnarvon aeromagnetic survey for Tasman Oil and because anomalies from the former survey were thought to arise from a magnetic horizon located above basement. Reliable depth estimates require well defined anomalies, and this condition was not always met, especially for surveys narrowly confined in a single direction where the anomalies were large. Nonetheless, most of the broad features of Plate 4 are considered reliable having been confirmed and supported by seismic and gravity data, and found to be consistent with regional geology.

In the northern onshore region of the Carnarvon Basin, magnetic results indicate a prominent north-south basement ridge (the Yanrey Ridge, Fig. 1) extending from near the northeast corner of Exmouth Gulf, near latitude 22°S , continuously to 24°S and with interruptions to 25°S . Less than 1500 m of sediment cover on basement was indicated east of this ridge near $22^{\circ} 30'\text{S}$, but increasing thicknesses were interpreted both to the north (the Onslow Embayment) and to the south (the Merlinleigh Sub-basin). Basement depths in excess of 4500 m were interpreted for the coastal area extending as far south as Lake McLeod, except for an anomalous local basement 'high' in the south-central area of North West Cape.

In the southern Carnarvon Basin, the aeromagnetic surveys showed the presence of shallow basement in Hamelin Pool east of Faure Island (Plate 4) and thicker section along the coast from Dirk Hartog Island southwards to $27^{\circ}30'\text{S}$. In this area results indicate a rise in basement toward the Hardabut Fault, which forms the western boundary of the exposed shield rocks of the Northampton Block (Fig.1). West of Bernier Island, a region of shallow basement separating two basins to the north and south was inferred. Sediment cover seems to be particularly thin near the shelf edge between $24^{\circ}30'\text{S}$ and 25°S , where basement depths of less than 750m have been interpreted. In the vicinity of Dirk Hartog Island acceptance of onshore and offshore magnetic basement depth indications implies unusually steep easterly basement dip or faulting but this apparent dip must be regarded as of uncertain reliability because of the lack of overlap of onshore and offshore magnetic surveys in the area.

3.2 Gravity Surveys

Gravity measurements in the Carnarvon Basin began with the establishment by BMR of pendulum stations at major towns in 1950 (Dooley et al., 1961), in support of reconnaissance and detailed gravity surveys in 1950 and 1951 (Thyer, 1951a, 1951b). In 1953 a detailed gravity survey was done over the Rough Range structure (Dooley and Everingham, 1956) in support of unpublished seismic work by WAPET. The same year reconnaissance gravity coverage was extended by BMR to the southern Carnarvon Basin (Chamberlain et al, 1954), and a regional traverse was run between Onslow and Derby (Dooley, 1963). This work established the main regional features of the Bouguer gravity field.

The essential onshore gravity features shown in Plates 2A & 2B are little different from those established in the fifties. Gravity maps of the Carnarvon Basin by BMR are available at Scales of 1:2.5 million and 1:250,000. A reduced version of the latter at 1:500,000 is also available. Maps based on all data currently available have been produced at scales of 1:1 million and 1:5 million (Anfillof and others, 1976). Plates 2A and 2B are preliminary versions and are subject to minor changes.

WAPET undertook gravity surveys for a variety of exploration purposes in the area during the period 1955-1958, but these results are not generally available. The same company measured gravity along the lines of Wandagee Ridge seismic survey in 1962. Two unpublished gravity surveys in 1962 and 1965 by WAPET on Barrow Island were of limited value, as anomalies tended to reflect lateral density variations in surface rocks. Purcell (1969) has summarized the mainland gravity data of WAPET for the period 1950-1968.

The Murchison-Gascoyne helicopter gravity survey was undertaken in 1970 for Barewa Oil & Mining between the Murchison and Gascoyne rivers. The use of helicopters avoided the common restriction (on ground surveys) of being confined to established tracks, fence lines etc., but economics limited the survey to 950 stations on a 6.5 km grid. The survey objective, which was to test for the presence of a postulated graben, was achieved with a negative result. However the existence of areas of thicker section, especially the Gascoyne Depression within the Gascoyne Sub-basin, was indicated.

Over virtually the same area in 1971-1972, Oceania Petroleum conducted the Murchison-Gascoyne D-1 gravity survey as a ground operation. Results of this detailed operation (6500 stations at 0.8 km intervals on traverses approx. 12 km apart) confirmed the presence of, and refined the definition of, previously mapped gravity features.

Two other large scale reconnaissance helicopter gravity surveys, conducted by BMR during the period 1960-1969, resulted in complete coverage of the onshore Carnarvon Basin at a station spacing of 11 km or less. The results of these surveys have been briefly discussed by Fraser (1974a, 1974b) who has termed the study region the Gascoyne Regional Gravity Complex, and by Fraser and others (1976). Studies have also been undertaken of the isostatic anomalies of large onshore areas of the Carnarvon Basin, based on models of the continental margin (Flavelle, 1973).

Available offshore gravity results are derived partly from the BMR Continental Margin surveys of 1970-1973, and partly from the geophysical survey of the northwest continental shelf by BMR in 1968 (Whitworth, 1969), and are presented in plates 2A and 2B as free air anomalies.

Results The onshore regional Bouguer anomalies of the Carnarvon Basin (Plates 2A and 2B) are dominated in the south by a northeast-trending gravity ridge extending along the southeast boundary of the basin from the Northampton Block to the Carrandibby Inlier. Another positive trend branches off this northeast ridge to the northwest from near 115°E , and extends north to the coast near 22°S . Over much of its length this north-trending gravity feature is known as the Wandagee gravity ridge. The 'Y' shaped ridge pattern observed thus separates three regions of low gravity. To the east of the 'Y' is an area of negative gravity anomalies which is the gravity expression of the Coolcalalya and Byro Sub-basins. The intense northern gravity 'low' correlates with the thick sediments of the Merlinleigh Sub-basin, while the gravity 'low' to the west is related to the presence of sediments in the Gascoyne Sub-basin.

The north coastal area from North West Cape to the east of Onslow exhibits a large regional gravity 'high' which has three distinct components. These are:

1. The strongly positive gravity anomaly over the Cape itself. This lies at the intersection of two major tectonic trends, the southwest extension of the Rankin Trend and the southwest boundary of the Exmouth Plateau. The gravity anomaly may be related to either trend, although the negative effect of deep water on the free air anomalies of Plate 2A makes the latter connection less obvious. When expressed as Bouguer anomalies, however, the offshore results southwest of the Exmouth Plateau suggest that a positive belt, possibly associated with a transform fault (Willcox and Exon, 1976), is intimately linked to the Cape 'high', indicating that crustal thinning is a likely cause. The amplitude and wavelength of the anomaly support the hypothesis of a deep crustal source. Some deep refraction probes are needed to help in the interpretation of this poorly understood feature.
2. The northern extension of the Wandagee gravity ridge, coinciding with shallow basement on the Yanrey Ridge.
3. The board anomaly over the Peedamullah Shelf, a region of shallow basement.

Further to the north, well defined gravity 'lows' correspond to the Barrow and Dampier Sub-basins, and these are bounded to the north by a large elongate positive anomaly which lies about 130 km offshore. It trends NE-SW subparallel to the coast and coincides with the structurally high Rankin Trend. The depth of the source of the gravity anomaly over this economically important structural trend is unknown. It is suggested that computer modelling of the gravity field in this area could produce useful information on the anomaly source, and its depth.

A large elongate N-S free air anomaly, extending between latitudes 24°S and 26°S . and reaching maxima of 30 mgal, exists near the shelf edge in the central Gascoyne basin. This gravity anomaly is evidently related to the Bernier Platform, an area of shallow basement inferred from magnetic data. Shallow basement may extend over a much larger area than previously thought. Gravity data suggest that shallow basement extends onto the continental slope west of Dirk Hartog Island.

For a discussion of gravity and other geophysical results over the Exmouth Plateau, the reader is referred to Willcox and Exon (1976).

3.3 Seismic Surveys

Plates SA & SB illustrate the distribution of known seismic lines in the Carnarvon Basin at the time of writing. The numbers indicate the approximate locations of individual seismic surveys. Appendix 2 provides a key to the numbers, giving survey names, operators, dates and other information on the surveys.

Onshore seismic The earliest seismic surveys in the Carnarvon basin were initiated by BMR in 1951 (Chamberlain et al, 1954) when BMR carried out investigations of the Giralalia Anticline south of Exmouth Gulf. In 1955 a small seismic survey was conducted by BMR in the Wandagee area. This was followed by several surveys by WAPET during the period 1952-1961, for which results are unavailable.

In the early 1960's WAPET's onshore seismic effort in the Carnarvon Basin was largely concentrated on and near North West Cape, and involved the investigation of structures having surface expression. The seismic reflection technique using explosives as energy source produced only limited results, so that the refraction technique was used to a significant extent and there was early experimentation with an alternative energy source, viz., the Vibroseis system. Early exploration by WAPET included surveys near Lake McLeod and on the Wandagee Ridge. During the early 1960s BMR was active in the central and southern Carnarvon Basin, with three reflection seismic surveys and some refraction shooting.

From the mid-1960s onward, seismic activity was spread throughout the entire basin. Techniques continued to be influenced by the difficulty in achieving reliable reflection results. Source, geophone, and spread multiplicity were increased and the weight drop method was introduced. Surveys were conducted near Onslow, on the North West Cape, and in the Merlinleigh Sub-basin by WAPET, who also carried out a detailed reflection survey on Barrow Island. Results of this period were reported on by Pearson (1969).

Continental Oil Company of Australia did two surveys east of Shark Bay. Marathon Petroleum Australia conducted by far the largest seismic survey of the onshore Carnarvon Basin in 1967. This was the Mia Mia seismic survey, which employed the weight drop method and extended over 2400 km of traverse.

No further seismic operations for which results are available under the Petroleum Search Subsidy Act 1959-1973 were undertaken until 1972-73 when small scale detailed surveys were undertaken by WAPET on Barrow Island and North West Cape, and by Oceania Petroleum south of Hamelin Pool.

Offshore seismic The earliest offshore seismic work was undertaken in 1961 for WAPET in Exmouth Gulf and along a narrow near-shore strip between North West Cape and Carnarvon, primarily to test for possible offshore extensions of structures previously explored by land surveys. Rather than discuss the offshore surveys in chronological order, it will be more convenient to consider various areas separately, beginning with the northern Carnarvon Basin and then moving southwards.

In 1964 BOCAL carried out its first marine seismic survey on the Northwest Shelf, which was a regional reconnaissance survey covering parts of the Dampier Sub-basin and Rankin Platform, and extending to the northeast beyond the boundaries of the Carnarvon Basin. This marked the beginning of a long series of offshore surveys by the same operator in this area, a characteristic feature of which was the steady introduction of new technology in all phases of the seismic technique; detectors, energy source, recording instruments, position control, and processing. By 1966, 3-fold multiple coverage and digital processing were being used in an effort to overcome severe problems with multiple reflections.

Extension of BOCAL's seismic reconnaissance grid, and detailing of previously indicated structures continued year by year on the Northwest Shelf, but the northern Carnarvon Basin received no further attention until 1969. The Aquapulse energy source was then introduced, together with high source and detector multiplicity which allowed both vertical and horizontal stacking. These powerful exploration techniques were successively applied to the North Turtle and Legendre areas (1969), and to the Dampier Sub-basin, Rankin Bank and Pilbara Block margin areas (1970).

In 1971, BOCAL applied the Maxipulse energy source to the detailing of the prospective Rankin Platform and further defined potential structures in the Beagle Sub-basin. An improvement in data quality compared with previous results was obtained. Exploration effort was also directed at the seaward flanks of the outer Beagle Sub-basin. Sonabuoys and refraction profiles were recorded.

The success of the Maxipulse system ensured its further use in 1972 by BOCAL on the Montebello-Turtle, Malus-Hedland, and Steamboat Spit surveys. The first of these was aimed at detailing existing prospects and/or exploring for new leads on the Rankin, Madeleine-Dampier, and Legendre Trends and at investigating the possible northeasterly extensions into the Beagle Sub-basin of the two first-mentioned trends, and their relationships to the North Turtle Arch. This latter feature is now accepted as the northern boundary of the Carnarvon Basin. The Malus-Hedland seismic survey investigated stratigraphic trap potential along the Dampier Sub-basin/Pilbara Shelf margin, and detailed structures on the Rankin Trend and in the Dampier and Beagle Sub-basins. The Steamboat-Spit seismic survey provided a clearer picture of the complexly faulted Angel field in the Dampier Sub-basin and investigated other areas outside the Carnarvon Basin.

An airgun energy source was used on the De Grey Nose seismic survey by BOCAL in 1973 to obtain high resolution shallow data inshore from the Beagle and Dampier Sub-basins to determine the stratigraphic trap potential of the area.

Four other surveys by BOCAL, for which data are restricted, were undertaken over the period 1972 to 1975. A grid of traverses at a one mile spacing resulted from the North Rankin-Goodwyn survey, which extended over the North Rankin and Goodwyn fault blocks and which delineated the complex fault system of the area. The Kendrew Trough survey successfully tested the combination of Maxipulse explosive charge and high multiplicity (10 lbs and 1200%) over three prospective areas. The large scale Kendrew-Cootamundra survey served multiple objectives; further extension of the reconnaissance grid over inshore areas of the Beagle Sub-basin, an area having potential for stratigraphic traps; and detailing of numerous individual prospects in both the Dampier and Beagle Sub-basins. The Dampier-Beagle survey of 1975 also pursued a variety of objectives in both sub-basins, but was mainly directed towards providing additional detail over several previously known structures, some of which were recommended for drilling. New prospects were discovered in deeper water areas.

South of the Dampier Sub-basin intensive offshore seismic exploration began in 1965 in widely separated areas. Surveys by WAPET were concentrated on prospects around North West Cape and Barrow Island, and major portions of these surveys fell within the PSSA excluding circles around Rough Range No. 1 well (48 km radius) and Barrow Island oil field (80 km radius). Consequently only limited portions of the results obtained up to 1968 are available. The work consisted of the Barrow, Long Island, Muiron, Helby, Table, Jurabi, Fraser, and Barrow Waters surveys, in which airguns, dynamite, and Aquapulse energy sources were used, to fulfill objectives ranging from reconnaissance surveying to confirmation of closure over individual structures. Some lines were in inshore shallow water areas, and were programmed to supplement results of land surveys. Results of surveys up to 1968 were summarised by Bozanic (1968) and Pearson (1969). A considerable number of structural leads, some of which coincided with small islands, were indicated by those surveys. During the period 1968-1975 a number of small surveys were done in the area for WAPET under the Petroleum (Submerged Lands) Act 1967-1974 (P(SL)A). Following its usual practice for areas relinquished by petroleum exploration companies, the Western Australian Department of Mines has released some of the basic data for these surveys, but interpretative results are not available to the public.

Continental Oil undertook seismic reconnaissance in Shark Bay in 1965, and successfully linked onshore seismic data with stratigraphy intersected in Dirk Hartog No. 1 well. In the Abrolhos area in the same year BP Petroleum Development Australia tested 6-fold multiple coverage seismic on a limited scale with encouraging results during an otherwise single coverage survey which produced generally poor quality data.

The first of two surveys by Canadian Superior in the tenement which they held between 23°S and 27°30'S was the West Carnarvon reconnaissance seismic survey of 1966. Although digital techniques were applied to the 3-fold data, reverberations generated at or near the sea floor were of a strength sufficient to make the results almost unuseable. Multiplicity was increased in the succeeding survey of 1967 to 6-fold and fair quality data down to one second of record time were recorded.

Marine seismic activity in the southernmost Carnarvon Basin consisted of BP Petroleum's Geelvink Channel (1970), Endeavour Oil's Ronsard (1971), and Ocean Ventures' Bernier (1971) surveys. The Geelvink Channel and Bernier surveys included magnetometer surveys as well as seismic. Those lines of the Geelvink Channel survey which fell within the Carnarvon Basin largely served reconnaissance objectives. An airgun energy source provided reasonable energy return, but continuity of reflection character was poor. The Bernier Survey consisted of two widely separated detailed projects, near the Pendock ID No. 1 and Edel No. 1 wells, with reconnaissance lines linking the two areas. The Maxipulse energy source employed provided significant improvement in data quality over previous work. One conclusion from the results of the survey was that Pendock ID No. 1 had not been drilled on the crest of the Pendock structure.

The Ronsard survey, west of Lake McLeod, had as its principal objective the definition of Palaeozoic structures, which had been shown by the Pendock well to be prospective, but the poor quality of the seismic results obtained using an airgun energy source, and the lack of supporting magnetometer data, made it impossible to distinguish from the results between the presence of intrusive sills, salt flows, or limestone reefs.

The BMR Northwest Shelf geophysical survey in 1968 and the BMR Continental Margin survey in 1970-73 included reconnaissance traverses over the offshore portions of the Carnarvon Basin using a sparker energy source and relatively inexpensive seismic recording equipment. The quality of seismic results from these surveys is generally poorer than those obtained on petroleum company surveys since 1968.

In 1971 Shell Development (Australia) carried out a regional marine geophysical survey mainly on the continental slope of Western Australia from near Timor in the north to the vicinity of Perth in the south. The survey included seismic, gravity and magnetic recording. A number of traverses were surveyed on the western margin of the Carnarvon Basin and in particular on the Exmouth Plateau. In late 1971 to early 1972 Esso Australia also surveyed several seismic lines on the Exmouth Plateau. In 1972 Australian Gulf Oil carried out a reconnaissance seismic, gravity and magnetic survey over the Northwest Shelf which included regional traverses on Exmouth Plateau in the Dampier and Beagle Sub-basins.

Results. The results of some major seismic surveys in the Carnarvon Basin have been generalised for presentation at a scale of 1:1 000 000 on Plates 6A & 6B. The plates do not include the results of seismic surveys on the Exmouth Plateau, which have been reported on by Hogan & Jacobsen (1975), and Wilcox & Exon (1976).

In drawing the seismic contours, reflection time to depth conversion has generally been made on a gross scale, neglecting local velocity variations.

The quality of seismic results varies widely throughout the basin. The most intense application of modern techniques has been in the northern sub-basins, where several reflections have been reliably mapped. These have been identified stratigraphically from numerous wells in the area, and include a near base Tertiary, an Upper Cretaceous (Toolonga Calcilutite), and Lower Cretaceous-Upper Jurassic horizons. The pre-Upper Jurassic reflectors are absent from the Rankin Trend, and below the depth of penetration of modern seismic techniques in the Dampier & Beagle Sub-basins. Where sediments thin towards the Pilbara block margin, Triassic and Permian horizons have been mapped.

However the seismic reflection most widely recognised and most reliably mapped in the northern part of the basin is that originating at an unconformity near the base of the Cretaceous section. This horizon is illustrated in Plate 6B and the northern part of Plate 6A. In some areas it reflects economically significant structures in underlying Mesozoic rocks, especially along the Rankin Platform. Plate 6B includes the names given to a number of structures by petroleum exploration companies.

Division of the Dampier and Beagle Sub-basins into various tectonic elements is well illustrated by the seismic contour map. Complex block faulting along the Rankin Trend is evident. Faulting is thus an important factor in the formation of structural traps for petroleum in this area. However correlations of seismic horizons between individual fault blocks is often difficult, so that alternative interpretations are possible. Over the northern half of the Carnarvon Basin the seismic data also show the existence of large fault systems forming the south-eastern boundaries of the Exmouth and Barrow sub-basins.

Over most of the onshore southern Carnarvon Basin the post-Palaeozoic section is thin or absent and so older horizons have been presented on the seismic map. Onshore and in Shark Bay the contours shown indicate the approximate form of the Silurian Tumblagooda Sandstone in some areas, and of an unidentified lower Palaeozoic horizon elsewhere. Because they are derived from poorer quality land and marine seismic results than contours on the base of Cretaceous horizon in the north, these contours are of lesser reliability and there is also some doubt about their identification.

Contours are not shown for the offshore area between 24°S and 25°S . As previously discussed this is an area of shallow basement (the Bernier Platform). Seismic coverage over this feature is of low density, largely because the sedimentary section is thin and has been considered non-prospective. Data are of poor quality. However, one fault-controlled anticline (the Ronsard structure), which trends parallel to the coast about 25 km offshore, has been mapped from shallow seismic data near latitude 24°S .

Offshore and to the south of Dirk Hartog Island, an intra-Mesozoic horizon, a pre-Mesozoic unconformity, and possibly a Lower Jurassic horizon have been indicated.

PETROLEUM PROSPECTS

4.1 Discoveries of petroleum

Together with the Gippsland, Cooper, Perth and Surat Basins the Carnarvon Basin is one of the few sedimentary basins in Australia where there has been any marked success in the discovery of hydrocarbons. Thomas and Smith (1974) provide a summary of the history of hydrocarbon discoveries in the basin and further details of BOCAL discoveries are given in Powell (1973) and Martinson et al (1973). Table 2 provides data on hydrocarbon discoveries, including reservoir formation, whether oil, gas or condensate, and test figures where available.

WAPET's exploration of the Carnarvon Basin had an encouraging start with the drilling of its first well, Rough Range No. 1, in 1953 on the Rough Range Anticline near Exmouth Gulf. A successful drill stem test of the Birdrong Formation flowed 550 bbl/d of oil. This was Australia's first discovery of oil which flowed to the surface. However stepout

TABLE 2
CARNARVON BASIN HYDROCARBON DISCOVERIES

Field or well	Reservoir	Depth	Hydrocarbons	Test Figures
Barrow Island Field (see Table 9)				NB: DST - Drill stem test FIT - Formation interval test bbl - barrels 1.1 x 10 ³ ft ³ /d, 1" choke 1973 testing: 175 bbl/d and 1550 x 10 ³ ft ³ /d
Flag No. 1	Barrow Fm.	1278.6-1292 m	gas	
Pasco Island Field:	Barrow Fm.	5700' Sand (1738.5 m)	oil and gas	
Pasco No. 1			10.3 m oil pay; 10.0 m gas pay in 3 sands	
Pasco No. 2			dry	
Pasco No. 3			1 m oil pay; 7 m gas pay	
Legendre No. 1	Barrow Fm.	1894.4-1899.2 m		DST: 822-1014 bbl/d, 44.7 API, 3/8"-1" choke gas:oil = 1.06x10 ³ ft ³ :bbl
Angel No. 1	Barrow Fm.	2735.9-2738.9 m	gas, condensate	DST No. 1: gas 12.85x10 ⁶ ft ³ /d condensate 720 bbl/d, 3/8" choke
		2687.1-2690.1 m		No. 2: gas 13.20x10 ⁶ ft ³ /d condensate 685 bbl/d, 3/8" choke
Rough Range No. 1	Birdrong Sst.	1098-1109 m	oil	550 bbl/d
Cape Range No. 2	Birdrong Sst.	2984.1-3080.5 m	gas	DST: 1193x10 ³ ft ³ /d on 1/8" choke
Flinders Shoal No. 1	?	791.6-799.2 m	gas and oil	2.3x10 ⁶ ft ³ /d; 1/2 bbl/d, 23° API
Angel No. 2	Barrow Fm.	2699.3-2706 m	gas and condensate	DST:- 12.1x10 ⁶ ft ³ /d; 52 bbl/10 ⁶ ft ³ , 3/8" choke
		2719.7-2718.5 m	gas and condensate	DST:- 7.4x10 ⁶ ft ³ /d; 50 bbl/10 ⁶ ft ³ , 3/8" choke
		2744.1-2753.2 m	gas and condensate	DST:- 11.2x10 ⁶ ft ³ /d; 58.6 bbl/10 ⁶ ft ³ , 3/8" choke
Angel No. 3	Barrow Fm.	2741.3-2749.9 m	gas and condensate	DST:- 14.22x10 ⁶ ft ³ /d; 46.4 bbl/10 ⁶ ft ³ , 1/2" choke
North Rankin No. 1	Toolonga Calcilutite	2574.2-2584.9 m	gas	DST:- 5.75x10 ³ ft ³ /d + oil

	Mungaroo Beds	2838-2842.6 m	gas and condensate	DST:- $7.02 \times 10^6 \text{ ft}^3/\text{d}$; 95.5 bbl/d
		3011.9-3016.5 m	gas and condensate	DST:- $9.93 \times 10^6 \text{ ft}^3/\text{d}$; 370 bbl/d
		3104.9-3111 m	gas and condensate	DST:- $9.97 \times 10^6 \text{ ft}^3/\text{d}$; 269 bbl/d
		3208.6-3211.7 m	gas and condensate	DST:- $9.79 \times 10^6 \text{ ft}^3/\text{d}$; 298 bbl/d
		3252.8-3255.9 m	gas and condensate	DST:- $11.42 \times 10^6 \text{ ft}^3/\text{d}$; 317 bbl/d
North Rankin No. 2	Mungaroo Beds	2721.2-2737.7 m	gas and condensate	DST:- $18.7 \times 10^6 \text{ ft}^3/\text{d}$; 23.8 bbl/ 10^6 ft^3 , $\frac{7}{8}$ " - $\frac{1}{2}$ " choke
		2760.2-2746.5 m	gas and condensate	DST:- $10.9 \times 10^6 \text{ ft}^3/\text{d}$; 25.5 bbl/ 10^6 ft^3 , $\frac{3}{8}$ " - $\frac{1}{2}$ " choke
		2844.1-2870.1 m	gas and condensate	DST:- $20.4 \times 10^6 \text{ ft}^3/\text{d}$; 25.1 bbl/ 10^6 ft^3 , $\frac{7}{8}$ " - $\frac{1}{2}$ " choke
		3169.9-3198.8 m	gas and condensate	DST:- $18.3 \times 10^6 \text{ ft}^3/\text{d}$; 27 bbl/ 10^6 ft^3 , $\frac{3}{8}$ " - $\frac{1}{2}$ " choke
North Rankin No. 3	Mungaroo Beds	3094.2-3140.2 m	gas and condensate	DST:- $28.2 \times 10^6 \text{ ft}^3/\text{d}$; 28.1 bbl/ 10^6 ft^3 , $\frac{1}{2}$ " choke
North Rankin No. 4	Mungaroo Beds	2916.6-2999.9	gas and condensate	DST:- $7.2 \times 10^6 \text{ ft}^3/\text{d}$; 28 bbl/ 10^6 ft^3 , $\frac{1}{2}$ " choke
Dockrell No. 1	Mungaroo Beds	2987-2995 m	gas and condensate	DST:- $13 \times 10^6 \text{ ft}^3/\text{d}$; 4329 ft^3/d (condensate), 19.05 mm choke
		3004-3008.5 m	gas and oil	DST2. $2 \times 10^6 \text{ ft}^3/\text{d}$; 10687 ft^3/d (oil) 9.525-19.95 mm choke
Egret No. 1	Mungaroo Beds	3121.3-3130.5 m	gas and oil	DST:- $2.87 \times 10^6 \text{ ft}^3/\text{d}$; 2729 bbl/d, API, 39° $\frac{1}{2}$ " choke
Eaglehawk No. 1	Mungaroo Beds	2779.1-2789.8 m	oil	DST:- 233 bbl/d, API 30, $\frac{5}{8}$ " - $\frac{1}{2}$ " choke
		2752-2767.8 m		DST:- $0.4 \times 10^6 \text{ ft}^3/\text{d}$, 1645 bbl/d, API 29.3, $\frac{5}{8}$ " - $\frac{1}{2}$ " choke
Lambert No. 1		3101-3106 m	gas, condensate and oil	DST:- $2580.83 \times 10^6 \text{ ft}^3$; 59.55×10^6 bbl/d, API 51° $\frac{1}{2}$ " - $\frac{1}{4}$ " choke
Goodwyn No. 1	Mungaroo Beds	2843.5-2848.7 m	gas and condensate	DST:- $11.4 \times 10^6 \text{ ft}^3/\text{d}$; 490 bbl/d, API 57°, $\frac{3}{8}$ " - $\frac{3}{8}$ " choke
		3148.5-3153.7 m	gas and condensate	DST:- $7.6 \times 10^6 \text{ ft}^3/\text{d}$; 45 bbl/ 10^6 ft^3 , $\frac{1}{2}$ " - $\frac{3}{8}$ " choke
Goodwyn No. 2	Mungaroo Beds	2842.9-2909.7 m		? ; 70-90 bbl/ 10^6 ft^3
Goodwyn No. 3	Mungaroo Beds	2881-2893 m	gas and condensate	DST:- $17.3 \times 10^6 \text{ ft}^3/\text{d}$; 68 bbl/ 10^6 ft^3 , API 47.7°, $\frac{1}{2}$ " - $\frac{1}{2}$ " choke
		2987.8-2995.7 m	condensate	DST:- 2478 bbl/d, $\frac{1}{2}$ " choke
		3017.1-3028 m	condensate	DST:- 2730 bbl/d 47.7° API, $\frac{1}{2}$ " - $\frac{1}{2}$ " choke
Goodwyn No. 4	Mungaroo Beds	2900-2901 m	gas and condensate	DST:- $10.85 \times 10^6 \text{ ft}^3/\text{d}$; 50.6 bbl/ 10^6 ft^3 , $\frac{5}{8}$ " - $\frac{1}{2}$ " choke
		2858-2905 m	gas and condensate	DST:- ?, .485 bbl/ 10^6 ft^3 , $\frac{1}{2}$ " choke

West Tryal Rocks No. 2

Mungaroo Beds

3435-3450 m

gas and condensate

DST:- $10 \times 10^6 \text{ ft}^3/\text{d}$; 104 bbl/d, $\frac{1}{2}$ " choke

3295-3305 m

gas and condensate

DST:- $14 \times 10^6 \text{ ft}^3/\text{d}$; 220 bbl/d, $\frac{1}{2}$ " choke

Hilda No. 1

Munderong Shale

2669.5 m

gas and oil

FIT:- $21 \text{ ft}^3/\text{d}$; 8100 cc

drilling proved that the oil accumulation at Rough Range was very small and non-commercial.

WAPET discovered oil in Barrow No. 1 well on Barrow Island in 1964. This well flowed 985 bbl/d of oil from the Late Jurassic '6700 ft Sand' and hydrocarbons were also indicated in other formations. Stepout drilling confirmed a commercial oil accumulation in the shallow Aptian Windalia Sand Member. The Barrow Island oil field was declared commercial in 1966 and the only commercial production to date in the basin has been from this field. Mapping on the main producing horizon of the field shows the structure to be a broad north-plunging anticlinal nose truncated to the south by the complex down-to-the-south Barrow Fault (Crank, 1973). During 1972 and 1973 a deep test well (Barrow Deep No. 1) was drilled on Barrow Island to a total depth of 4650 m, where it was within Dingo Claystone of Middle Jurassic age. Between 3242 m and 3500 m thin porous and permeable Middle Jurassic sandstones were penetrated. Subsequent tests revealed high pressure gas and gas condensate. However, supernormal hole pressures below 2652 m present problems in the further evaluation of the deeper horizons below Barrow Island. Non-commercial indications of hydrocarbons have been obtained in wells drilled on Pasco Island, about 7 km south of Barrow Island, and other small islands in the vicinity.

BOCAL's first well in the Dampier Sub-basin, Legendre No. 1 drilled in 1969, established the presence of 600 m net of potential Jurassic - Lower Cretaceous reservoir sandstone. A maximum flow of 1014 bbl/d of 44.7° API gravity oil from 6.7 m of Lower Cretaceous sandstone below 1893 m was obtained on testing. Legendre No. 2 proved disappointing and the Legendre oil accumulation was considered non-commercial.

Since 1971 a number of structures have been drilled by BOCAL on the Rankin Platform. Most of these have provided indications of hydrocarbons. The three initial structures tested (North Rankin, Rankin and Goodwyn) have gas and condensate accumulations of considerable magnitude in Upper Triassic reservoirs. In addition, oil is present in the Upper Triassic at Rankin No. 1, in the Toolonga Calcilutite at North Rankin No. 1, and probably in the basal Tertiary at North Rankin No. 1 (Martison et al., 1973). Near the northern end of the Rankin Platform oil was discovered in Eaglehawk No. 1 and Egret No. 1, while southwest of Rankin No. 1 Dockerell No. 1 encountered gas, condensate and oil.

Still further to the southwest, in WAPET's area, West Tryal Rocks Nos 1 and 2 were drilled to test the southwest extension of the Rankin Platform. These wells encountered significant quantities of gas in Late Triassic and Early Jurassic sands of the Mungaroo Beds.

Off the Rankin Platform the only hydrocarbon field of possible commercial significance discovered to date is the Angel gas/condensate field, located near the northwestern end of the Madeleine-Dampier Trend. Here the hydrocarbons were located in Upper Jurassic (Late Tithonian) sandstones which are probably equivalent to the lower part of the Barrow Group (Thomas and Smith, 1974).

4.2 Petroleum Accumulation In Relation To Basin And Continental Margin Development

Falvey (1974) has proposed a generalized model for the formation of Atlantic-type continental margins by rifting and subsequent breakup of continents by sea-floor spreading. He recognises three main stages, giving rise to three different litho-tectonic elements, namely: pre-rift, rift valley, and post-breakup, which are in general separated by two angular unconformities. It is believed that this model can be applied to the development of the Carnarvon Basin since the Late Palaeozoic, and that it has a bearing on the generation and entrapment of hydrocarbons within the basin.

In the later Palaeozoic, Gondwanaland fronted the Tethys Sea to the north and within the continent in the vicinity of the present Carnarvon Basin a 'pre-rift intracratonic basin' developed, within which Permian and Triassic fluvio-deltaic and shallow-marine sediments accumulated on a Precambrian and Early to Middle Palaeozoic basement. These sediments constitute important source and reservoir rocks of the Carnarvon Basin, the hydrocarbons having been developed, in all likelihood, from the largely land plant derived organic content of the sediments.

The rift valley stage in the breakup of the former continent reached its climax in the Middle Jurassic (Callovian) with the appearance of new seafloor between the separating continental blocks, and resulted in a complex development of horsts and grabens peripheral to the separating cratonic blocks. Since the movement of the peripheral block relative to Australia was to the northwest, the main trend of faulting and of the horst

and graben structures produced was northeasterly, as exhibited by the structural trends in the Damperi Sub-basin and the Kangaroo Syncline further to seaward. The throws of some of the major faults bounding the horsts and grabens exceeded 2000 m. Extensive cross-faulting also developed. The rifting stage of continental breakup gave rise to topographically high areas in close proximity to grabens in which coastal and shallow marine sedimentation took place as the result of erosion during the Jurassic. The resulting sediments contributed reservoir and perhaps source rocks to the Carnarvon Basin.

A 'final uplift pulse associated with pre-breakup upwelling in the mantle' (Falvey, 1974) caused erratically distributed unconformities in the Late Jurassic and Early Cretaceous and the consequent deposition of shallow water clastics which include some of the most important reservoir rocks of the basin, e.g. the Dupuy Member of the Dingo Formation, and the Barrow Formation.

Cooling of the lithosphere following the beginning of seafloor spreading between the separating continents produced subsidence and a rapid marine transgression, in accordance with Falvey's model. The on-lapping sands deposited at this time are exemplified by sands at and near the base of the Upper Cretaceous Winning Group, which are important reservoir rocks in the basin. The subsequent holomarine deposits of the sedimentary wedge deposited on the new continental shelf include some of the more important cap rocks of the basin.

Progradation caused the outbuilding of the shelf and upper slope in the Tertiary and the sedimentary wedge tilted seawards, possibly because of cooling and contraction of the old lithosphere in the vicinity of the new continental margin as the mid-ocean ridge accreted itself further from the margin, and possibly because of the weight of accumulating sediments. The rapid burial of the older sediments by a thick Cretaceous-Tertiary sedimentary wedge in the offshore part of the basin probably contributed to the generation of hydrocarbons, while seaward tilting may have played a significant part in the migration of petroleum.

4.3 Petroleum prospects, area by area

The Carnarvon Basin is a large basin with many disparate parts which differ widely in prospectivity for petroleum. It is thus convenient to consider the various elements of the basin separately.

Pilbara Shelf The Pilbara Shelf is a wide zone of thin sediments covering the seaward extension of the Precambrian Pilbara Block and extending northeast from the Dampier Archipelago. Only one well has been drilled on it. Haug No. 1 well was drilled to 825 m to test a postulated pinch-out of Triassic sands. However, it encountered a sequence of predominantly lutitic Triassic beds beneath a mainly sandy Cretaceous sequence derived from the Pilbara Block, which was 100% water saturated. The Pilbara Shelf is regarded as having virtually no hydrocarbon potential.

Cape Preston Shelf The Cape Preston Shelf is a southwesterly extension of the Pilbara Shelf between the Dampier Archipelago and the Sholl Island Fault. Hematite Petroleum drilled two shallow wells, Coonga No. 1 and Mardie West No. 1, to depths of less than 176 m. No information is available concerning these wells, but it seems reasonable to assume that they encountered very shallow basement.

Peedamullah Shelf The Peedamullah Shelf lies between the downthrown-to-the-northwest Sholl and Flinders Faults north of Onslow. It is partly onshore and partly offshore and, being downfaulted, it has a thicker sedimentary section than the shelf areas to the northeast. This section consists of northwest-dipping Palaeozoic to Triassic beds with a Cretaceous-Tertiary onlap.

The area lies undip from the petroliferous Dampier Sub-basin and numerous small gas shows have been reported from shallow wells. It may be expected that any reservoir beds, if present, would be the equivalents of those in the Barrow Island field, that is, the Windalia Sand Member of the Munderong Shale and the Birdrong Sandstone/Yarraloola Conglomerate/Wogatti Sandstone, but these might well prove to be fresh water saturated near the basin margin. Petroleum prospects of the shelf are regarded as fairly poor.

The following petroleum wells have been drilled:

TABLE 3
PETROLEUM WELLS ON PEEDAMULLAH SHELF

<u>Well name</u>	<u>Operator</u>	<u>Total depth</u> (metres)	<u>Bottom formation age</u>
<u>On offshore islands</u>			
Sholl No. 1	WAPET	1271.6 m	Lower Permian
Fortescue No. 1	WAPET	609.6 m	Permian
North Sandy No. 1	WAPET	609.6 m	Mid-Lower Triassic
Mangrove Island No. 1	WAPET	285.9 m	Lower Permian
Beagle No. 1	WAPET	559.3 m	Permian
Mary Anne No. 1	WAPET	533.4 m	Mid-Lower Jurassic
Direction Island No. 1	WAPET	627.7 m	Lower Permian
<u>Onshore</u>			
Surprise No. 1	Hematite	216.4 m	-
Mulyery No. 1	WAPET	139.6 m	Upper Jurassic
Windoo No. 1	Hematite	217.9 m	-
Mardie No. 1	WAPET	221.9 m	Palaeozoic
Mardie No. 2	WAPET	164.9 m	Lower Cretaceous
Woorawa No. 1	Hematite	202.4 m	-
Peedamullah No. 1	WAPET	328.3 m	Devonian
Yarraloola No. 1	WAPET	271.9 m	Carboniferous
Cane River No. 1	Hematite	694 m	Lower Carboniferous
Cane River No. 2	Hematite	413 m	-
Cane River No. 3	Hematite	254.8 m	-
Cane River No. 4	Hematite	172.8 m	-
Cane River No. 5	Hematite	200.9 m	-
Minderoo No. 1	WAPET	609.6 m	Upper Carboniferous

Ashburton and Merlinleigh Sub-basins As already indicated, these sub-basins between the Wandagee Fault and the Pilbara Block (Fig. 1) contain large thicknesses of mainly Palaeozoic and Lower Mesozoic sediments. They contain some good source rocks and the Ashburton Sub-basin in particular contains some sandstones with good porosities and permeabilities. Wells have encountered some small gas shows, but most potential reservoir rocks encountered to date have either been tight or water-flushed. Petroleum potential of the sub-basins is regarded as low.

The following petroleum wells have been drilled:

TABLE 4
PETROLEUM WELLS IN ASHBURTON AND MERLINLEIGH SUB-BASINS

<u>Well name</u>	<u>Operator</u>	<u>Total Depth</u> (metres)	<u>Bottom formation age</u>
Cunahoo No. 1	WAPET	797.9 m	Upper Permian
Wandagee No. 2	WAPET	308.8 m	Lower Permian
Quail No. 1	WAPET	3580.8 m	Silurian
Kennedy Range No. 1	WAPET	2226.6 m	Lower Permian
East Marrilla No. 1	WAPET	638.3 m	Lower Carboniferous (Permian absent)
Moorgoree No. 1	Hartogen	128.3 m	No information
Moorgoree No. 2	Hartogen	189.0 m	No information
Bidgemia No. 1	Hartogen	184.4 m	No information
Merlinleigh Nos 1-5	WAPET	135.5 m to 305.7 m	No information

Gascoyne Sub-basin The sediments of the Gascoyne Sub-basin are similar to those in the Ashburton and Merlinleigh Sub-basins to the northeast. Silurian to Permian sediments up to 5000 m thick are overlain by Cretaceous to Recent carbonates 0 to 1000 m in thickness. Good source and seal rocks appear to be lacking in the sub-basin and possible sandstone reservoirs penetrated have either lacked suitable porosity and permeability or have been water saturated. This applies particularly to the Tumblagooda Sandstone and also to the transgressive Birdrong Sandstone at the base of

the Cretaceous. Wells have encountered only insignificant traces of hydrocarbons.

Edel No. 1 well, drilled offshore in the southern part of the sub-basin, provided evidence of considerable volcanic activity. This, together with the flat-lying disposition of the Palaeozoic and Mesozoic strata, which would have militated against hydrocarbon migration, and the prevalence of unconformities within the Palaeozoic section, must be considered as downgrading factors for the hydrocarbon potential of the Gascoyne Sub-basin.

However, Pendock ID No. 1 well, drilled offshore in the northern part of the sub-basin, encountered a Devonian reef at 1289 m (Appendix 3). The possibility of reef plays on the shelf areas of the sub-basin should not therefore be overlooked.

The following petroleum wells have been drilled:

TABLE 5
PETROLEUM WELLS IN GASCOYNE SUB-BASIN

<u>Well name</u>	<u>Operator</u>	<u>Total depth</u>	<u>Bottom formation age</u>
<u>Onshore</u>			
Warroora No. 1	WAPET	1826.4	Permian
Chargoo No. 1	WAPET	427.9	Lower Permian
Gnaraloo No. 1	WAPET	501.7	Carboniferous
Wandagee No. 1	WAPET	1073.2	Silurian
Wandagee No. 3	WAPET	222.5	pre-Cretaceous
Cape Cuvier No. 1	WAPET	457.2	Devonian
Grierson Nos 1,2,3	WAPET	457.2	-
Dirk Hartog Nos 1-17	WAPET	max.1523.4 m	Silurian
Hamelin Pool No. 1	Magellan Petroleum	1595.3 m	No information
Hamelin Pool No. 2	Central Pacific Minerals	?	No information
Yaringa No. 1	Continental Oil	2288.4 m	No information

Table 5 (cont'd)

<u>Well name</u>	<u>Operator</u>	<u>Total depth</u>	<u>Bottom formation age</u>
Tamala No. 1	Oceania Petroleum	?	No information
Kalbarri No. 1	Oceania Petroleum	?	No information

Onshore (northeast extension of sub-basin shelf)

Lockyer No. 1	WAPET	765.7 m	Upper Triassic
Onslow No. 1	WAPET	2997.7 m	Lower Permian
Glenroy No. 1	WAPET	648.3 m	-
Urala No. 1	WAPET	762 m	Upper Triassic
Wonangarra No. 1	WAPET	575.5 m	-
Yanrey No. 1	WAPET	430.7 m	Precambrian

Offshore

Pendock ID No. 1	Genoa Oil	2500.9 m	Silurian
Edel No. 1	Ocean Ventures	2748.7 m	? Silurian
Dirk Hartog No. 3	WAPET	272.8 m	-
Dirk Hartog No. 13	WAPET	297.2 m	-

Beagle Sub-basin It has already been indicated that the Beagle Sub-basin shows a similarity in tectonic style to that of the Dampier Sub-basin which it adjoins. However, it appears that in the Beagle Sub-basin the Middle Jurassic 'breakup unconformity' sandstones are largely missing or are replaced by claystones. Picard No. 1 well alone has a basal Neocomian sandstone, but this and all other hitherto tested potential reservoir sands in the sub-basin are 100% water saturated. Moderately good source rocks exist in the Jurassic and hydrocarbon traces in wells become more pronounced from the Tertiary to the Jurassic.

Exploration to date in the Beagle Sub-basin has been disappointing and petroleum prospects must be rated much poorer than in the Dampier Sub-basin. However, relatively few wells have been drilled and the area cannot yet be dismissed as unprospective.

The following petroleum wells have been drilled:

TABLE 6
PETROLEUM WELLS IN BEAGLE SUB-BASIN

<u>Well name</u>	<u>Operator</u>	<u>Total Depth</u>	<u>Bottom formation age</u>
<u>On the Picard Trend</u>			
Sable No. 1	BOCAL	3971.5 m	Upper Triassic
Ronsard No. 1	BOCAL	2848 m	Lower Jurassic
Picard No. 1	BOCAL	4216 m	Lower Jurassic
(Hydrocarbon traces in Lower Jurassic)			
Depuch No. 1	BOCAL	4003 m	Lower Cretaceous
<u>Northeast flank of De Grey Nose</u>			
Cossigny No. 1	BOCAL	3203.4 m	Middle Triassic
<u>West flank of North Turtle Arch</u>			
Poissonier No. 1	BOCAL	1962 m	-

Dampier Sub-basin Some details of hydrocarbon discoveries in the Dampier Sub-basin have already been given. This sub-basin is clearly the most prospective part of the Carnarvon Basin and the prospectivity of the outer portions of the sub-basin must be considered high by any standards.

Occurrence of hydrocarbons in the sub-basin are mainly associated with two major unconformities. They occur immediately below the mid-Jurassic 'rift onset' unconformity in Upper Triassic to mid-Jurassic rocks of detritic origin (Rankin Platform) and above the late Jurassic 'break up' unconformity, in Late Jurassic and Early Cretaceous transgressive marine sands (Egret, Angel, Legendre). The unconformities provided suitable porous reservoir sandstones both in the weathered zones below the unconformities and in the overlying sediments.

In the Lewis Trough the Jurassic rocks are thought to be up to 3000 m thick, while they are much thinner and draped over Triassic horst blocks on the prospective Rankin Platform and Madeleine-Dampier Trend. The Cretaceous rocks of the 'post breakup' stage are from about 100 m to 1500 m thick in the troughs and from about 800 m to 1200 m over the two positive trends. The Tertiary sequence thickens from about 500 m near the Pilbara Shelf to almost 3000 m over the Kendrew Terrace.

The source of the hydrocarbons now within the Late Triassic-Early Jurassic sandstones has generally been considered to be the thick Jurassic shales of the Barrow and Dampier Sub-basins. However, some wells on the Rankin Platform have provided data to suggest that the Cretaceous shales are also a source of oil and that the Triassic shales may, under favourable conditions, generate gas (Thomas and Smith, 1974). The source potential studies by BEICIP Robertson Research - (1973-75) on the Goodwyn, Rankin, Angel, Legendre and Enderby wells show organic carbon contents are rarely below 1% and often exceed 1.5% in the shaley rocks of the Mesozoic section in general. This makes almost all of the shaley section a potentially good to excellent source.

Most of the hydrocarbon discoveries have been on the Rankin Platform, where typically the hydrocarbon traps consist of complexly faulted horst blocks of Triassic deltaic sediments overdraped by Cretaceous marine beds. The Triassic Mungaroo Beds constitute the reservoir rocks, the source rocks are thought to be mainly the thick Jurassic Dingo Claystone of the adjacent troughs, while caprock seals are provided by Cretaceous lutites.

The Rankin Platform consists of a series of horsts trending northeasterly from the Barrow Sub-basin in the south to the Beagle Sub-basin in the north. Extensive cross-faulting adds greatly to the complexity of the horst structures. The Rankin Platform (or Rankin Trend) is basically similar to the other positive trends in the Dampier Sub-basin, but it differs from them in that its horsts are more elevated and are covered by either a minimal thickness of Jurassic sediments or no Jurassic at all.

BOCAL drilled 15 wells on the Rankin Platform up to the end of 1975 and all have encountered hydrocarbons except Malus No. 1 and Lowendal No. 1. Details of the wells in the Dampier Sub-basin which encountered hydrocarbons are included in Table 2, while the unsuccessful wells are listed below. Reserves in the North Rankin, Goodwyn, and Angel fields are given in Table 8.

While most of the more attractive targets in the Dampier Sub-basin have already been drilled, many targets remain and further discoveries can be expected.

TABLE 7
PETROLEUM WELLS IN THE DAMPIER SUB-BASIN WITHOUT HYDROCARBONS

<u>Well Name</u>	<u>Operator</u>	<u>Total Depth</u>	<u>Bottom formation age</u>
Enderby No. 1	BOCAL	2151.0 m	? Permian
Hampton No. 1	BOCAL	2584 m	?
De Grey No. 1	BOCAL	2087.9 m	Jurassic
Rosemary No. 1	BOCAL	3909.1 m	Lower Jurassic
Legendre No. 2	BOCAL	3618.3 m	Lower Jurassic
Nelson Rocks No. 1	BOCAL	2190 m	?
Dampier No. 1	BOCAL	4141.6 m	Upper Jurassic
Madeleine No. 1	BOCAL	4427.5 m	Jurassic
Lowendal No. 1	BOCAL	3642 m	?
Malus No. 1	BOCAL	3657 m	Upper Triassic

Barrow Sub-basin The Barrow Sub-basin, on trend with the Dampier Sub-basin to the northeast and only partially separated from it by the Rankin-Preston Arch, shows some similarities with the more northerly sub-basin. The major trends of the Dampier Sub-basin are not readily apparent in the Barrow Sub-basin but a northeast structural grain is evident. The Barrow Sub-basin has the form of a broad syncline or half graben, but well and seismic data suggest that most of the elevated structures in the central and western parts of the sub-basin have cores of block-faulted older rocks, similar to the draped horsts of the Dampier Sub-basin. West Tryal Rocks No. 1, like the Rankin Platform wells, encountered hydrocarbons in Late Triassic and Early Jurassic sands of the Mungaroo Beds.

TABLE 8

MAJOR DAMPIER SUB-BASIN RESERVES
(BOCAL, 1973)

FIELD	<u>GAS IN PLACE, in 10³m³</u>				
	Proven	Probable	Proven + Probable	Possible	Total
North Rankin	192,130,845	154,695,771	346,826,616	50,092,773	396,919,389
Goodwyn	37,066,953	68,555,457	105,622,410	72,803,007	178,425,417
Angel	23,673,012	44,372,739	68,045,751	81,977,715	150,023,466
Total	252,870,810	267,623,967	520,494,777	204,873,495	725,368,272

<u>CONDENSATE IN PLACE, in 10⁶bbl</u>					
North Rankin	186.587	150.233	336.820	48.647	385.467
Goodwyn	60.869	112.576	173.445	119.552	292.997
Angel	45.896	86.029	131.925	158.935	290.860
Total	293.352	348.838	642.190	327.134	969.324

As far as source rocks are concerned, the Dingo Claystone is remarkably thick in the Barrow Sub-basin and no well has hitherto passed through it. This Jurassic marine phase merged into the Neocomian deltaic Barrow Formation in which the initial discovery of hydrocarbons in the Barrow Island field was made. As indicated previously, commercial oil production on Barrow Island was from the Aptian Windalia Sand Member.

Although the success ratio for wells in the Barrow Sub-basin has not been as high as in the Dampier Sub-basin, there has been enough encouragement from exploration to date for the central and northwesterly parts of the sub-basin to be rated fairly prospective. Results of wells on the southeastern margin of the sub-basin have so far been disappointing.

The following petroleum wells have been drilled:

TABLE 9
PETROLEUM WELLS IN THE BARROW SUB-BASIN

<u>Well name</u>	<u>Operator</u>	<u>Total Depth</u>	<u>Bottom formation age</u>
<u>Near southeastern margin</u>			
* Flinders Shoal No. 1	WAPET	3616.1 m	Permian
Ripple No. 1	WAPET	2278.7 m	-
Airlie No. 1	WAPET	2218.6 m	Upper Jurassic
Thevenard No. 1	WAPET	2075.7 m	Upper Jurassic
Tortoise No. 1	WAPET	2133.6 m	Jurassic
Anchor No. 1	WAPET	3048.6 m	Lower Jurassic
Long Island no. 1	WAPET	2158.3 m	Middle Triassic
Peak Island No. 1	WAPET	2141.5 m	Upper Jurassic
Muiron No. 1	WAPET	1785.2 m	Jurassic
West Muiron No. 1	WAPET	780.9 m	No information
West Muiron No. 1A	WAPET	345.3 m	No information
West Muiron No. 2	WAPET	3320 m m	No information

Table 9 (Cont'd)

<u>Well name</u>	<u>Operator</u>	<u>Total Depth</u>	<u>Bottom formation age</u>
<u>Median belt</u>			
Trimouille No. 1	WAPET	2435.4 m	Lower Cretaceous
* Flag No. 1	WAPET	3802.4 m	Jurassic
Pepper No. 1	WAPET	2743.2 m	Lower Cretaceous
* Pasco No. 1	WAPET	1900.2 m	Upper Jurassic
Pasco No. 2	WAPET	2442.7 m	Upper Jurassic
Pasco No. 3	WAPET	2452.5 m	Upper Jurassic
<u>Northwestern Area</u>			
Tryal Rocks No. 1	WAPET	3697.5 m	Middle Jurassic
North Tryal Rocks No. 1	WAPET	3657.6 m	Triassic
West Tryal Rocks No. 1	WAPET	3866 m	Triassic
West Tryal Rocks No. 2	WAPET	3825 m	Triassic

* These wells encountered hydrocarbons. See Table 2.

Barrow Island wells

Over 500 wells penetrated to Windalia Sand Member leve, about 50 wells penetrated the top of the Barrow Formation, while only 18 wells penetrated the Upper Jurassic. It is possible that Late Triassic - Early Jurassic sands exist at Barrow Island, but evidence from Barrow Deep No. 1 (T.D. 5085 m) suggests that, if present, they are too deep to be commercially exploitable. Table 10 gives details of Barrow Island field production in 1974 and also cumulative totals (W.A. Mines Department, 1974).

Exmouth Sub-basin The Exmouth Sub-basin can be regarded as a southern extension of the Barrow Sub-basin, the division between the two sub-basins being arbitrarily chosen as the southern limit of the Neocomian Barrow Group. Deposition during and before the Jurassic was probably continuous between the two sub-basins.

TABLE 10
BARROW ISLAND FIELD PRODUCTION*

Reservoir		1974				CUMULATIVE			
		Oil in m ³ and (bbls)	Liquid petroleum ₃ gas in m ³ and (bbls)	Natural gasoline in m ³ and (bbls)	Gas 10 ³ m ³	Oil in m ³ and (bbls)	Liquid petroleum ₃ gas in m ³ and (bbls)	Natural gasoline in m ³ and (bbls)	Gas 10 ³ m ³
Windalla Sand		2 140 642 (13 464 213)	5 101 (32 084)	5 748 (36 155)	133 452	16 361 302 (102 909 320)	9 897 (62 253)	10 832 (68 133)	1 632 512
Muderong Greensand		19 932 (125 371)	0	0	2 904	174 605 (1 098 233)	0	0	26 375
Barrow Formation	5500 ⁺ Sand	0	0	0	0	2 477 (15 580)	0	0	14 621
	6200 ⁺ Sand	0	0	0	0	9 140 (57 489)	0	0	80 926
	6600 ⁺ Sand	11 844 (74 498)	0	0	1 760	59 390 (373 551)	0	0	27 435
	6700 ⁺ Sand	8 089 (50 882)	0	0	8 879	185 859 (1 169 010)	0	0	103 835
Dingo Claystone	10 600 ⁺ Sand	212 (1 334)	0	0	1 805	212 (1 334)	0	0	1 805
	10 900 ⁺ Sand	180 (1 131)	0	0	1 085	180 (1 131)	0	0	1 085
	11 250 ⁺ Sand	219 (1 379)	0	0	10 260	219 (1 379)	0	0	10 260
TOTAL FIELD		2 181 120 (13 718 808)	5 101 (32 084)	5 748 (36 155)	160 145	16 793 384 (105 627 027)	9 897 (62 253)	10 832 (68 133)	1 893 859

* W.A. Mines Department, Annual Report 1974

The onshore portion of the sub-basin is dominated structurally by the large Cape Range anticline, the smaller Rough Range Anticline and the parallel Patterson and Rough Range Faults, all of which trend north-northeasterly. The area has been well tested by drilling, with no commercial success despite the oil flow from the Early Cretaceous Birdrong Sandstone in Rough Range No. 1. The anticlines differ from other hydrocarbon-bearing structures in the Carnarvon Basin in that they resulted from Late Tertiary tectonism, although Thomas and Smith (1974) report that the surface anticline of Barrow Island also has some element of Tertiary growth. In some parts of the Exmouth Sub-basin post-Jurassic erosion has removed the Jurassic altogether, so that Cretaceous sediments rest on the Triassic.

The offshore part of the Exmouth Sub-basin has not been tested by drilling, except for the recently drilled West Muiron structure, which may be partly within the sub-basin. Seismic surveys indicate a thick sedimentary section offshore, deepening to the northwest, and a number of anticlinal structures have been indicated. The occurrence of oil in Rough Range No. 1 suggests that the offshore part of the sub-basin may have some hydrocarbon potential, but the continental shelf in this region is only about 30 km wide and much of the sub-basin is in water more than 200-m deep.

The following petroleum wells have been drilled onshore:

TABLE 11
PETROLEUM WELLS IN THE EXMOUTH SUB-BASIN

<u>Well Name</u>	<u>Operator</u>	<u>Total depth</u>	<u>Bottom formation age</u>
Cape Range No. 1	WAPET	2444.2 m	Middle Jurassic
* Cape Range No. 2	WAPET	4623.8 m	Jurassic
Cape Range No. 3	WAPET	1139. m	Upper Jurassic
Cape Range No. 4	WAPET	1175.9 m	Upper Jurassic
Sandy Point No. 1	WAPET	3045.6 m	Lower Jurassic
Sandy Point No. 2	WAPET	1676.4 m	?
Wingaloo No. 1	WAPET	1228.3 m	?
Learmonth No. 1	WAPET	2327.5 m	Lower Permian
Learmonth No. 2	WAPET	1870.6 m	Triassic (Jurassic absent)

Table 11 (Cont'd)

<u>Well name</u>	<u>Operator</u>	<u>Total depth</u>	<u>Bottom formation age</u>
Paterson No. 1	WAPET	2286 m	Upper Jurassic
Exmouth No. 1	WAPET	536.1 m	Upper Cretaceous
Exmouth No. 2	WAPET	618.4 m	Upper Cretaceous
* Rough Range No. 1	WAPET	4452 m	Devonian
Rough Range No. 1A	WAPET	1114.7 m	Upper Jurassic -
Rough Range Nos 2-10	WAPET	1126.8 m to 1243.3 m	Lower Cretaceous Stepout wells to Birdrong Sandstone
Rough Range South Nos. 1, 3, 4	WAPET	873.6; 579.1; 697.7 m	Cretaceous
Rough Range South No. 5	WAPET	1450.8 m	Permian
Rough Range South No. 6	WAPET	485.9 m	Cretaceous
Whaleback No. 1	WAPET	1528 m	Lower Permian (Middle and Lower Jurassic and Triassic absent)

* these wells encountered hydrocarbons. See Table 2.

Exmouth Plateau The Exmouth Plateau seems on geophysical evidence to be geologically fairly similar to the northern Carnarvon Basin. By analogy there could exist in the area suitable petroleum source rocks (especially Triassic and Neocomian sandstones). The depth of burial may have been adequate for petroleum generation in the source rocks in the pre-Cretaceous sequence.

Many large fault blocks analagous to those of the Rankin Platform appear to exist on the Plateau and if so they are likely to contain Triassic sands cap-sealed by Jurassic and Cretaceous shales. These structures are likely petroleum targets. Other possible targets are stratigraphic traps in a deltaic Jurassic-Neocomian sequence.

Exploration and development in such an area as this, where water depths exceed 800 m and primary targets are more than 200 km from shore, will be costly and difficult, perhaps limiting commercial interest to major hydrocarbon fields and to oil fields rather than gas/condensate fields.

5. FUTURE EXPLORATION REQUIRED

5.1 Geophysical

Aeromagnetic coverage of the Carnarvon Basin is complete except for the Dampier and Beagle Sub-basins and deep water areas such as the Exmouth Plateau. There is a moderately good regional coverage of marine magnetic traverses in the two northerly sub-basins and, because of the advanced state of seismic exploration in those areas, extension of aeromagnetic coverage over the Dampier and Beagle Sub-basins would seem to rate low priority now.

However, aeromagnetic coverage of the deeper water parts of the basin, which have been only sparsely covered by seismic lines, could be a useful prelude to systematic, more detailed seismic exploration of those areas. This is particularly so in the southern portion of the basin where Edel No. 1 well has indicated the presence of volcanics readily detectable by magnetometer within the sedimentary section. Unfortunately, aeromagnetic surveying of the Exmouth Plateau could involve difficult navigational problems because of the great distances from land involved.

The magnetic coverage of the Carnarvon Basin is made up of a large number of separate surveys recorded at different magnetic epochs, with different magnetometer altitudes and other parameters. It would be useful to reprocess existing magnetic data on a common basis to produce a single magnetic intensity map of the basin. Such a map could be expected to show regional trends better than existing data and it would also be useful in resolving conflicts in interpretation between adjacent surveys.

Regional gravity coverage is complete over the onshore part of the Carnarvon Basin and there are considerable areas with semi-detailed cover. Further semi-detailed or detailed gravity work could be useful onshore in helping to solve specific exploration problems, particularly where the quality of seismic data is poorest.

Although Plates 2A and 2B show gravity contours over the offshore areas, offshore data is mostly very sparse. It is to be hoped and expected that gravity recordings made in conjunction with future seismic traverses will provide the necessary fill-in data to upgrade the reliability of offshore gravity contours. Systematic marine gravity surveys, per se, do not appear to be warranted at this stage of exploration of the Carnarvon Basin.

On the other hand further interpretational studies on existing gravity data are warranted. As a first step the available rock density data in the basin could be assembled and collated. Gravity features such as the large positive anomalies near North West Cape and the Rankin Trend should be analysed to determine their depths of origin and hence possible modes of origin.

The degree of seismic coverage within the basin is very variable, varying from very dense in parts of the Dampier Sub-basin to very sparse or non-existent onshore in areas such as the Gascoyne Sub-basin. There is a need for more seismic work in most areas of the basin, although the seismic objectives will vary from providing more detailed mapping to complexly faulted and folded structures with good hydrocarbon potential on the Rankin and Medeleine-Dampier Trends to providing basic reconnaissance information on some onshore areas. Onshore, the difficulties of obtaining useful data require the application of the most modern seismic techniques with maximum effort.

Considering likely prospectivities in various parts of the basin, the priority for further seismic work would seem to be for a semi-detailed grid of traverses on the Exmouth Plateau and the deep water margins of the Dampier, Barrow and Beagle Sub-basins in order to locate possible drilling targets. Any structural leads indicated will of course require further detailing prior to drilling.

5.2 Drilling

There is much scope for further drilling in the Carnarvon Basin, but as prospectivity and intensity of past exploration vary greatly from area to area it is difficult to generalise about future drilling requirements. Decisions to drill future wells will naturally depend on seismic and other evaluation of geological situations and assessment of the economics of exploring in various environments.

Onshore the prospectivities of the various sub-basins are fairly low, but the cost of drilling is low compared with offshore areas and, apart from the North West Cape area, wells are very sparse. There is considerable need for further drilling in the southern, onshore portion of the basin to improve stratigraphic knowledge, particularly where the quality of seismic results is very poor.

Although most of the more obviously attractive structures offshore in water depths of less than 200 m have already been drilled, numerous moderately attractive drilling prospects remain on the continental shelf in the Beagle, Dampier, Barrow and Exmouth Sub-basins, although many of these require better seismic definition. As seismic coverage is extended over the deeper water areas and, as deep water drilling technology and economics improve, drillable prospects in those areas will undoubtedly emerge.

6. CONCLUSIONS

The Carnarvon Basin is a large, disparate Basin which has been explored almost continuously for petroleum since about 1950. Despite WAPET's early apparent success in Rough Range No. 1 well in 1953, exploration onshore has been disappointing and most of the onshore part of the basin must be regarded as having fairly low prospectivity. However, much of the southern Carnarvon Basin onshore is lacking both seismic coverage and drilled holes and it cannot therefore be said to have been adequately explored.

Since the 1960's exploration of the northern, offshore portion of the basin has proceeded steadily, making this one of the most intensely prospected areas in Australia. Significant discoveries have been made at Barrow Island, on the Rankin Platform and elsewhere in the Barrow and Dampier Sub-basins and further discoveries, possibly related to existing finds, may be expected. By contrast, the southern offshore portion of the basin on the continental shelf seems to be less favourable geologically for petroleum accumulation and has been less intensively explored. But as large areas with appreciable sediment thicknesses are devoid of a single well they can scarcely be dismissed as unprospective at this stage.

Reconnaissance geophysical surveys have indicated that deep water areas on the outer margin of the continental shelf and on the Exmouth Plateau hold considerable promise of petroleum prospects for the future.

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APPENDIX 1 (a)

PETROLEUM EXPLORATION WELLS, CARMARVON BASIN

COMPANY Well Name BMR File no. if subsidized	Latitude South Longitude East o ' "	1:250 000 sheet area	Elevation (metres) GL/WD KB/RT	Date spudded TD reached	TD (metres)	Status at 31.12 of year drilled
B.O.C. OF AUSTRALIA LTD (BOCAL)						
Angel No. 1 BMR file 71/617	19 30 20 116 35 48	E50/14	WD 79.8 RT 9.5	12.10.71 12. 1.72	3410.7	Abandoned gas - condensate well
Angel No. 2 BMR file 72/857	19 27 57 116 39 25	E50/14	WD 86.6 RT 9.5	7. 3.72 21. 5.72	4396.7	Abandoned gas - condensate well
Angel No. 3	19 32 30 116 37 43	E50/14	WD 67.1 RT 9.5	27. 4.73 21. 6.73	3779.8	Abandoned gas - condensate well
Cossigny No. 1 BMR File 72/3063	19 19 53 117 17 26	E50/15	WD 112.8 RT 12.5	15.10.72 5.11.72	3203.5	PA (dry hole)
Dampier No. 1 BMR file 68/2052	19 52 21 116 00 49	E50/14	WD 76.2 RT 9.1	22.11.68 9. 4.69	4141.6	Abandoned well with show of oil and gas
De Grey No. 1 BMR file 71/616	19 29 20 117 05 08	E50/15	WD 94.5 RT 29.0	10. 9.71 16.10.71	2087.9	PA (dry hole)
Depuch No. 1 BMR file 73/283	18 50 07 117 55 19	E50/11	WD 134.0 KB 10.0	4. 2.74 30. 3.74	4300.0	PA (dry hole)
Dockrell No. 1	19 47 17 115 46 47	E50/14	WD 110.0 RT 29.9	30. 6.73 17. 8.73	3895.0	Abandoned gas - condensate and oil well
Eaglehawk No. 1 BMR file 73/3177	19 30 30 116 16 37	E50/14	WD 120.4 RT 12.5	10.11.72 14.12.72	3505.2	Abandoned oil well
Egret No. 1 BMR file 72/3357	19 30 23 116 20 50	E50/14	WD 118.9 RT 12.5	24.12.72 16. 5.73	3657.6	Abandoned oil well
Enderby No. 1 BMR file 70/737	20 09 25 116 24 24	F50/2	WD 53.9	10. 9.70 10.10.70	2149.1	PA (dry hole)

COMPANY Well Name BMR file no. if subsidized	Latitude South Longitude East o ' "			1:250 000 sheet area KB/RT	Elevation (metres) GL/AD	Date spudded TD reached	TD (metres)	Status at 31.12 of year drilled
BOCAL cont'd								
Goodwyn No. 1 BMR file 71/732	19 115	41 53	37 44	E50/14	WD 125.6 RT 29.0	22.10.71 25.11.71	3535.7	Abandoned gas - condensate well
Goodwyn No. 2	19 115	39 51	53 53	E50/14	WD 133.5 KB 9.5	27. 3.72 28. 5.72	3750.0	Abandoned gas - condensate well
Goodwyn No. 3	19 115	44 52	09 40	E50/14	WD 118.9 RT 30.2	16.12.72 8. 2.73	3657.6	Abandoned oil and gas well
Goodwyn No. 4	19 115	41 50	38 54	E50/14	WD 129.8 RT 30.2	24. 2.73 7. 6.73	3632.3	Abandoned gas - condensate well
Hampton No. 1	20 116	07 32	05 47	F50/2	WD 50.0 RT 30.0	22. 3.74 23. 4.74	2584.0	Abandoned well with show of gas
Hauy No. 1 BMR file 72/3186	19 117	47 15	39 15	E50/15	WD 65.5 RT 30.2	25.11.72 8.12.72	825.4	PA (dry hole)
Lambert No. 1	19 116	27 29	23 23	E50/14	WD 125.0 KB 10.0	13.11.73 30. 1.74	3700.0	Abandoned oil well
Legendre No. 1 BMR file 68/2016	19 116	40 43	16 57	E50/14	WD 51.8 RT 9.1	7. 6.68 17.11.68	3472.6	Abandoned well with show of oil
Legendre No. 2 BMR file 70/769	19 116	37 46	27 49	E50/14	WD 57.9	16.10.70 16.12.70	3618.3	PA (dry hole)
Lowendal No. 1	19 115	52 38	49 03	E50/14	WD 83.0 RT 30.0	31. 1.74 16. 3.74	3642.0	PA (dry hole)
Madeleine No.1 BMR file 69/2006	19 116	38 21	59 31	E50/14	WD 68.9 RT 9.1	15. 5.69 10.11.69	4427.5	Abandoned well with show of oil and gas
Malus No. 1 BMR file 72/3058	19 115	45 32	16 02	E50/14	WD 85.4 RT 9.8	7.10.72 5.11.72	3657.6	PA (dry hole)

COMPANY Well Name BMR file no. if subsidized	Latitude South Longitude East o ' "			1:250 000 sheet area	Elevation (metres) GL/WD KB/RT	Date spudded TD reached	TD (metres)	Status at 31.12 of year drilled
BOCAL cont'd								
Nelson Rocks No. 1	19 116	33 51	37 19	E50/14	WD 74.9 RT 10.1	30. 6.73 30. 7.73	2189.9	PA (dry hole)
North Rankin No. 1 BMR file 71/254	19 116	35 07	55 30	E50/14	WD 122.2 RT 30.2	3. 5.71 25. 6.71	3533.5	Abandoned gas - condensate well
N. Rankin No. 2	19 116	33 08	54 46	E50/14	WD 126.5 RT 12.5	9. 6.72 1. 8.72	3749.9	Abandoned gas - condensate well
N. Rankin No. 3	19 116	31 10	41 14	E50/14	WD 127.1 RT 29.3	4. 8.72 14. 9.72	4062.5	Abandoned gas - condensate well
N. Rankin No. 4	19 116	35 06	07 42	E50/14	WD 127.1 RT 30.2	30. 9.72 11.11.72	4062.4	Abandoned gas - condensate well
Picard No. 1 BMR file 72/2710	18 117	59 37	00 20	E50/11	WD 140.8 RT 9.5	28. 7.72 23. 9.72	4216.0	PA (dry hole)
Poissonnier No. 1	19 118	18 09	31 20	E50/15	WD 83.0 RT 29.0	20.12.73 22. 1.74	1962.0	PA (dry hole)
Rankin No. 1 BMR file 71/495	19 115	47 44	56 31	E50/14	WD 93.0 RT 9.5	31. 7.71 23. 9.71	4110.5	Abandoned oil and gas - condensate well
Ronsard No. 1 BMR file 72/3330	19 117	08 09	31 39	E50/15	WD 160.0 KB 10.1	12.10.73 11.11.73	2848.1	PA (dry hole)
Rosemary No. 1 BMR file 72/3127	19 116	57 20	16 41	E50/14	WD 65.4 RT 9.5	13.11.72 26. 3.73	3909.1	PA (dry hole)
Sable No. 1 BMR file 72/2770	19 116	14 54	04 59	E50/14	WD 150.9 RT 12.5	21. 8.72 12.10.72	3971.5	PA (dry hole)
Tidepole No. 1	19 115	46 53	07 06	E50/14	WD 110.0 KB 30.5	18.10.75 26.11.75	3491.0	Abandoned oil and gas well

COMPANY Well Name BMR file no. if subsidized	Latitude South Longitude East o ' "			1:250 000 sheet area	Elevation (metres) GL/WD KB/RT	Date spudded TD reached	TD (metres)	Status at 31.12 of year drilled
CONTINENTAL OIL COMPANY OF AUSTRALIA LTD								
Yaringa No. 1 BMR file 66/4215	26 114	03 21	58 35	G50/9	GL 21.3 KB 26.8	2. 7.66 14. 8.66	2290.9	PA (dry hole)
GENOA OIL N.L.								
Pendock ID No. 1 BMR file 69/2020	23 113	17 20	02 10	F49/16	WD 131.1 KB 10.4	18. 7.69 30. 7.69	242.6	PA (dry hole)
Pendock ID No. 1A BMR file 69/2020	23 113	17 20	02 10	F49/16	WD 131.1 KB 10.4	29. 7.69 13.11.69	2501.9	PA (dry hole)
HARTOGEN EXPLORATION PTY LTD								
Bidgemia No. 1	25 115	16 20	00 20	G50/5	GL 201.8 RT 203.3	6.11.72 23.11.72	227.7	PA (dry hole)
Moogooree No. 1	24 115	15 15	20 30	G50/1	GL 271.9 RT 272.4	8.10.72 15.10.72	137.8	PA (dry hole)
Moogooree No. 2	24 115	16 12	50 40	G50/1	GL 276.5 RT 277.1	18.10.72 27.10.72	205.7	PA (dry hole)
Coonga No. 1	21 116	03 01	08 48	F50/6	GL 5.8 RT 7.9	14.12.72 19.12.72	176.5	PA (dry hole)
HEMATITE PETROLEUM PTY LTD								
Cane River No. 1 BMR file 71/751	21 115	40 05	51 54	F50/5	GL 7.7 RT 10.3	29.11.71 9.12.71	694.0	PA (dry hole)
Cane River No. 2	21 115	38 15	13 51	F50/5	GL 4.5 RT 7.3	17.12.71 23.12.71	413.0	PA (dry hole)
Cane River No. 3	21 115	42 19	28 29	F50/5	GL 14.9 RT 17.7	29.12.71 2. 1.72	185.6	PA

6/11/72
11.13
11.13

COMPANY Well Name BMR file no. if subsidized	Latitude South Longitude East ° ' "			1:250 000 sheet area	Elevation (metres) GL/WD KB/RT		Date spudded TD reached	TD (metres)	Status at 31.12 of year drilled
HAEMATITE PETROLEUM PTY LTD cont'd									
Cane River No. 4	21 115	35 33	54 45	F50/6	GL RT	13.1 15.9	16. 1.72 21. 1.72	172.8	BA (dry hole)
Cane River No. 5	21 115	47 28	22 48	F50/5	GL RT	34.1 36.9	8. 1.72 10. 1.72	200.9	PA (dry hole)
Mardie West No. 1	21 115	11 55	56 24	F50/6	GL RT	6.4 8.5	5.12.72 8.12.72	135.3	PA (dry hole)
Surprise No. 1	21 115	17 49	58 27	F50/6	GL RT	9.8 12.8	14.11.72 28.11.72	216.4	Abandoned well with show of gas
Windoo No. 1	21 115	21 46	18 55	F50/6	GL RT	2.1 4.3	17.10.72 22.11.72	218.9	Abandoned well with show of gas
Woorawa No. 1	21 115	21 47	55 33	F50/6	GL RT	13.4 15.9	14. 9.72 27. 9.72	202.4	Abandoned well with show of gas
MARATHON PETROLEUM AUSTRALIA LTD									
Remarkable Hill No. 1 BMR file 68/2050	22 114	57 09	20 20	F50/9	GL KB	106.7 110.9	15.10.68 2. 2.69	3206.5	PA (dry hole)
OCEAN VENTURES PTY LTD									
Edel No. 1 BMR file 72/2074	27 113	06 23	48 23	G49/16	WD KB	92.9 29.6	23. 5.72 21. 7.72	2749.6	PA (dry hole)
OCEANIA PETROLEUM PTY LTD									
Kalbarri No. 1 BMR file 72/3358	27 114	16 06	01 27	G50/13	GL KB	129.2 133.2	11. 9.73 2.10.73	1539.5	PA (dry hole)
Tamala No. 1 BMR file 72/3358	26 113	38 38	48 4	G49/12	GL KB	2.7 7.0	4. 4.73 6. 5.73	1225.3	PA (dry hole)

COMPANY Well Name BMR file no. if subsidized	Latitude South Longitude East o ' "			1:250 000 sheet area	Elevation (metres) GL/WD KB/RT		Date spudded TD reached	TD (metres)	Status at 31.12 of year drilled
OIL SEARCH LTD									
Byro Deep Bore	26 115	04 32	38 22	G50/10	GL 268.2 KB -		1934?	676.0	PA (dry hole)
WEST AUSTRALIAN PETROLEUM PTY LTD (WAPET)									
Airlie No. 1	21 115	19 09	30 55	F50/5	GL 4.9 KB 9.1		11. 9.67 5.10.67	2218.6	PA (dry hole)
Anchor No. 1 BMR file 69/2019	21 114	32 42	51 37	F50/5	WD 18.0 RT 24.4		12. 7.69 28. 8.69	3048.6	PA (dry hole)
Barrow No. 1 BMR file 64/4030	20 115	48 22	58 58	F50/1	GL 51.8 KB 55.2		7. 5.64 4. 8.64	2982.5	Abandoned oil well
Barrow No. 2	20 115	49 22	24 26	F50/1	GL 46.9 KB 50.3		30. 8.64 20.10.64	2328.7	Abandoned oil well
Barrow No. 3	20 115	49 22	24 57	F50/1	GL 45.7 KB 49.1		4.11.64 29.11.64	2209.8	Abandoned oil well
Barrow No. 4	20 115	50 23	16 25	F50/1	GL 30.8 KB 34.1		15.12.64 20. 1.65	2382.3	Abandoned oil well
Barrow No. 5	20 115	48 23	05 26	F50/1	GL 65.8 KB 69.2		12. 2.65 16. 3.65	2252.5	Abandoned oil well
Barrow No. 6	20 115	48 23	58 24	F50/1	GL 61.6 KB 64.9		1. 4.65 12. 5.65	2354.9	Abandoned oil well
Barrow No. 7	20 115	43 25	57 16	F50/1	GL 45.7 KB 49.1		18. 5.65 16. 6.65	2439.0	Abandoned oil well
Barrow No. 8	20 115	48 23	58 50	F50/1	GL 63.7 KB 67.1		8. 7.65 4. 8.65	2255.8	Abandoned oil well

COMPANY Well Name BMR file no. if subsidized	Latitude South Longitude East o ' "			1:250 000 sheet area	Elevation (metres) GL/WD KB/RT		Date spudded TD reached	TD (metres)	Status at 31.12 of year drilled
WAPET cont'd									
Barrow No. 9	20 115	51 24	38 53	F50/1	GL 14.0 KB 17.4		18. 8.65 23. 9.65	2432.6	Abandoned oil well
Barrow No. 10	20 115	49 24	54 52	F50/1	GL 36.0 KB 39.3		25. 9.65 8.10.65	749.8	Abandoned oil well
Barrow No. 11	20 115	50 22	42 29	F50/1	GL 34.4 KB 37.8		10.10.65 19.10.65	695.2	Abandoned oil well
Barrow No. 12	20 115	49 24	00 49	F50/1	GL 50.0 KB 53.3		22.10.65 31.10.65	781.5	Abandoned oil well
Barrow No. 13	20 115	49 21	47 32	F50/1	GL 38.7 KB 42.1		2.11.65 8.11.65	718.1	Abandoned oil well
Barrow No. 14	20 115	48 22	58 26	F50/1	GL 51.2 KB 54.6		10.11.65 17.11.65	723.6	Abandoned oil well
Barrow No. 15	20 115	51 21	10 34	F50/1	GL 26.5 KB 29.9		18.11.65 22.11.65	686.1	Abandoned oil well
Barrow No. 16	20 115	51 20	31 39	F50/1	GL 20.1 KB 23.5		28.11.65 3.12.65	731.2	Abandoned oil well
Barrow No. 17	20 115	49 20	00 39	F50/1	GL 28.7 KB 32.0		5.12.65 11.12.65	948.2	Abandoned oil well
Barrow No. 18	20 115	48 26	57 12	F50/1	GL 18.6 KB 21.9		13.12.65 22.12.65	799.5	Abandoned dry observation well
Barrow No. 19	20 115	47 22	13 30	F50/1	GL 42.4 KB 43.0		2. 1.66 10. 1.66	749.5	Abandoned oil well
Barrow No. 20	20 115	47 24	37 51	F50/1	GL 33.2 KB 36.6		12. 1.66 19. 1.66	751.3	Abandoned oil well

COMPANY Well Name BMR file no. if subsidized	Latitude South Longitude East o ' "			1:250 000 sheet area	Elevation (metres) GL/WD KB/RT		Date spudded TD reached	TD (metres)	Status at 31.12 of year drilled
WAPET cont'd Barrow No. 21	20 115	50 20	19 11	F50/1	GL 29.0 KB 32.3		22. 1.66 27. 1.66	742.2	Abandoned oil well
Barrow No. 22	20 115	51 23	09 27	F50/1	GL 15.2 KB 18.6		2. 2.66 9. 2.66	825.7	Abandoned oil well
Barrow No. 23	20 115	45 23	55 53	F50/1	GL 57.6 KB 61.0		15. 2.66 20. 2.66	786.4	Abandoned oil well
Barrow No. 24	20 115	48 22	30 30	F50/1	GL 51.5 KB 54.9		24. 2.66 25. 3.66	2240.0	Abandoned oil well
Barrow No. 25	20 115	40 26	17 19	F50/1	GL 16.2 KB 19.5		12. 4.66 17. 5.66	2534.1	PA
Barrow No. 26	20 115	43 25	41 32	F50/1	GL 52.1 KB 55.8		21. 5.66 15. 6.66	2400.3	Abandoned gas well
Barrow No. 27	20 115	49 23	24 28	F50/1	GL 66.1 KB 69.5		5. 7.66 22. 7.66	2226.3	Abandoned gas well
Barrow No. 28	20 115	48 23	45 12	F50/1	GL 57.3 KB 60.7		5. 8.66 25. 8.66	2133.6	Abandoned oil well plugged back to 708.7m
Barrow development wells are not included									
Barrow Deep No. 1 BMR file 72/2862	20 115	50 22	07 58	F50/1	GL 38.4 KB 46.6		16. 9.72 19. 6.73	4650.0	Abandoned gas well
Beagle No. 1 (Core hole)	21 115	11 38	50 00	F50/5	GL 4.6 RT 6.1		31. 5.69 16. 6.69	559.3	PA (dry hole)
Biggada No. 1	20 115	48 23	35 11	F50/1	GL 50 RT 58		20. 6.75 29.11.75	3624.0	Abandoned gas well

COMPANY Well Name BMR file no. if subsidized	Latitude South Longitude East o ' "			1:250 000 sheet area	Elevation (metres) GL/WD KB/RT	Date spudded TD reached	TD (metres)	Status at 31.12 of year drilled
WAPET cont'd								
Cape Cuvier No. 1	24 113	13 23	30 44	G49/4	GL 71.9 KB 73.2	16. 7.55 5. 9.55	457.2	PA (dry hole)
Cape Range No. 1	22 114	03 00	57 32	F50/9	GL 147.2 KB 150.0	2. 9.54 27.12.54	2444.2	PA (dry hole)
Cape Range No. 2	22 113	05 59	50 41	F49/12	GL 281.6 KB 285.3	20. 4.55 14. 4.56	4629.0	PA (dry hole)
Cape Range No. 3A	22 113	08 59	43 54	F49/12	GL 266.7 KB 269.4	14. 7.56 - - .56	1139.0	PA (dry hole)
Cape Range No. 4	22 113	19 56	26 09	F49/12	GL 130.8 KB 133.5	21. 9.56 10.10.56	1175.9	PA (dry hole)
Chargoo No. 1	23 113	35 55	52 49	F49/16	GL 26.5 KB 27.7	14-20.10.67	427.9	*
Cunahoo No. 1 BMR file 72/53	22 114	00 53	48 47	F50/9	GL 12.2 RT 15.2	22. 3.72 31. 3.72	797.4	PA (dry hole)
Director Island No. 1 (Core Hole)	21 115	32 07	03 42	F50/5	GL 4.6 RT 6.1	26. 4.68 6. 5.68	672.7	PA (dry hole)
Dirk Hartog No. 1	25 113	43 03	15 05	G49/8	GL - KB 3.0	1955	338.3	*
Dirk Hartog No. 2	25 113	44 00	10 45	G49/8	GL - KB 18.0	1955	256.0	*
Dirk Hartog No. 3	25 112	45 58	10 20	G49/8	GL - KB 27.4	1955	272.8	*

COMPANY Well Name BMR file no. if subsidized	Latitude South Longitude East o ' "			1:250 000 sheet area	Elevation (metres) GL/WD KB/RT		Date spudded TD reached	TD (metres)	Status at 31.12 of year drilled
WAPET cont'd									
Dirk Hartog No. 4	25 113	42 00	00 20	G49/8	GL - KB 37.5		1955-56	457.2	*
Dirk Hartog No. 5	25 113	45 01	40 50	G49/8	GL - KB 47.2		1956	281.6	*
Dirk Hartog No. 6	25 113	47 02	40 00	G49/8	GL - KB 37.8		1956	304.8	*
Dirk Hartog No. 7	25 113	46 04	10 30	G49/8	GL - KB -		1956	81.7	*
Dirk Hartog No. 7A	25 113	46 04	40 50	G49/8	GL - KB 18.0		1956	274.3	*
Dirk Hartog No. 8	25 112	48 58	25 50	G49/8	GL - KB 57.6		1956	237.1	*
Dirk Hartog No. 8A	25 112	48 58	25 50	G49/8	GL - KB 57.6		1956	364.5	*
Dirk Hartog No. 9	25 113	52 06	25 15	G49/8	GL - KB 2.4		1956	54.9	*
Dirk Hartog No. 9A	25 113	52 06	25 15	G49/8	GL - KB 2.4		1956	257.6	*
Dirk Hartog No. 10	25 113	56 09	50 20	G49/8	GL - KB 3.0		1956	267.0	*
Dirk Hartog No. 11	25 113	57 07	20 35	G49/8	GL - KB 7.0		1956	249.0	*
Dirk Hartog No. 12	25 113	57 06	45 05	G49/8	GL - KB 17.1		1956	277.4	*

COMPANY Well Name BMR file no. if subsidized	Latitude South Longitude East o ' "			1:250 000 sheet area	Elevation (metres) GL/WD KB/RT		Date spudded TD reached	TD (metres)	Status at 31.12 of year drilled
WAPET cont'd									
Dirk Hartog No. 13	26 113	02 01	00 00	G49/8	GL - KB 2.7		1956	297.2	*
Dirk Hartog No. 14	25 113	53 08	25 45	G49/8	GL - KB 31.4		1956	297.2	*
Dirk Hartog No. 15	25 113	53 02	27 02	G49/8	GL - KB 34.1		1956	321.0	*
Dirk Hartog No. 16	25 113	49 06	22 21	G49/8	GL - KB 1.2		1956	259.1	*
Dirk Hartog No. 17	25 113	51 04	00 00	G49/8	GL - KB 1.2		1956	259.1	*
Dirk Hartog No. 17A	25 113	51 04	49 43	G49/8	GL - KB 89.9		1956	164.9	*
Dirk Hartog No. 17B	25 113	51 04	58 40	G49/8	GL 87.2 KB 89.9		18. 2.57 - .- .57	1523.4	PA (dry hole)
East Marilla No. 1 BMR file 72/960	22 114	54 36	48 58	F50/9	GL 59.1 RT 62.2		15. 4.72 25. 4.72	638.3	PA (dry hole)
Exmouth No. 1	22 114	33 06	01 38	F50/9	GL - KB 14.6		1956	536.1	*
Exmouth No. 2	22 114	21 08	25 17	F50/9	GL KB 20.7		1956	618.4	*
Flacourt No. 1	20 115	44 22	44 40	F50/1	GL 50.3 RT 53.3		8. 6.68 13. 6.68	816.9	Abandoned oil well
Flag No. 1	20 115	27 38	55 45	F50/2	WD 36.6 RT 23.2		2. 9.69 30. 1.70	3802.7	Abandoned well with show of gas

COMPANY Well Name BMR file no. if subsidized	Latitude South Longitude East o ' "			1:250 000 sheet area	Elevation (metres) GL/ TD KB/RT		Date spudded TD reached	TD (metres)	Status at 31.12 of year drilled
WAPET cont'd									
Flinders Shoal No. 1	21 115	04 31	16 18	F50/6	WD 14.9 RT 25.9		10. 4.69 9. 7.69	3616.1	Abandoned well with show of gas
Fortescue No. 1 (Core Hole)	21 115	01 51	05 17	F50/6	GL 4.6 RT 6.1		20. 6.69 26. 6.69	609.6	PA (dry hole)
Giralia No. 1	22 114	59 14	35 20	F50/13	GL 109.7 KB 112.5		3. 6.55 20. 7.55	1243.6	PA (dry hole)
Glenroy (W.A.) No. 1	21 114	49 52	05 28	F50/5	GL 3.0 KB 4.6		19.10.66 28.10.66	648.3	PA (dry hole)
Gnaraloo No. 1	23 113	40 47	38 28	F49/16	GL 46.3 KB 47.9		30.10.67 10.11.67	501.7	*
Grierson No. 1	24 113	12 46	00 20	G49/4	GL - KB 11.9		1955	438.0	*
Grierson No. 2	24 113	12 47	00 05	G49/4	GL - KB 4.3		1955	450.5	*
Grierson No. 3	24 113	12 45	02 30	G49/4	GL - KB 1.5		1955	442.0	*
Hilda No. 1	21 114	12 38	01 2	F50/5	WD 144.0 KB 12.0		10. 3.74 28. 4.74	1546.0	PA (dry hole)
Hilda No. 1A	21 114	12 38	00 13	F50/5	WD 139.0 KB 19.0		28. 4.74 23. 9.74	3466.0	Abandoned well with show of oil and gas
Hope Island No. 1 BMR file 68/2003	22 114	09 28	34 35	F50/9	GL 4.9 RT 9.1		26. 2.68 13. 3.68	1426.5	PA (dry hole)

COMPANY Well Name BMR file no. if subsidized	Latitude South Longitude East o ' "			1:250 000 sheet area	Elevation (metres) GL/WD KB/RT	Date spudded TD reached	TD (metres)	Status at 31.12 of year drilled
WAPET cont'd								
Kennedy Range No. 1 BMR file 66/4235	24 114	29 59	50 19	G50/1	GL 295.0 KB 298.7	1.12.66 19. 1.67	2226.6	PA (dry hole)
Learthmonth No. 1	22 114	10 03	58 31	F50/9	GL 20.1 KB 22.9	24. 9.57 6. 2.58	2327.5	PA (dry hole)
Learthmonth No. 2 BMR file 63/1327	22 114	17 03	35 48	F50/9	GL 21.9 KB 25.3	22. 1.64 29. 2.64	1870.6	PA (dry hole)
Locker No. 1 BMR file 67/4253	21 114	43 45	16 35	F50/5	GL 2.7 KB 4.3	6. 6.67 9. 7.67	765.7	*
Long Island No. 1 BMR file 66/4217	21 114	37 41	10 10	F50/5	GL 4.9 KB 9.1	21. 9.66 31.10.66	2158.3	PA (dry hole)
Mangrove Island No. 1 (Core Hole)	21 115	14 46	22 04	F50/6	GL 4.6 RT 6.1	6. 6.68 14. 6.68	285.9	PA (dry hole)
Mardie No. 1	21 115	21 42	14 23	F50/6	GL 4.9 KB 6.4	20. 7.67 16. 8.67	221.9	*
Mardie No. 2 (Core Hole)	21 115	20 43	42 28	F50/6	GL 6.1 RT 7.9	7. 5. 69 12. 5.69	164.9	PA (dry hole)
Mardie No. 1A (Core Hole)	21 115	21 42	19 30	F50/6	GL 6.7 RT 9.4	21.11.74 3.12.74	164.3	Abandoned well with show of gas
Marilla No. 1 BMR file 63/1200	22 114	55 30	45 00	F50/9	GL 47.2 KB 48.8	17. 3.63 3. 4.63	456.6	*
Mary Anne No. 1 (Core Hole)	21 115	17 30	55 04	F50/5-6	GL 4.6 RT 6.1	12. 5.68 20. 5.68	533.4	PA (dry hole)

COMPANY Well Name BMR file no. if subsidized	Latitude South Longitude East o ' "			1:250 000 sheet area	Elevation (metres) GL/WD KB/RT	Date spudded TD reached	TD (metres)	Status at 31.12 of year drilled
WAPET cont'd								
Merlinleigh No. 1	24 114	29 59	48 15	G50/1	GL 290.2 KB 292.0	18-26. 5.66	304.8	*
Merlinleigh No. 2	24 114	28 59	45 27	G50/1	GL 292.9 KB 294.4	30. 5.66 15. 6.66	306.3	*
Merlinleigh No. 3	24 114	29 59	08 53	G50/1	GL 293.8 KB 295.4	30. 6.66 6. 7.66	166.1	*
Merlinleigh No. 4	24 114	29 58	08 57	G50/1	GL 289.6 KB 291.1	6-10. 7.66	135.6	*
Merlinleigh No. 5	24 114	28 59	27 07	G50/1	GL 290.2 KB 291.7	14-18. 7.66	175.3	*
Minderoo No. 1 BMR file 63/1200	21 115	50 04	40 40	F50/5	GL 10.7 KB 12.2	9-27. 4.63	609.6	*
Muiron No. 1 BMR file 67/4259	21 114	39 21	04 18	F50/5	GL 4.9 KB 9.1	1.12.67 24.12.67	1785.2	PA (dry hole)
Mulyery No. 1 (Core Hole)	21 115	18 47	26 48	F50/6	GL 4.6 RT 6.1	11. 1.68 18. 1.68	139.6	PA (dry hole)
Ningaloo No. 1	22 113	34 46	25 40	F49/12	GL 114.3 RT 107.9	18. 3.71 5. 4.71	1228.3	PA (dry hole)
North Sandy Island No. 1 (Core Hole)	21 115	06 38	25 56	F50/6	GL 4.6 RT 6.1	24. 5.68 1. 6.68	609.6	PA (dry hole)
North Tryal Rocks No. 1 BMR file 72/2069	19 115	59 19	18 11	E50/13	WD 106.7 RT 12.1	3. 6.72 28. 7.72	365.6	Abandoned well with show of gas

COMPANY Well Name BMR file no. if subsidized	Latitude South Longitude East o ' "			1:250 000 sheet area	Elevation (metres) GL/WD KB/RT		Date spudded TD reached	TD (metres)	Status at 31.12 of year drilled
WAPET cont'd									
Observation No. 1 BMR file 67/4275	21 114	44 32	28 12	F50/5	GL KB	4.9 9.1	1. 1.68 12. 2.68	2289.0	PA (dry hole)
Onslow No. 1 BMR file 66/4218	21 114	45 52	56 17	F50/5	GL KB	0.0 4.9	1. 9.66 8.11.66	2997.7	PA (dry hole)
Pasco No. 1	20 115	58 19	19 30	F50/1	GL KB	7.6 11.9	20. 4.67 25. 5.67	1898.9	Abandoned oil well
Pasco No. 2	20 115	57 19	41 20	F50/1	GL KB	3.7 7.9	31. 5.67 - . 6.67	112.8	PA (dry hole)
Pasco No. 2A	20 115	57 19	51 20	F50/1	GL KB	3.7 7.9	11. 6.67 19. 7.67	2441.1	PA (dry hole)
Pasco No. 3	20 115	58 19	05 52	F50/1	GL KB	10.1 15.2	24. 7.67 16. 8.67	2450.9	Abandoned oil and gas well
Paterson No. 1 BMR file 63/1211	22 113	27 55	34 56	F49/12	GL KB	97.5 100.9	8.11.63 14. 1.64	2286.0	PA (dry hole)
Peak No. 1 BMR file 67/4260	21 114	36 30	17 22	F50/5	GL KB	4.9 9.1	17.10.67 23.11.67	2141.5	PA (dry hole)
Peedamulla No. 1 (Core Hole)	21 115	24 37	26 50	F50/6	GL RT	5.5 7.0	24.12.67 7. 1.68	328.3	PA (dry hole)
Pepper No. 1	21 115	03 18	29 05	F50/5	WD KB	7.6 27.4	13. 3.70 3. 5.70	2743.2	Abandoned well with show of gas
Quail No. 1 BMR file 63/1010	23 114	57 29	04 57	F50/13	GL KB	114.6 118.3	19. 5.63 16. 1.64	3580.5	PA (dry hole)

COMPANY Well Name BMR file no. if subsidized	Latitude South Longitude East o ' "			1:250 000 sheet area	Elevation (metres) GL/WD KB/RT		Date spudded TD reached	TD (metres)	Status at 31.12 of year drilled
WAPET cont'd									
Ripple Shoals No. 1	21 115	07 24	10 03	F50/5	WD 7.9 KB 24.1		6. 2.70 4. 3.70	2278.7	PA (dry hole)
Rough Range No. 1	22 144	25 04	07 54	F50/9	GL 56.7 KB 60.7		5. 9.53 - .- .54	4452.2	Abandoned oil well
Rough Range No. 1A	22 114	25 04	06 55	F50/9	GL - KB 70.7		1954	1114.7	Abandoned oil well
Rough Range No. 2	22 114	25 04	50 05	F50/9	GL 94.8 KB 97.5		4. 7.54 8. 8.54	1243.3	PA (dry hole)
Rough Range No. 3	22 114	24 05	40 09	F50/9	GL 61.3 KB 64.0		15. 9.54 12.10.54	1193.3	PA (dry hole)
Rough Range No. 4	22 114	25 04	23 54	F50/9	GL 59.7 KB 62.5		16.10.54 3.11.54	1146.0	PA (dry hole)
Rough Range No. 5	22 114	25 04	07 33	F50/9	GL 71.9 KB 74.4		10.11.54 26.11.54	1149.7	PA (dry hole)
Rough Range No. 6	22 114	25 04	13 49	F50/9	GL 60.4 KB 62.8		1954 1955	1126.8	PA (dry hole)
Rough Range No. 7	22 114	26 04	40 06	F50/9	GL 86.0 KB 88.4		1955	1240.5	PA (dry hole)
Rough Range No. 8	22 114	26 03	46 44	F50/9	GL 102.4 KB 105.2		1955	1194.5	PA (dry hole)
Rough Range No. 9	22 114	26 04	50 22	F50/9	GL 51.2 KB 53.6		1955	1171.7	PA (dry hole)
Rough Range No. 10	22 114	25 05	05 02	F50/9	GL 61.0 KB 66.4		1957	1139.6	PA (dry hole)

COMPANY Well Name BMR file no. if subsidized	Latitude South Longitude East o ' "			1:250 000 sheet area	Elevation (metres) GL/WD KB/RT	Date spudded TD reached	TD (metres)	Status at 31.12 of year drilled
WAPET cont'd								
Rough Range South No. 1	22 113	37 57	17 38	F49/12	GL 85.0 KB 87.8	1956	873.6	*
Rough Range South No. 2	22 114	23 00	48 20	F50/9	GL 79.2 KB 82.0	1956	464.2	*
Rough Range South No. 3	22 114	30 02	09 29	F50/9	GL 56.1 KB 58.8	1956	579.1	*
Rough Range South No. 4	22 114	32 01	00 28	F50/9	GL 67.4 KB 70.1	1956	697.7	*
Rough Range South No. 5	22 113	34 59	25 16	F49/12	GL 106.4 KB 108.8	1956	1450.8	*
Rough Range South No. 6	22 114	32 00	22 42	F50/9	GL 96.6 KB 99.4	1956	485.9	*
Sandy Point No. 1	22 113	25 47	52 47	F49/12	GL 111.6 RT 115.2	30.11.67 29. 1.68	3045.2	PA (dry hole)
Sandy Point No. 2	22 113	22 50	18 42	F49/12	GL 100.9 RT 104.9	17. 4.71 6. 5.71	1676.4	PA (dry hole)
Sholl Island No. 1	20 115	57 53	00 50	F50/2	GL 4.9 KB 9.1	7. 1.67 31. 1.67	1271.6	PA (dry hole)
Stokes Point No. 1	20 115	52 22	55 55	F50/1	GL 17.4 RT 21.6	9. 5.68 15. 6.68	2484.1	PA (dry hole)
Thevenard No. 1	21 115	27 01	45 05	F50/5	GL 4.9 RT 9.1	28. 3.68 28. 4.68	2075.7	PA (dry hole)

COMPANY Well Name BMR file no. if subsidized	Latitude South Longitude East o ' "			1:250 000 sheet area	Elevation (metres) GL/WD KB/RT		Date spudded TD reached	TD (metres)	Status at 31.12 of year drilled
WAPET cont'd									
Tortoise No. 1 BMR file 66/4229	21 114	35 51	08 11	F50/5	GL KB	4.9 9.1	14.11.66 13.12.66	2133.6	PA (dry hole)
Trimouille No. 1	20 115	24 34	11 09	F50/2	GL KB	4.9 9.1	12. 2.67 15. 3.67	2435.4	PA (dry hole)
Trimouille No. 1A	50' E of No. 1			F50/2	GL KB	4.9 9.1	21. 3.67 3. 4.67	685.8	PA (dry hole)
Trimouille No. 1B	960'SE of No. 1			F50/2	GL KB	4.9 9.1	20. 5.67 2. 6.67	228.6	PA (dry hole)
Tryal Rocks No. 1	20 115	24 09	42 07	F50/1	WD KB	152.0 -	17. 5.70 16. 8.70	3695.1	PA (dry hole)
Urala No. 1	21 114	49 43	06 22	F50/5	GL RT	2.1 3.7	15. 9.68 7.10.68	762.0	PA (dry hole)
Wandagee No. 1 BMR file 62/1215	23 114	53 23	15 51	F50/13	GL KB	68.6 71.3	25. 4.62 12. 6.62	1073.2	*
Wandagee Corehole No. 1	23 114	53 23	15 51	F50/13	GL KB	68.6 71.3	6. 1.62 14. 1.62	219.8	*
Wandagee Corehole No. 2	23 114	53 31	13 38	F50/13	GL KB	- 103.0	16-25. 1.62	308.8	*
Wandagee Corehole No. 3	23 114	49 20	43 03	F50/13	GL KB	55.8 -	30. 1.62 2. 2.62	222.5	*
Warroora No. 1	23 113	30 52	30 48	F49/16	GL KB	26.2 29.0	1955	1826.4	PA (dry hole)

COMPANY Well Name BMR file no. if subsidized	Latitude South Longitude East o ' "			1:250 000 sheet area	Elevation (metres) GL/WD KB/RT	Date spudded TD reached	TD (metres)	Status at 31.12 of year drilled
WAPET cont'd								
West Muiron No. 1 BMR file 72/2738	21 114	34 14	34 40	F50/5	WD 140.2 RT 6.1	16. 8.72 29. 9.72	780.9	PA (dry hole)
West Muiron No. 1A BMR file 72/2738	21 114	34 14	44 45	F50/5	WD 63.1 RT 12.2	5.10.72 19.10.72	345.3	PA (dry hole)
West Muiron No. 2	21 114	35 13	39 31	F50/5	WD 61.6 KB	9. 8.75 10.10.75	3320.0	PA (dry hole)
West Tryal Rocks No. 1 BMR file 72/3108	20 115	13 02	45 04	F50/1	WD 137.8 RT 12.2	23.10.72 4. 3.73	3866.4	Abandoned gas - condensate well
West Tryal Rocks No. 2	20 115	12 03	55 58	F50/1	WD 126 RT 12	1.10.74 25.11.74	3825	Abandoned gas - condensate well
Whaleback No. 1 BMR file 63/1319	22 113	43 51	35 37	F49/12	GL 53.9 KB 57.0	30. 7.63 21.10.63	1528.0	PA (dry hole)
Windoo No. 1A	21 115	21 40	18 55	F50/6	GL 5.8 RT 7.9	8.12.74 5.12.74	174.3	Abandoned well with show of gas
Wonangarra No. 1 (Core hole)	22 114	09 41	03 20	F50/9	GL 6.1 RT 7.9	21. 4.69 2. 5.69	575.5	PA (dry hole)
Yanrey No. 1	22 114	15 34	16 57	F50/9	GL 13.7 KB 16.5	1957	439.7	*
Yarraloola No. 1	21 115	23 45	07 52	F50/6	GL 15.2 KB 16.8	27.11.67 19.12.67	271.9	*

BMR STRATIGRAPHIC HOLES, CARNARVON BASIN

APPENDIX 1 (b)

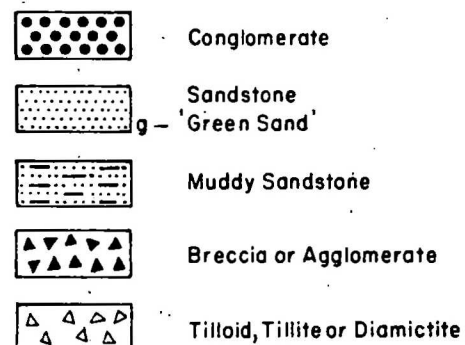
Strat. hole name	Latitude South Longitude East			1:250 000 sheet area	Elevation (metres)		Date spudded T.D. reached	T.D.(metres)	Reference
	o	'	"		GL	KB			
BMR No. 5 (Giralia)	22 114	39 14	25 25	F50/9	GL 74.1 KB 75.6		26. 6.58 31. 7.58	630.9	BASTIAN, L.U. & WILLMOTT, S.P., 1965 - Bur. Miner. Resour. Aust. Rep. 84, 1-17.
BMR No. 6 (Muderong)	24 114	05 46	55 30	G50/1	GL 173.7 KB 175.3		10. 8.58 19. 8.58	305.4	PERRY, W.J., 1965 - Bur. Miner. Resour. Aust. Rep. 81, 1-16
BMR No. 7 (Muderong)	24 114	05 46	55 30	G50/1	GL 173.7 KB 175.3		21. 8.58 14. 9.58	602.6	PERRY, W.J., 1965 - Bur. Miner. Resour. Aust. Rep. 81, 1-16
BMR No. 8 (Mt Madeline)	25 115	44 40	50 40	G50/6	GL 243.8 KB 245.4		25. 5.59 12. 7.59	915.6	MERCER, C.R., 1967 - Bur. Miner. Resour. Aust. Rep. 37, 114.
BMR No. 9 (Daurie Creek)	25 115	32 52	20 50	G50/6	GL 274.3 KB 275.8		16. 7.59 12. 8.59	700.7	MERCER, C.R., 1967 - Bur. Miner. Resour. Aust. Rep. 108, 1-19 (Figs.1,3,4, & Plate 2).

Elevation
GL - Ground level
WD - Water depth
KB - Kelly bushing
RT - Rotary table

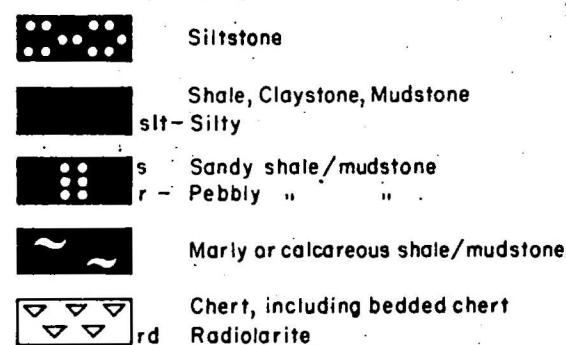
Status
* - Petroleum exploration wells drilled
for stratigraphic purposes
PA - Plugged and abandoned.
"Abandoned" includes wells that have been
secured, suspended or plugged for possible
re-entry.

CLASTIC SEDIMENTS

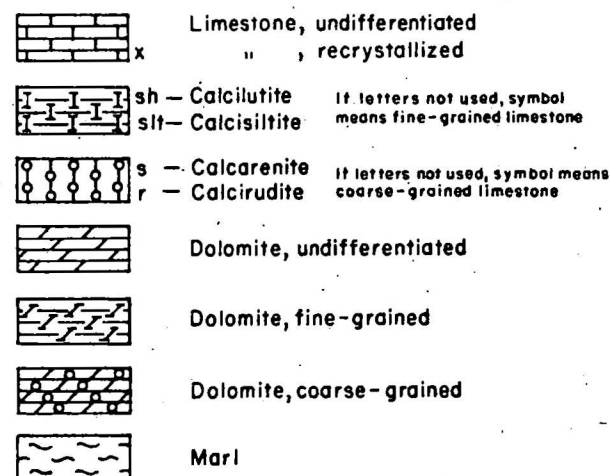
Coarse-Grained



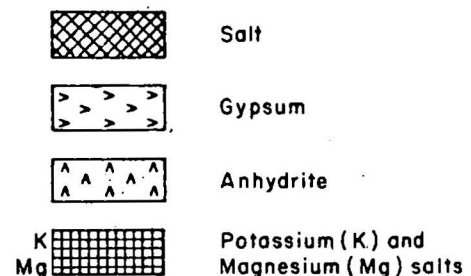
Fine-Grained



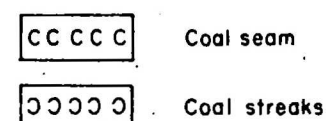
CARBONATES



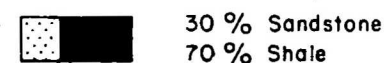
EVAPORITES



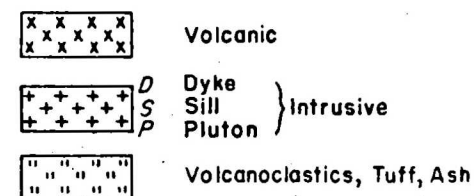
COAL



INTERBEDDED ROCKS



IGNEOUS ROCKS



METAMORPHIC ROCKS



Disconformity

Unconformity

Erosion surface

Normal fault
(in composite section)

Thrust or
reverse fault
(in composite section)

Bauxite

Phosphate

Lignite

Coal streaks

Coal seam

Asphalt

Bitumen

Surface section

Subsurface section

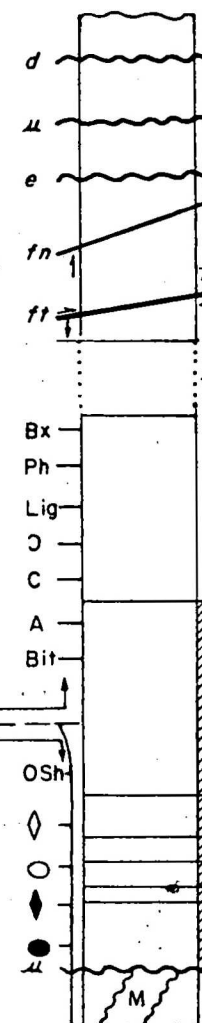
Oil Shale

Gas show

Oil show

Gas

Oil



Dots indicate concealed section

Vertical line indicates stratotype

Fossil indicating fresh water environment
(including subaerial fossil-plants, vertebrates etc.)

Fossil indicating brackish water environment

slt - rock grain size

Fossil indicating marine environment

Hatching indicates marine sediments

Euxinic shales, etc. etc.

Numbers indicate fossils critical for
correlation either between localities
or with time scale, and refer to a
list of names elsewhere on the sheet

APPENDIX 2
GEOPHYSICAL SURVEYS

Magnetic surveys

Survey Name & Type	Map Key Number (Plates 3A, 3B)	Year	Operator	Contractor	Survey Altitude	Traverse Spacing km	Total Traverse Length km	Reference
Carnarvon Basin airborne surveys	1	1956	BMR	-	500'	1.6		BMR Record 1957/9
	2	1957	"	-	"	"		BMR Record 1960/132
	3	1959	"	-	"	"		BMR Record 1961/56
	4	1961	"	-	"	"		BMR Record 1962/191
West Carnarvon aeromagnetic	5	1965	Tasman Oil	Adastra Hunting Geophysics	1500'	1.6-10	8200	PSSA 65/4615
Offshore Onslow aeromagnetic	6	1967	WAPET	Adastra Hunting Geophysics	1000'	1.6-6.5	3900	PSSA 67/4628
Offshore Bernier aeromagnetic	7	1969	WAPET	Hunting Geology and Geophysics	1000'	2.4-13	4400	PSSA 69/3031
NW Continental Shelf marine geophysical	8	1968	BMR	Compagnie Generale de Geophysique	"	20	25000	BMR Record 1969/99
Offshore West Beagle aeromagnetic	9	1969	WAPET	Hunting Geology and Geophysics	?	3.2	4500	PSSA 69/3050
Geelvink Channel marine seismic and magnetic	10	1970	BP Petroleum Development Australia	Geophysical Services International (GSI)	Sea Level	6-14	1430	PSSA 70/241
Bernier Marine Seismic and magnetic	11	1971	Ocean Ventures	Western Geophysical	"	7-25	1420	PSSA 71/722
Houtman marine seismic magnetic gravity	12	1971	WAPET	GSI	"	6-12	360	P(SL)A 71/13
SW Cape marine seismic magnetic gravity	13	1971	WAPET	GSI	"	-	105	P(SL)A 71/18
Offshore Australia marine seismic, magnetic and gravity	13A	1971	Shell Development (Australia)	Seismograph Service (Marine)	"	-	8005	P(SL)A 71/19

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Magnetic surveys contd.

Survey Name & Type	Map Key Number (Plates 3A, 3B)	Year	Operator	Contractor	Survey Altitude	Traverse Spacing km	Total Traverse Length km	Reference
Quoin Head marine seismic and magnetic	14	1972	Ocean Ventures	Western Geophysical	Sea Level	6-20	1010	P(SL)A 72/4
Naturaliste marine seismic and magnetic	15	1972	Ocean Ventures	GSI	"	4-12	76	P(SL)A 72/5
Tamala Detail marine seismic and magnetic	16	1972	Ocean Ventures	GSI	"	13	84	P(SL)A 72/6
Gulf regional reconnaissance seismic, magnetic and gravity	17	1972	Australian Gulf Oil	Gulf Oil	"	-	5200	P(SL)A 72/9
Murchison marine seismic and magnetic	18	1972	Ocean Ventures	GSI	"	6	560	P(SL)A 72/16
Kalbarri marine seismic and magnetic	19	1972	Ocean Ventures	GSI	"	4-10	230	P(SL)A 72/18
Zeevyk marine seismic and magnetic	20	1972	BP Petroleum Development Australia	Western Geophysical	"	4-6	120	P(SL)A 72/23
Alpha marine seismic and magnetic	21	1972	WAPET	GSI	"	10-20	770	P(SL)A 72/24
Yardie-Barrow marine seismic and magnetic	22	1972	WAPET		"	5-10	200	P(SL)A 72/26
WA-7P	23	1972	Oceania Petroleum	Western Geophysical	"	20	660	P(SL)A 72/31
BMR Continental Margin surveys	24	1970-73	BMR	-	"	50	-	BMR Record 1974/15
Zuytdorp marine seismic and magnetic	25	1973	Continental Oil Company of Australia	Western Geophysical	"	15	825	P(SL)A 73/2

Magnetic surveys contd.

Survey Name & Type	Map Key Number (Plates 3A, 3B)	Year	Operator	Contractor	Survey Altitude	Traverse Spacing km	Total Traverse Length km	Reference
Mermaid 2 seismic and magnetic	26	1974	WAPET	GSI	Sea Level	2-10	77	P(SL)A 74/10
West Sholl marine seismic and magnetic	27	1974	WAPET	GSI	"	?	108	P(SL)A 74/11
Wave Marine seismic and magnetic	28	1974	WAPET	GSI	"	?	78	P(SL)A 74/17

APPENDIX 2 (contd.)

Land seismic surveys

Map Key No. (Plates 5A & 5B)	Survey Name and Type	Year	Operator	Contractor	Energy Source	KM Surveyed	CDP Coverage %	Reference
1	Giralla seismic	1951	BMR	-	Explosives	-	100	BMR Record 1954/67 1951/62
2	Wandagee reconnaissance	1955	BMR	-	Explosives	48	100	BMR Record 1962/117
3	Wandagee Ridge seismic	1961-62	WAPET	Geophysical Services International (GSI)	Explosives	240	100	PSSA 62/1576
4	Salt Marsh seismic	1961-62	WAPET	GSI	Explosives	179	100	PSSA 62/1585
5	Quail Anticline	1962-63	WAPET	GSI	Explosives	179	100	PSSA 62/1622
6	Whaleback	1962	WAPET	GSI	Explosives	113	100	PSSA 62/1635
7	Kubura-Learmonth	1962	WAPET	GSI	Explosives	35	100	PSSA 62/1637
8	Ningaloo	1963	WAPET	GSI Seismograph Service Ltd (SSL)	Explosives Vibroseis	122	100	PSSA 63/1504
9	Paterson Trap	1963	WAPET	GSI SSL	Explosives Vibroseis	116	100	PSSA 63/1509
10	Southern Carnarvon Basin seismic Refraction Traverse A	1963	BMR	-	Explosives	-	-	Geophys. Prog. Report 1964/6
11	Traverse C	1964	BMR	-	Explosives	64	100	BMR Record 1967/10
12	Traverse D Pelican Hill Bore	1964	BMR	-	Explosives	39	100	BMR Record 1965/40
13	Barrow Island Refraction seismic	1963	WAPET	GSI	Explosives	60	-	PSSA 63/1536
14	Wooramel reconnaissance	1965	Continental Oil	Ray Geophysics Western Geophysical	Explosives Weight Drop		1200	PSSA 64/4545

Land seismic surveys contd.

Map Key No. (Plates 5A & 5B)	Survey Name and Type	Year	Operator	Contractor	Energy Source	KM Surveyed	CDP Coverage %	Reference
15	Yalbalgo-Yaringa seismic	1965	Continental Oil	Western Geophysical	Explosives Weight Drop		400-1200	PSSA 65/11021
16	Kennedy seismic	1965	WAPET	GSI	Explosives	29	100-400	PSSA 65/11038
17	Barrow 2 seismic	1965	WAPET	GSI	Explosives	-	100	(confidential)
18	Merlinleigh Anticline seismic	1966	WAPET	Western Geophysical	Weight Drop	29	600	PSSA 66/11075
19	Onslow	1966	WAPET	Western Geophysical	Weight Drop	170	200-600	PSSA 66/11073
20	Cane River	1967	WAPET	United Geophysical	Explosives	61	300	PSSA 67/11159
21	Locker	1967	WAPET	United Geophysical	Explosives	301	300-600	PSSA 67/11162
22	Nia-Nia	1967	Marathon Petroleum	Ray Geophysics	Weight Drop	2410	100-600	PSSA 67/11179
23	Mandu	1968	WAPET	GSI	Explosives	33	600	PSSA 68/3042
24	Lyndon-Quobba	1972	WAPET	GSI Digicon	Explosives	221	600	PSSA 72/891
25	Hamelin	1972	Oceanla Petroleum	Austral-United Geophysical	Explosives	79	600-1200	PSSA 72/2075
26	Murat	1973	WAPET	GSI	Vibroseis	42	1200	PSSA 73/231
27	Norwegian 2	1973	WAPET	GSI	Explosives	5	1200	PSSA 73/274
28	Barrow 3 seismic	1973	WAPET	GSI	Vibroseis	16	2400	PSSA 73/227

Marine seismic surveys

Map Key No. (Plates 5A & 5B)	Survey Name and Type	Year	Operator	Contractor	Energy Source	KM Surveyed	CDP Coverage %	Reference
29	Exmouth Gulf seismic	1961	WAPET	SSL	Explosives	1210	100	PSSA 62/1563
30	Northwest Shelf W.A. & N.T.	1964	BOCAL	Western Geophysical	Explosives	1900	200	PSSA 64/4529
31	Abrolhos	1965	B.P. Pet- roleum	Western Geophysical	Explosives	1160 64	100 600	PSSA 65/4592
32	Shark Bay	1965	Continental Oil Company	Western Geophysical	Explosives	295	600	PSSA 64/4551
33	Barrow	1965	WAPET	GSI	Explosives	248 628	100 300	PSSA 65/11031
34	Montebello-Hermaid Shoal	1965	BOCAL	Western Geophysical	Explosives	4100 2120 116	200 300 600	PSSA 65/11015
35	West Carnarvon	1966	Canadian Superior	GSI	Explosives	2220	300	PSSA 66/11089
36	Rankin-Troubadour	1966	BOCAL	Western Geophysical	Explosives	2750	300	PSSA 66/11104
37	Zeeuyk Channel marine seismic	1966	B.P. Pet- roleum	United Geophysical	Explosives	98	100	PSSA 66/11112
38	West Gnarraloo	1967	Canadian Superior	GSI	Explosives	900	600	PSSA 67/11158
39	Long Island	1967	WAPET	Western Geophysical	Explosives	314	300	PSSA 67/11153
40	Muiron	1967	WAPET	GSI	Explosives	550 111	400 300	PSSA 67/11167
41	Helby	1968	WAPET	Western Geophysical	Aquapulse	130	1200	PSSA 68/3045

Map Key No. (Plates 5A & 5B)	Survey Name and Type	Year	Operator	Contractor	Energy Source	KM Surveyed	CDP Coverage 1	Reference
42	Table seismic	1968	WAPET	GSI	Airguns Explosives Explosives	48 490 282	2400 400 400-600	PSSA 68/3001
43	Northwest Shelf seismic magnetic gravity	1968	BMR	CGG	Sparker Airguns	24 200	100	BMR Record 1969/99
44	Legendre-Marle seismic	1969	BOCAL	Western Geophysical	Aquapulse	7000	2400	PSSA 69/3005
45	Jurabi seismic	1969	WAPET	GSI	Explosives	14.5	600	PSSA 68/3049
46	Fraser seismic	1969	WAPET	GSI	Airguns Explosives	198 219	2400-3600 600-1200	PSSA 69/3015
47	Geelvink Channel seismic and magnetic	1970	B.P. Petroleum	GSI	Airguns	1440	2400	PSSA 70/241
48	Barrow Waters seismic	1970	WAPET	GSI	Airguns	214	2400	PSSA 70/127
49	Tyral-Evans seismic	1970	BOCAL	Western Geophysical	Aquapulse	7400	1200-2400	PSSA 70/245
50	Ronsard seismic	1971	Endeavour Oil	GSI	Airguns	338	2400	PSSA 71/79
51	Geelvink Channel D-1 seismic	1971	B.P. Petroleum	Western Geophysical	Aquapulse	300	2400	PSSA 71/35
52	Bernier seismic & magnetic	1971	Ocean Ventures	Western Geophysical	Maxipulse	1450	2400	PSSA 71/722
53	Trinouille-Dillon seismic	1970-1971	BOCAL	Western Geophysical	Aquapulse Maxipulse	6550	1200-2400	PSSA 70/976
54	Rankin Trend seismic	1971	BOCAL	Western Geophysical	Maxipulse	795	1200-2400	PSSA 71/538

Map Key No. (Plates 5A & 5B)	Survey Name and Type	Year	Operator	Contractor	Energy Source	KM Surveyed	CDP Coverage %	Reference
54 A	Offshore Australia marine seismic, magnetic and gravity	1971	Shell Development (Australia)	Seismograph Service (Marine)	Airguns	8005		P(SL)A 71/9
55	Montebello-Turtle seismic	1972	BOCAL	Western Geophysical	Maxipulse	2880	1200-2400	PSSA 72/509
56	Malus-Hedland seismic	1972	BOCAL	Western Geophysical	Maxipulse	570	2400	PSSA 72/2701
57	Steamboat Spit seismic	1972	BOCAL	Western Geophysical	Maxipulse	2640	2400	PSSA 72/3253
58	De Grey Nose seismic	1973	BOCAL	GSI	Airgun	630	2400	PSSA 73/213
59	BMR Continental Margin seismic, magnetic and gravity	1970-1973	BMR	Compagnie Generale de Geophysique	Sparker	-	100	BMR Record 1974/15
60	Tryal Rocks seismic	1968	WAPET	Western Geophysical	Aquapulse	88	1200	P(SL)A 68/2
61	Roëilly seismic	1969	WAPET	GSI	Airguns	75	3600	P(SL)A 69/12
62	Murchison seismic	1970	WAPET	GSI	Airguns	66	2400	P(SL)A 70/6
63	Barrow Waters seismic	1970	WAPET	GSI	Airguns	400	2400	P(SL)A 70/15
64	WA-26-P experimental seismic	1970	Hartogen Explorations	GSI	Airguns	45	2400	P(SL)A 70/20
65	Carnarvon Basin seismic	1971	Ocean Venture	Western Geophysical	Maxipulse	246	2400	P(SL)A 71/8
66	Unsubsidized data from various surveys	1965-1971	BOCAL	Western Geophysical	Various	-	Various	P(SL)A 71/10
67	North Tryal Rocks seismic	1971	WAPET	Western Geophysical	Maxipulse	565	2400	P(SL)A 71/11

Map Key No. (Plates 5A & 5B)	Survey Name and Type	Year	Operator	Contractor	Energy Source	KM Surveyed	CDP Coverage %	Reference
68	Houtman Seismic magnetic and gravity	1971	WAPET	GSI	Airguns	360	2400	P(SL)A 71/13
69	Flag seismic	1971	WAPET	GSI	Airguns	39	2400	P(SL)A 71/15
70	Detail various structures, Cape to Barrow areas	1971	WAPET	GSI	Airguns	1620	2400	P(SL)A 71/18
70A	Exmouth Plateau seismic	1971-72	Esso Australia	Western Geophysical	Aquapulse	1270	1200	P(SL)A 72/39
71	Queen Head seismic and magnetic	1972	Ocean Ventures	Western Geophysical	Maxipulse	1010	2400	P(SL)A 72/4
72	Naturaliste seismic and magnetic	1972	Ocean Ventures	GSI	Airguns	97	2400	P(SL)A 72/5
73	Tanala seismic and magnetic	1972	Ocean Ventures	GSI	Airguns	84	2400	P(SL)A 72/6
74	Gulf regional geophy- sical reconnaissance seismic, magnetic and gravity	1972	Australian Gulf Oil	Gulf Research and Development	Aquapulse	4670	2400	P(SL)A 72/9
75	Murchison seismic and magnetic	1972	Ocean Ventures	GSI	Airguns	560	2400	P(SL)A 72/16
76	Kalbarri seismic and magnetic	1972	Ocean Ventures	GSI	Airguns	230	2400	P(SL)A 72/18
77	North Rankin-Goodwyn seismic	1972	BOCAL	Western Geophysical	Maxipulse	870	2400	P(SL)A 72/19
78	Zeevyk seismic magnetic gravity	1972	Amoco Australian Exploration	Western Geophysical	Maxipulse	121	2400	P(SL)A 72/23

Map Key No. (Plates 5A & 5B)	Survey Name and Type	Year	Operator	Contractor	Energy	KM Surveyed	CDP Coverage %	Reference
79	Barrow 3, Murat, Yardie 2 seismic	1972	WAPET	GSI	Aquaflex Airguns	100	2400	P(SL)A 72/26
80	Alpha seismic magnetic gravity	1972	WAPET	GSI	Airguns	610	4800	P(SL)A 72/24
81	W.A.-7P seismic	1972	Oceania Petroleum	Western Geophysical	Maxipulse	408	4800	P(SL)A 72/31
82	Monte Bello seismic	1972	WAPET	?	?	?	?	P(SL)A 72/35
82A	Kendrew Trough	1973	BOCAL	Western Geophysical	Explosives	335	1200	P(SL)A 73/12
82B	Zuytdorp marine seismic and magnetic	1973	Continental Oil Co. of Australia	Western Geophysical	Maxipulse	825	2400	P(SL)A 73/2
83	Murat seismic	1973	WAPET	?	?	?	?	P(SL)A 73/20
84	Hilda seismic	1973	WAPET	GSI	Airguns	2130	4800	P(SL)A 73/23
85	Sultan seismic	1973	WAPET	GSI	Airguns	2130	4800	P(SL)A 73/24
86	Murat 2 seismic	1974	WAPET	GSI	Airguns	162	2400	P(SL)A 74/1
87	Airlie seismic	1974	WAPET	GSI	Airguns	317.5	4800	P(SL)A 74/8
88	Barrow 5 shallow water seismic	1974	WAPET	GSI	Explosives	544	600-1200	P(SL)A 74/9
89	Mermaid (2) seismic and magnetic	1974	WAPET	GSI	Airguns	116	4800	P(SL)A 74/10
90	West Sholl seismic and magnetic	1974	WAPET	GSI	Airguns	133	4800	P(SL)A 74/11

Map Key No. (Plates 5A & 5B)	Survey Name and Type	Year	Operator	Contractor	Energy Source	KM Surveyed	CDP Coverage %	Reference
91	Ashburton seismic	1974	WAPET	GSI	Airguns	261	2400	P(SL)A 74/12
92	Bluebell seismic	1974	WAPET	GSI	Airguns	492	4800	P(SL)A 74/16
93	Wave seismic & magnetic	1974	WAPET	GSI	Airguns	78	4800	P(SL)A 74/17
94	Blackledge seismic	1974	WAPET	GSI	Airguns	228	4800	P(SL)A 74/18
95	Flag 3 seismic	1974	WAPET	GSI	Airguns	55	4800	P(SL)A 74/19
96	Kendrew-Cootamundra seismic	1974	BOCAL	GSI	Airguns Magnapulse	9191	1200 2400	P(SL)A 74/31
97	Observation shallow water seismic	1974	WAPET	GSI	Explosives	135	1200	P(SL)A 74/32
98	Rest shallow water seismic	1974	WAPET	GSI	Airguns	92	2400	P(SL)A 74/33
99	Dampier-Beagle seismic	1975	BOCAL	GSI	Airguns	1035	?	P(SL)A 75/5
100	Alpha 2 seismic and magnetic	1975	WAPET	GSI	Airguns	158	4800	P(SL)A 75/6
101	Norwegian 3 seismic	1975	WAPET	GSI	Airguns	98	?	P(SL)A 75/7
102	Airlie (2)	1975	WAPET	GSI	Airguns	43	4800	P(SL)A 75/8
103	Hermite seismic and magnetic	1975	WAPET	GSI	Airguns	160	4800	P(SL)A 75/9
104	Tessa-Troubadour	1975	BOCAL	GSI	Airguns	?	?	P(SL)A 75/11

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Map Key No. (Plates 5A & 5B)	Survey Name and Type	Year	Operator	Contractor	Energy Source	KM Surveyed	ODP Coverage %	Reference
105	Airline (3)	1975	WAPET	GSI	Airguns	159	7	P(SL)A 75/12
106	Spar	1976	WAPET	GSI	Airguns	54	7	P(SL)A 76/5
107	Hermitte (2)	1976	WAPET	GSI	Airguns	263	7	P(SL)A 76/6

Marine gravity surveys

Survey name and type	Year	Operator	Contractor	Traverse Spacing km	No. of Km surveyed	Reference
Northwest Continental Shelf marine gravity seismic and magnetic	1968	BMR	-	20	25000	BMR Record 1969/99
BMR Continental Margin gravity seismic magnetic	1970-73	BMR	-	50	-	BMR Record 1974/15
Houtman marine seismic, magnetic & gravity	1971	WAPET	GSI	6-12	360	P(SL)A 71/13
Southwest Cape marine seismic, magnetic & gravity	1971	WAPET	GSI	-	105	P(SL)A 71/18
Offshore Australia marine seismic, magnetic & gravity	1971	Shell Development (Australia)	Seismograph Service (Marine)	-	8005	P(SL)A 71/9
Gulf regional geophysical reconnaissance seismic, magnetic and gravity	1972	Australian Gulf Oil	Gulf	-	5200	P(SL)A 72/9

APPENDIX 2 Cont.

Land gravity surveys

Survey name and type	Year	Operator	Contractor	Traverse spacing km	Station spacing km	No. of stations	Reference
Pendulum observations	1950	BMR	-	-	-	59	BMR Bulletin 46
Reconnaissance gravity	1950	BMR	-	30-40	6.4	260	BMR Record 1951/69
Giralia detail gravity	1951	BMR	-	-	0.4	63	BMR Record 1951/68
Rough Range detail gravity	1953	BMR	-	1-3	0.4	300	BMR Record 1956/148
Onslow-Derby gravity traverse	1953	BMR	-	-	32	44	BMR Record 1963/13
Carnarvon Basin reconnaissance gravity	1953	BMR	-	10-20	5-9	-	BMR Record 1954/44
Wandagee Ridge detail gravity	1962	WAPET	-	-	0.4	375	(Confidential)
Barrow Island reconnaissance gravity	1962	WAPET	-	-	-	-	(")
Barrow Island detail gravity	1965	WAPET	-	-	-	-	(")
Reconnaissance helicopter gravity	1968	BMR	Wongela Geophysical	11	11	3961	BMR Record 1974/26
Reconnaissance helicopter gravity	1969	BMR	Wongela Geophysical	11	11	3297	BMR Record 1974/27
Murchison Gascoyne helicopter gravity	1970	Barewa Oil & Mining	Wongela Geophysical	6.5	6.5	956	PSSA 70/326
Murchison Gascoyne D1 detail gravity	1971-72	Oceania Petroleum	Austral United Geophysical	12	0.8	6576	PSSA 71/555

NEEL TULLY SUB-BASIN

AGE	UNIT	QUAIL NO. 1		LITHOLOGY
		Depth (m) D.F.	Thickness (m)	
QUATERNARY	Undifferentiated	4	5	Sand, red, fine to coarse grained, poorly sorted, clayey and clay, <u>sediment to light grey and yellow-red</u>
UNCONFORMITY				
PERMIAN (Artinskian)	Coyrie Fa.	9	58	Predominantly dark to medium grey siltstone, pyritic with occasional brachiopod fragments, containing a few calcareous beds which grade into silty limestone
	Billides Fa.	67	206	Sequence of interbedded sandstone and siltstone. Sandstone is light grey, commonly silty, kaolinitic and siliceous; siltstone is dark grey, siliceous, sandy in part, occasionally calcareous. Few thin coal seams between 168 m and 174 m
	Roogooloo Sandstone	273	113	Sandstone, well to moderately sorted, interbedded with dark grey, carbonaceous, siliceous siltstone (decreasing in amount with depth) with traces of black, lignitic, in parts vitreous coal
	Cordalla Greywacke	386	50	Sandstone, brown to grey, fine to medium grained, fine to very fine siliceous and silty beds, pyritic, slightly calcareous and siltstone, dark grey, siliceous, with some calcareous beds grading into limestone. Basal interval of siltstone from 405 m to 447 m
	Callitharra Fa.	446	146	A fairly fossiliferous (with the exception of the interval from 463 m to 537 m) siltstone, containing bryozoa, brachiopods, forams and polychaetes. Siltstone is dark grey, pyritic, sandy in part, siliceous, poorly bedded and calcareous with thin beds of limestone towards the base of the unit
(Sakmarian)	Lyons Group	592	1509	Interbedded siltstone, claystone, sandstone, siltstone, shale, quartz greywacke and minor limestone. The siltstone, quartz greywacke and some siltstone are characterized by their extremely poor sorting. In Quail No. 1 this group has been divided into seven units based on the distribution of the siltstone
UPPER CARBONIFEROUS	Siltstone Unit	2161	57	Mainly siltstone, medium to dark grey, fine to medium grained with silty luster, grading in part to fine grained quartz greywacke
	Sandstone Unit	2168	285	Fairly uniform sandstone with a matrix of secondary quartz and in part of dolomite and calcite with occasional thin beds of siltstone, shale, quartz greywacke and limestone. The sandstone unit has negligible porosity throughout
UNCONFORMITY				
LOWER CARBONIFEROUS	Carbonate Unit	2453	257	2453 m - 2582 m: predominantly calcilitite with interbedded calcarenite and minor calcareous siltstone and shale. The upper 9 m is grey, fine grained, quartzitic sandstone 2582 m - 2710 m: predominantly dolomite with interbedded calcilitite and calcarenite
UNCONFORMITY				
UPPER DEVONIAN	Sandstone Unit	2710	31	Sandstone, white and light grey, fine grained, well sorted, quartzitic, pyritic, non porous; believed to be equivalent to the Willeradio Formation and Numbla Sandstone, or may be an upper member of the Gneucine Formation
MIDDLE-UPPER DEVONIAN	Gneucine Formation	2741	341	2741 m - 2760 m: dolomite grading to calcilitite 2760 m - 3026 m: calcarenite in the upper 76 m but mainly calcilitite with interbedded shale, siltstone, dolomite and minor sandstone 3026 m - 3082 m: interbedded sandstone with a few beds of dolomite, calcilitite, siltstone and shale
	Sturien Unit 'A' (Nanyarra Greywacke?)	3082	124	Sandstone, generally fine grained, moderately to poorly sorted and silty, containing a few beds of siltstone, and traces of shale and claystone
SILURIAN	Dirk Hartog Limestone	3206	343	3206 m - 3355 m: dolomite, with some calcitic beds interbedded with siltstone and minor sandstone 3355 m - 3417 m: interbedded anhydrite, light to dark grey and pink, occurring in beds and veins, dolomite, siltstone and traces of shale 3417 m - 3549 m: interbedded dolomite, siltstone, with minor shale and claystone
UNCONFORMITY				
STURIAN	Imbulgunda Sandstone	3549	31-	Sandstone, very fine grained, well sorted, quartzitic, clay matrix, minor amounts of disseminated graphite(?) grading to siltstone, very clayey and sandy
	TOTAL DEPTH	3580		

Notes

- 1) No signs of crude oil were noted in the Well. Insignificant traces of methane were detected in the drilling and from 185 m to T.D. Traces of gasoline fractions were present in mud samples in the interval 356 m - 457 m.
- 2) Argillaceous calcilitites and shales of the Lower Carboniferous Carbonate Unit and Gneucine Formation constitute the only possible source rocks penetrated in this well but retain no traces of oil and very little gas, possibly due to deep burial and compaction.

(from MAPET, 1964)

DAMPIER SUB-BASINS (Legendre-Rosemary Trend)

AGE	UNIT	ROSEMARY NO. 1		LITHOLOGY
		Depth(m)	K.B./Thickness(m)	
		10		Sea Level
			64	
		74		S&S Bed
			397	No samples recovered
		471		
CRETACEOUS	Maria		552	Sandstone & claystone
(Lower Maestrichtian)		1023		with minor dolomite
(Campanian)	Marl		75	Claystone
		1098		
(Cenomanian)			186	Claystone with minor
		1284		coal
(Cenomanian-Albian)			202	Claystone
	Wimring	1486		
(Aptian)			342	Claystone with minor
	Group	1828		sandstone
(Basal Aptian-Neocomian)			119	Sandstone with minor
		1947		claystone
(Upper Neocomian)			213	Claystone with minor
		2160		sandstone & dolomite
(Lower Neocomian)	Barrow		47	Claystone with minor
	Beds	2207		sandstone
JURASSIC	Barrow		71	Sandstone
(Upper Tithonian)	Beds	2278		
(Lower Tithonian)	"Dampier"		125	Sandstone
		2403		
(Kimmeridgian)	Beds		49	Sandstone
		2452		
(Kimmeridgian-Oxfordian)			159	Claystone with minor
		2611		sandstone
(Oxfordian)	"Legendre"		87	Claystone and siltstone
	Beds	2698		with minor sandstone
(Callovian)			421	Claystone with minor
		3119		siltstone and sandstone
(Callovian-Bathonian)	"Legendre"		23	Claystone siltstone and
	Beds	3124		sandstone
(Bathonian-Bajocian)	"Enderby"		266	Sandstone, claystone and
		3368		siltstone with minor coal
(Toarcian)	Beds		541	Sandstone with interbedded
		T.D.		claystone & siltstone with
		3909		minor coal

Notes

- 1) Well developed potential reservoirs were intersected in sandstone of Tithonian to Kimmeridgian age below a potential seal of Neocomian claystone. High gas readings were obtained during drilling but five Formation Interval Tests and electric log interpretation showed all zones to be water bearing.

(from BOGAL, 1973)

DAMPFIER SUB-BASIN (RANKIN PLATFORM)

	AGE	UNIT	GOODWYN NO. 1		LITHOLOGY
			Depth(m)	R.T. / Thickness(m)	
			465		No samples taken
	Pliocene to middle Miocene	Trealla equivalent	1111	1033	Dominantly calcarenite with interbedded calcilutite, sandstone, dolomite, calcisiltite and marl
			1498		
	Lower Miocene (Burdigallian)		1525	27	Dominantly calcilutite overlain by calcarenite
	(Aquitainian)		1811	286	Dominantly calcisiltite with interbeds of calcilutite and marl
TERTIARY	Oligocene			157	Dominantly calcilutite with interbeds of calcisiltite and marl
			1968		
	Pocene (Upper)			93	Dominantly calcilutite with interbeds of calcisiltite and marl
		Giralia equivalent	2061		
	(Middle)		2131	70	Dominantly marl overlain by calcilutite and calcisiltite
	(Lower)	Gardabia Group equiv.	2313	182	Dominantly marl with interbedded claystone
	Paleocene			151	Dominantly calcilutite with interbedded calcisiltite overlying marl
			2464		
	Maestrichtian to Campanian	Miria Marl equiv.		151	Dominantly marl with interbedded calcareous claystone
			2615		
CRETACEOUS	Santonian	Toolonga Calcilutite equiv.		67	Dominantly calcilutite
			2682		
	Coniacian			12	Calcilutite overlying marl
			2694		
	Turonian			16	Calcarenite overlying marl
			2710		
	Cenomanian			27	Dominantly marl
			2737		
	Albian			37	Marl
			2774		
	Aptian			9	Claystone
			2783		
	Neocomian	Birdrong equiv.		14	Claystone, glauconitic at base
			2797		
TRIASSIC	Upper			469	Dominantly claystone interbedded with sandstone
			3266		
	Middle (?)		T.D.	270	as above
			3536		

Notes

- (1) Produciabale gas and condensate occurs in the Upper Triassic sandstones between 2797 and 3175 m; Hydrocarbons were present in the Toolonga Calcilutite equivalent but the formation was too tight to warrant testing.
- (2) Barrow Beds are absent in this well.
- (3) All Jurassic sediments are absent as at Rankin No. 1 and North Rankin No. 1

(from BOCAL, 1972)

BARRON SUB-BASIN

AGE	UNIT	WEST TRYAL ROCKS No. 1 Depth(m) Thickness RT (m)	LITHOLOGY
TERTIARY (Recent-Late)	Un differentiated		Predominantly calcillutite, calcarenite and calcisiltite with rare interbeds of chalk; below 997 m there is a great variety of microlutites with traces of pyrite and glauconite in parts
Miocene	Carbonates	150 1163	
UNCONFORMITY			
(Middle Miocene)	Cape Range Group	1313 510	Mainly calcillutite, calcisiltite and early calcillutite with minor calcarenite, chalk and earl, and rare limestone, dolomite and chert
Oligocene			
UNCONFORMITY			
(Late-Middle Eocene)	Girella Calcarenite	1929 211	Upper unit of earl, calcisiltite, calcillutite with minor limestone; middle unit of mainly limestone; thin lower unit with chalk, calcisiltite, limestone and a thin (1.5 m) basal, tight sandstone
UNCONFORMITY			
(Early Eocene)	Cardabia Group	2140 119	Mainly dark, early calcillutite with minor limestone, chalk, claystone and calcisiltite and a basal transgressive, very fine grained glauconitic, shaly or marine sandstone
Eocene			
UNCONFORMITY			
UPPER CRETACEOUS	Polonysa 2 Equivalent	2269 34	A thin upper unit of sandy calcillutite grading downwards to earl and early sand; lower unit of dark claystone with traces of silt, glauconite and pyrite grading to silty sandstone in parts with a 1.5 m basal sand
UNCONFORMITY			
LOWER-UPPER CRETACEOUS	Gearle Siltstone	2132 297	Mainly earl, calcillutite with calcareous claystone shale and siltstone
UNCONFORMITY			
LOWER CRETACEOUS	Girdalia Radiolarite	2589 38	Mainly siltstone, dark grey, glauconitic, calcareous, radiolarite cement, with rare interbeds of claystone and earl
UNCONFORMITY			
LOWER CRETACEOUS	Hudong Shale	2627 606	Interbedded siltstone, clay and shale with darker colours (red-brown); minor earl and lignite and rare limestone
UNCONFORMITY			
LOWER JURASSIC	Hungary Shale	3233 635	Mainly thick bedded, coarse sandstones with interbeds of shale and light coloured claystone with minor coal. Sandstones are typically carbonaceous. Grain size and porosity decrease near the top of sands due to increased clay matrix, and in some cases porosity decreases in the bottom of the sands due to increased silica cement
UPPER TRIASSIC			
TOTAL DEPTH		3866	

NOTES

- 1) Depths for sidetracked hole
- 2) The absence of a thick under gravel section encountered in North Trial Rocks resulted in a significant hydrocarbon accumulation in the West Trial Rocks Structure. Log analysis indicates the presence of 90 m of possible pay. The hydrocarbon column extends over a gross interval of 265 m with a transitional hydrocarbon-water contact from 3490-3501 m.

(from MAPET, 1973)

BARRON SUB-BASIN

AGE	UNIT	BARRON DEEP No. 1 Depth(m) Thickness A.B. (m)	LITHOLOGY
TERTIARY (Miocene)	Ireslia Limestone	8 177	Limestone, medium to finely crystalline, richly fossiliferous grading to coquina in parts, and sand
UNCONFORMITY			
(Eocene)	Girella Calcarenite	157 1177	Limestone, hard, calcarenitic in part, low porosity and sand, medium, subrounded, moderately sorted quartz, and siltstone, red-brown, low porosity, very fine calcareous, non to slightly calcareous
UNCONFORMITY			
(Palaeocene-Eocene)	Cardabia Group	1327 687	Calcillutite, with loose fossil fragments, becoming more coarse with depth, grading to calcarenite, very fine to silty, slightly fossiliferous, increasingly glauconitic with depth
UNCONFORMITY			
UPPER CRETACEOUS (Santonian-Campanian)	Isolompa Calcillutite	200 68	Chalk, slightly glauconitic, occasionally sandy, and minor beds of calcarenite, grading to calcisiltite with depth, and limestone in interval 200-223 m
UNCONFORMITY			
UPPER CRETACEOUS (Campanian-Turonian)	Upper Gearle Siltstone	268 38	Siltstone, massive, calcareous, glauconitic, grading to mudstone, with minor thin interbeds of calcarenite and calcisiltite and traces of limestone grading to chalk
UNCONFORMITY			
LOWER-UPPER CRETACEOUS (Albian-Campanian)	Lower Gearle Siltstone	307 298	Siltstone, slightly glauconitic and pyritic, with rare fossil radiolaria, and minor beds of calcarenite grading to calcisiltite in part and limestone with traces of sandstone and siderite in the lower part of the interval

BEAGLE SUB-BASIN

AGE	*UNIT	COSSIGNY NO. 1		LITHOLOGY
		Depth (m)	R.T./Thickness (m)	
		125	(sea bed)	
				No samples prior to running marine riser
		433		
TERTIARY				
(Pliocene-U. Miocene)			128	Dominantly calcisiltite with calcilutite, calcarenite and minor dolomite
		561		
		625		
(U.-M. Miocene)			326	Dominantly dolomite with calcarenite, calcilutite, calcisiltite, recrystallised limestone and minor sandstone
		887		
(M. Miocene-Burdigalian)			188	
		1075		
(U-M Eocene)	Giralia		139	Calcisiltite and calcilutite with beds of chert
		1214		
(L. Eocene)	Cardabia		65	
		1279		
(Basal U-M Palaeocene)	Grp		52	Marl and claystone with minor calcisiltite and calcilutite
		1331		
CRETACEOUS				
(L. Maestrichtian-Campanian)	Miria Marl		246	
		1577		
(Santonian)	Toolonga Calcilutite		69	Calcilutite
		1646		
(Basal Sant-Turonian)	Winning Grp		151	Claystone and minor marl
		1797		
M. JURASSIC			318	
L. JURASSIC	Legendre Fm	2115		Dominantly massive sandstones, dominantly fine grained and moderately sorted, with minor claystone siltstone and coal
(Toarcian)			179	
		2294		
EARLY U. TRIASSIC	Mungaroo Beds		446	
		2740		
		2874		Dolomite and recrystallised limestone
M. TRIASSIC			464	Dominantly sandstone with claystone and siltstone and minor coal
		2940		
		TD		
		3204		

Notes

- 1) *Unit names have been interpreted from the ages and lithologies supplied by the Company.
- 2) No significant hydrocarbons were recorded in this well and wireline logs indicate that the entire section penetrated was water saturated.

(from BOCAL, 1972)

DAMPIER SUB-BASIN (De Grey Nose)

AGE	BADY NO. 1 Depth(m) R.T./Thickness(m)	LITHOLOGY
	30	Sea level
	96	Sea bed
	259	No samples prior to running marine riser
AGE INDETERMINATE	107 366	Dominantly claystone with interbedded dolomite and minor sandstone overlying limestone
	126	No returns probably limestones?
UPPER CRETACEOUS (Albian)	492 555	63 Dominantly claystone and silt- stone with minor sandstone
LOWER CRETACEOUS (Aptian)	556	
	592	63
(U. Neocomian)	619	61
	680	
M. TRIASSIC	782	Dominantly claystone with minor sandstone and siltstone
	791	
	793	Dominantly sandstone with minor claystone
L. TRIASSIC	794	11
	805	
AGE INDETERMINATE	20	Altered fine to medium grained basic igneous rocks
	T.D. 825	

Notes

- 1) No hydrocarbons were detected
- 2) In other wells drilled in the basin the contact between the Albian and the Aptian is unconformable.

(from BOGAL, 1973)

AGE	UNIT	BARROW DEEP No. 1		LITHOLOGY
		Depth (m) K.B.	Thickness (m)	
LOWER CRETACEOUS (Albian-Aptian)	Windalia Radiolarite	605	12	Siltstone, glauconitic, with traces of radiolaria and fossil fragments, with minor interlamination of sandstone, grading siltstone, and rare brown siderite(?)
	Ruderng Shale	517	2687	
LOWER CRETACEOUS (Aptian)	Top Windalia Sand Member	517	26	Sandstone, very fine to silty, moderately to poorly sorted, glauconitic, good to fair porosity, with strong petrolierous odour and traces of oil stain, occasionally grading to sandy siltstone; interbedded and interlamated shale from 635-644 m
	Base Windalia Sand Member	553	192	Shale, slightly glauconitic, pyritic and micaceous, grading to siltstone particularly near top and bottom of the interval, with minor sandstone and traces of dolomitic limestone and calcarenite.
LOWER CRETACEOUS (Aptian-Neocomian?)	Ruderng Greensand Member	845	402	Sandstone/greensand, generally fine grained, with a silty matrix, moderately well sorted, very glauconitic, poor to fair visual porosity, and a light to moderate petrolierous odour, but no stain
	Barrow Group	8857	11007	
	Unit A	9650	3742	Sandstone, very fine to very coarse and granular, poorly sorted, traces pyrite, feldspar and glauconite, very good visual porosity and interbeds of siltstone, and minor coal and traces of dolomite
	Unit B	1256	344	Siltstone, occasionally carbonaceous, argillaceous, and sandstone fine to very coarse, moderately to poorly sorted, with good visual porosity, and minor beds of coal, and dolomite
LOWER CRETACEOUS (Neocomian)		1500	18	Shale, very soft, luggy, with minor siltstone, soft argillaceous
		1518	95	Sandstone, and minor thin interbeds of siltstone, and claystone/shale and traces of dolomite
	Unit C	1603	264	Mainly sandstone with interbedded siltstone and shale and minor dolomite. The interval called the "6000' Sand" constitutes the basal sequence of Unit C and trace to poor oil and gas shows were observed during penetration
	"6000' Sand"	1624	-	
	Unit D	1862	122	Siltstone and sandstone ("6200' Sand" - only a trace gas show recorded during penetration), with minor dolomite and claystone
	"6200' Sand"	1885	-	
	Dingo Claystone	1985	2665	Mainly of marine claystones, siltstones, and shales, with significant sand developments at late Middle to early Late Jurassic levels
	Top Dapuy Sand Member	1985	193	Exhibited trace to poor gas shows during drilling
	"6700' Sand?"	2031	-	Only minor indications of hydrocarbons
	Base Dapuy Sand Member	2177	-	2177-2880 m: thick sequence of petrolierous siltstones grading with depth to claystones and shales From 2880 m on, the section became more sandy and from about 3240 m, three major porous and permeable Middle Jurassic sandstone bodies were intersected each exhibiting fair to good shows
NEOGENE/UPPER	Top 10800' Sand	3242	12	Top zone; calculated open flow potential (COFP) 0.42 MMCKD with some condensate and water; inconclusive test due to apparent severe formation damage; proven net gas pay 3 m and probable gas pay 4.3 m
JURASSIC	Base 10600' Sand	3254	-	
	Top 10900' Sand	3329	34	Middle zone; COFP 0.25 MMCKD with some condensate and water, and considerable depletion; proven net gas pay 3.7 m
	Base 10900' Sand	3363	-	
	Top 11250' Sand	3424	76	Bottom zone; COFP 5.66 MMCKD with some condensate and water, and very little if any, depletion; proven net gas pay 9.5 m
	Base 11250' Sand	3500	-	
	TOTAL DEPTH	4650	-	In addition to these three main zones there are 4.3 m of possible gas pay at 3129 m - 3133 m

Notes

1) Barrow Group, and all subdivisions thereof, are WAPET informal names

2) The primary objectives - the Upper Triassic to Lower Jurassic sandstones - are probably too deep to be commercially exploitable

3) Palaeontological data has shown that the Middle Jurassic - Upper Jurassic boundary may lie at about 3185 m, above the gas sands

(from WAPET, 1973)

BEAGLE SUB-BASIN

AGE	*UNIT	ROMSARD NO. 1 Depth(m) R.R./Thickness(m)	LITHOLOGY
SEA BED		170	
		325	No samples prior to installing the marine riser
		495	
TERTIARY	Lower Pliocene	158	Calcilutite
		653	
	Upper Miocene To Burdigalian	696	Calcarenite, dolomite
		1349	
	Aquitainian	279	Calcarenite, calcilutite with minor calcisilite
		1628	
	Oligocene	Caperange Gp	57
		1685	Calcilutite, calcisilite
	Upper to Middle Eocene	Giraffa	126
		1811	Calcilutite, calcisilite
	Lower Eocene		
		1830	
	Upper Palaeocene	Cardabia	25
		1855	Marl, claystone
	Middle Palaeocene	Group	65
UPPER CRETACEOUS	Lower Palaeocene		1920
		39	Marl, claystone
		1959	
	Upper Maestrichtian	Miria Marl	47
		2006	Marl, claystone
	Lower Maestrichtian		
		2040	Marl, claystone
	Campanian	Toolonga Calcilutite	155
		2195	Claystone, marl, calcilutite
	Santonian		2215
LOWER CRETACEOUS		20	Calcilutite
	Coniacian	Winning Group	10
		2225	Marl
	Albian		31
		2256	Claystone, marl, calcilutite
LOWER JURASSIC	Early Aptian to Late Neocomian	Winning Group	38
		2294	Claystone
	Toarcian		472
		2766	Sandstone, claystone
	Pre-Toarcian	Legendre Fm.	82
		T.D.	
		2848	Sandstone, claystone

Notes

- 1) * Unit names have been interpreted from the ages and lithologies supplied by the Company
- 2) No significant hydrocarbon shows were recorded
- 3) Thirty eight metres of Lower Cretaceous (early Aptian - late Neocomian) sediments were penetrated in Romsard No. 1, indicating that inundation of the block occurred at a time earlier than at Sable No. 1 or Cossigny No. 1.
- 4) A regional unconformity (nominated seismic event "F") which has only been previously recorded in the Beagle Sub-basin in Picard No. 1 separates sediments of Albian and Aptian age.
- 5) The ultra-Upper Cretaceous unconformity has not been recorded previously in the Beagle Sub-basin.

(from BOCAL, 1973)

DAMPIER SUB-BASIN (RANKIN PLATFORM)

AGE	UNIT	EAGLEHAWK NO. 1		LITHOLOGY
		Depth(m)	R.T./Thickness(m)	
		13		Sea level
		173		Sea bed
TERTIARY (Pliocene)				No samples
		429	1226	
(M. Miocene)				Sandstone, calcarenite, calcirudite, dolomite
		1359		
(M. Miocene)				Calcarenite, calcisiltite
			251	
(Burdigalian)				Calcilutite, marl
		1610		
(Aquitania)			103	Calcisiltite, calcilutite, marl
(Basal Aquitanian)				
			2	Calcilutite
(Upper Oligocene)				
		1796		
				Calcisiltite, marl,
(Oligocene)			322	
				Claystone
		2120		
(U&M Eocene)	Dinallie			Calcilutite, claystone, chert
		2230		
(L. Eocene)			201	Marl, claystone
	Cardabia	2431		Marl, claystone
(V. Paleocene)			134	
				calcilutite
	Group	2565		
(Basal U. Pal)				Marl, claystone
(M. Paleocene)			17	Glauconitic sandstone
		2582		
UPPER CRETACEOUS				
(U. Maestrichtian)			23	Calcilutite, marl
(U - M Maestrichtian)	Miria	2605		
			15	Marl, claystone
		2620		
(L. Maest.)	Marl		59	Marl, claystone
		2679		
(U. Campanian)			22	Marl,
(L. Campanian)	Toolonga	2701		
			9	Calcilutite
		2710		
(Santonian)	Calcilutite		3	Calcilutite
		2713		
(Basal Santonian)			4	Calcilutite, Marl
(Coniacian)		2717		
			8	Calcilutite, marl
		2725		
(Turonian)	Winning		6	Calcilutite, marl
		2731		
(U&M Cenomanian)	Group		6	Calcilutite, marl
(Basal Cenomanian)		2737		Calcilutite, marl
(Albian)			3	
		2740		
LOWER CRETACEOUS				
(Aptian)	Winning			
(Neocomian)	Group		10	Claystone

SENDER SUB-BASIN (Bardia Platform)

AGE	(EQUIVALENT) *UNIT	DEPTH NO. 1		LITHOLOGY
		Depth(m)	R.T./Thickness(m)	
SEA LEVEL		15		
SEA BED		131		
	Burdigalian to Pliocene	442	1233	No samples Calcarenites, sandstone, dolomite
	Burdigalian	1364	190	Calcarenites, calcilutite, calcsilite
	Aquitania	1553	154	Calcilutite, calcsilite
		1707		
TERTIARY	Oligocene Capernage Cp.		358	Calcsilite, calcilutite & minor calcarenites, marl, claystone
		2065		
	Upper & Middle Eocene		71	Calcilutite with 15-40% chert
	Giralia	2136		
	Middle Eocene		9	Claystone
		2145		
	Lower Eocene		211	Marl, claystone
		2356		
	Upper Paleocene Cardabia Group		137	Marl, minor calcilutite & claystone
		2493		
	Basal U. Pal. Mid Paleoc.		96	Marl, minor claystone Siltstone & glauconitic sandstone
		2589		
	Upper Maestrichtian			Calcilutite, marl, claystone
		2616		
	Upper - Middle Maestrichtian Miria		13	Marl, claystone
		2629		
UPPER	Lower Maestrichtian Marl		79	Marl, minor claystone
		2708		
CRETACEOUS	Upper Campanian		50	Marl
		2758		
	Lower Campanian Toolonga Calcilutite		13	Calcilutite
		2771		
	Santonian Toolonga Calcilutite		33	Calcilutite
		2804		
	Basal Santonian		12	Calcilutite, marl
	Coniacian			
		2816		
		2833		
	Turonian		11	Marl
	Winning			
		2844		
	Upper & Middle Cenomanian		24	Marl
		2868		
	Basal Cenomanian Albian Group		38	Calcilutite, marl
		2906		
LOWER	Aptian and Upper Neocomian		75	Claystone
		2981		

DAMPIER SUB-BASIN (Cont'd)

AGE		(EQUIVALENT) *UNIT	EGRET NO. 1 Dpeth(m) R.T./Thickness(m)		LITHOLOGY
CRETACEOUS	LOWER NEOCOMIAN	Legendre		114	Claystone, minor siltstone
			3095		
UPPER JURASSIC	TITHONIAN	Fm.		203	Sandstone claystone, minor siltstone
			3298		
UPPER TRIASSIC	RHAETO-NORIAN	Mungaroo Beds		360	Sandstone, claystone
			T.D. 3658		

Notes

- (1) * Unit names have been interpreted from the ages and lithologies supplied by the Company.
- (2) Crude oil of 39° A.P.I. gravity was recovered from the top sand in the Tithonian section, the first occurrence of oil in Upper Jurassic sediment in the Dampier Sub-basin. On drill stem testing between 3119 m and 3129 m oil was produced at a rate of 2729 b.p.d. accompanied by gas at a rate of 2.37 MMCFD through a $\frac{3}{4}$ " surface hole.

(from BOCAL, 1973)

DAMPIER SUB-BASIN (BANKIN PLATFORM)

EAGLEHAWK No. 1			
AGE	UNIT	Depth (m) R.T./Thickness(m)	LITHOLOGY
		2750	
UPPER TRIASSIC			
(Rhaeto-Norian)	Mungaroo	740	Sandstone, claystone
	Beds	TD	Siltstone, coal
		3490	

Notes

(1) The uppermost Triassic section contained crude oil with a specific gravity between 29.3° and 30° A.P.I.. On drill stem testing between 2750m and 2766 oil was produced at a rate of 1645b.p.d. accompanied by gas at a rate of 0.141 MCFD through 5/4 inch bottom hole and 5/8 inch surface brooks.

(from BOGAL, 1973)

GASCOYNE SUB-BASIN

AGE	UNIT	PENDECK No. 1 Depth (m) K. 8.	Thickness (m)	LITHOLOGY
QUATERNARY (Pleistocene)	Essex Sandstone	141	87	Dolomite, coquinitic limestone, fine to hard reddish brown siliceous sandstone and minor grey-white quartzite
UNCONFORMITY				
TERTIARY (Miocene)	Irealla Limestone	208	110	Sequence of interbedded sandstone, light grey to white unsorted, calcareous, soft and friable with abundant bentonite and keolomite in the matrix, glauconitic in part, poor to fair porosity, poor permeability, and dolomite, light brown to cream, fossiliferous with abundant forams and bryozoa, poor to fair vuggy porosity
DISCONFORMITY				
Miocene	Talki Limestone	318	50	Dolomite, light brown, very fossiliferous with scattered forams and bryozoa, having fair vuggy porosity
	Reada Calcareous	368	54	Dolomite, brown to tan, abundant forams and bryozoa, fair vuggy porosity, with traces of limestone
	DISCONFORMITY			
Eocene	Givella Calcareous	427	95	Dolomite, tan to brown, with traces of glauconite and pyrite, dense with poor porosity and permeability and limestone with the two lithologies grading into one another
	Jubilee Calcareous	517	55	Limestone (calcareous), light brown to cream, abundant bryozoa and forams, slightly argillaceous and glauconitic, with poor porosity and permeability
	Cashia Calcareous	572	23	Dolomite, orange to orange-pink, very finely crystalline and tight
	Basal Cardale Group	595	164	Limestone, grey to greenish grey, dolomitic in parts, very argillaceous grading to earl, poorly fossiliferous, extremely glauconitic, with poor porosity and permeability
DISCONFORMITY				
(Paleocene)	Koroja Calcareous	759	35	Limestone (calcareous) consisting primarily of coarse fibrous incoarsened fragments in a soft greenish-grey glauconitic calcituffite matrix, with poor to fair porosity in part and poor permeability
	DISCONFORMITY			
	Isolonga Calcituffite	794	34	Limestone (calcituffite), greenish grey, argillaceous and soft with minor traces of fibrous incoarsened fragments throughout, poor porosity and permeability
DISCONFORMITY				
D. CRETACEOUS	Gaspé Siltstone	828	140	Shale or mudstone and minor siltstone, grey, calcareous and siliceous with abundant lignite or carbonaceous material
	Windfall Radiolarite	968	30	Siltstone and radiolarite, light to medium grey, mottled in parts with occasional white specks (bentonite?)
	Redwing Shale	1006	16	Shale grading to siltstone with abundant thin interbeds of fine grained, glauconitic sandstone
	Birdsong Fa.	1022	8	Sandstone, light grey, fine-medium grained, slightly calcareous and glauconitic with abundant intergranular pyrite. Sand is loose and friable with excellent porosity and permeability
UNCONFORMITY				
CARBONIFEROUS	Hoogmoed Fa.	1030	77	Dolomite with minor thin interbeds of shale
	Gowden Fa.	1107	132	Unit 'A': limestone, very fossiliferous, argillaceous in parts and dolomitic in streaks, trace vuggy porosity, interbedded with thin shale beds
		1289	320	Unit 'B' (roof): dolomite, dense, argillaceous in parts with traces of pyrite and black carbonaceous material, fossiliferous with fossil components typical of those which characterize the Devonian Reef Complex of Western Canada; occasional thin shaly stringers
DEVONIAN		1609	1656	Unit 'C': limestone, argillaceous or chalky in streaks, fossiliferous, dolomitic in parts, poor porosity and permeability
	Longyear Greywacke	1665	135	Sandstone, generally fine grained, poorly sorted, glauconitic in part with traces of biotite and pyrite poor to fair porosity, poor permeability, with minor interbeds of siltstone and shale
	UNCONFORMITY			
SILURIAN		1850	342	Unit 'A': dolomite and anhydrite with thin interbeds and lenses of siltstone, sandstone and shale; dolomite has poor porosity and permeability
	Clark Hartog Fa.	2192	95	Unit 'B': sandstone with traces of siltstone and shale; sandstone has poor porosity and permeability; slight trace of oil staining observed near top of unit
		2286	215	Unit 'C': dense dolomite with minor amounts of anhydrite
TOTAL DEPTH		2501		

Notes

- 1) No significant hydrocarbon shows. Interval from 1718 m to 1722 m showed light brown, live oil staining. This interval appeared to be a tight zone between two more porous, flushed sandstone units. Only other show of hydrocarbons was some faint, light brown staining in a fine to very fine grained sandstone from 2195 m to 2201 m.
- 2) Jurassic sandstone. Inelastic, argillaceous shales. It appears that the pinchout or erosional edge of these sediments occurs somewhere between Pendock No. 1 and Whalbeck No. 1 wells.

(free GEMO 011 R.L., 1976)

GASCOYNE SUB-BASIN

13

AGE	UNIT	TAMALA NO. 1 Depth(m)K.B./Thickness (m)		LITHOLOGY
QUATERNARY (Pleistocene)	Coastal limestone	Surface (4)	34+	White, fine to medium grained calcarenite with minor quartz sandstone
TERTIARY (Paleocene)	Upper Cardabia Group	38	122	White to yellow glauconitic calcarenite with abundant fossil fragments and soft calcareous glauconitic mud- stone
UPPER CRETACEOUS (Campanian) (Santonian)	Toolonga Calcilutite	160	183	Fossiliferous calcarenite, calcareous glauconitic mud- stone, argillaceous cal- cilutite
LOWER CRETACEOUS (Turonian)	Winning Group Alinga Fm	343	16	Calcareous shale, glauconitic mudstone, minor chert
(Albian)	Windalia Radiolarite	359	14	hard, siliceous slightly calcareous shale, in part very glauconitic
(Aptian)	Muderong Shale	373	5	Shale, brown to blue and hard or light grey and fissile, with trace of brown chert
(Aptian)	Birdrong Sandstone	378	20	Light, grey sandstone and coarse grained loose quartz
UNKNOWN- DEVONIAN?	Unknown Fm	398	27	Grey to orange to red brown sandstone with calcareous cement, thin shale beds
?	?	?	?	?
SILURIAN (Llandoveryan- Ludlovian)	Dirk Hartog Fm	425	693	Dolomite & limestone with interbedded siltstone and mudstone
?	?	?	?	?
SILURO-ORDOVICIAN (Llandoveryan- Ashgillian)	Tumblagooda Sandstone	1118 T.D. 1225	107+	Fine grained, white to red brown sandstone with thin shale beds

NOTES

- (1) The basal Cretaceous section is similar to that in Dirk Hartog No. 17B (drilled in 1956 on Dirk Hartog Island) except for the absence of Eocene sediment, and the presence of the Turonian Alinga Formation.

(from OCEANIA PETROLEUM PTY LTD, 1973)

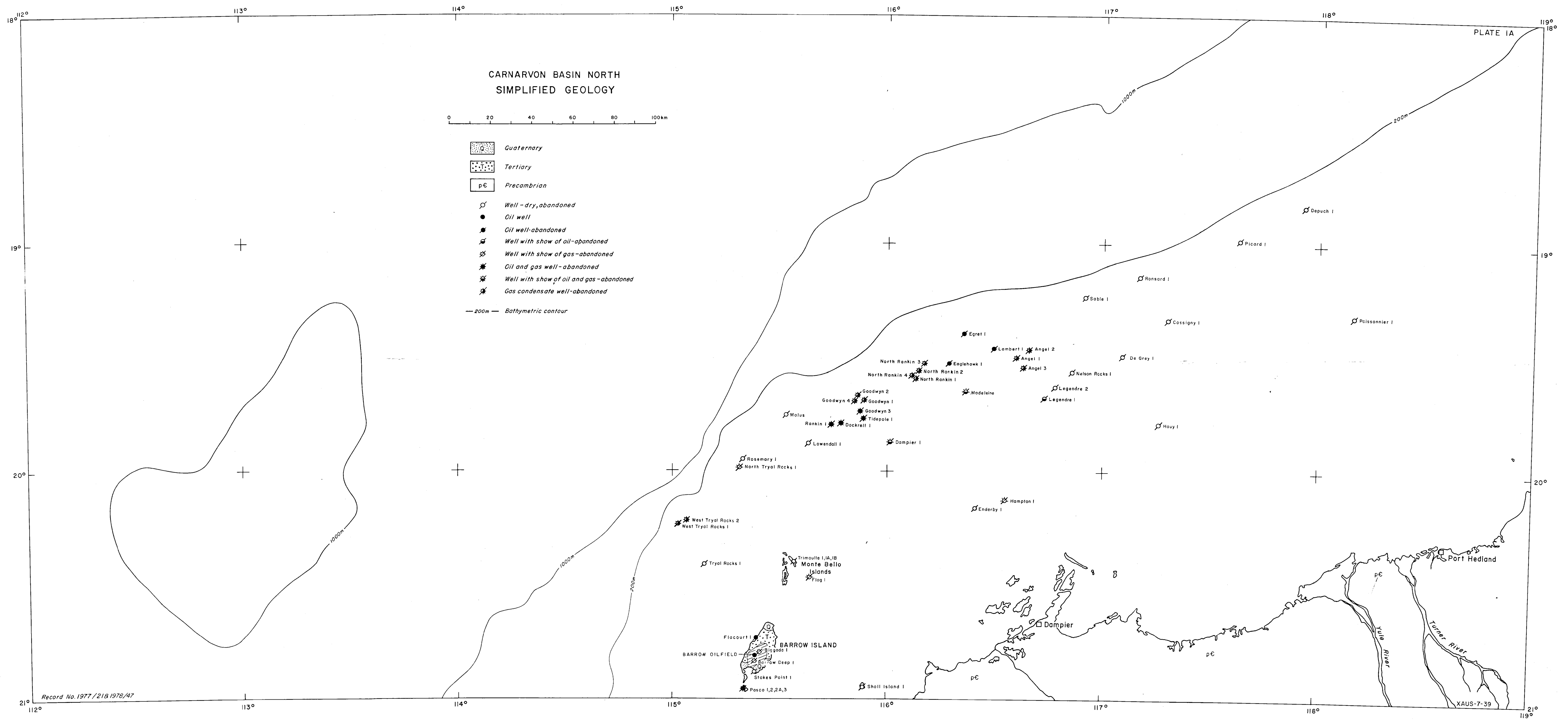
GASCOYNE SUB-BASIN

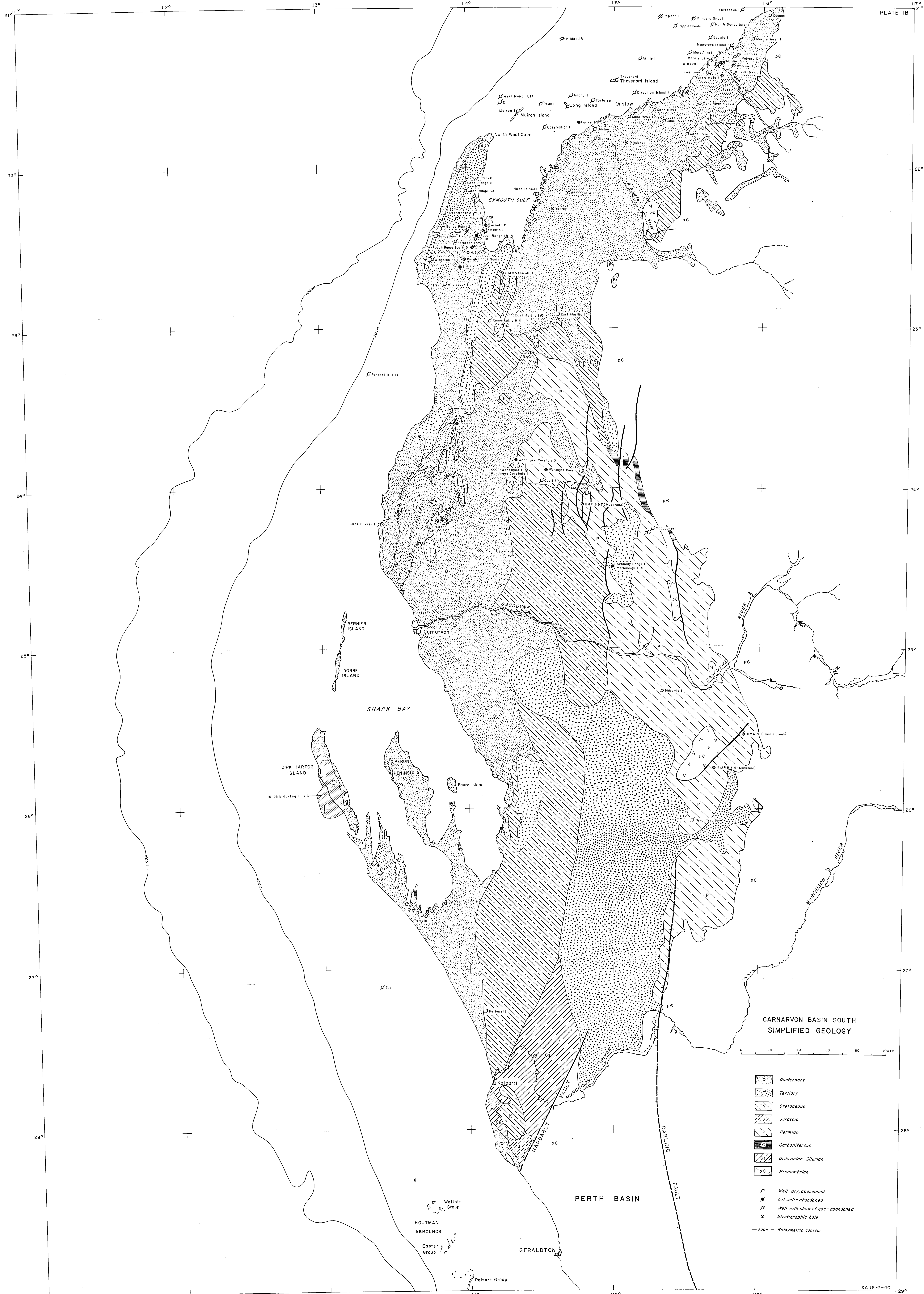
AGE	UNIT	KALBARRI NO. 1 Depth(m)K.B./Thickness (m)		LITHOLOGY
QUARTERNARY (Pleistocene)	Coastal Limestone	Surface (4)	16+	Surface sand grading into soft sandstone with calcareous cement numerous crinoid fragments
UPPER CRETACEOUS (Campanian) (Santonian)	Toolonga Calclutite	20	104	Sandstone, glauconitic calcareous mudstone, soft chalky calcilutite, bryozoa fragments common
LOWER CRETACEOUS (Aptian)	Winning Group Bridrong Sandstone	124	58	Grey sandstone, interbedded siltstone, some bryozoa and shell fragments, glauconites in basal parts
SILURIAN (Ludlovian- Llandoveryian)	Dirk Hartog Formation	182	90	Finely interbedded argillaceous dolomite and dolomitic shale, some sandstone beds
SILURO-ORDOVICIAN (Llandoveryian- Ashgillian)	Tumblagooda Sandstone	272	1268+	Largely pink to red brown sandstone with thin beds of shales, siltstones and anhydrites
		T.D. 1540		

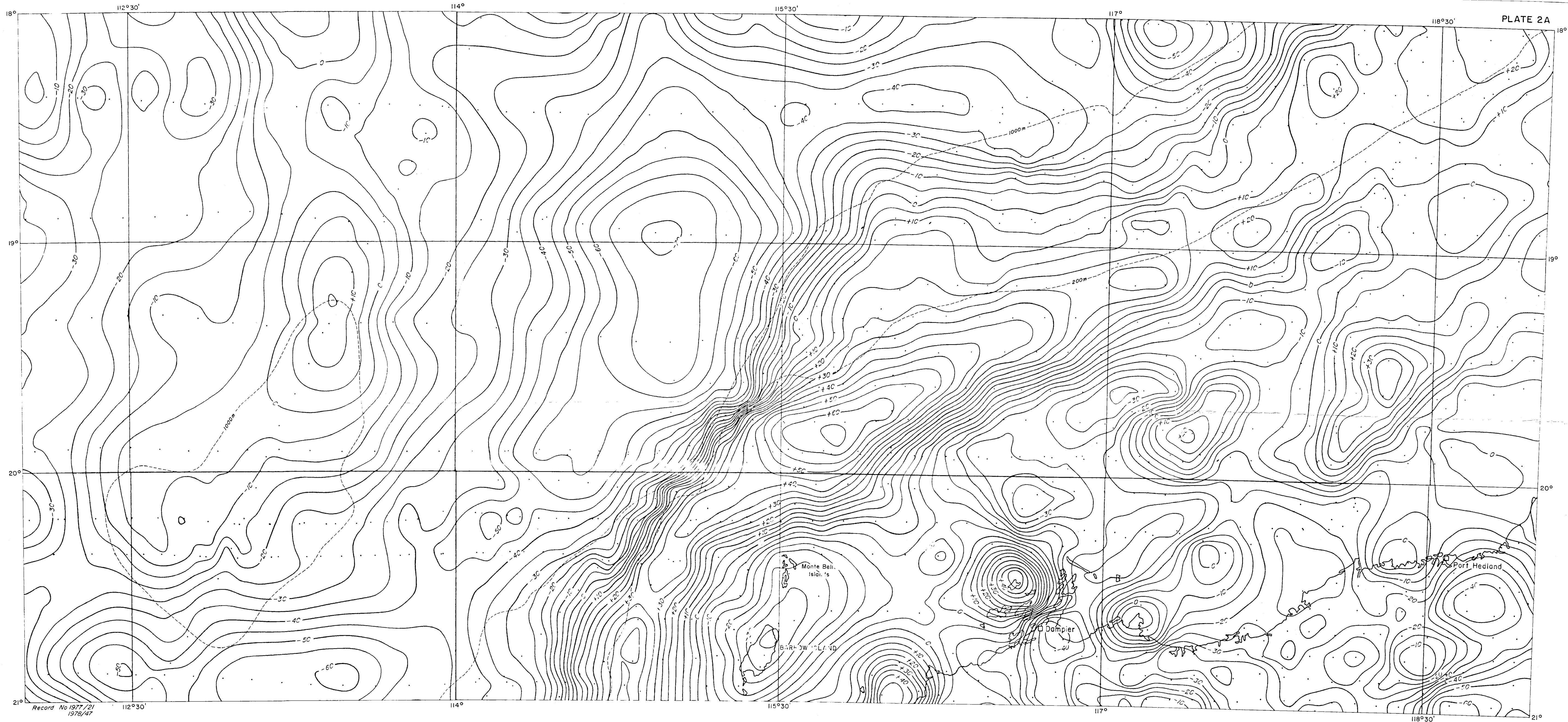
NOTES

(1) No indications of hydrocarbons.

(from OCEANIA PETROLEUM PTY LTD, 1973)







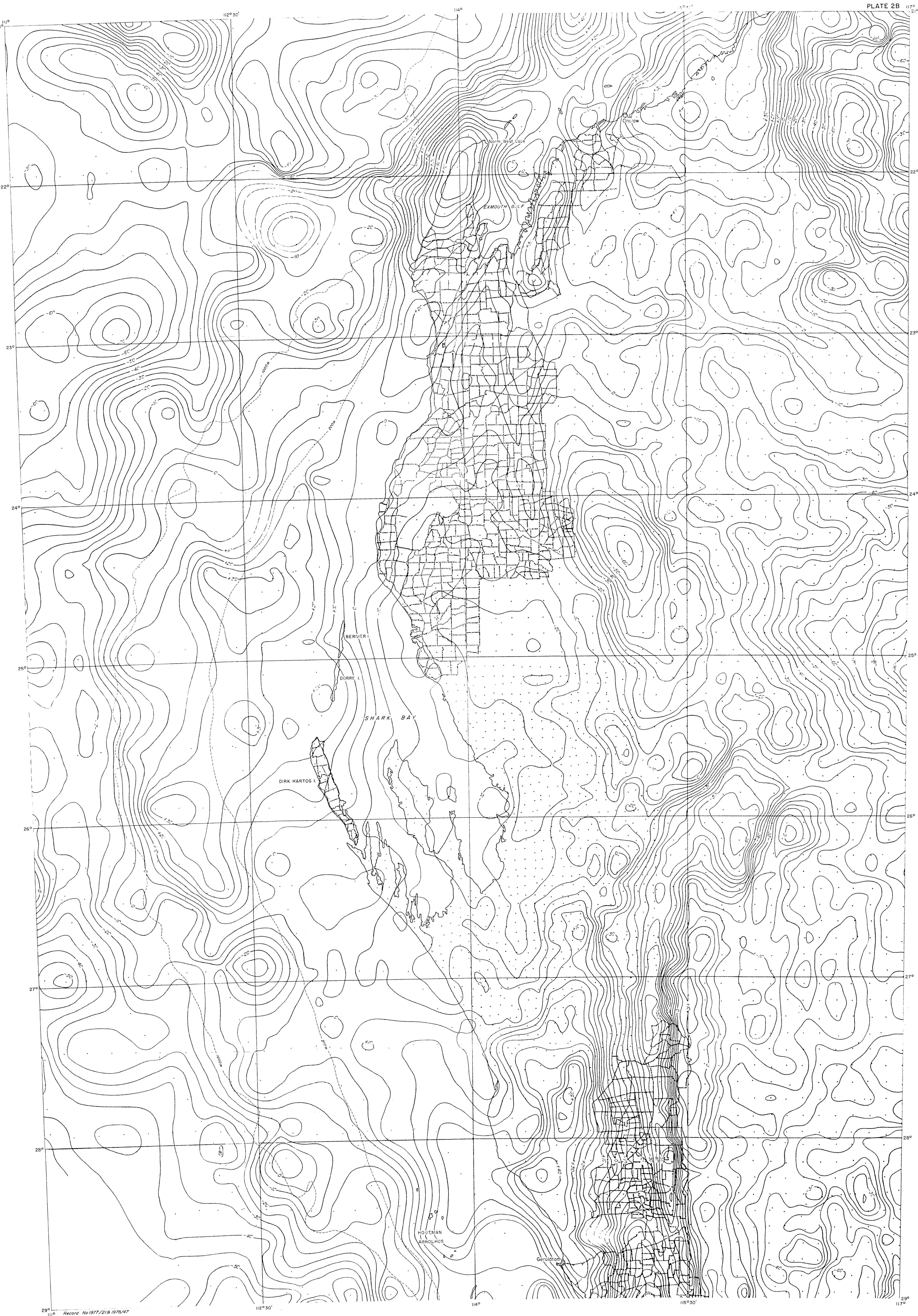
— 20 — Bouguer anomaly contour
• Gravity station
--- 200m --- Bathymetric contours

Note: The Bouguer anomaly contours shown are subject to change, particularly offshore where control is sparse. In the offshore area no correction has been made for the water layer.

CARNARVON BASIN NORTH
GRAVITY ANOMALIES

1:1 000 000





Record No 1977/219 1976/47

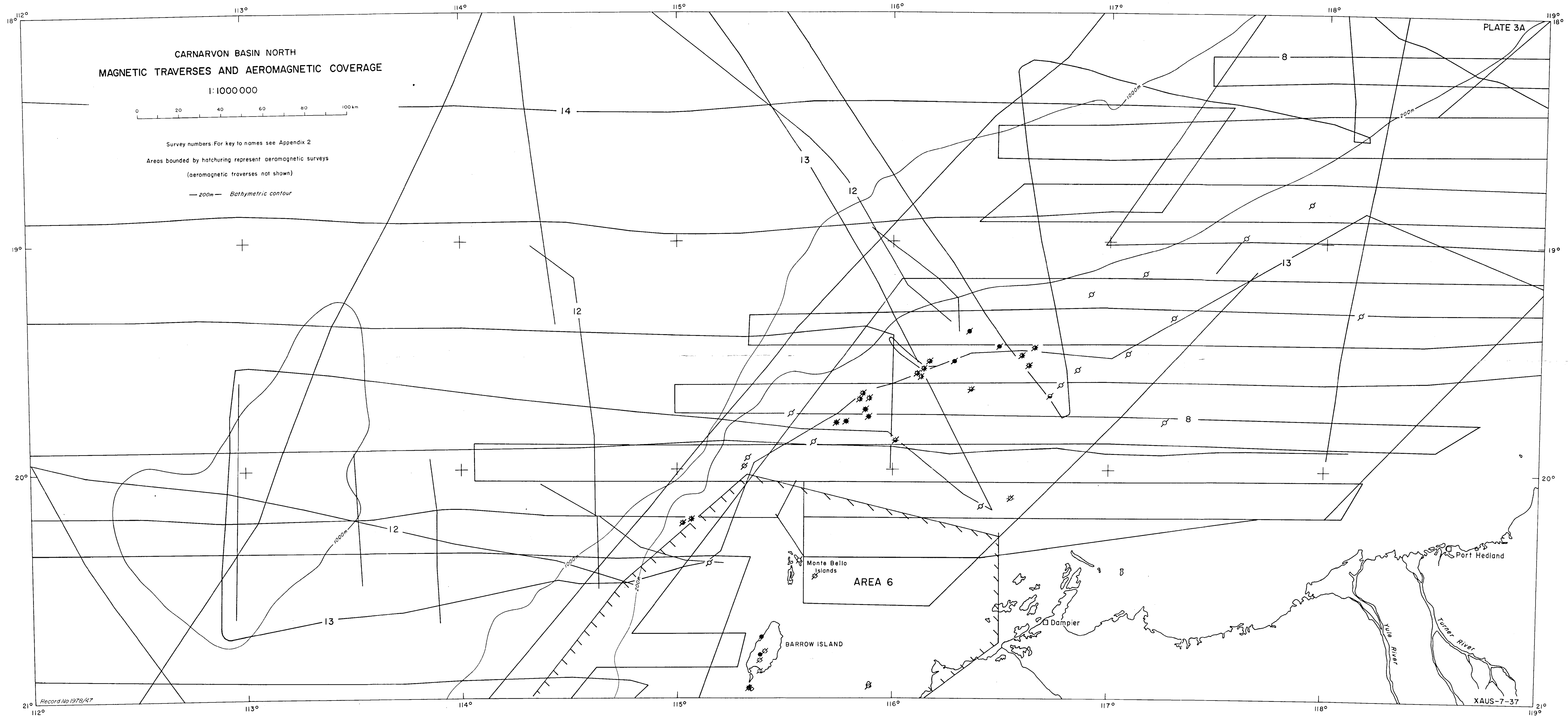
— 20 — Bouguer anomaly contour
 • Gravity station
 — 200m — Bathymetric contour

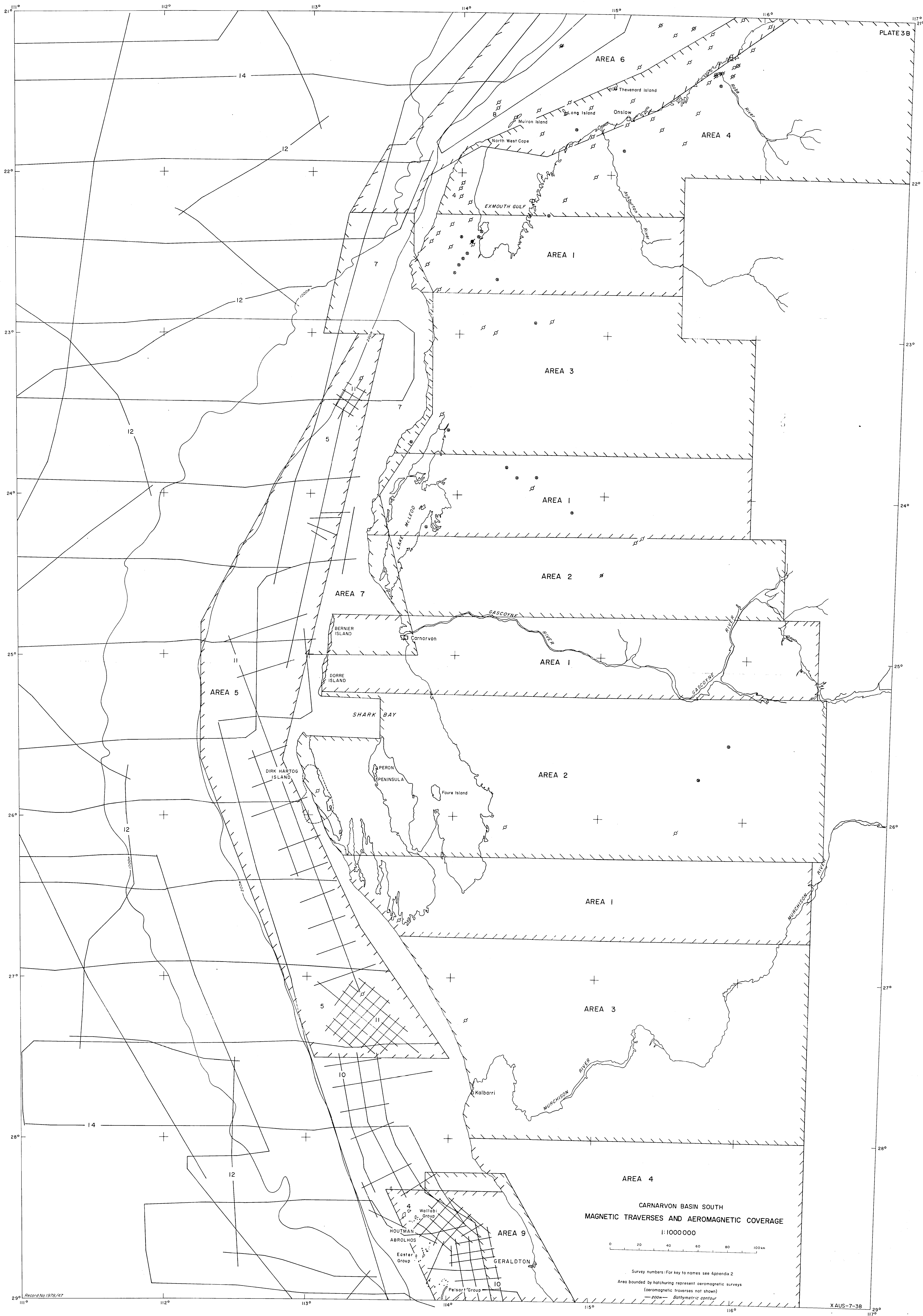
Note: The Bouguer anomaly contours shown are subject to change, particularly offshore where control is sparse. In the offshore area no correction has been made for the water layer.

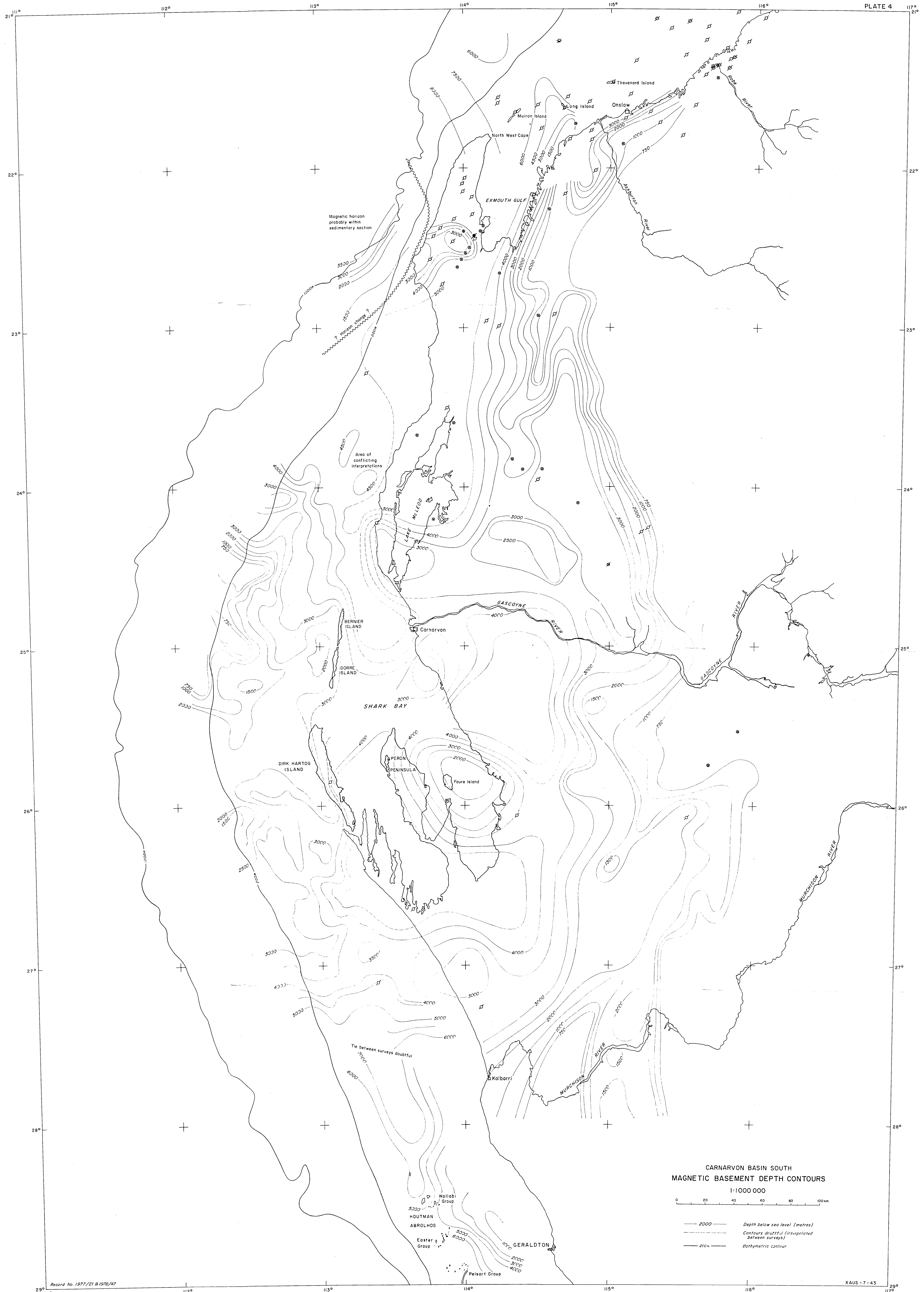
CARNARVON BASIN SOUTH
 GRAVITY ANOMALIES
 1:1 000 000

0 20 40 60 80 100 km

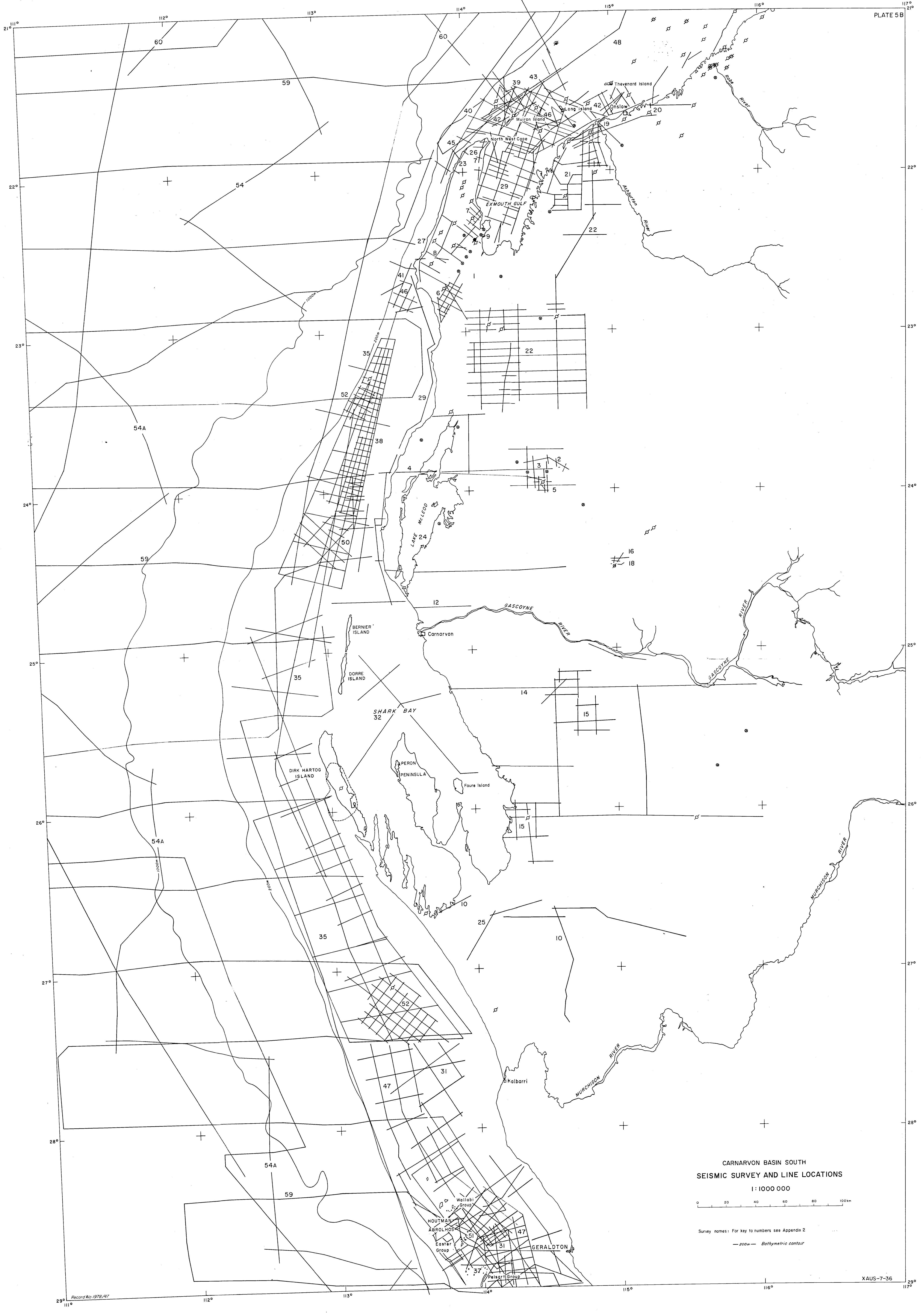
XAUS-7-34











CARNARVON BASIN SOUTH
SEISMIC SURVEY AND LINE LOCATIONS
1:1000 000

0 20 40 60 80 100km

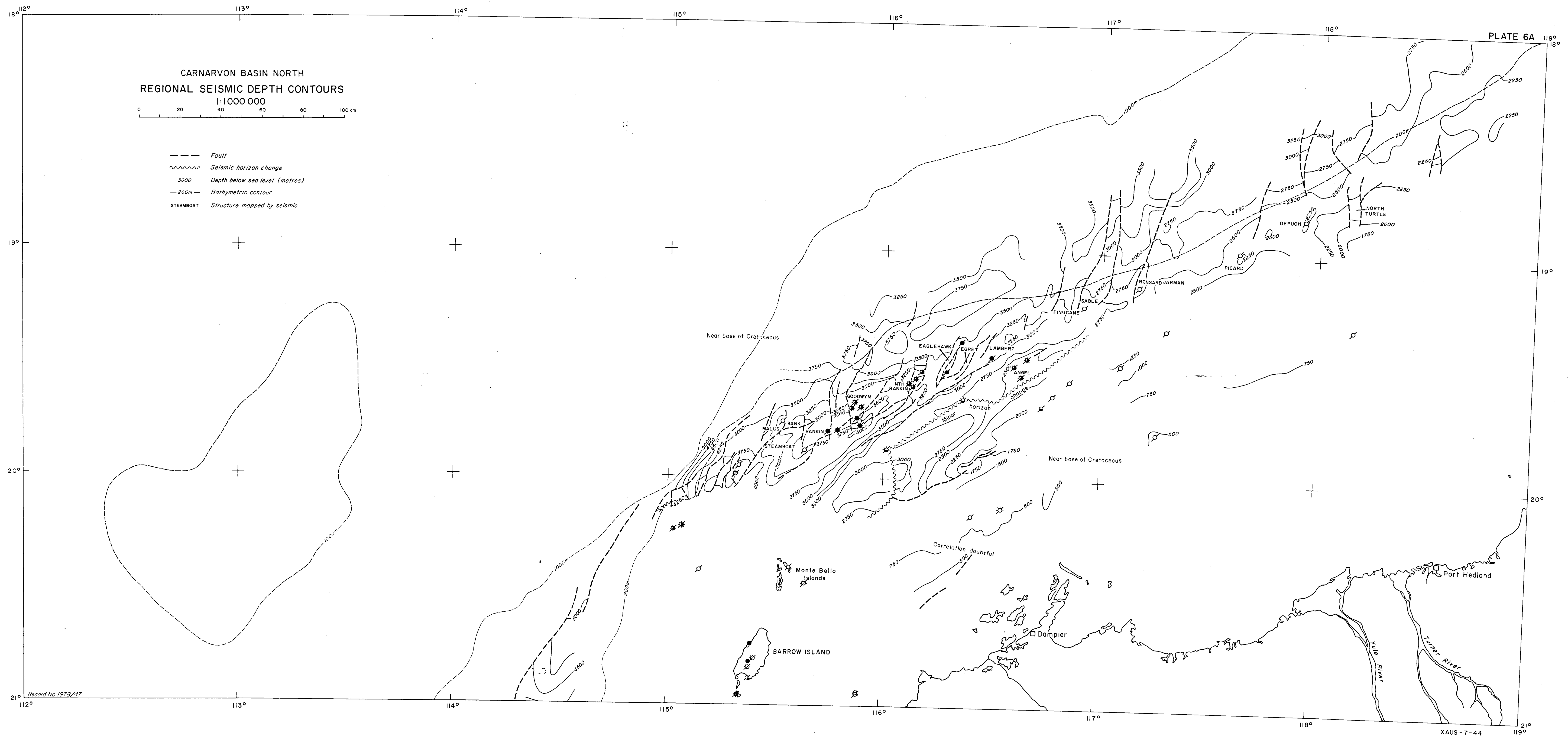
Survey names: For key to numbers see Appendix 2

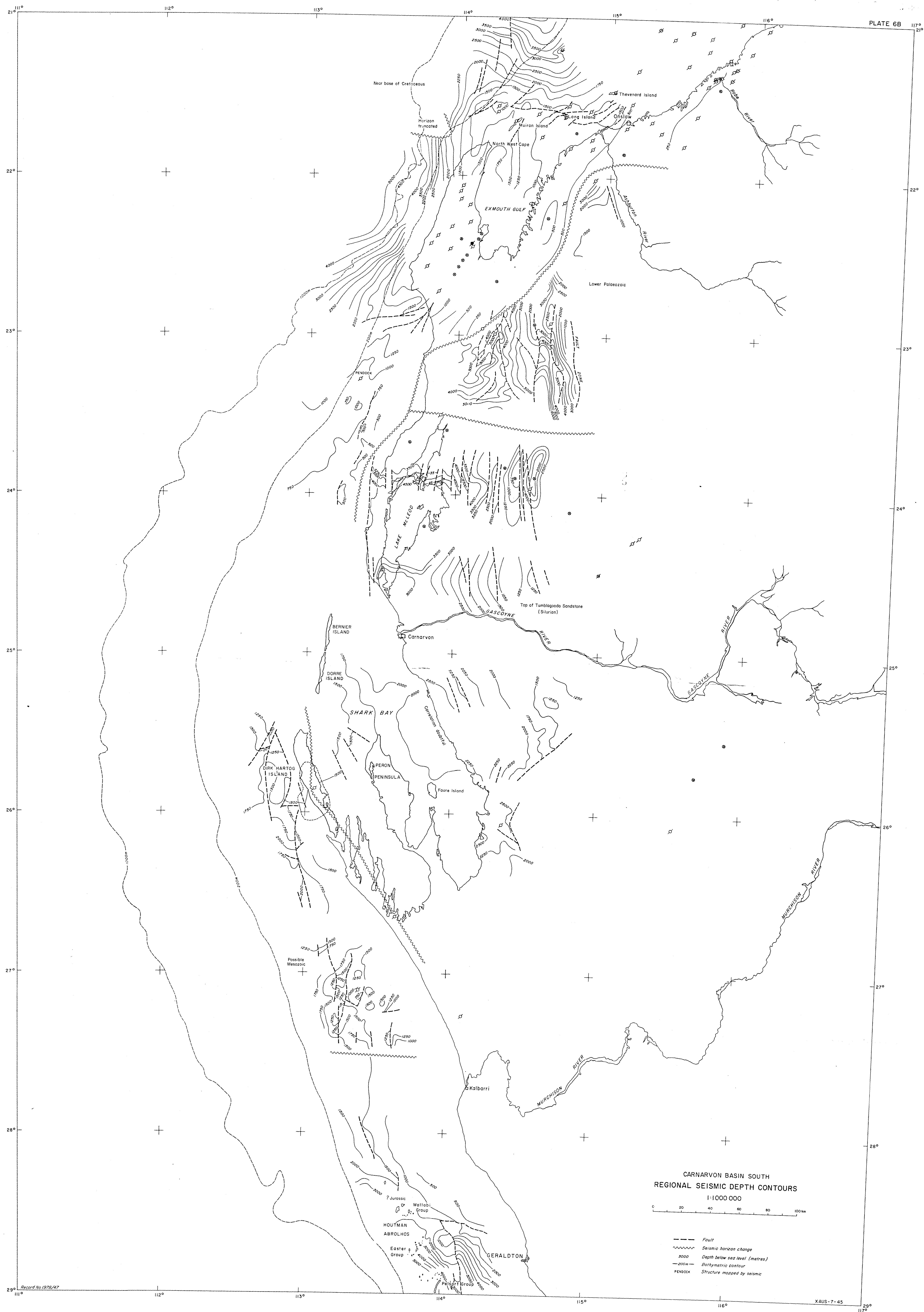
— 200m — Bathymetric contour

CARNARVON BASIN NORTH
REGIONAL SEISMIC DEPTH CONTOURS

1:1000 000
0 20 40 60 80 100 km

- Fault
~~~~~ Seismic horizon change  
3000 Depth below sea level (metres)  
---200m--- Bathymetric contour  
STEAMBOAT Structure mapped by seismic





CARNARVON BASIN : WESTERN AUSTRALIA  
ESCAP ATLAS OF STRATIGRAPHY (IGCP PROJECT No.32)

WEST TRYAL ROCKS I

NORTH TRYAL ROCKS I

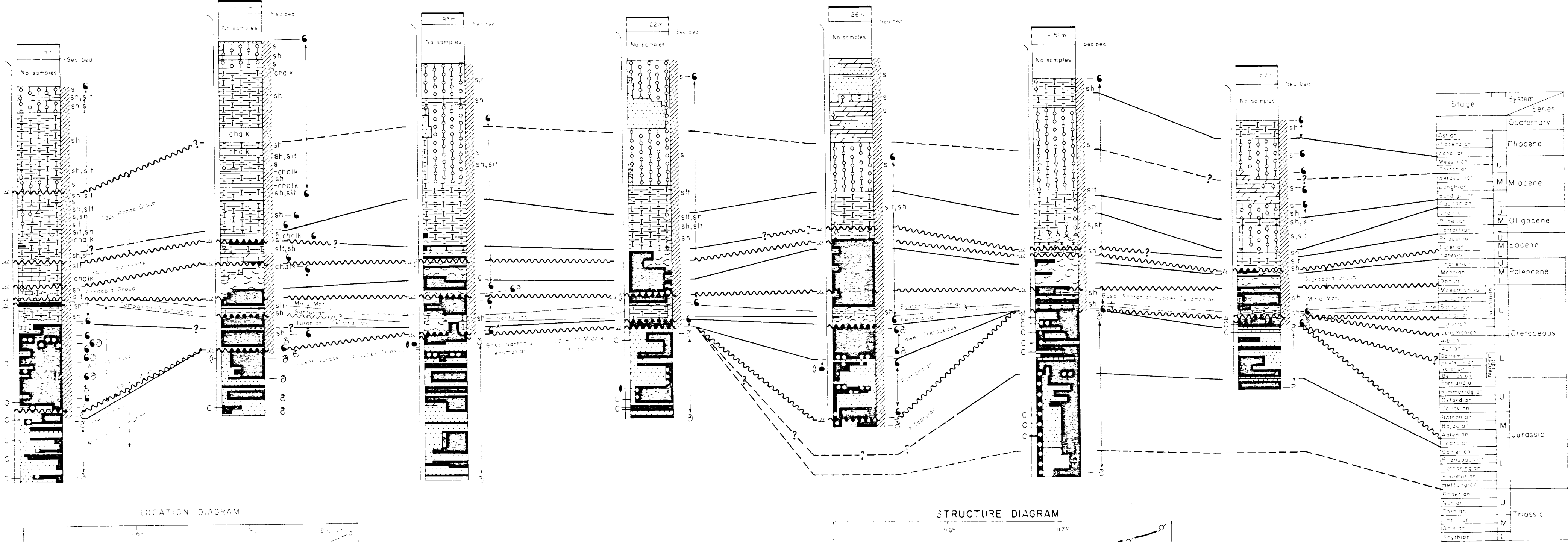
RANKIN I

NORTH RANKIN I

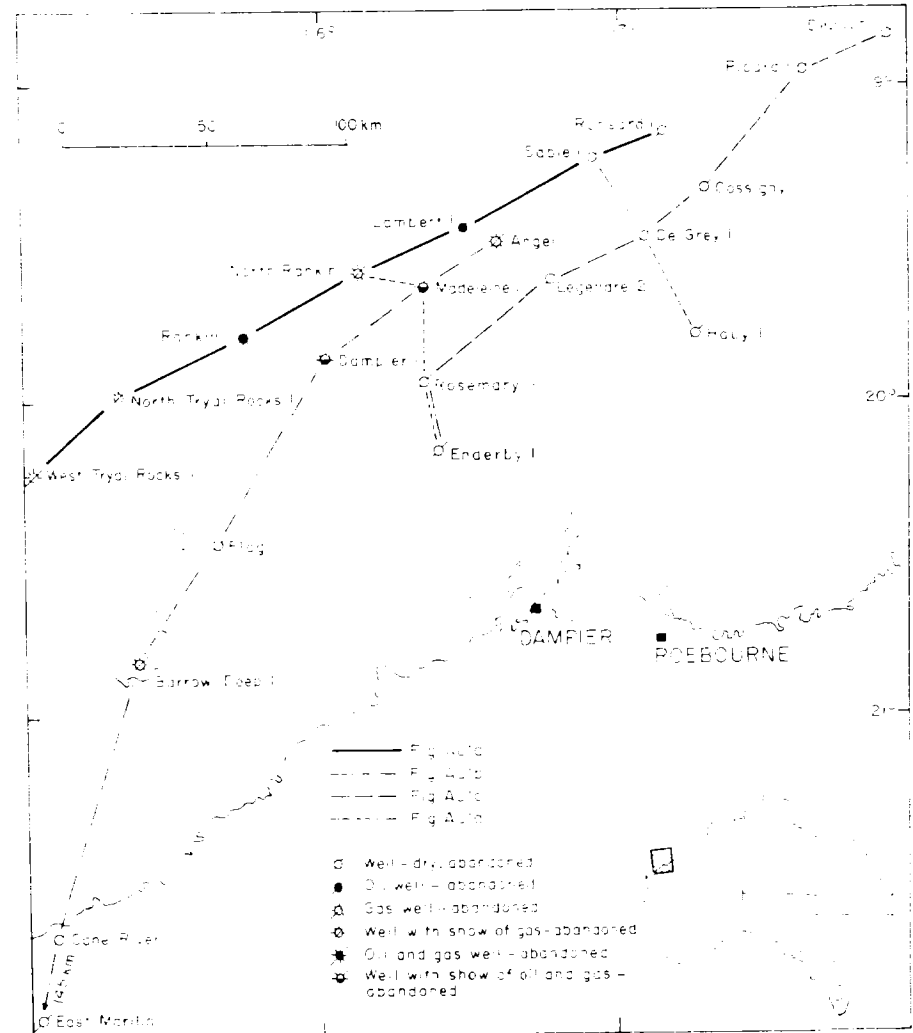
LAMBERT I

SABLE I

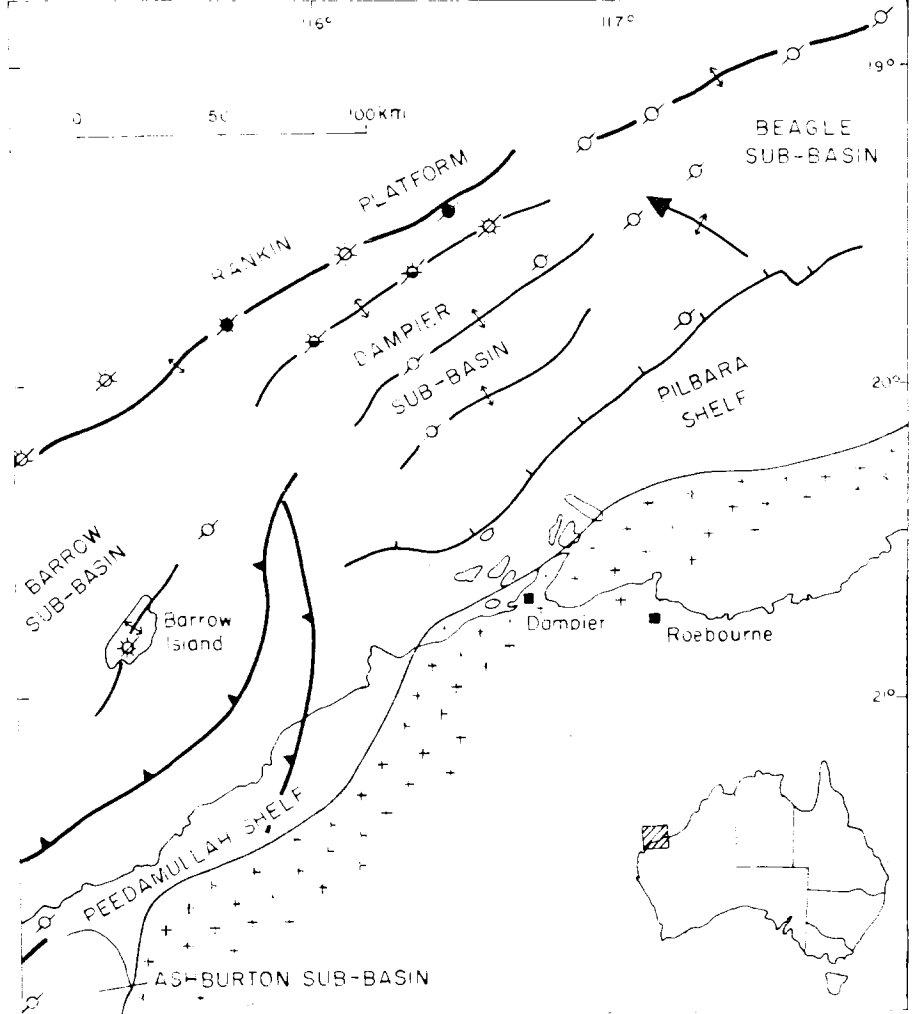
RONSDARD I



LOCATION DIAGRAM



STRUCTURE DIAGRAM



AUSTRALIA Au Ia Carnarvon Basin



CARNARVON BASIN : WESTERN AUSTRALIA  
 ESCAP ATLAS OF STRATIGRAPHY (IGCP PROJECT No.32)

EAST MARILLA I.

CANE RIVER I

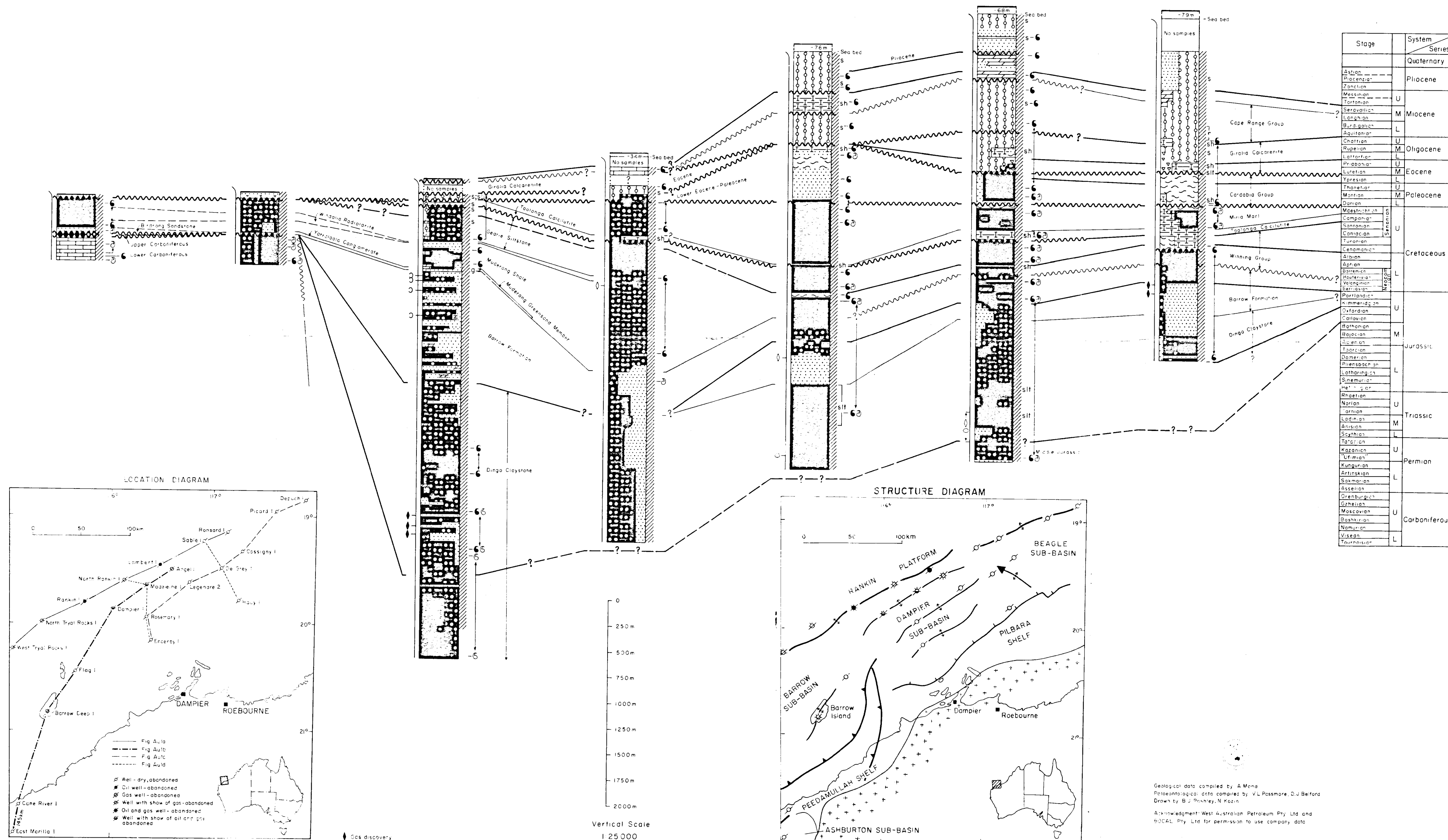
BARROW DEEP I

FLAG 1

DAMPIER I

MADELEINE I

ANGEL I



Geological data compiled by A. Mond  
 Palaeontological data compiled by V.L. Passmore, D.J. Belford  
 Drawn by B.J. Pashley, N. Kozin

Acknowledgment: West Australian Petroleum Pty. Ltd. and SOCCAL Pty. Ltd. for permission to use company data.

AUSTRALIA Au 1b Carnarvon Basin



# CARNARVON BASIN : WESTERN AUSTRALIA

## ESCAP ATLAS OF STRATIGRAPHY (IGCP PROJECT No.32)

ENDERBY I

ROSEMARY I

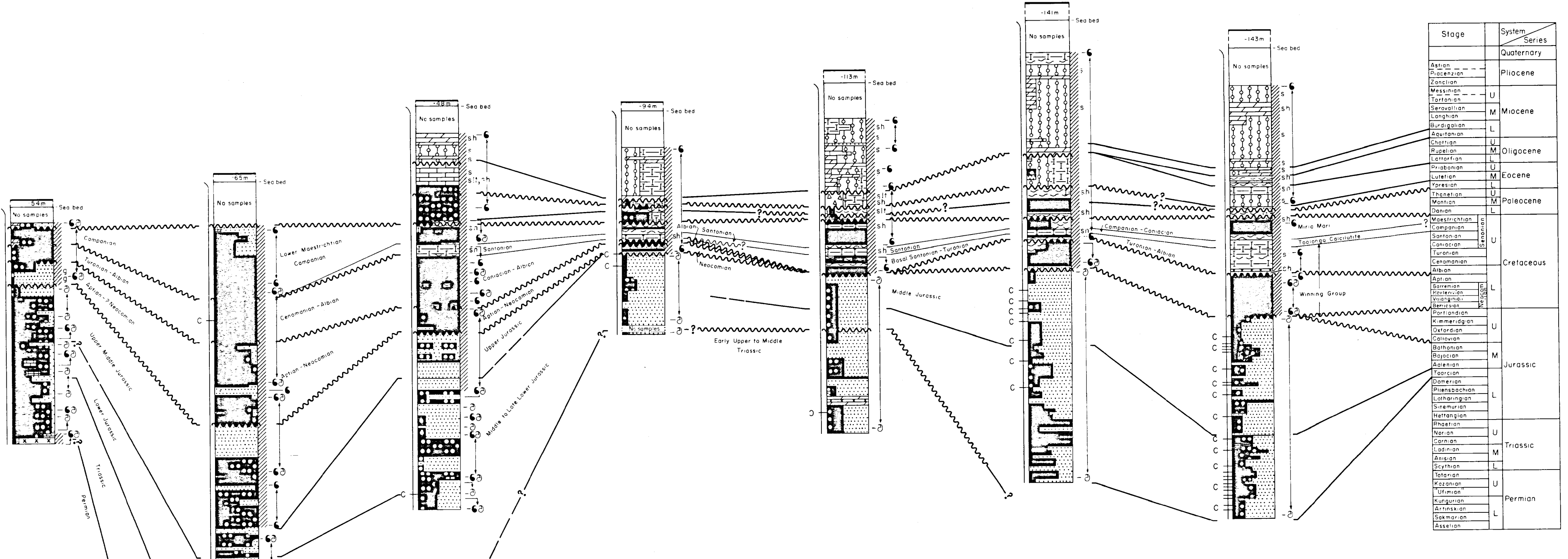
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DE GREY I

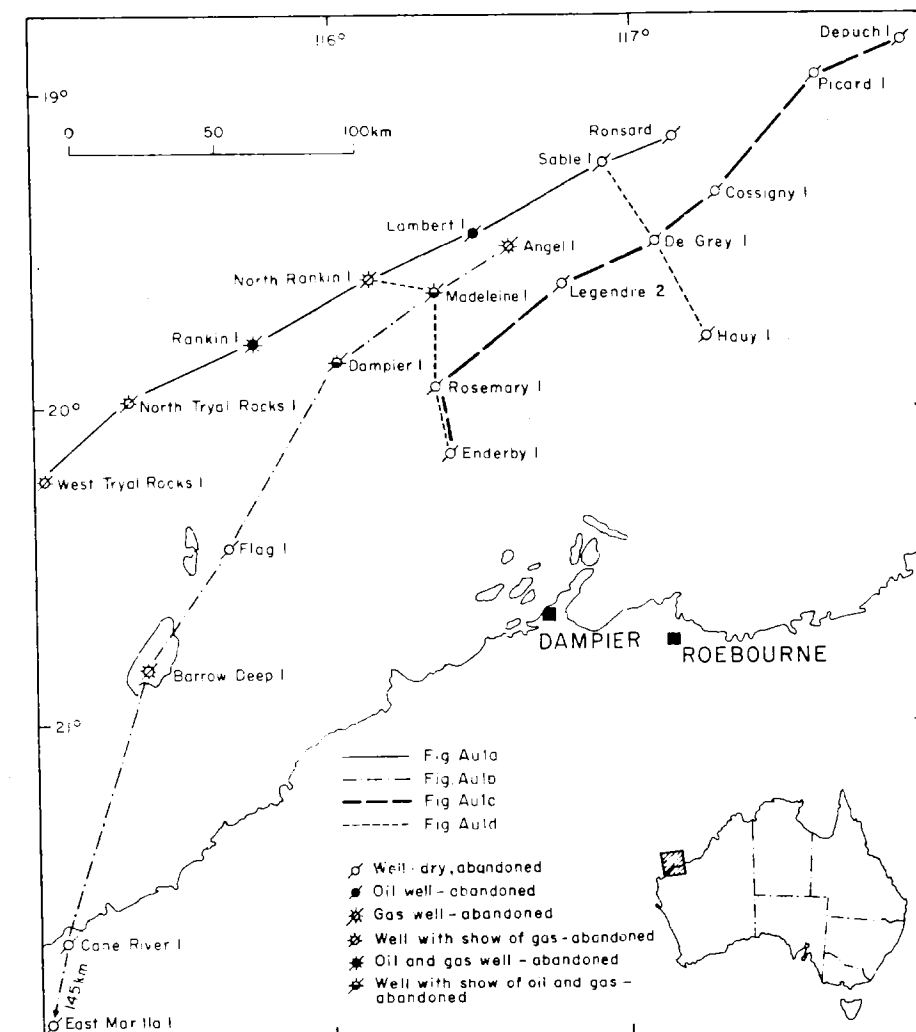
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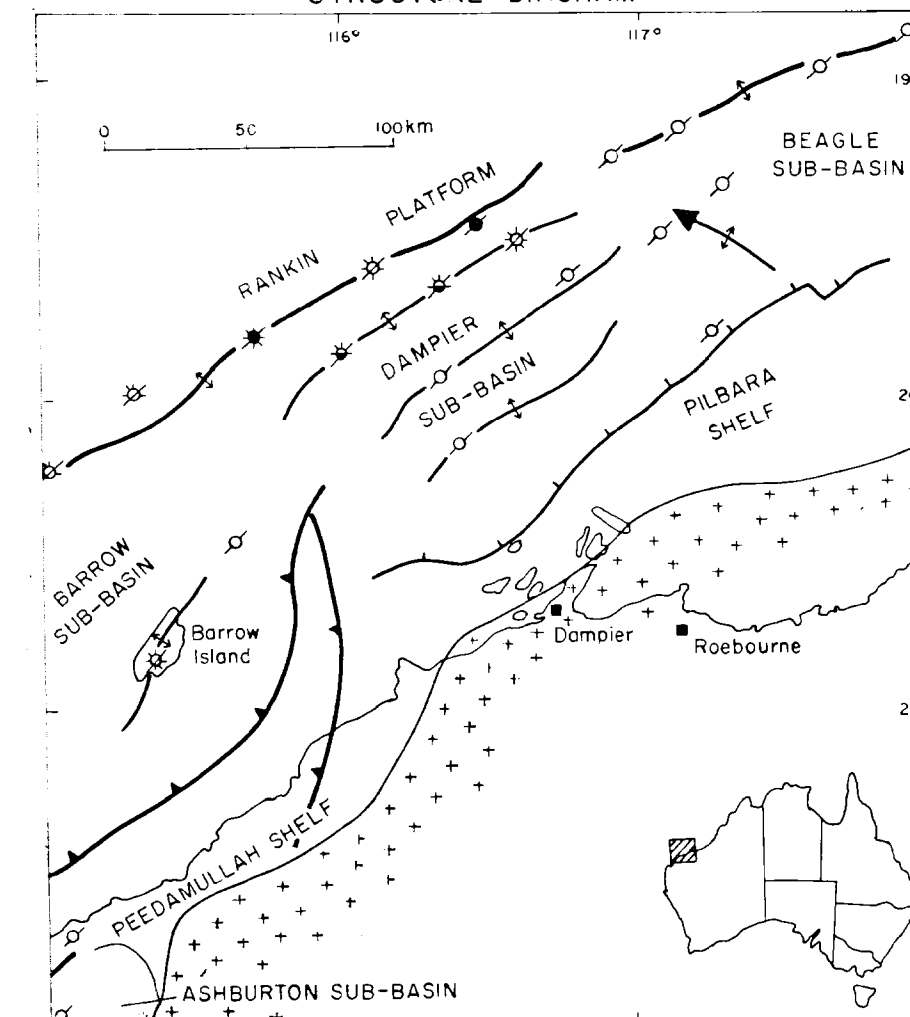
DEPUCH I



LOCATION DIAGRAM



STRUCTURE DIAGRAM



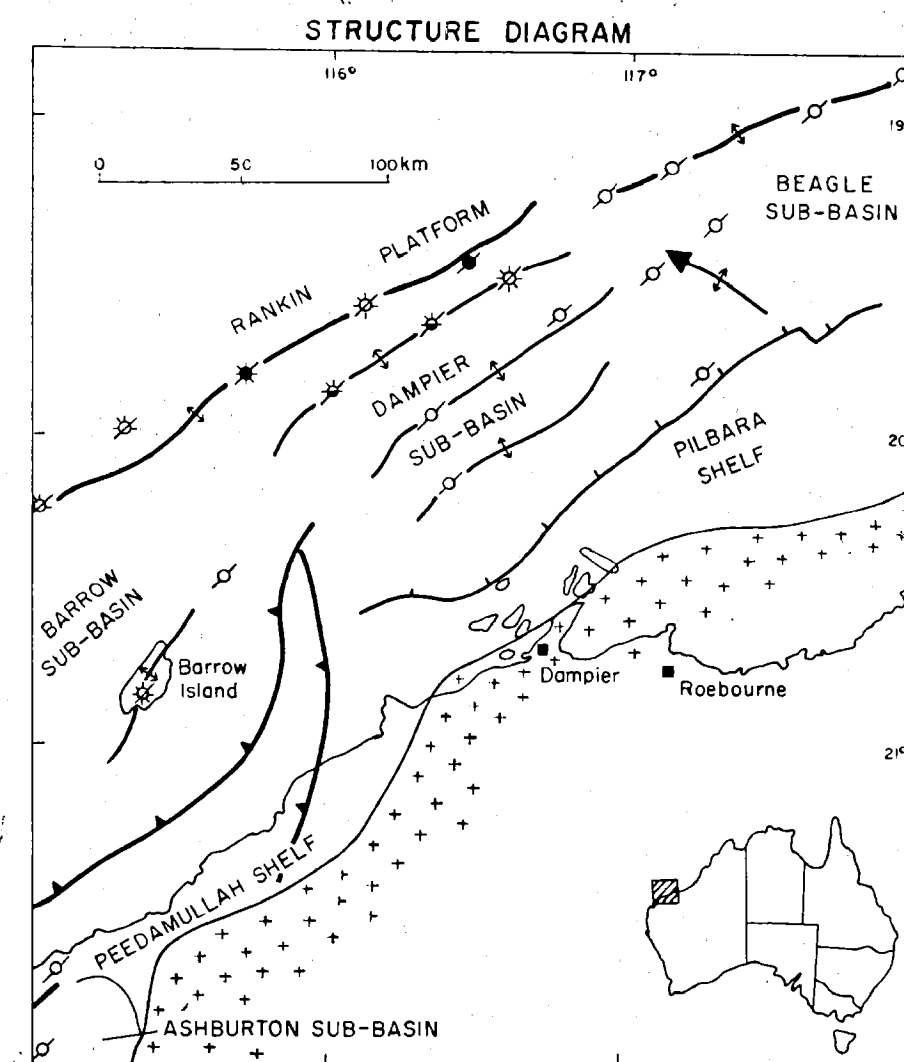
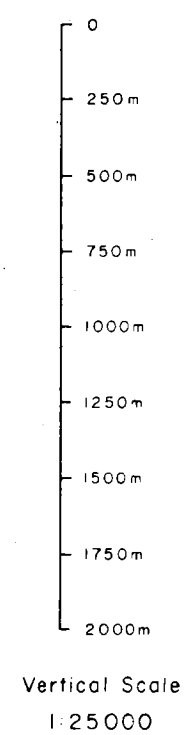
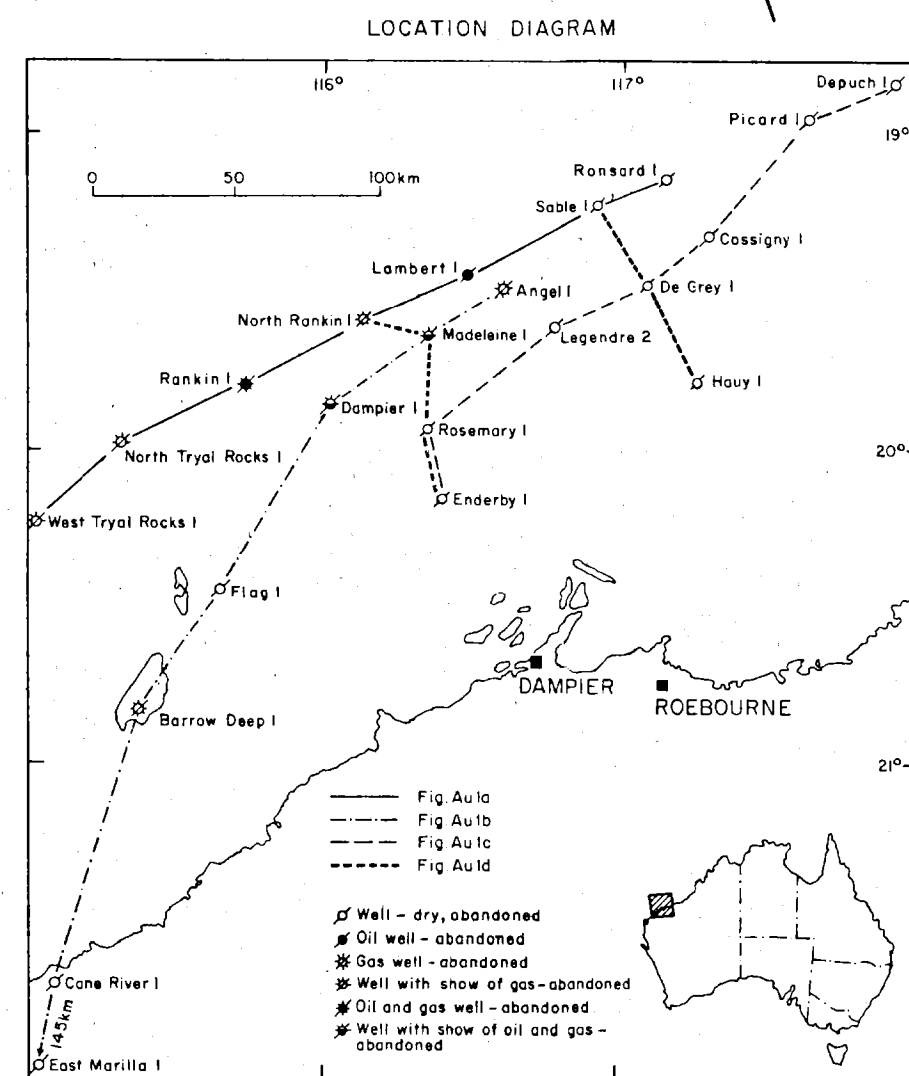
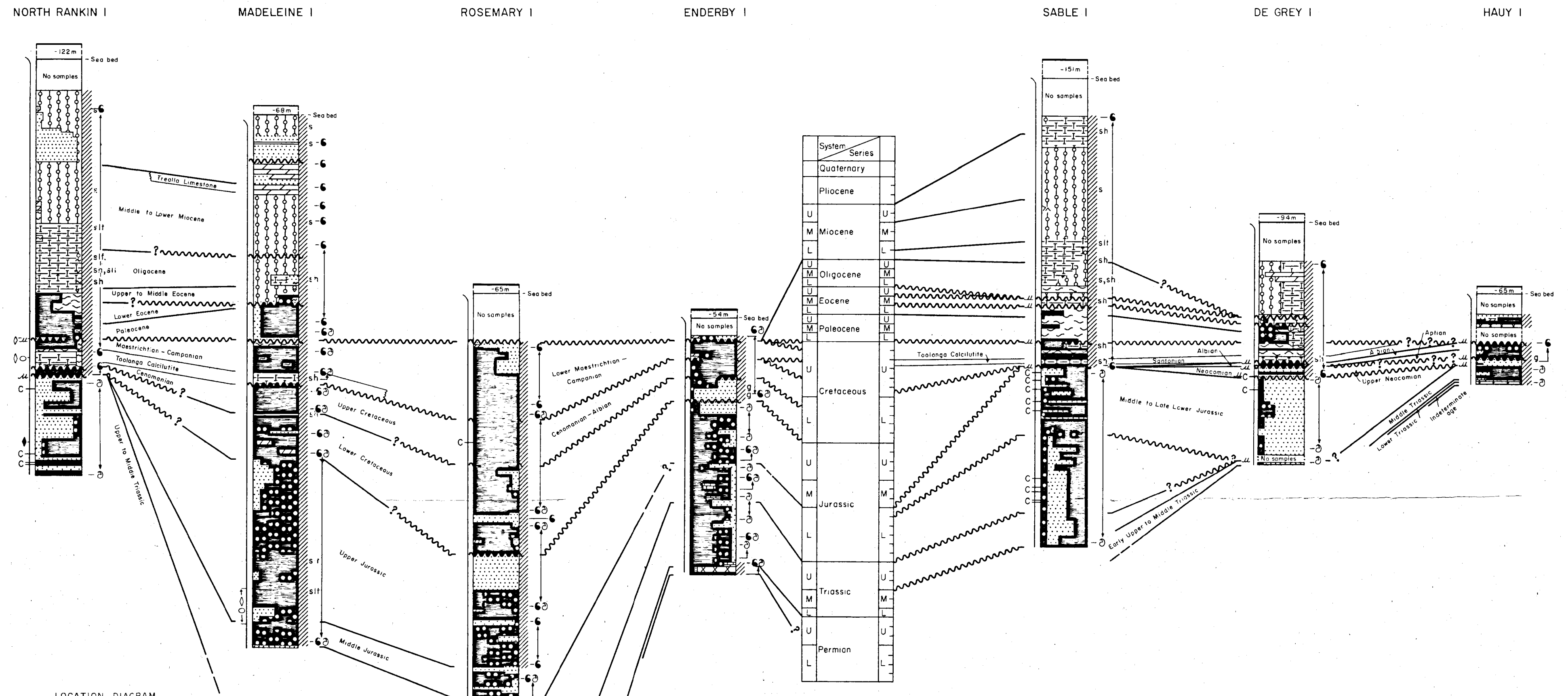
Vertical Scale  
1:25000

Geological data compiled by A. Mond  
Paleontological data compiled by V.L. Passmore, D.J. Beiford  
Drawn by B.J. Pashley, N. Kozin  
Acknowledgment West Australian Petroleum Pty. Ltd. and  
SOCAL Pty. Ltd. for permission to use company data

AUSTRALIA Au 1c Carnarvon Basin

BMR File No. XAJS-7-66

CARNARVON BASIN : WESTERN AUSTRALIA  
 ESCAP ATLAS OF STRATIGRAPHY (IGCP PROJECT No.32)



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