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ENV 903

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SHELL DEVELOPMENT (AUST.) PTY. LTD.

ONSHORE GEOLOGY

GREAT AUSTRALIAN BIGHT TO KANGAROO ISLAND

by

J. R. Cundill

of

Cundill, Meyers & Associates Pty. Ltd.

I N D E X

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- 2 " " 2 (Eastern Eucla Basin).
- 3 " " 3 (Eyre Peninsula & St. Vincent's Basin).
- 4 Pre Cambrian Structure Map Eucla Basin.
- 5 Lower and Middle Cambrian Isopach.
- 6 Permian Isopach.
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- 8 Base Tertiary, Structure and Subcrop Map.
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INTRODUCTION.

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This study of the onshore geology from the Great Australian Bight to Kangaroo Island was undertaken in the latter part of 1967 and early 1968, at the request of Shell Development (Australia) Pty. Ltd.

Thanks are due to Dr. C. Periam of Shell, for his suggestions regarding the project, and for expediting the supply of much of the material on which the project is based. Thanks are also due to officers of the Mines Departments of South Australia and West Australia for their full support in obtaining information and references, and to geologists Mr. D. Rutledge and Mr. J. Gausden, who assisted with the preparation of the report.

PREVIOUS WORK.

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Some of the earliest geological surveys were carried out in 1885 by Brown, and in 1897 by Tate. Geologists from State Government geological surveys conducted surveys in the earlier part of the twentieth century, notably Gibb Maitland, in connection with artesian water.

A great deal of palaeontological and stratigraphic work has been carried out by Ludbrooke, the value of which has been very great.

Other important recent palaeontological contributions have been made by Harris and Lindsay. Advances in the understanding of the geology of the area over recent years has been possible by the efforts of many geologists from the South Australian and West Australian Mines Departments.

During the period 1954-1959 the B.M.R. conducted regional gravity and aeromagnetic reconnaissance surveys in the Eucla basin. Little geophysical survey was done on the offshore portion of the basin until 1965 when marine seismic refraction studies were carried out on the continental margin to the south of Australia. In 1964 SA D+M the B.M.R. conducted more extensive reconnaissance seismic refraction surveys in the South Australian portion of the Eucla Basin. In the period 1965-66 Shell Development (Aust) conducted aeromagnetic surveys and reconnaissance marine seismic surveys in the region of Kangaroo Island to near the South-West Australian border. In 1966 an aeromagnetometer survey was carried out in the Eucla Basin offshore shelf.

Well drilling in the Eucla Basin has been carried out since the early 1890's when Albala Karoo Bore, which is situated about 45 miles east of Eucla, Nullarbor No. 5 bore which is located to the north of the Nullarbor homestead, and Croydon Bore near Adelaide were drilled.

In the period 1902-1903, the West Australian Government drilled the Madura bore, at Madura, to a depth of 2101 ft. Madura No. 2 to the north of Madura and Government Bores 11, 12, 13 situated between Balladonia and Madura, were then drilled to shallower depths. In 1907 the W. A. Government drilled the Loongana Bore, which is near Loongana, to depth of 1371'. In 1913 Gilgurablie Bore and Murran Wijninnie Bore were drilled near the Nullarbor homestead. During the period 1914-15 the Commonwealth Government drilled bores from the 846 mile peg to the 315 mile peg on the Trans Australian Railways. The wells were mostly shallow, (400-600'), although the 671 mile bore has a depth of 1470' and the 741 mile bore a depth of 1372'.

Drilling resumed in 1920 when the Black Swamp Oil Bore was drilled to a depth of 352' and the Mallabie Bore to 850'. In 1924 the S.A. Dept. of Mines drilled the Mullata Lignite Bore. In the 1930's the Peninsula Oil Bore No. 1 was drilled by the Peninsula Oil Co. In 1954 Maralinga Bores 1 - 15 were drilled near Maralinga in the Eastern Eucla Basin by the Dept. of Mines.

The 1960's has seen a large increase in the number of wells drilled. In 1960 Exoil Oil Co. drilled the two wells of Eyre No. 1 and Gambanga No. 1. In 1961 the S.A. Dept. of Mines drilled Minlaton No. 1 bore at Minlaton, and in 1962-3 Beach Petroleum drilled the bores of Grange No. 1 and Hallions No. 2 to the north of Adelaide. In 1964 Alliance Oil Development drilled the Eucla Bore near Eucla. In 1966 Beach Petroleum drilled Edithburgh Bore, Stansbury West No. 1, and Outback Oil Co. drilled Hughes 1, 2 and 3, Denman No. 1 and Outback Cook Bore No. 1 in the Eucla Basin. Beach Petroleum drilled Stansbury Town No. 1 in 1967.

WELL DATA SHEET.

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The Well data sheets, (Plates 1, 2 and 3), represent a summary of all the significant available data covering the following bore and well information. Ninety bores and wells appear on the sheets, arranged generally from west (left) to east (right). Sheet 1 contains wells in the western and central Eucla Basin, Sheet 2 the eastern Eucla Basin, and Sheet 3, the Eyre peninsula and St. Vincent's basin wells.

The information is set out as follows:

1. Well name

In the case of the Trans Continental railway bores, the mileage from Port Augusta has been used in each case. To avoid confusion, W.A. Government bores on this line (which have mileages listed from Kalgoorlie) have their locations converted to ex Port Augusta mileages.

To facilitate looking up a bore on the sheets, an index has been provided. This is arranged alphabetically, or numerically in the case of the Railway bores, and appears on Sheet 1.

2. Operator.

3. Total Depth.

4. Location.

5. Date drilled.

6. Logs run.

7. KB or surface elevation.

In cases where no elevations are available, interpolated values have been taken from the Eucla basin topographic map. This topographic Map (Plate II) was prepared for this report from spot heights appearing on the 4 mile sheets, and from known well elevations.

8. Main sources of information.

Each reference used has been assigned a number. Key to the numbers is as follows: (For further details of references, see main reference list at end of report).

- | | |
|----------------------------------|---|
| 1. Alliance Oil Development | Eucla No. 1 Completion Report |
| 2. Amdel (1965) | Report No. MP 1043-65 to S.A. Dept. of Mines. |
| 2A. Commonwealth Railways (1915) | Plan and section of bores Kalgoorlie to Port Augusta. |
| 3. Cornish (1964) | Light No. 1 Completion Report. |
| 4. Crawford (1965) | The Geology of the Yorke Peninsula Bull. 39 S.A.G.S. |
| 5. Cundill, Meyers & Assoc. | Completion Reports: Stansbury West No. 1 |
| 6. Cundill, Meyers & Assoc. | Edithburgh No. 1 |
| 7. Geosurveys (1963) | Troubridge Island No. 1 Completion Report. |

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|-------------------------------|---|
| 7A Geosurveys (1967) | Stansbury Town No. 1 Completion Report. |
| 8. Harris (1964) | Mesozoic Sediments of Polda Basin |
| 9. Harris & Ludbrook (1966) | Permian Sediments in the Eucla Basin |
| 10. Harris (1967) | Personal communication |
| 11. Johnson (1956) | Preliminary Report on Groundwater investigation in County Hopetown |
| 12. Kendall (1961) | Report on Reconnaissance Seismic Survey in S.A. portion of the Eucla Basin. |
| 13. Ludbrooke (1957) | Paleontological Examination of Bores in the West Eucla. |
| 14. Ludbrooke (1958) | Stratigraphic sequence in West portion of Eucla Basin. |
| 15. Ludbrooke (1958) | Subsurface stratigraphy of the Maralinga area. |
| 16. Ludbrooke (1960) | Eyre No. 1 and Gambanga No. 1 Stratigraphy and Paleontology. |
| 17. Ludbrooke (1961) | Minlaton and Stansbury Stratigraphic Bores Subsurface Stratigraphy and Micropaleontology. |
| 18. Ludbrooke (1962) | Correlation of the Tertiary Rocks of S.A. |
| 19. Ludbrooke (1963) | Troubridge Shoal Stratigraphic Well. Subsurface stratigraphy. |
| 20. Ludbrooke (1966) | Hughes - Denman Drilling - Stratigraphic and micropalaeontological study. |
| 21. Lindsay (1965) | Stratigraphy and Micropalaeontology of three deep bores in hundred of Port Gawler. |
| 22. Lindsay (1967) | Adelaide Plains Stratigraphy and Micropalaeontology. |
| 22A Maitland (1907) | Presidential address to ANZAAS |
| 23. Maitland (1912) | Geology of W.A. Bull of W.A.G.S. 50/52. P.23. |
| 24. Maitland (1918) | Petroleum possibilities of Nullarbor Plain. |
| 25. Outback Oil Co. | Subsidy (Application for Magnetometer Survey) Eucla Shelf. |
| 25A Rutledge | Personal communication. |
| 26. S.A. Mining Review (1963) | Myponga Bore |
| 27. S.A. Mines Dept. | Bull. 13 |
| 28. S.A. Mines Dept. | Bull. 23 |
| 29. S.A. Mines Dept. | Letter to Shell. Lithologic Log (Cook bore) |
| 30. S.A. Mines Dept. | Letter to Shell 1959. Includes lithologic descriptions of some bores |

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|---|---|
| 31. S.A. Mines Dept. | Well Report List:
Hd Sleaford Sec. 15
Hd Flinder Sec. 2 No. P
Hd Shannon Sec. 11 No. 4 |
| 31A S.A. Mines Dept. Well
Reference List | |
| 32. Shell | Letter to Ludbrooke (1966)
Reply: S.A. Mines Dept. to Shell |
| 33. Shell (1914) | Precis of Interstate Conference
on Artesian Water. |
| 34. Shell (1924) | Precis of Interstate Conference
on Artesian Water. |
| 34A Tracers Australian
Drill Tickets. | |
| 35. Ward (1944) | The Search for Oil in Australia
G.S.S.A. Bull. No. 22. |
| 35A Ward (1946) | The occurrence of Ground Water
in S.A. P/271. |
| 36. W. A. Mines Dept. (1914) | Annual Progress Report -
Geological Survey |
| 37. Wapet (1961) | Eyre No. 1, Gambanga No. 1,
Completion Reports and Cross
Sections. |

GEOLOGY.

0012

PRE CAMBRIAN-ARCHEAN AND PROTEROZOIC.

No detailed study of the Archean and Proterozoic rocks have been made for this report.

Archean rocks of the "West Australian" shield extend eastward to underlie Yorke Peninsula in South Australia. Extensive granitization had occurred of previous sedimentary cycles, so that for all intents and purposes, the Archean was a crystalline rock mass, during Proterozoic sedimentation.

Off the east edge of this shield area - to the east of Yorke Peninsula - a great geosyncline developed. This was the Adelaide Geosyncline, in which, during Upper Proterozoic and Lower Palaeozoic times, up to 40,000 feet of sediments accumulated, most in shallow water. Conglomerates and sandstones initiated the succession, followed by volcanics, carbonates, glacials and continental deposits. Further carbonates and continental deposits followed in the south.

The whole was then subjected to the great diastrophism of later Cambrian times, and was folded, faulted, metamorphosed and intruded by granites. The resulting fold belt forms the present Flinders Ranges - Mt. Lofty Ranges - Kangaroo Island pattern. All hydrocarbon potential of the preceeding sediments of the area were destroyed by this diastrophism.

The Marinoan series is the uppermost unit of the Proterozoic and is thus the part of the Proterozoic most frequently encountered in bores. It consists of a sequence of purple, green, reddish or grey shales and silts, with some sandstones, and dolomites. Dessication and depositional features suggest deposition in a very shallow water, oxygenated probably continental enviroment. If this is so, hydrocarbon potential must be regarded as being low, even apart from considerations regarding the great antiquity of the sediments.

In the east Eucla Basin area (See Plate 5), there is also a broad area where the Marinoan is present. The area widens to the north, but there is a possibility that it does not extend south of the present coast, except perhaps through a limited area.

Plate 4 indicates structure on the Pre Cambrian in the Eucla Basin. The low area near the Eyre No. 1 well, and in the eastern part of the Eucla Basin, are of significance in the light of subsequent sedimentation, and suggest mild downwarping in these areas.



CAMBRIAN.

0013

DISTRIBUTION

Lower and Middle Cambrian sediments occupy an area around St. Vincent's Gulf (Plate 5). Possible lower or middle Cambrian? sediments are also present in the Eucla basin.

In addition, The Kanmantoo Group, which may be of younger Cambrian age, is present in the southern part of Kangaroo Island and in the Flinders Ranges. These beds, however, have been involved in the metamorphism of the Adelaide geosyncline, and are now mostly phyllites and quartzites. The metamorphism occasionally reached sillimanite grade. They have not been included with the Lower and Middle Cambrian isopachs, but rather included with the basement complex. Some of the lower Cambrian succession have also been slightly metamorphosed on the Fleurieu peninsula.

STRATIGRAPHY

The stratigraphy of the lower and middle Cambrian is dealt with under the following headings:

Yorke Peninsula
Fleurieu Peninsula
Kangaroo Island
Eucla Basin

(a) Yorke Peninsula

On Yorke Peninsula, the foreland part of Cambrian sedimentation, Cambrian sediments largely escaped the deleterious effects of the Adelaide Geosyncline diastrophism. Wells in the Yorke Peninsula have found the Cambrian carbonates to be unmetamorphosed, and in places, to have good porosity and permeability. Folds are fairly gentle, and faulting not extensive, except in the north east.

The best development of Cambrian sediments is found in the subsurface, where they attain a maximum thickness of 4214 feet in the Stansbury West No. 1 Well. The sequence has been divided into five formations, namely the lowermost Cambrian Transitional Beds, the lower Cambrian Kulpara dolomite and Parara Limestone, and the lower to middle Cambrian Ramsay Formation and Upper Red Beds. Unconformities occur between the Parara and Ramsay formations and at the top of the Upper Red Beds. Correlation between subsurface and outcrop is reasonably good, but the Kulpara-Parara boundary is difficult to pick in the subsurface, and is generally arbitrarily taken at the top of the secondary dolomitization.

The simplified stratigraphic sequence is as follows:

PERMIAN
Unconformity

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Upper Red Beds

Lower to Middle Cambrian

Ramsay Limestone
(includes Lower Red Beds
at base)

Parara Limestone and Minlaton
Conglomerate (where present)

Lower Cambrian

Kulpara Dolomite

Transitional Beds.

Pre Cambrian

A discussion of the sequence in the Yorke Peninsula wells follows below.

Stansbury West No. 1:

- (i) Transitional Beds 5375 to 5708 ft. - 333 ft. of sandstones and minor siltstones.

The topmost 45 ft. of this section comprises pink and light grey, brown and mauve mottled sandstones. They are generally poorly sorted and consist of very fine to medium grain sub-angular quartz and reddish feldspar set in a siliceous dolomitic matrix. Core No. 12 (5387-5392 ft.) illustrates this lithology and shows the gradational sandy dolomite and dolomitic sandstone features of the "Transitional beds" to Kulpara contact. Occasional large included shale fragments are also visible in this core. These sandstones are hard and extremely tight. Between 5420 and 5640 ft. the sandstones become predominantly light grey in colour with only traces of feldspar, as well as included clastic mica and green mafic fragments. Minor interbeds of grey, siliceous, dolomitic sandstones also occur. In the interval 5640-5653 ft. the sandstones become pink in colour with highly variable fine to very coarse grain size. These sandstones consist of poorly sorted sub-rounded quartz, pink and white feldspars with minor mica and mafics in a dolomitic part siliceous matrix. Below 5653 ft. the lithology remains similar but the quartz becomes more rounded and the siliceous cement content decreases, with the consequent development of poor to fair intergranular porosity.

- (ii) Kulpara Dolomite 4226 to 5375 ft. - 1149 ft. of dolomite

The contact between the Kulpara and the overlying Parara limestone is gradational. This is illustrated by the lithology of the interval 4226-4270 ft. where medium to dark grey cryptocrystalline partly dolomitic limestones grade to and are interbedded with light grey crypto to fine crystalline vuggy and dense dolomites.

The limestones contain a fine recrystallised dolomite and calcite crystals while the dolomites occur in a crypto to fine crystalline form with occasional coarse calcite crystals and calcite lined vugs. Core No. 9 illustrates this lithology, with interbedded dolomites and limestones being present. The limestone in this core is dense with the dolomites showing variable dense to good vuggy and intercrystalline porosity.

Below 4270 ft. a straight dolomite lithology prevails. Two basic varieties occur: (i) A light grey crypto to very fine part crystalline dolomite with medium to very coarse euhedral to subhedral calcite crystals in part associated with the vuggy and fracture porosity which is common throughout the section. Occasional fractures, stylolites and carbonaceous streaks also occur. In addition to the vuggy and fracture porosity, fair to good intercrystalline, microvugular and pin point porosity is also developed. (ii) A medium to dark grey and brown dolomite. This dolomite is micro to very fine crystalline and has a variable argillaceous content as compared to (i) above. Scattered medium to coarse dolomite and calcite rhombs occur throughout, but in general the dolomite is denser with only minor streaky porosity. This lithology is subsidiary to (i) and becomes the dominant lithology only in the interval 4825 to 5230 ft.

(iii) Parara Limestone 3035 to 4226 ft. - 1191 ft. of limestones and minor dolomites.

The top 40 ft. of this formation consists of white moderately soft and chalky limestones with dolomite veining, and traces of gypsum. The underlying 33 ft. shows a development of white to pink hard cryptocrystalline to very fine crystalline dolomites. These are very dense and are interbedded with dark grey, hard, massive, carbonaceous and pyritic shales. The remainder of the sequence is comprised of light to dark grey, or brown limestones. They vary from cryptocrystalline to very fine crystalline with argillaceous streaks and partings and rare carbonaceous infilled stylolites. Rare intercrystalline, vuggy and fracture porosity also occurs.

Cores No. 6 (3149 ft), 7 3315-3325 ft) and 8 (3822-3829 ft) illustrates the lithology. The gross features shown by the cores indicate slumping, solution and fracture features. In cores Nos. 7 and 8 vague relic shapes suggest an original allochemical content (either intracasts or organic). No evidence for the presence of the Archeocyatha reefs were discernable, although determination would probably be difficult due to fairly intense syngenetic recrystallisation.

(iv) Ramsay Formation. 1900 to 3035 ft - 1135 ft. of limestones, shales, dolomites and sandstones.

Prior to the drilling of Stansbury West No. 1 this formation had not been penetrated or defined fully. The Ramsay limestone was recognised as a 200-300 ft. thick unit, from surface and subsurface geology. The Minlaton stratigraphic bore penetrated 106 ft. of Ramsay limestone below the Permian to Cambrian unconformity. In the Stansbury West No. 1 well the Ramsay limestone unit is 1135 ft. thick, consisting of primarily carbonate sediments with minor clastic lithologies.

For convenience of description the formation has further been subdivided into 4 units (A.B.C.D.) These units are somewhat arbitrarily defined but show a number of characteristic electric and lithologic features.

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Unit A 1900 to 2205 ft. - 305 ft of limestones and minor shales and sandstones. Basically this unit comprises light to dark grey cryptocrystalline to microcrystalline limestones. In part these are dolomitic and show numerous stylolitic and other solution features infilled with carbonaceous material. Minor amounts are present of *Archeocyatha*, trilobite fragments, sponge spicules and there is some evidence for an original pelletal and oolitic texture. Some green and red brown sandstones, and green grey shales are present in Unit A.

Unit B 2205 to 2425 ft. - 220 ft. of sandstones and shales. This unit shows a dominantly sandstone-shale lithology. The upper 110 ft. of this unit consists of red-brown to buff, moderately hard, very fine to fine grained sandstone comprised of a subangular, quartz, mica flakes and grey lithic fragments and rare feldspar set in an argillaceous part silicic matrix. The remainder of the unit consists of dark grey and green grey shales. This shale is sub fissile, silty, micaceous and in part sandy and shows minor streaks of sandstone as described above with a markedly increased argillaceous content.

Unit C 2425 to 2715 ft. - 290 ft. of limestone and dolomites. The top 140 ft. of this unit is comprised of medium to dark grey limestones showing crypto to fine crystalline texture. Occasional sandy, silty and argillaceous laminations are developed throughout as well as scattered stylolites. The remainder of the sequence consists of hard, fine crystalline dolomites. In part these dolomites are sandy, pyritic and gypsiferous. Interbeds of shale and limestone as described above are common throughout. Core No. 5 (2495 to 2506 ft.) illustrates the general lithology and shows a high organic content with sponge spicules and minor brachiopod fragments visible.

Unit D 2715 to 3035 ft. - 320 ft. of shales and minor limestones. This unit is correlative with the lower red bed sequence encountered in the Minlaton stratigraphic bore. Because of lithologic and electric similarities it has here been included in the general Ramsay Formation. Notable differences as compared to the Minlaton bore are the decrease in its red-bed character and a dominantly shale lithology. The unit consists of red and purple brown, green and grey shales. These are moderately hard, finely micaceous, silty and in part dolomitic. The only departure from this lithology is the development of a medium grey limestone bed between 2795 and 2828 ft. This limestone is of interest in that it correlates with the cellular limestone developed in the Minlaton stratigraphic bore. At Minlaton this limestone developed excellent cellular porosity. In the Stansbury West No. 1 well, however, it shows a hard cryptocrystalline to fine crystalline dense nature with interbedded light and medium grey fine crystalline shaly dolomites. This would indicate a fairly rapid facies change and could be of considerable interest as a future oil or gas play.

(v) Upper Red Beds. 1100 to 1900 ft. - 800 ft. of sandstones and shales.

The topmost 660 ft. of this section consists of fairly uniform sequence of sandstones with minor shaly partings and interbeds. The sandstones as seen in the cuttings and Core No. 2 (1137-1144 ft) are generally red-brown in colour, and moderately hard with very fine grained sub-angular quartz, mica flakes and occasional grey and green lithic grains set in an argillaceous partly silicic and calcareous matrix. Core No. 2 shows minor low angle cross-bedding with some indications of bedding not exceeding 5 degrees. The argillaceous partings and shale interbeds show a dark brown and grey-green colour, being slightly fissile, finely micaceous, silty and becoming slightly dolomitic in the basal part of the sequence. The shale content increases downwards. Core No. 3 (1738 to 1744 ft.) shows interbedded sandstones and shales with fairly common vertical subvertical fractures and minor cross bedding dipping at 5 degrees. In the interval 1760-1900 ft.

the section is predominantly dark grey and brown fissile to blocky shale. This shale is generally very fine to coarsely micaceous, silty, and in part has a high fine sand content.

Edithburgh No. 1:

- (i) Transitional Beds. 3118 to 3437 ft. - 319 ft. of sandstones and dolomites.

The Transitional beds are broadly divisible into three lithologic units. In the interval 3118 to 3202 ft. pink and red, very fine grained sandstones constitute the dominant lithology. These sandstones consist of sub-angular to sub-rounded quartz set in a dolomitic matrix. Occasionally the sandstones show a brown colouration with coarse included angular quartz grains. Gradations to sandy dolomites occur frequently throughout the unit. In the interval 3202 to 3327 ft. dolomites form the basic lithology. Predominantly these are grey-brown in colour with some pink and brown mottling. Grain size varies from very fine to fine with occasional medium grain size. Both compact and sucrosic recrystallisation textures are present. In part micritic calcite forms the cementing bond between the dolomite rhombs. The argillaceous content is variable with frequent silty and sandy laminations along with rare included glauconite pellets. Minor interbeds of a white to light grey fine grained sandstone also occur. These sandstones consist of angular to sub-angular quartz, rare rock fragments and glauconite pellets set in a dolomitic matrix. The basal lithologic unit from 3327 to 3434 ft. is comprised of a brown soft and friable sandstone. The sandstone consists of fine to medium, poorly sorted, angular quartz, pink and brown feldspar, rare rock fragments and glauconite pellets set in a sparse silicic matrix. The basal 20 ft. shows coarse to granule size included angular quartz grains. Core No. 3 (3205 to 3216 ft.) illustrates the lithology of the dolomites. Stylolites and argillaceous partings and laminations are common. Minor thin interbeds and irregular lens-like bodies of a hard green dolomitic mudstone also occur. Dips of less than 5 degrees are in evidence.

- (ii) Parara-Kulpara units. 2266 to 3118 ft. - 852 ft. of dolomites, minor shales and sandstones.

The dolomites represented in this section show a fairly consistent lithology throughout. In general, they are grey to white in colour with grain sizes varying from micro to fine crystalline. Two basic and recrystallisation textures occur together; (a) compact, and (b) sucrosic. The sucrosic recrystallisation texture is restricted to the coarser crystalline material with associated development of vugular and intercrystalline porosity. A further association of this porosity and texture with open solution and fracture features may also be noted. The vugs are commonly infilled and/or lined with fine to medium dolomite, calcite and rarely quartz crystals. A variable content of sand and argillaceous material is also present, generally not exceeding 10%.

- (iii) Ramsay Formation. This is subdivided in the Edithburgh well into a lower limestone unit and an upper red bed unit as follows:

(a) The limestones of the lower unit are 79 ft. thick. They are brown and white in colour and show grain sizes varying between crypto and fine crystalline. Occasionally they are finely bioclastic, and in part are slightly argillaceous with traces of gypsum plates occurring throughout. Interbeds of limestones showing a sucrosic and chalky texture are common.

(b) The upper unit is 482 ft. thick and consists predominantly of

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a red brown to occasionally blue grey sandstone. The sandstones are very fine grained, moderately hard and consist of sub angular to sub rounded quartz, minor feldspar, rare rock fragments, feldspars and mica flakes, forming a tightly packed mosaic in a sparse silicic and calcite matrix. Interbeds of red, brown, grey, blue mottled, massive, mudstones are common throughout. The mudstones are partly sandy and pebbly with fine to coarse, subrounded to rounded, clear, dull and orange quartz, igneous, metamorphic, quartzite, calcite fragments and pebbles. The basal 60 ft. contains interbedded green shales. These shales are dolomitic and micromicaceous.

Stansbury Town No. 1:

(i) Transitional Beds: Lower Cambrian. 4000 to 4135 ft. - 135 ft. of sandstones, dolomites and shales. The main lithologies are as follows: 4000 to 4044 ft. Sandstone, orange, brown, white, red-brown, hard, fine to coarse grained, tight, consisting of subangular quartz, green soft ?glauconite (?epidote), part chocolate brown silty argillaceous matrix, part very dolomitic. 4044 to 4082 ft. Dolomite, dark chocolate brown, orange-brown, green, white, mottled, moderately hard to hard, very fine crystalline, sucrosic, very argillaceous, silty and sandy. 4082 to 4111 ft. Shale, dark red-brown, moderately hard, blocky, silty to finely sandy, slightly micaceous. 4111 to 4135 ft. Sandstone, orange, red-brown, green, soft and friable, fine to coarse grained, consisting of subangular to angular clear quartz, minor orange feldspar, in a kaolinitic and occasionally silicic cement.

(ii) Kulpara Dolomite. 3530 to 4000 ft. - 470 ft. of dolomite. The dolomite is variously white, light grey, pink, purple and mottled, moderately hard to hard, occasionally vugular and generally crypto to very fine crystalline. Gypsum as thin plates is occasionally present over the top 100 ft. Stylolitic seams are probably common and Core 12 shows that at least part of the dolomite has been intraformationally brecciated and recemented. The dolomite becomes sandy towards the base and contains green soft pellets of ?glauconite.

(iii) Minlaton Conglomerate. 3442' to 3530' - 88 ft. of Conglomerate. The Minlaton conglomerate comprises a hard orange, red-brown and pink to buff conglomerate, containing subangular to subrounded granules, pebbles and cobbles of gneiss and dolomite in a matrix of dark red brown silty and sandy micaceous shale. The gneiss is concentrated in the top of the conglomerate while the base of the unit contains only dolomite pebbles and cobbles. The dolomite is pink, brown and grey, hard, dense and micro to occasionally medium crystalline.

(iv) Ramsay Limestone. 3200 to 3442 ft. - 242 ft. of limestones, dolomites, minor shales. The top 132 ft. consists of limestone containing shale interbeds over the top 50 or so feet. The limestone is dark grey, brown, white, crypto to microcrystalline, hard, dense, occasionally oolitic and of predominantly orthochemical origin. Traces of sphalerite and chalcopryrite occur as small blebs and crystalline aggregates. A varied fauna including Hyalolithes, Lingulella, Redlichia, Obolella and cystids is present and the limestone is slightly dolomitic, micaceous and very sandy. The interbedded shale is dark grey, occasionally black, moderately hard, slightly calcareous, micaceous and silty. The remainder of the Ramsay limestone comprises interbedded dolomite, with minor limestone and shale as in the top 132 ft. The dolomite is white to light grey, pink or brown, moderately hard to hard, dense, microcrystalline, calcareous and sometimes micaceous and very sandy.

(v) Unnamed Middle Cambrian Units. 3010 to 3200 ft. - 190 ft. of sandstone and shale. The interval 3010 to 3150 ft. comprises light orange, grey and green, fine grained sandstone, moderately hard, and consisting of well sorted unimodal subangular clear and haematite stained quartz,, brassy silvery and dark brown micas and minor feldspar, in an argillaceous, calcareous and/or siliceous matrix. A few thin interbeds of green-grey slightly silty and micaceous shale are also present. From 3150 to 3200 ft. the lithology is dark green-grey, moderately hard, silty and micaceous shale.

2643 to 3010 ft. - 367 ft. of oolitic limestones and shales. From 2643 to 2684 ft. the unit comprises light brown to grey oolitic limestone, hard, dense and micro to very fine crystalline. Beneath this limestone, from 2684 to 2747 ft. occurs a dark greenish-grey moderately hard shale. The shale is brittle, micromicaceous, calcareous and slightly pyritic. Both the shale and limestone are fossiliferous, containing worm burrows, trilobites and brachiopods. From 2747 to the base of the unit at 3010 ft. a dolomitic limestone was intersected. The limestone is interbedded with shale in part, commonly has a nodular to concretionary aspect and is grey, hard, dense, micro to fine crystalline, sandy, stylolitic and occasionally oolitic. The limestone is commonly dolomitic and all gradations between pure dolomite and pure limestone occur, the limestone predominating. From 2800 to 2842 ft, and below 2970 ft. occur interbeds of dark grey to black, silty calcareous and ?carbonaceous shales. Laminae of gypsum occur, commonly associated with the more dolomitic interbeds. Blebs and crystalline aggregates of sphalerite, chalcopryrite and pyrite are fairly common over the more calcareous intervals. The limestones and dolomites are orthochemical in origin with only a limited amount of material (clay and quartz silt) of terrigenous origin.

(vi) Upper Red Beds. 843 to 2643 ft. - 180 ft. of sandstone and shale. The sandstones (lithic to feldspar greywacke class of Pettijohn), are predominantly orange, red-brown, purple, white or red in colour, moderately hard to hard, very fine to fine grained and display only an occasional trace of intergranular porosity. They consist of fairly well sorted, angular to subangular clear and orange quartz grains, common to abundant clear brassy and silvery mica flakes, minor plagioclase feldspar and lithic fragments in an alternatively argillaceous, calcareous, siliceous or gypsiferous matrix. Trilobite tracks and worm casts are occasionally present in the cores from this interval. Discrete interbeds, laminations and streaks of shale are present below 1550 ft., and down to 2250 ft. are dark chocolate brown, red and purple brown, green, moderately hard, sub-fissile, very silty and micaceous in part. The shale also occurs as clay galls and angular shale flakes. Gypsum is present in small quantities throughout the "Upper Red Beds" sequence as vein and fracture fillings, thin discontinuous interbeds and irregular inclusions. The presence of gypsum, worm casts and trilobite tracks in the sandstones, together with common clay galls and shale flakes indicate a very shallow near shore marine environment of deposition, possibly partly deltaic, with periodic exposure to the atmosphere of the depositional interface.

Minlaton No. 1:

(i) Transitional Beds. 3075 to 3261 ft. (T.D.) - 187 ft+. Dense dolomite, dolomitic limestone, dolomite arkose and grey arkose with carbonaceous partings.

(ii) Kulpara Limestone. 2520 to 3075 ft. - 555 ft. Grey and occasionally white dolomite, very fine to microcrystalline, with abundant carbonaceous stylolites and calcitic veinlets.

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(iii) Parara Limestone. 1177 to 2520 ft. - 1343 ft.
 Grey, concretionary, fossiliferous limestone, with abundant archaeocyatha between 1254-1288'6" and 1304 and 1485 ft.
 Below 2111 ft. limestones were light grey with abundant carbonaceous stylolites, "splashes" of galena and calcite veinlets.

(iv) Ramsay Limestone 616 to 1177 ft. - 561 ft.
 Grey concretionary, stylolitic limestone, with clastic bands, interbedded chocolate and grey siltstone and minor gypsum below 721 ft.

A number of older wells penetrated incomplete and sometimes doubtful Cambrian sections. What little information is available is listed below:

Minlaton Oil No. 1:

0-253'	Limestone with Archaeocyatha	) Ramsay Formation?
253-292'	Shale, sandstone and grit	
292-548'	Limestone with some shale	
548-855'	Crystalline limestone	) Parara Limestone?
855-1800'	Light-dark grey limestone	
T.D. 1800'		

Adelaide Oil No. 1:

1696-1886'	Red, calcareous sandstone	Upper Red Beds
1886-1942'	Limestone	Ramsay Formation?
T.D. 1942'		

Peninsula Oil No. 1:

The well penetrated chocolate shales from 237 feet to total depth of 315 ft., which may possibly belong to the Upper Red Beds.

Clinton Oil Bore:

The well penetrated a possible 226 ft. of unknown Cambrian sediments to a total depth of 516 ft.

Outcrop Areas.

Outcrops of Cambrian rocks are restricted to the northern half of the peninsula and large areas are covered by soil and calcareous kunkar.

Transitional Beds Equivalent.

A thin section of red conglomerates, grits and sandstones, often feldspathic, outcrop south of Maitland and on Mt. Rat, and reach a maximum thickness of 300 ft. The unconformity with the shield Archean is exposed at Mt. Rat. In the Kulpara area, the Kulpara limestone conformably overlies an apparent Pound Quartzite equivalent (Upper Proterozoic?)

Kulpara Limestone.

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In the Kulpara area, a sequence of dominantly grey and light and dark blue-grey limestones about 1200 feet thick, which Daily (1956) named the Kulpara Limestone, overlies the Pound Quartzite with apparent conformity. A prominent band of yellow dolomite occurs in its upper part. Dolomitic and siliceous limestone with chalcedony nodules is also present. The formation is unfossiliferous in the Kulpara area, but characteristic brachiopod assemblages and *Archaeocyatha* occur near its top in the Ardrossan and Curramulka areas. *Collenia* has been found in the Clinton Bore near the base of a limestone sequence of Kulpara Limestone facies. A thickness of 300 to 350 ft. is recorded for the Kulpara Limestone in the Ardrossan area, but this thickness appears to represent only the top part of it.

Parara Limestone.

A dark blue-grey mottled and rubbly argillaceous limestone sequence, the Parara Limestone, is conformable with the Kulpara Limestone. On Yorke Peninsula, outcrops of this limestone are known only from the Ardrossan, Curramulka, Dowlingville and Kulpara-Clinton areas. A maximum thickness of 450 ft. was recorded by Daily (1956) in the Kulpara area, its top being everywhere either removed by erosion or obscured by younger deposits.

Ramsay Formation.

The only known outcrops occur 4 miles south of Curramulka, and the thickness is unknown. The outcrop consists of mottled, dark blue-grey argillaceous limestone. Scattered small outcrops of conglomerate, red arkosic sandstone and limestone conglomerate occur at Pine Point and Rocky Point, and may be equivalent to the lower more clastic part of the Ramsay formation.

Upper Red Beds.

No outcrops are known, but fragments of red sandstone found south of Curramulka may be equivalent.

(b) Fleurieu Peninsula

A well exposed succession of Cambrian rocks outcrops south of Adelaide along the coast, from Sellick Hill to Carrickalinga Head.

The base is formed by a blue siliceous limestone (Lower *Archaeocyatha* Limestone) 100 feet thick, then follows an alternation of mottled limestones and marls with minor sandy layers. The mottled limestones consist of bluish calcareous layers, up to 2 inches thick, alternating with siliceous silty bands - a structure which has been described as due to algal activity. In the vicinity of Myponga Jetty these beds contain *Hyolithes cominis* and *Helcionella tatei*, which are elsewhere associated with *Yorkella*. They are thus considered as Lower Cambrian. They are succeeded by the Upper *Archaeocyatha* limestone, a massive, bluish formation, over 1000 feet thick. *Archaeocyatha* are sometimes obscured by recrystallisation which has given rise to a fine grained marble. These limestones are overlain by shales, siltstones and slates, up to 1500 feet in thickness, often vividly coloured red and green, and carrying phosphatic nodules arranged along the bedding plane. The succession ends with a greywacke which outcrops at Carrickalinga

Head, and which is correlated with the base of the ⁰⁰²²Kanmantoo Group.

A thick alluvial blanket and the sea mask bedrock between Carrickalinga Head and the Rapid Bay area. This prevents a direct field correlation between the fossiliferous Cambrian beds described above and the formations attributed to this period on the eastern flank of the Mt. Lofty Ranges. These formations are more or less metamorphosed and have not yet yielded any fossil remains. Their correlation with the Sellick Hill-Carrickalinga Cambrian beds is inferred from structural evidence, from facies analogies and from their general position within the regional stratigraphic column. The Rapid Bay marbles and possibly the Macclesfield marble appear to be the equivalents of the Archaeocyatha beds of Sellick Hill. The phosphatic shales and slates overlying the Archaeocyatha limestone would thus be represented by the dark phosphatic phyllites which succeed the Rapid Bay marble, and, at the top of the succession, the Carrickalinga Head greywacke would be the equivalent of the basal beds of the Kanmantoo Group.

Correlation with the Yorke Peninsula section has not been established but the Archaeocyatha limestones may be equivalent to the Kulpara-Parara limestones, and the overlying rocks to the lower part of the Ramsay Formation or the Upper Red Beds.

(c) Kangaroo Island.

Lower-Middle Cambrian rocks outcrop on the northern side of Kangaroo Island, and reach a maximum thickness of 6,500 feet. The following stratigraphic units have been recognised:

1. Purple and green shales. The oldest Cambrian formation so far recognised on Kangaroo Island, is a purple, grey and green shale sequence, containing minor intercalations of cross bedded and slump bedded red arkosic sandstones and greywackes. The formation attains a minimum thickness of about 1000 ft., the base being nowhere visible. Abundant trilobite tracks and worm castings have been located in these beds, which were formerly mapped as Adelaide System phyllites.
2. Stokes Bay Sandstone. This unit which conformably overlies the purple and green shale sequence, is composed of massive current-bedded and slump bedded red and white arkosic sandstones. Sprigg gives a possible thickness of 1000 ft. for these beds. No fossils have yet been located within the formation.
3. Smith Bay Shale. The Stokes Bay sandstone is conformably overlain by a sequence of purple and grey to green micaceous shales and flagstones with interbedded red arkosic sandstones. Trilobite tracks have been found in these shales in Freestone Creek (Madigan, 1928) and more recently trilobites themselves have been located in a thin argillaceous limestone at the same locality. The beds occupy a syncline and attain a possible thickness of almost 1000 feet, but the top of the formation is not visible. A purple micaceous shale and red arkosic sandstone sequence, with a fault contact at its base, and attaining a thickness of 450 ft, occurs below the White Point Conglomerate to the east of Emu Bay. This sequence, which contains undescribed trilobites, is believed to represent the uppermost beds of the Smith Bay Shale.
4. White Point Conglomerate. This unit, about 1200 ft. thick, conformably overlies the Smith Bay Shales. It is characterised by conglomeratic strata with minor interbedded green and red shales. The conglomerates contain pebbles and boulders of diverse rock types such as granites, schists and Archaeocyatha limestones. It is probable that they are derived from scarps in which Archaeocyatha limestones were present, together with older rocks. This would provide evidence of tectonic movements in Lower Cambrian time.

5. Emu Bay Shale. The White Point Conglomerate is conformably overlain by Emu Bay Shale, which is composed of brown and purple shales associated with flagstones and with minor conglomeratic lenses and attains a thickness of 350 ft. The shales contain a trilobite fauna characteristic of the upper zone of the Lower Cambrian (Redlichia, Lusatia, associated with Isoxys and Hyolithes) and are conformably overlain by the Boxing Bay Formation.

6. Boxing Bay Formation. This unit is 2500 feet thick and consists of alternating reddish cross-bedded arkosic quartzites, shales, flagstones and conglomerates. Its lower portion is considered by Daily as Lower Cambrian, while the upper beds may range into the Middle Cambrian.

The section is lithologically distinct and no direct correlation is possible with the Yorke and Fleurieu Peninsulas.

(d) Eucla Basin.

Sediments of presumed Lower Cambrian age have been encountered in seven wells in the Eucla Basin. The rocks are of red bed facies and are unfossiliferous, and the age has been assigned largely on lithological similarities with the Yorke Peninsula Cambrian. No outcrops of these sediments are known in the Eucla Basin.

Hughes No. 3:

From 630 to total depth of 918 ft, the well passed through grey, purple, and pink dolomites, interbedded with grey and red sandstone and siltstone, pink-grey limestone and oolites. The dolomite shows traces of stylolites. It is pyritic and cherty in places, and is thought to be similar to the Kilpara dolomites of the Yorke Peninsula.

Hughes No. 2:

Between 748 ft. and total depth of 797 ft. the well penetrated dolomite, grey, oolitic and cherty in places, with fairly common stylolites.

Hughes No. 1:

Between 870 and 890 ft. the well encountered dolomite, light grey, dense with small pyrite nodules and vugs. Interbedded siltstones and limestones are present from 890 to 1088 ft. The siltstones are red and green-grey, finely micaceous, calcareous and pyritic, with some microscopic quartz veins. The limestone is dolomitic, with pyrite crystals, chlorite, mica, minute pyrite veinlets and calcite and gypsum veins.

Outback Cook No. 1:

Between 525 ft. and total depth of 915 ft. this well passed through 390+ feet of Cambrian limestones and sandstone.

Denman No. 1:

This well passed through 313 ft. of red-bed sediments between 957 and 1270 ft. The sediments consist mainly of red and mottled green dolomitic and micaceous siltstone. The siltstone is sandy and grades to sandstone in places.

DEPOSITIONAL HISTORY.

Yorke Peninsula appears to have represented the fore-land for the Adelaide Geosyncline during Upper Proterozoic-Lower Palaeozoic times. A marine transgression over the Archaeozoic shield rocks during the Proterozoic was followed by a further transgression in Lower Cambrian times. Cambrian sediments unconformably overlies Archaeozoic mainly in the central part of the peninsula and commonly conformably overlies Proterozoic in the northern part. Possibly some of the Proterozoic was removed by erosion between the two transgressions.

The initial Cambrian transgression resulted in the deposition of the Transition beds. Stable shelf conditions then prevailed over a wide area, and the Parara-Kulpara carbonates of the Yorke Peninsula and the Archaeocyatha limestones of the Fleurieu Peninsula were deposited in the shallow warm water, probably in the form of carbonate banks.

Between these banks, and probably beyond their outer limits thick, normal marine deeper shelf clastic sequences (including shales) were laid down. These are exposed now in the northern part of Kangaroo Island. It is possible that these sediments were transported to their present position between carbonate banks of the Yorke and Fleurieu Peninsulas, i.e. through the present St. Vincent's Gulf area. Slumping in these clastics raises the possibility of some intermittent turbidity current action. This may be applicable to the conglomerate section which contains a variety of pebbles and boulders ranging from granite to Archaeocyatha limestone, and which would appear to be a shallow water deposit in a deeper water environment.

On the Yorke Peninsula uplift and erosion occurred after Kulpara-Parara deposition. In some areas erosion proceeded to the extent that the Archeozoic was exposed. The Minlaton conglomerate is present in places, and appears to be basically related to this period.

More stable conditions returned with the deposition of the Ramsay limestone, although variations in environment are evident in the red bed and dark shale interbeds. Finally the Upper Red Bed sequence was laid down as general uplift occurred in the area, prior to renewed erosion of the Cambrian. The upper red beds were apparently deposited in very shallow water close to land. Although intermittent exposure is apparent, the presence of trilobites attests to a marine influence. Equivalents of the Ramsay limestone and upper red beds may be present in the clastic sequence of Kangaroo Island, but no correlation is possible at present.

To the east and south of the stable area further large thickness of Cambrian sediments were deposited in the Adelaide Geosyncline. These sediments are represented by the Kanmantoo Group and have suffered severe diastrophism during subsequent orogenies.

There is some evidence of orogenic movement in the Cambrian, but the main movements are post-Cambrian, possibly late Ordovician to Devonian. The Cambrian sediments on Yorke Peninsula and northern Kangaroo Island are relatively undisturbed. Folding is gentle and faulting is not extensive, except in the northwest part of the peninsula. The sediments on Fleurieu Peninsula have been fairly extensively folded, with associated faulting and metamorphism.

The relatively thin interbedded red bed carbonate sequence in the eastern part of the Eucla Basin is of possible Cambrian age, and probably reflects shallow marine incursions. It may represent the southern limit of a Cambrian interior intra-cratonic basin, or may possibly be linked with the present offshore area.

HYDROCARBON PROSPECTS

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No significant shows of oil or gas have been found in Cambrian sediments in the area under consideration. Edithburgh No. 1 well recovered salt water from the Kulpara dolomite, which contained up to 650 parts per million dissolved methane and 7 ppm ethane, and inflammable gas was reported in small quantities, possibly from the Cambrian, in two old cable-tool drilled holes near Minlaton. (Minlaton No. 1 and Adelaide Oil No. 1). The Minlaton gas analysed 76% hydrogen and 7.5% methane. No Adelaide Oil No. 1 gas samples were submitted for analysis.

Wells drilled on the Yorke Peninsula have found thick sections of fair porosity in the Upper Red Beds and the permeability appears to be high. Porosity is present in the Ramsay Limestone at Minlaton, but has not been found elsewhere in this limestone.

The Parara Kulpara Limestone develops fair to excellent vuggy fracture and intercrystalline porosity in the subsurface wherever it has been dolomitized. In the Edithburgh well the dolomite is about 850 ft. thick and shows poor to fair vuggy, intercrystalline solution and fracture porosity generally throughout. Three drill stem tests recovered salt water almost to surface. Poor to fair porosity appears to be generally developed in the Transitional beds as well.

Carbonate reservoir rocks on the Yorke Peninsula appear to lack suitable adjacent source rocks. Facies changes, however, appear to occur rapidly across St. Vincent's Gulf from Yorke Peninsula to North Kangaroo Island, the change being from a predominantly carbonate to a predominantly clastic section. The clastic section on Kangaroo Island includes thick shales. These are marine and in places the presence of an abundant trilobite fauna is evident.

Hydrocarbon prospects would appear to be better in the St. Vincent's Gulf area between Yorke Peninsula and Kangaroo Island than on the Yorke Peninsula itself. Sedimentation has probably been more continuous and the good carbonate reservoir beds of the Yorke Peninsula would be in closer proximity to the possible source beds of Kangaroo Island.

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7
Edith. P.
W. in Pt.

If Cambrian sediments are present at all in the offshore area west of Kangaroo Island, they may be in the form of carbonates nearer Eyre Peninsula, and clastics, including shales, nearer Kangaroo Island. Such a hypothetical distribution of possible source and reservoir rock would upgrade Cambrian prospects in the area. The concept however, is quite speculative, and based only on analogy with facies change between Yorke Peninsula and the Kangaroo Island north area.

Some porosity is possibly present in the Cambrian sediments in the Eucla Basin, but no shows have been obtained from them. The sediments may thicken to the north, but if this is so, insufficient evidence is available as yet to comment intelligently on their hydrocarbon prospects in this direction.

PERMIAN.

DISTRIBUTION

0026

Permian glaciogene marine sediments outcrop on the Fleurieu and Yorke Peninsulas and North Kangaroo Island. The Permian probably extends across the Gulf of St. Vincent between these areas and could exceed 1500 ft. in thickness.

Sandstones and grits which are generally considered to be of Cambrian age (but without evidence) outcrop in the Blue Range area of the Eyre Peninsula. (See Plate 6). These could possibly be of Permian age, along with similar sandstones and conglomerates in the Mt. Wedge-Talia area. It is suggested that these form part of continuous trend of Permian sediments (See under Depositional History).

Thin Permian sediments (less than 300 ft. thick) have been postulated in some Eucla Basin bores, and appear to be restricted to the Maralinga-Denman-Yangoonable area, at least as far as their on-shore distribution is concerned (See Plate 6).

STRATIGRAPHY

The Permian sections encountered in wells drilled in the various areas are described below:

A. Yorke Peninsula:

Stansbury West No. 1:

This well intersected 995 ft. of Permian glaciogene marine sediments which may be divided into three units. The basal 665 ft. consists of interbedded clay, claystone and sandstone. The clay and claystone is chocolate brown, soft to firm, very sandy with rounded to subrounded, clear and red quartz, black and brown lithic grains and some igneous and metamorphic pebble fragments. The sandstone is light grey, medium grained, loosely consolidated, with subangular to subrounded quartz in a kaolinitic part calcareous matrix, and with traces of intergranular porosity. This is overlain by 158 ft. of blue to grey, soft to firm, sandy clay, with fine to coarse, subrounded, poorly sorted, clear quartz, lithics, and pebble fragments. The uppermost 182 ft. is a similar light grey clay with common quartz, lithics and pebbles.

Edithburgh No. 1:

The Permian section here consists of a relatively undifferentiated sequence of clays, claystone and sandstones. The topmost 40 ft. of this section consists of grey, soft massive clays. These clays are in part micaceous, sandy and silty. Below 390 ft. the clays take on a blue grey colour and contain occasional included rock fragments and pebbles consisting of quartzite, igneous and metamorphic rocks. Below 489 ft. the clays are interbedded with light grey and red fine grained sandstones. These sandstones are poorly sorted with angular quartz set in a sparse silicic and calcite cement matrix. In the interval 460 to 890 ft. the sandstones become predominant. The sandstones are light grey in colour, fine to coarse grained, with well rounded quartz set in a clay matrix. The quartz grains show a high degree of rounding and sphericity. The sandstones are in general poorly consolidated and disaggregate on washing. Occasional pebbles and boulders of granite and schist with interbedded brown grey and green clays also occur.

The remainder of the sequence is comprised of interbedded claystones and sandstones with minor intercalations of a grey, soft, kaolinitic, carbonaceous siltstone. The claystones of this section show variable colours ranging from brown to red to pink and green and are generally massive, but in part are sub-fissile. They show numerous included very fine to silt grade quartz grains and in part are finely micaceous with occasional included quartzite, granite and schist fragments and pebbles. The sandstones are in general light grey in colour, fine to medium grained, with subrounded fairly well sorted quartz, poorly consolidated in a sparse clay matrix. The basal part of this sequence from 1648 to 1705 ft. shows an increased boulder and sand content.

Stansbury No. 1:

This well intersected 525 ft. of blue grey and chocolate sandy clay with pebbles of granite, quartz and quartzite. Abundant pebbles occur in lower 35 ft.

Troubridge Shoal No. 1.

This well was abandoned after penetrating 750 ft. of Permian which consisted of grey sandy claystones and clayey sandstones, calcareous in part, with fragments of granite, slate, quartzite, and also some garnet and pyrite. Sporadic occurrences of marine forams in this well have been identified as being of Lower Permian age.

Stansbury Town No. 1:

653 ft. of Lower Permian sediments were intersected here. These consist of interbedded claystones and sandstones. The claystone is dark brown, sandy, with subrounded to rounded quartz and lithics, with pebble fragments becoming very common towards the base. The sandstone is light grey, unconsolidated, with subrounded quartz in clay matrix.

Minlaton No. 1:

596 ft. of Permian section similar to that in Stansbury No. 1 is present in this well.

Peninsula Oil No. 1:

The 512 ft. of Permian here has been described as "Permo-Carboniferous Till" with quartz and mica grains, and pebbles and boulders of granite, schist and minor limestone, in a clay matrix.

B. Fleurieu Peninsula and Kangaroo Island:

Wells in this area which have intersected permian glaciogene sections are as follows:

Kingscote bore 1074 ft, Myponga bore 418 ft, Welsh Oil bore 182 ft, Black Swamp 352 ft, Donna No. 1, 1950+ ft. No detailed descriptions are available for these sections.

C. Eastern Eucla Basin:

0028

Possible Permian is present in bores in the Maralinga area. Bore No. 3 intersected 109 ft. of grey-white, gritty, kaolinitic, sandy clay with massive kaolin in the basal 17 ft. The 109 ft. unit overlays 18 ft. of grey, clayey, coarse quartz sand. In Bore No. 8 the section consists of grey clayey quartz grit and kaolinized gritty silt, with pebbles and flat boulders in the basal 20 ft. Bore No. 13 intersected 127 ft. of brown and light blue-grey, clayey, gritty and pebbly sand, with faceted pebbles in the basal 6 ft.

South of Maralinga, the Watson or 452 mile bore apparently encountered 244 ft. of Permian sediments.

The Hughes Nos. 1, 2 and 3 and Denman No. 1 bore also have sections recognised by Ludbrooke as Permian.

In Hughes No. 1 the section consists of 11 ft. of green grey micaceous siltstone with light brown dolomite nodules and pyrite, overlain by 42 ft. of sandstone with fine angular sparsely cemented quartz grains, with pyrite and chlorite. In the Hughes No. 2 well 18 ft. of yellowish fine angular quartz sandstone with chlorite is present. A similar sandstone is found in Hughes No. 3, with pitted quartz grains, minor cement, pyrite, and well rounded opaque minerals.

In Denman No. 1 the section consists of 44 ft. of grey-white medium grained sandstone with a feldspathic matrix, and some pyrite. This is overlain by 113 ft. of pale green (minor red) siltstone with some coarse quartz grains, and brown dolomite. The upper 16 ft. is a fine to medium grained porous sandstone with some pyrite, and rounded opaque grains.

The Yangoonabie bore close to the coast has a 255 ft. Permian section consisting of grey claystone with occasional quartz grains, and granite fragments up to 1 cm, towards base.

A number of other bores have bottomed in "sands and gravels" which are probably Permian. These are listed below:

512 mile bore - 60+ ft, Nullarbor Plains No. 2 - 83+ ft.
Nullarbor Plains No. 1 - 9+ ft, Muddangana bore - 10+ ft.
Gilgurablie bore - 33+ ft, Mallabie bore - 25+ ft.
White Well bore - 3+ ft, Nullarbor Plains No. 5 - 79+ ft.
Delissa bore - 3+ ft.

FAUNA.

In the Eucla Basin the best documented Permian section is that in Yangoonabie (Nullarbor No. 8) bore. Of Permian forams in this sequence Hyperammina hebdenensis Crespin and Thurannimoides sphaeroidalis (Plummer) are most common and persistent, associated with Hyperammina acicula (Parr), species of Ammodiscus, Hemidiscus, Saccamina and Reophax, Ammodiscus inclusa (Cushman and Waters), Tolypammina undulata Parr, and Hippocrepinella biaperta Crespin. An abundant moderately well preserved microflora of pollens and spores is also present. The foraminiferal and microfloral assemblages combined suggest an Artinskian age. No other diagnostic Permian fossils have been found in the Eucla Basin.

In the Troubridge Island well in the St. Vincent's basin, a few forams are present in the Permian section. These include Cf Hyperammina sp., Ammodiscus Conahensis and Trochammina sp. Forams are also reported from the Stansbury Town Well.

In the Stansbury Stratigraphic Bore forams occur abundantly in several zones. Arenaceous forms only are present, mainly Hyperammina acicula, Ammodiscus OOnahensis, Ammodiscus inclusa and Tolypammina undulata. No plant spores were found with the forams.

DEPOSITIONAL HISTORY

The pattern of Permian deposition is dominated by the presence, substantiated in the east and hypothetical in the west, of a remarkable narrow trough of glacial sediments, in excess of 500 miles long, and ranging in gross width from 12 miles to about 45 miles wide. This trough, or broad valley, extends from the Fleurieu, north eastward across Yorke Peninsula, across Spencer's Gulf to the Blue Hills - Cleve area. From here it swings in a wide arc across Eyre Peninsula, to the present coastline at Anxious Bay, and joins up with an aeromagnetic anomaly which runs westward across the continental shelf.

The trend is shown in Plate 6.

It may even extend further to the east from the Fleurieu peninsula. Sub parallel to, and seaward to the Coorong, is a trough, perhaps as deep as 4,000 ft. containing possible Permian glacial marine sediments.

The origin of this striking feature is difficult to conceive. Its extreme length and width seems to preclude an entirely glacial origin, and the presence of marine forams indicates the presence, in a restricted sense, of the sea, and least in the central areas of the trough. On the flanks of the trough, boulder tills and associated fluvoglaciials may be seen, in Yorke Peninsula and the Mt. Lofty Ranges. These may represent the margins of glacial valley systems.

In the bores in the more central areas of the trough, sandy clays are more common, and contain some marine forams. This suggests a more normal marine environment, which although it is in cold water, is not immediately adjacent to glacial terminations. In the Yorke Peninsula, glacial erratics occurring up to 800 ft. above sea level, suggest that at one time, most of the peninsula was covered by sea carrying floating ice.

The trough was fed, in the higher areas, from ice sheets, with valley glaciers merging to Piedmont glaciers, which shed ice and clastics into the trough. This situation occurred at least in the southern Mt. Lofty Ranges and Yorke Peninsula, and may have occurred on Eyre Peninsula. Some connection with the Tasmanian ice sheet has been proposed for the trough in the Coorong area.

The trough itself, to which the sea had access, is too broad to have been formed by glaciers. There may have been some basic tectonic control, but this would run counter to the dominant structural trends of the area. One possibility is that a glacier system entered the sea near the edge of the present continental shelf in the Australian Bight, in early Permian times, and the sea gradually encroached on the glacial valley system, widening it, and following it inland as the ice retreated. This could have resulted in the long, marine valley, stretching such a long distance inland to the Mt. Lofty Ranges where the retreating ice sheet finally disappeared.

0030

This theory requires an initial ice sheet covering a large area, a view held by David (1932) who stated "Towards the close probably of Carboniferous time over half of Australia, an area of about 1,500,000 square miles lying south of a line stretching from Brisbane to King Sound, was under ice. It was a veritable Antarctica. High peaks, like those of the Macdonnell and Musgrave Ranges, rose as dark nunataks above the vast snowfield of this stupendous ice sheet, much of the gathering ground of which lay far to the south of the present south coast of Australia".

In the Eucla Basin, very little is known of the depositional history of the Permian. In the Maralinga area, the kaolinitic grits suggest rather short transport, and this is supported by the homogeneity of the pebbles, which are mostly quartz. This is in contrast to the assorted glacial material in the Permian around St. Vincent's Gulf. In most of the other supposed Permian sections in East Eucla area, quartz is also a dominant constituent, along with some chlorite and some dolomite, and occasional fragments of granite. The combination suggests a granitic source, with possibly a contribution of reworked Cambrian carbonates.

It was assumed that the sequences referred to above would be Sakmarian in age, but in the Yangoonabie bore a 255 ft. section of dominantly Permian clays with forams and microflora, were found to be Artinskian in age. These could conceivably represent a more marine, later infilling of glacial valleys. The fauna and lithology of the Yangoonabie bore suggest a restricted marine, possibly lagoonal type of environment, with no real evidence of glacial influence except perhaps near the base.

Some connection could be expected through the Eucla Basin with the Lower Permian of the interior basin of W. Aust. which appears to link up with the Canning Basin Permian. At present, however, there is not much evidence to link up the relatively small Permian area (Plate 6) at the east end of the Eucla Basin with the broad area to the north, except perhaps through the Maralinga area, or the Hughes-Denman areas.

HYDROCARBON POTENTIAL

St. Vincent's Gulf area.

Patchy porosity is present in the Permian sandstones of this area, but the high clay content may restrict permeability. The origin of the sediments is dominantly glacial, with limited marine influence. They occur in a relatively narrow, long trough and source potential for Permian in this area should probably be regarded as fairly low. This comment would apply to any Permian in the trough offshore from Anxious Bay. However, more normal marine sedimentation away from the long linear valleys, i.e. elsewhere offshore, may have more potential.

Eastern Eucla Basin.

The Permian sandstones and grits provide the major aquifers in this area, indicating useful reservoir potential. Comparable beds located in any much thicker Permian sections in association with source beds could have hydrocarbon potential. No potential Permian source rocks appear to be present, however, except perhaps near the coast in the area of the Yangoonabie bore. The onshore prospects of Permian in this part of the Eucla basin are poor, but any thicker, more marine sections, if they are present, could have improved prospects.

MESOZOIC.

0031

DISTRIBUTION.

As seen in Plate 7, the Cretaceous of the Eucla basin occupies an east-west trending basin, the axis of which lies between the Trans Continental railway and the coast. The length of this basin is over 400 miles, and the width probably in excess of 130 miles, longer than the Gippsland basin and Otway basin combined. Its northern and southern limits are not yet known.

The maximum known thickness of Cretaceous is 1114+ ft. at Madura No. 1, and the thickest isopach shown on Plate 7 is 1300 ft. However the drawing of the isopachs was carried out rather conservatively, and it is possible that as much as 2000 ft. of Cretaceous is present in this basin.

Like the Otway basin, the Upper Cretaceous section is present only in the deeper part of the basin. The probable area of Upper Cretaceous (Senonian) glauconitic greensands is indicated in Plate 7. It is suggested that these beds attain a thickness of in excess of 750 ft. in the deeper part of the basin.

A small area of Upper Jurassic sediments is present in the Polda Basin.

EUCLA BASIN

0032

The Cretaceous sequence in the Eucla Basin is as follows:

		Max. known thickness	
Upper Cretaceous	Senonian	↑ glauconitic greensands	596
	Cenomanian	↑ mudstones & siltstones fine sandstones & shales)	578
Lower Cretaceous	Albian	↑ mudstone, siltstone, glauconitic greensands)	
	Aptian	↑ glauconitic siltstone, carbonaceous mudstone, non marine siltstone)	
	Neocomian?? -Aptian	↓ gritty feldspathic sandstone, coaly silts cobble sandstone, fine & coarse sands & conglomerate. ("Loongana Conglomerate")	

Only a few of the bores in the Eucla basin have been properly documented, most of the remainder of the information being very sketchy. The majority of the bores were drilled for water a considerable time ago.

Loongana Conglomerate.

The name was first used by Fairbridge in the 741 mile bore on the Trans Continental Railway. This bore is referred to by the W. A. Government as "W.A. Government Survey Exploratory Bore No. 3, 337 milespeg Trans Continental Railway, 28 miles west of Loongana". The mileages used in this report however, are converted to measurements from Port Augusta, for the sake of consistency, as most of the Railway bores were located in this way. The W.A. Government bores were measured from near Kalgoorlie in an eastward direction.

In this bore the Loongana conglomerate is apparently 74 ft. thick and consists of "fine and coarse sands and fine and coarse sands with hard bands and granite boulders"

In the 632 mile bore the unit may be 106 ft. thick, and include 30 ft. of fine and coarse sand.

0033

In the Hughes No. 1, 2 and 3 wells there are sections 197 ft., 180 ft. and 87 ft. thick respectively at the base of the Mesozoic sequence which may be equivalent to the Loongana conglomerate. They consist mainly of gritty feldspathic sandstone, but in the Hughes No. 2, and 3 wells they were underlain by 22 ft. of green grey, very micaceous chloritic silt with fragments of coaly matter.

In the Denman No. 1 bore there is a 194 ft. section of sandstones and grit which may also be equivalent. The section is comprised of quartz and microcline grit and sandstone consisting of coarse quartz, feldspar, pyrite and glauconite in a feldspathic matrix. The sandstone contains wood fragments, partly pyritized in places.

900' → 1132' (232')

In the Yangoonabbie Bore, there is a sequence of Neocomian-Aptian age consisting of 197 ft. of feldspathic cobbly sandstone and siltstone, underlain by 20 ft. of pyritic grit. This section overlies Permian in the well, and may be equivalent to the Loongana conglomerate.

"Relatively thin beds of sand, gravel, and conglomerate" at the base of the Mesozoic section in the Guinewarra bore may also be a Loongana conglomerate equivalent.

972' - 1136' (164')

In the Madura No. 1 Well, Ludbrooke (1958) found the Mesozoic sequence to be initiated with a 87 ft. sandstone section, with very little material extant. It consists of brown, unconsolidated sandstone, comprised of angular quartz grains, feldspars, chlorite and muscovite and "grey fine laminated micaceous shale with coarse subangular quartz grains, plant fragments and muscovite". No age was assigned to this section, but it appears to be a possible Loongana conglomerate equivalent.

In the Gambanga No. 1 well there is a 58 ft. section of dark grey or grey brown carbonaceous feldspathic sandstone overlying basement. The sandstone may be equivalent to the Loongana conglomerate.

In the Eucla No. 1 well there is 22 ft. of gravel overlying Archean granite and underlying Lower Cretaceous sediments. It is 22 ft. thick and consists of sub rounded granite fragments and fine to coarse grains of quartz.

Mallabie:- 850' - 1090' (240')
[Co. 1050' - 1090']

Distribution and Depositional History.

The "Loongana Conglomerate" appears to be present in the Madura 1, Gambanga No. 1 and Eucla No. 1, and at least in places along the Trans Railway between the 741 mile bore and Denman, and also in the Guinewarra-Yangoonabbie area. Loongana conglomerate equivalents may be present elsewhere in poorly documented bores. Where the Mesozoic rests directly on Permian coarse clastics, it may be confused with these beds. The presence of feldspars and granite material, suggest a fresh, or briefly transported sediment probably largely terrestrial in origin, deposited as the area began to subside in Lower Cretaceous times. The additional presence of carbonaceous material and in places, pyrite, would suggest deposition in swamp or lagoonal environments.

0034

Cenomanian - Albian - Aptian.

Sediments of these ages make up most of the Mesozoic sequence in the Eucla basin. Together with the Upper Cretaceous sequence they constitute the "Madura Shale" section. The term Madura shale was first used by Fairbridge in the Madura No. 1 bore.

Above the Loongana conglomerate at the Madura No. 1 well, Ludbrooke (1958) identified 35 ft. of section as being Aptian, overlain by 456 ft. of Cenomanian-Albian. The Aptian section consists of dark grey-brown, micaceous, carbonaceous sandstone and grit containing angular quartz, botryoidal haematite, chlorite, kyanite, feldspar, actinolite and pyrite. The sandstone contained abundant arenaceous forams, which included Involutina sp., Haplophragmoides dickinsoni Crespin, Haplophragmoides sp., Textularia anacoorensis Crespin, Siphotextularia sp., Spiroplectammina spp., Dorothia sp., Trochammina cf. raggatti Crespin, Trochammina minuta Crespin, Trochammina sp., Involutina spp., Haplophragmoides dickinsoni Crespin, Haplophragmoides spp., Haplophragmoides chapmani Crespin, Textularia anacoorensis Crespin, Spiroplectammina sp., Dorothia sp., Marssonella cf. ozawai Cushman, Gaudryina cf. parallela (Reuss).

The Cenomanian-Albian section at Madura No. 1 consists of sandstone and mudstone. The sandstone is grey or greenish grey, fine grained, carbonaceous, clayey, silty, glauconitic, micaceous and pyritic. The mudstone is grey, sandy, pyritic and glauconitic. No forams were observed in this section, but radiolaria were present.

741 Mile Bore (W.A. Government 337 Mile Bore): Only an Albian section appears to be present at this well, between the Loongana conglomerate and the Wilsons Bluff Limestone, suggesting that neither the older Lower Cretaceous beds nor the younger Upper Cretaceous beds were deposited this far north. The Albian is 640 ft. thick and consists of soft and hard sandy shales, grey carbonaceous mudstone, and minor hard greenish grey limestone. Thin greenish grey fine grained glauconitic quartz sandstones may be present. The mudstone is grey, carbonaceous, glauconitic, micaceous and pyritic and contains radiolaria and a few forams.

Eyre No. 1: In this well 378 ft. of Albian-Cenomanian? sediments overly granite basement. Once again the older Aptian section at Madura No. 1 well is missing. The upper part which is possibly Cenomanian consists of 170 ft. of dark grey, dark green and dark brown glauconitic, sandy, micaceous, and in places very carbonaceous mudstone and siltstone. It is very fossiliferous and contains abundant forams including Textularia sp., Haplophragmoides sp., and Trochammina. Radiolaria are common and include Cenosphaera and cf. Cenodiscidae. Some vertebrate remains, including bone fragments are present, as well as fish spines, teeth and scales. Dolomite oolites are also present in places. The lower part is made up of 80 ft. of dark green glauconitic and pyritic siltstone overlying 128 ft. of quartz sand, consisting of green, coarse, gritty glauconite stained quartz with a few glauconite grains. It is possible that a green glauconitic matrix was present, but was washed out during drilling. The siltstone contains abundant arenaceous forams, which include Haplophragmoides dickinsoni. The sand section contains fish teeth, spines and vertebrate fragments.

Gambanga No. 1 Well: In this well there is a thin section Cenomanian? - Albian in age. It consists of 16 ft. of carbonaceous

micaceous and pyritic mudstone and coaly shale. It overlies a section of 58 ft. thick of dark grey, carbonaceous feldspathic sandstone which overlies a granite gneiss basement. The feldspathic sandstone may be equivalent to the Loongana conglomerate. In the Hughes Denman area the Aptian portion of the Lower Cretaceous is present, but the younger beds are absent. The sequence in the Hughes 1, 2 and Denman wells begins with a 50 to 70 ft. section of grey, sandy, glauconitic, pyritic, micaceous mudstone containing carbonaceous plant material, and some garnet and zircon grains. Trochammina raggatti and Textularia anacooraensis are present in the Denman 1 well. The remainder, or upper part of the Aptian sequence is 190 ft, 240 ft. and 283 ft. thick in Hughes 1, 2, 3 and Denman No. 1 respectively. In the Hughes No. 1 well it consists of grey very glauconitic, pyritic, micaceous siltstone, with some cone-in-cone calcite. Radiolaria are common, including Dictyomitra. Lingula fragments are present as well as sponge spicules and Haplophragmoides. In Hughes No. 2 a similar sequence is present, along with some carbonaceous matter, plant fragments and dolomite grains. Some of the glauconite is limonitized and forams are rare. Similar glauconitic siltstone is also present at Denman No. 1 along with cone ^{and} cone calcite and abundant glauconite. Radiolaria are common, and one intercal contains abundant forams.

Yangoonabie Bore: The sequence at Yangoonabie again appears to be mainly Aptian. There is a lower unit 25 ft. thick of grey siltstone and sandstone, overlain by 210 ft. of marine green grey mudstone, and 142 ft. of non marine green grey siltstone grading to fine sandstone.

In the Alliance No. 1 Well, there is 11 ft. of soft dark grey clay with a few forams, which is of Upper Albian age. Forams include Trochammina deliculata. The thin section underlies Wilsons Bluff limestone and overlies gravel, which is possibly equivalent to the Loongana conglomerate.

Elsewhere in the Eucla basin the Mesozoic (or probable Mesozoic) is poorly documented. In water bore drillers logs it is termed variously "shale", "clays", "blue shale", "grey clay", "lignitic clays", "sandy clay", "blue black shale", "blue sandy shale" etc. Its position in the sequence is inferred from the better documented wells.

Post Cenomanian - Senonian? Greensands.

This sequence appears to complete the Cretaceous succession in the Eucla basin. It is present only in the deeper parts of the basin, and has been identified only in three wells, Madura No. 1, Gambanga No. 1 and Eyre No. 1. The sequence is characterised by glauconitic greensands, but there is also a basal mudstone unit at Madura 1.

Madura No. 1: The section is 596 ft. thick at this well, and consists of 544 ft. of greensand, underlain by 52 ft. of mudstone. The mudstone is dark grey, soft, glauconitic, carbonaceous and pyritic. The foraminiferal fauna includes Haplophragmoides spp., Spiroplectammina sp., Gaudiya sp., Verneuilina sp., Marssonella trochus, Trochammina sp., Ammobaculites sp., Spiroplectammina sp., Dorolhia sp. Cibicides sp. The "greensand" is grey green, highly glauconitic, silty, carbonaceous, and contains fine to coarse quartz grains. Some haematite is present, and some hard bands have an ironstone matrix. Pyrite, chlorite, and muscovite are present in places. Fossils include some fish remains, and a few arenaceous forams including Haplophragmoides sp.

0036

Eyre No. 1: The section at this well is 180 ft. thick and consists of grey green glauconitic, silty greensand, containing medium to coarse quartz grains. Pyrite is present in a few places as well as minor carbonaceous siltstone and mudstone. A few arenaceous forams including Haplophrogmoides sp. are present along with some Inoceramus fragments, a few vertebrate teeth, and bone fragments.

Gambanga No. 1: The section at this well is 295 ft. thick and consists of greensand containing medium and coarse grained quartz grains, and abundant glauconite, both as grains and matrix, and some dolomite grains.

Depositional History (Lower & Upper Cretaceous)

As mentioned under distribution, the Mesozoic sediments appear to occupy a long narrow area in the Eucla basin.

It is evident that the eastern end of this area was a basin of deposition in Marinoan, Cambrian and Permian times. The Isopach map (Plate 7) and X-sections indicate that there are a number of important departures from the Palaeozoic pattern, however. These are:

- (1) The basin axis is east-west.
- (2) The thickest part of the basin is at the west end.
- (3) Only early Lower Cretaceous sediments are present at the east end of the basin (Neocomian-Aptian) while further westward, progressively younger Cretaceous sediments (Albian, and Upper Cretaceous) appear in the sequence.
- (4) The Pre Cambrian structure map (Plate 4) shows a deepening in the area west of Eyre. Although this is a deeper low than at the east end of the Eucla basin, it did not result in any Palaeozoic sedimentation. It may therefore, be related to the thickened Mesozoic, and to a lesser extent the slightly thicker Tertiary sequence in this area. If it is related, then the age of the downwarp in this area is presumably post Lower Permian and Pre Cretaceous.
- (5) This leaves us with two alternatives to account for the Upper Cretaceous at the west end of the Eucla Basin, and its absence at the east end.
 - (a) It was deposited in the eastern area and subsequently eroded.
 - (b) A marine connection was present south or south westward between Gambanga 1 and Eyre 1 (a distance of about 130 miles) and that the Upper Cretaceous sea only covered this end of the basin.

Most of the Cretaceous sequence has a strong marine influence, both in the lower and upper Cretaceous. Only the Loongana conglomerate and the thin Cenomanian-Albian section at Gambanga have a strong continental content. The rest of the Cretaceous shows a varying, but in places abundant content of forams, radiolaria, fish fragments, and glauconite. Deposition was under moderately stable shelf environment in shallow water. The presence of glauconite, some pyrite, carbonaceous material, and lack of limestone (except for some cone-in-cone calcite) in the sequence suggests a slightly reducing environment and a pH only slightly above neutral, and a rather restricted circulation. The sequence appears to reflect periods of long stability, with a number of periods of slight instability, or faster subsidence, during which the sands were deposited.

Hydrocarbon Prospects

0037

The only record of hydrocarbons in the Cretaceous of the Eucla Basin is in the Muddangana bore, where the driller reported "Black shale with trace of oil". This is without verification, and probably should not be regarded as being significant.

The Cretaceous basin, as shown on Plate 7, is of considerable length.

Although the basin may possibly contain a considerable section of Cretaceous sediment, the slight information available to date does not suggest that this is so. The sequence is quite prospective, however, with a good development of shallow marine sands, and a definite interfingering and probable connection seaward with marine argillaceous material. Any deeper offshore equivalents of the Cretaceous section must be highly regarded. Cap rock may be found over sands in the sequence itself, or possibly in the overlying lower marly member of the Wilsons Bluff, which is present in the southerly Eyre 1 and Eucla 1 wells.

There is, as previously stated a possibility of a marine connection for the basin, south or south westward between the Eyre 1 and Gambanga 1 wells. In view of this, some reconnaissance geophysical exploration could be warranted in the offshore in this region, since, should a thick section of Cretaceous be present, it may be prospective.

0038

POLDA BASIN.

In the Polda No. 1 well, between the base of the Middle Eocene (224 ft) and total depth of 565 ft. is a 341'+ thick section of Upper Jurassic sediments.

The lower 180 ft. consists of interbedded clays, sands and silts. The sands are grey or brown, silty and clayey, and consist of medium to coarse, sub angular to sub rounded quartz and some gravel sized granitic fragments. The sands occur in beds between 5 ft. and 23 ft. thick. The silts are green grey, slightly sandy and contain abundant weathered feldspar and gneissic fragments. The clay, which is the dominant lithology, is very dark grey or greenish grey, greyish green or brown, silty, carbonaceous, and near the base contains occasional weathered igneous and metamorphic fragments. An A.M.D.L. petrological report on a sample from near the bottom of the hole (560 ft.) states that "this is an even grained, slightly metamorphosed arkose. It consists of about equal quantities of feldspar and quartz, both with inferring anhedral forms, and averaging 0.1 mm. The feldspars, which are quite fresh, consist of perthite and oligoclase, and displacement of twinning in the latter indicates late stage shearing. There is a small quantity of incipient green-brown biotite developing in the interstices, otherwise sericite is commonly rimming the clastics.

Other mafics consist of minor chlorite, green hornblende, with rare epidote. Zircon and apatite are accessories. In addition to the biotite, some recrystallisation of the quartz has occurred!"

Depositional History.

It is apparent that the Jurassic sequence was deposited in a dominantly continental environment. The lower feldspathic sands, arkose and granite fragments, do not suggest a great amount of transport or reworking. The upper clay, silt and lignite section suggests deposition in a fresh, or brackish water swamp area, as sedimentation became quieter and the rate of subsidence decreased in this mostly landlocked area.

The significance of the Polda basin Jurassic in a regional context, is not clear. It may be of significance that from west to east along the Eucla Basin the sediments present at the top of the Mesozoic sequence become progressively older, from Senonian (Upper Cretaceous) near Gambanga, to Albian near Loongana, to Aptian near Hughes.

Hydrocarbon Prospects.

The part of the Jurassic sequence penetrated to date in Polda 1 has no oil potential. Its importance lies in that the presence of at least Mesozoic basin has been established. There is a possibility of Permian sediments under the Jurassic, and offshore equivalents of the Jurassic could possibly be marine and more prospective than in this small landward enclave.

TERTIARY.

0039

DISTRIBUTION.

Tertiary sediments are present in the Eucla, St. Vincents, Wanilla-Cummings and Poldas Basins (Plate 9). The basins are dealt with separately, commencing with the Eucla Basin.

EUCLA BASIN

Eocene

The Eocene sequence in the Eucla Basin consists of the Wilsons Bluff limestone, in certain areas the underlying Hampton conglomerate and in the eastern portion, the Pidinga clays and sands.

The Wilsons Bluff limestone has been differentiated in places into a lower glauconitic or marly member of Middle to Upper Eocene age, and an Upper member of Upper Eocene age. The Eocene clays and sands of the eastern area, are commonly carbonaceous or lignitic, and their precise age is uncertain. They do, however, underly at least the upper member of the Wilsons Bluff limestone in places. They may represent a facies change of the Hampton conglomerate, which may be Middle Eocene in age, or they may be a facies change of the lower part of the Wilsons Bluff itself.

Plate 10 is an isopach of the Wilsons Bluff limestone, on which has been superimposed the possible areas of Hampton conglomerate and a rough isopach of the Pidinga clays and sands in the east.

It must be appreciated that only in few wells has adequate work been undertaken to really identify unit boundaries. Only drillers logs, or scanty references are generally available, and a fairly high degree of speculative content is therefore necessarily present in these maps.

(a) Pidinga clays and sands.

Lignites of the Pidinga clay-sand sequences outcrop on the west side of Pidinga lake, on the eastern edge of the Eucla Basin. A shallow (48 ft.) hole in the area found 2 lignite seams, one 5'9" thick and one 7' thick. Drilling in the area generally has indicated a sequence of parallel carbonaceous pyritic clay and sand, containing decomposed wood, overlain by alunitic iron stained and gypseous clays.

In the Maralinga area, about 65 miles to the north-west of Pidinga drilling has disclosed paralitic, dark grey brown silty sands overlying possible Permian sediments. These are up to 100 ft. thick and contain lignite in several places. They are probably Pidinga equivalents. No forams were obtained, but pyritized shell fragments of "Turritella aldingae" Dentalium sp. Nuculava sp., and Liotina were present. These occur in Upper Eocene sediments elsewhere in South Australia.

In the Outback Cook No. 1 bore 129 ft. of "Eocene" is recorded below an "Upper Eocene" (Wilsons Bluff?) sequence.

In the Nullarbor No. 7 well, there is 210 ft. of continental sands and clays of probably Eocene (Pidinga) age.

In the Delissa bore, 283 ft. of sandy clay may be present, and if so, could possibly be equivalent to the Pidinga clays and sands.

In the Nullarbor Plains No. 5 well there is 261 ft. of dark clay, and in the Nullarbor Plains No. 1 (Roberts) well there is 353 ft. of black clay. At both localities the clay may be equivalent to the Pidinga clays and sands.

Where examined in bores in the basin, carbonaceous silts are present containing glauconite and limonite pellets. These are paralitic, and contain a few forams including Cibicides, Cassidulina and Lenticulina, suggesting some marine influence.

It should be emphasized that due to the sparcity of definite information in the basin, the area of the Pidinga beds is difficult to establish. In the drillers logs of water bores the Eocene and Cretaceous sediments have a similar gross character, and a fair amount of speculation is involved in delineating their limits.

(b) Hampton Conglomerate.

This name was used informally by Fairbridge (1953) in the Madura No. 1 Well.

In the south west area of the Eucla basin it is thought to be present in the Madura No. 1, Eyre No. 1, Cambanga 1, and possibly W.A. Government Bore No. 11.

Further to the east it is possibly present in the Outback Hughes 1, 2, 3 wells and Cook Bore, and 482 mile bore, the Guinewarra bore, the Yangoonabie bore, and possibly the Albala Karoo bore.

These areas are marked on Plate 10. The information is very sketchy however, the Hampton conglomerate could be present over a much wider area. On the other hand where Cretaceous beds are absent it could be confused with coarse Permian clastics. In the eastern area it possibly grades into the Pidinga clays and sands.

The best documented section is in the Madura No. 1 well. Here the unit is 24 ft thick. The top of the unit consists of 2 ft. of brown calcareous grit, consisting of coarse limonite grains, and polished coarse subrounded quartz. The remaining 22 ft. consists of brown coarse limonite quartz and gravel, with glauconite and limonitized glauconite.

0041

At the Eyre No. 1 well the unit is 35 ft. thick and consists of brown, ferruginous quartz sandstone.

At Gambanga No. 1 the Hampton conglomerate is 90 ft. thick and consists of brown and buff quartz sandstone. A few forams were present in Gambanga No. 1 which would suggest an Eocene age.

4 ft. of sand is present at the bottom of Nullarbor-Wilsons Bluff limestone sequence at W.A. Government's bore 11. Drilling ceased in this sand. Willmot (1961) doubts the existence of the Hampton conglomerate as a Tertiary unit in this area, and feels that it is part of the Mesozoic sequence.

In the eastern area, the occurrences in the Outback Hughes 1, 2 and 3 wells are 52 ft, 42 ft and 73 ft. thick respectively. In Hughes No. 1 the unit consists of light brown fine to coarse limonite quartz sand, containing glauconite, pyrite, coaly fragments and a sharks tooth. In Hughes No. 2 it consists of light brown sand with poorly sorted coarse subangular yellow and clear quartz grains and limonite. In Hughes No. 3 the unit consists of yellow quartz sand and grit. In Denman No. 1 the unit is 15 ft. thick and consists of brownish quartz sand with limonite and glauconite.

75 ft. of interbedded sands in the Cook bore and 55 ft. of coarse sand at the 482 mile bore at the base of the Wilson Bluff may be equivalents of the Hampton conglomerate. In the Guinewarra bore there is 29 ft. of sand and limestone, and in the Yangoonabbie bore 10 ft. of gritty sand which may be Hampton conglomerate equivalents.

(c) Wilsons Bluff Formation

In 1879, Tate, during the course of a camel mounted geological expedition, measured 188 ft. of "white polyzoal limestone" at Wilsons Bluff on the coast near Eucla, overlain by a "yellow polyzoal bed" and by "crystalline limestone" at the top of the cliff. Singleton (1954) named the "white polyzoal limestone" Wilsons Bluff Limestone, and therefore the Wilsons Bluff section may be regarded as the type section. Its base is not exposed. It forms the lower section of the cliffs fronting the Southern Ocean along the Great Australian Bight.

In some wells in the Eucla basin, a lower member is recognised in the Wilsons Bluff limestone. It is generally marly, and in places is glauconitic.

Sections of Wilsons Bluff limestone are exposed in the five deeper caves of the Eucla basin. These are Cocklebidy, Abrakurrie, Weebubbie, Warbla and Koonalda caves. Their locations and some of the sections are shown on Plate 10. The entries are through collapse dolines of the Nullarbor Limestone, and the caves are developed in the pure Wilson's Bluff calcarenite, which is friable and chalky but poorly jointed. The roofs of the caves are usually rather flat, and are about 40 to 60 ft. high. Some domes rise up to 225 ft. high. The walls are 80 to 120 ft. wide, and up to 2,700 ft. long and in places the caves contain lakes.

Madura No. 1 Well: The unit is 837 ft. thick in this well, and has been divided into an upper, mostly white bryozoal limestone member

737ft. thick, and a lower, greenish white, partially recrystallized glauconitic bryozoal limestone 136ft. thick. The base of the upper member is a dense, chalky limestone with chalcedonic bands.

Madura No. 2 Well: Only the upper 94ft. of the Wilson's Bluff was penetrated in this well. It consists of pink and cream recrystallized limestone with a few bryozoa and forams.

Eucla No. 1 Well: In this well the Wilson's Bluff limestone is 639ft. thick. It consists mostly of white or cream porous limestone consisting of bryozoa fragments in a chalky matrix. Fragments of echinoids and molluscs are also present as well as foraminifera. Some chert nodules and quartz grains are also present. At the base is a 66ft. thick section of grey chalky calcilutite with a few grains of quartz and numerous calcareous fossil fragments. It may be equivalent to the "lower member" elsewhere.

Eyre No. 1 Well: The Wilson's Bluff limestone is 1078ft. thick in this well and may be divided into an upper member 953ft. thick, and a lower member 125ft. thick. The upper member is referred to by different workers as limestone, calcarenite or dolomite. The limestone is white to cream, bryozoal, and also contains echinoids, small brachiopods and forams. The calcarenite is cream to pink, poorly to moderately consolidated, and fine to medium grained. It is richly fossiliferous, consisting largely of fossil fragments in a chalky or recrystallized matrix. Near the top, the formation is vuggy and cavernous, but below about 500ft. it becomes fairly dense and more often chalky. The dolomite is medium grained, brownish, and crystalline. It occurs partly as dolomitized calcarenite lenses or as scattered rhombs of dolomite in the calcarenite. A lower member consists of 125 ft. of grey green to bluish green, silty and clayey, glauconitic calcilutite, containing bryozoa, forams and brachiopods.

Gambanga No. 1: In this well the Wilsons Bluff limestone is 565 ft. thick. The upper member is 450 ft. thick, and consists of what has been variously termed calcarenite or partly recrystallized white to cream bryozoal limestone. It is fine to medium grained, partly chalky and soft, and contains abundant bryozoa, forams, echinoid spines and pelecypods. Occasional grains of subangular to rounded quartz are present in the lower part. The lower member is 115 ft. thick and consists of grey and green grey, soft, very fossiliferous glauconitic calcilutites, with forams, bryozoa and echinoid spines.

Hughes-Denman Wells: In the Hughes No. 1, 2 and 3 wells and Denman No. 1 well the Wilsons Bluff consists of white or cream chalky bryozoal limestone. The thicknesses in the four wells are 168 ft, 128 ft, 48 ft. and 123 ft. respectively. Patches of chalcedony are present at Hughes 1 and flint is present at Denman No. 1. Some angular sand grains and glauconite are present near the base at Hughes No. 2. The limestone is commonly recrystallized.

Nullarbor No. 8: In this bore the Wilsons Bluff is 428 ft. thick. The upper member is 400 ft. thick and consists of chalky and flinty bryozoal limestone. The lower member is 28 ft. thick and consists of glauconitic bryozoal limestone.

Maralinga: In the northernmost wells of the Maralinga drilling programme, the wells intersected thin sections of bryozoal calcarenites and calcareous sands overlying paralic Pindanga type silts. According to Ludbrook (1958) these may be marginal remnants of the Wilsons Bluff limestone.

0043

Drillers logs and other sources of information in the Eucla Basin refer to the Wilsons Bluff as being "hard or soft limestone", "coralline limestone", "soft limestone with flints", "granular limestone", "limestone with Protozoan remains", "white porous limestone", "polyzoal limestone" or "chert and limestone rock".

The fauna of the Wilsons Bluff limestone includes the following species:

Foraminifera: Cibicides pseudoconvexus, C. pseudougerinus, C. umbonifer, C. vortex, Stromatorbina torrei, Globiferina mexicana, Globigerinoides index, Globerigerinella micra, Globobuccina primitiva, Carpentaria rotaliformis, Asterigerina adalaidensis, Crespinella sp. nov., Maslinella Chammani, and species of Gaudryina, Lagena, Gutullina, Angulogerina, Uvigerina, Cassidulina, Gyriudina, Cubicides, Anomalina, Gumbelitria and Notorotalia.

Echinoidea: Stereocidaris australiae, Pseudechinus woodsii, Salenia, tertiaria, Australanthus longianus, Eupatagus sp.

Brachiopoda: Terebratulina triangularis, Magellania subcarnea.

Pelecypoda: Notostrea lubra, Chlamys eyrei, Spondylus gaederopoides.

Depositional History.

After Upper Cretaceous deposition, there was a hiatus, and possibly some erosion. Middle Eocene deposition began on a surface consisting mainly of Cretaceous sediments (See sub crop areas Plate 8). In the eastern part of the Eucla basin Tertiary sediments also overlies Permian, Cambrian, Marinoan and Archean rocks. The situation in the far northern portion of the Eucla basin is unknown, but it is probable that the Tertiary also overlies rocks older than Cretaceous in this area. Structure on the base of the Tertiary (Plate 8) indicates two main areas of downwarp, at the west and eastern ends of the Eucla basin. The total Tertiary Isopach (Plate 9) and the present topography on the Nullarbor limestone (Plate 11) suggests that the gradual downwarping movement continued in a similar pattern during and since Tertiary deposition.

Middle Eocene sedimentation began, with paralic clays, silts and lignites being deposited in the eastern part of the Eucla basin while the transgressive Eocene sea resulted in the Hampton Conglomerate being deposited further west.

In later, Middle and Upper Eocene times, stable shelf conditions prevailed over the western and most of the eastern area, and the Wilsons Bluff limestone was deposited. The Lower member contains some argillaceous material and glauconite, but the bulk of the unit is a bryozoal limestone of fairly uniform lithology, suggesting a stable, shallow, warm water environment.

The Wilson Bluff limestone, from Plate 10, thickens fairly uniformly toward the Madura-Eyre area. Greater variations in thickness are evident at the east end of Eucla basin. This may be related to the presence of thick Pidinga clays in this area, which although they mostly preceded Wilsons Bluff deposition, may also be a facies variation of the lower part.

Upper Oligocene to Lower Miocene

0044

Un-named Unit.

At the base of the Nullarbor limestone near Wilsons Bluff, Tate (1879) measured a "yellow, polyzoal bed". At Wilsons Bluff it was 10 ft. thick, and 71 miles east of Wilsons Bluff it had thickened to a maximum of 100 ft. He commented on its resemblance to the Mannum limestone of the Murray Basin. The fauna in the coastal section includes the following:

Foraminifera: Gaudryina collinsi, G. (Pseudogaudryina) crespiniae, Dorothia parri, Crespinella sp. nov. and species of Guttulina, Globulina, Sigmoidella Cubicoides, Anomalina, Eponides.

Bryozoa - very abundant.

Echinoidea: ?Stereocidaris australiae, Pseudechinus woodsii, Fibularia greyata.

Brachiopoda: Terebratulina davidsoni, Magellania subvarnea, M. tateana, Stethothyris insolita.

Pelecypoda: Chlamys eyrei, Chlamys gambierensis, Eotringonia seimundulata and species of Spondylus, Carditidae and Tellina.

West of Madura, at the base of the Nullarbor limestone on the Hampton Scarp, are partially recrystallised, rather friable bryozoal calcarenites, with lithological and faunal differences to the Nullarbor limestone. The echinoids Fibularia greyata, Lovenia forbesi, pseudechinus woodsii and the molluscs, chlamys eyrei, chlamys gambierenses and Eotringonia semiundulata are present. It may be a unit distinct from both the Nullarbor and Wilson's Bluff, and appears to correlate with the Mannum formation of the Murray Basin, and may be Late Oligocene to early Miocene in age.

In the Madura No. 2 well, 30 miles north of Madura 1, there is a unit about 106 ft, thick which may represent a transitional zone between the Nullarbor limestone and the Wilson's Bluff, and may again be of Late Oligocene to early Miocene age. It consists of hard or soft mostly recrystallised limestone, with a few bryozoa, forams, occasional glauconite and a coral.

Where the Hampton Scarp merges with the coastal sea cliffs, the un-named unit is generally difficult to examine, without specialized climbing equipment. The Nullarbor limestone can be examined at the top of the cliffs, but the Upper Oligocene to early Miocene, yellowish bryozal unit occupies a central position in the cliff face.

Abrakurrie Cave: In this cave (personal communication Lowry, 1967), about 24 miles west north west of Eucla, 104 ft. of porous bryozoal limestone is present between the base of the Nullarbor limestone and above a disconformity at the top of the Wilson's Bluff formation. The unit is overlain by a 2 ft. algal biostrome at the base of the Nullarbor limestone proper. In the Cocklebidy cave about 30 miles north west of Eyre, there is a unit about 150 ft. thick between the base of the Nullarbor limestone and the Wilsons Bluff, which may be referable to the un-named unit. The base of the Nullarbor limestone is again marked by an algal biostrome in this locality.

Distribution.

0045

The distribution of the un-named unit is not really known. It is present in coastal wells and cliff sections, but its apparent absence to the north may be a function of poorer documentation of bores in this direction.

Depositional History

The limestone of the un-named unit was deposited in a warm water, shallow, stable shelf environment. After its deposition, the Eocene sea retreated from the area, and during most of the Oligocene, the present land area of the Eucla basin was apparently emergent, the sea returning in very late Oligocene or early Miocene times. No tectonism is evident during the intervening periods. Only a slight disconformity has been noted by some workers between the Nullarbor limestone and the Wilsons Bluff.

Miocene.

Nullarbor Limestone

Distribution.

The uppermost Tertiary unit in the Eucla basin is the Nullarbor limestone of Miocene age. The base of the unit near the head of the Bight and at Madura is lowermost Miocene, but the sections at Watson on the Trans Australian Railway north of the head of the Bight, and at Naretha on the Trans Australian Railway on the far west of the map area range up to late Miocene in age. The basal part has been correlated partly with the Upper part of the Mannum formation of the Murray basin, while the younger part of the sequence has been correlated with the Trealla limestone in Western Australia.

The thickness of the Nullarbor limestone is generally in the 50 ft. to 150 ft. range. No meaningful isopach can be constructed as so much of the thickness data is poorly documented and approximate, and errors would overshadow actual thickness differences. There is however, a hint of thinning to the north.

Lithology

Madura - outcrop on Hamilton Scarp: Here the Nullarbor limestone consists of hard dense crystalline limestone consisting mainly of calcareous algae.

Madura No. 2 well - 30 miles north of Madura: The Nullarbor limestone in this well consists of cream dense partially recrystallised limestone and occasionally of chalky limestone, with forams, molluscan moulds and abundant Miliolidae.

741 Mile Bore - 28 miles west of Loongana: The formation here consists of cream or pink crystalline limestone, with numerous bryozoa, corals, molluscan moulds and Miliolidae.

0046

Murrawijinie Bore: The Nullarbor limestone here is comprised of recrystallised or recalcified limestone, with bryozoa and molluscs.

Hughes 1, 2, 3 and Denman No. 1 Bores: The Nullarbor limestone in this area, is dense and recrystallised and glauconitic near the base.

In other bores encountering Nullarbor limestone, only drillers logs are generally available. These refer to "hard limestone", "hard fossiliferous limestone", "hard crystalline limestone", "hard crystalline limestone with small cavities", "soft decomposed limestone", "flinty limestone", "white limestone", "coralline rock", "white chalk", "yellow, pink and white limestone", "soft white limestone with hard white china boulders", "dense crystalline limestone", "pinkish silicified and re-crystallised limestone", etc. etc.

Fauna.

The Faunal assemblage in the Nullarbor limestone is as follows:

Foraminifera: Austrotrillina howchina (common), Marginopora vertebralis (common), Gypsina howchini and species of Textularia, Gaudryina, Niliolidae, Cornuspira, Flosculinea, Dentalina, Gullulina Anomalina.

Corals: Placotrochus deltoideus and other species, both solitary and reef building.

Pelecypoda: Cucullaea corioensis, Chlamys eyrei, C. dichotomalis, Vasticardium cf. victoriae Antigona (Hina) cainozoica, Corbula ephamilla and species of Limopsis, Neotrigonia, Myadora, Glans Cyclocardia (Arcturellina) Antigona and Macoma.

Scaphopoda: Dentalium spp.

Gastropoda: Species of Calliostoma, cf. Diastoma, Turrutella, Campanile, Theridium, Cypraea, Polinics, Semicassis, Cancellaria, Filodrillia, Micantapex, Consus.

The Calcareous algae - Lithothamnium is also present in places, particularly near the base of the Nullarbor limestone in the south.

Geomorphology

The outcropping Nullarbor limestone forms a very large area with very poorly developed Karst topography. The overall elevation rises imperceptibly from 150 to 250 ft. near the coast to about 800 ft in the northwest.

A topographic contour map (Plate 11) was produced from spot heights available on the 1: 250,000 Military sheets. On the scale of 1,000,000 with a 50' contour interval, the relief of the Nullarbor Plain resolves into systems of extremely broad, extremely slight "highs" and "lows". The lows tend to link up south-southeastward in the manner of a broad surface drainage pattern, but no surface drainage is evident, nor is implied by these comments. Drainage is limited to underground drainage and limestone solution rather than surface run-off. It is notable that the influence of joint control is recognisable in the trends of some highs and lows, despite the scarcity of information available for the topographic contouring.

0047

Although the Karst effects are very evident on the photo-mosaics of the area, the features on the ground are actually quite distant from one another, and most of the plain is virtually level and featureless to the observer on the ground. Collapse dolines and areas of solution effects are the main Karst features. These vary from 50 to several thousand feet across. In places they are several miles apart and in long arcuate trends, or they may be smaller, closer and arranged in rectilinear trends. They show up as dark areas on airphotos due to the presence of vegetation, soil, shadows, and departure from the sharp white limestone surface. They presumably reflect joint patterns, along which solution, cave formation and collapse have proceeded. Elsewhere, the joint patterns appear as white lines on the air photos.

The major joint direction appears to bear approximately 60° east of north. This trend is also evident on the air photo mosaic, particularly in the elongation of solution features. An extreme case of this occurs approximately 60 miles east-northeast of Eucla. Here a single joint direction is traceable for over 20 miles. Also paralleling this major joint direction is the coast and fossil cliff south-west from Madura.

A secondary joint direction approximately perpendicular to the major one is also suggested to a lesser extent, by the solution features.

As the plain is thought to represent an uplifted depositional surface tilted downward to the south and south east, it seems reasonable to assume that the major joint directions formed as a result of, and perpendicular to, the direction of tilting.

The density of solution features appears to increase toward the coast. This may be a climatic effect due to slightly higher rainfall and increased solution, or a change in the nature of the limestone in this direction. The solution effects would also be slightly more apparent in this area because of slightly increased vegetation, such as mallee, acacia or sandalwood.

The generally low rainfall has not generated much deep cave formation. Shallow caves between 15 ft and 80 ft. are fairly common and these are restricted to the Nullarbor limestone itself. They occur either as "blow holes" (solution holes several feet across and about 15 ft. deep), or as cavities in collapse dolines. They may be due largely to descending vadose water. The known deeper caves are very few and are developed in the Wilsons Bluff limestone. They are rather large in size, and have been discussed earlier in this report under Wilsons Bluff limestone. There are only five such substantial caves known in the Nullarbor, and these may have formed in a rather higher rainfall period in the Pleistocene. There is no evidence to support the popular idea that the Nullarbor has an abundance of large caves, although it is true that the area is not well explored speleologically.

A geomorphological study of the Nullarbor limestone from airphotos may be rewarding. It seems to represent a fossil depositional surface on which there has been little erosion. Although the directions of the extremely slight highs and lows may have been controlled by joint directions and by what little erosion that has taken place, deviations from the regional pattern, particularly where there are long arcuate trends of solution features, may be related to structures.

Geological History

0048

The deposition of the Nullarbor limestone represents the final stage in Tertiary sedimentation at least in the present land area. During Miocene times a shallow, warm sea occupied an extensive area inland from the present Australian Bight. Stable shallow shelf conditions prevailed throughout, resulting in a limestone unit remarkable for its uniform lithology and fauna. The adjacent land area must have been very flat, as very little terrigenous material is present in the sediments. The northern part of the Nullarbor limestone area is, however very little known. North of the Trans Railway line, there is an area 400 miles long and 150 miles wide covered by limestone, in which no well or bore has apparently been drilled.

Following deposition of the Nullarbor limestone there appears to have been a very gentle tilting downward to the south and south east. Joint formation was related to this tilting. There was probably no significant erosion of the Nullarbor limestone, except along the sea cliffs although the very slight highs and lows on the surface may have been caused by joint controlled differential solution. Shallow cave formation accompanied this solution. Very low rainfall inhibited erosion, and no streams existed in the area.

In Pleistocene times, the rainfall increased, and increased solution effects probably occurred, with the formation of the deeper caves, but surface streams were still absent from the area. The sea encroached into the area in Pleistocene times, eroding the Nullarbor limestone back to the Hampton Scarp. It subsequently retreated leaving the Roe Plains, south of the scarp, from which the Nullarbor limestone has been stripped.

Hydrocarbon Prospects

The only record of hydrocarbons in the Tertiary of the Eucla Basin is a note "gas bubbles in water" by a water well driller while drilling in Wilsons Bluff limestone in the Muddangabore. The observation is without verification and probably has little or no significance.

The Tertiary has virtually no petroleum potential onshore. The only hope offshore would be if the sequence was overlain by younger impermeable formations of considerable thickness. There is no strong evidence of Pliocene sedimentation onshore in the area, but it is conceivable that equivalents of the marine Pliocene sediments of the Adelaide Plains area could be present offshore. These, even if present, would not necessarily be caprock material. The reservoir potential of the Nullarbor and Wilsons Bluff limestone is probably fairly good. Much of the outcrop is dense and recrystallised, due apparently to weathering and movement of rainwater, but better porosity is suggested in the well sections, particularly in the Wilson's Bluff. In some places onshore organic matter is very abundant, and could provide a porous framework. In the Nullarbor limestone corals are present in the Watson-Coldea area near the basin margin, and algal biostromes are present near the base of the Nullarbor limestone in the south. Abundant bryozoa are present in the Wilson's Bluff limestone.

To be a prospect offshore the Nullarbor and Wilson's Bluff limestone and any hypothetical Pliocene cover would have to have survived Pleistocene erosion, which, on the land, has been effective in stripping off the Nullarbor limestone from an area between Eyre, Madura and Wilson's Bluff.

0049

ST. VINCENT'S BASIN

The Tertiary sequence in the St. Vincent's Basin is made up to alternating marine and continental sediments, as follows:

Pliocene	Dry Creek sands Hallett Cove Sandstone
Miocene, Oligocene and Upper Eocene	Port Willunga beds and equivalents
Upper Eocene	Blanche Pt. Marls Tortachella limestone South Maslin sands
Mid Eocene	North Maslin sands.

Mid Eocene.

The basal Tertiary sands (North Maslin sands) are generally dark and lignitic, and may contain interbeds of clay. In outcrop they are cross bedded and ferruginous. Coarse basal conglomerates are present in some of the areas near the edge of the Tertiary basin. In the type section 64 ft, of cross bedded very fine to coarse, pebbly sands are present with occasional clay lenses and plant remains.

In the Beach Grange 1 bore, the North Maslin sands are 102 ft. thick and consist of grey, pyritic, pebbly and gritty sands overlying Marinoan bedrock.

In the Croydon bore, a sequence of whitish grey, sandy and silty, partly carbonaceous and pyritic clays (The Mulloowurtie Clays") is probably equivalent to the North Maslin sands. It is 130 ft. thick.

Eocene lignites are present in the Inkerman-Balaklava field, where there is an average thickness of 18 ft. of lignite, and also at Clinton, where there is an average thickness of 22 ft. Lignite is also present at various other localities on the east side of St. Vincent's Gulf, including Noarlunga and Kangarilla. Eocene carbonaceous sediments also occur in the Barossa Valley.

Equivalents of Middle Eocene North Maslin sands do not appear to occur on Yorke Peninsula, and are also absent in the Troubridge Island No. 1 well.

Depositional History.

The initial Tertiary deposits are swamp or estuarine deposits and only a few marine microfossils have been found in them. They were apparently deposited on an uneven surface, and are present along the eastern side of the St. Vincent's Gulf, as well as at the northern extremity of the Gulf, and probably underly the Gulf itself. They are related in age to the carbonaceous lignitiferous Pidinga clays and sands of the Eucla basin, and represent continental and marginal marine deposition, prior to the main Eocene marine inundation.

On the west side of St. Vincent's Gulf, i.e. along the east coast of the Yorke Peninsula Upper Eocene, glauconitic coarse sands and sandy clays with lenses of shelly limestone are at the base of the Tertiary section. There is some doubt, however, if these are equivalent, as the South Maslin sands are absent in the Troubridge Island well.

Tortachilla Limestone

Overlying the South Maslin Sand in the Wullunga and Noarlunga areas on the south east portion of St. Vincent's Gulf is a thin section of glauconitic, very fossiliferous, shelly limestone referred to as the Tortachilla Limestone.

Small outcrops at Kingscote on Kangaroo Island of calcareous and bryozoal Eocene strata may be equivalent to the Tortachilla limestone. In the subsurface the Tortachilla limestone and its equivalents have been identified in the following wells:

Croydon Bore (60ft. thick) and Grange Bore (90ft. thick). In these two bores the Tortachilla consists of pale brownish grey, glauconitic limestones and sandy marls.

Light No. 1 Bore. In this bore the section is 11ft. thick, and consists of green, brown and grey glauconitic marly siltstones, limestones and mudstone.

In the 97A Bore about 13 miles northwest of the Light No. 1 Bore, the section is represented by pebbly, greenish brown, glauconitic sand containing abundant forams, molluscs, bryozoa, brachiopods, etc.

An unusually thick section is present in the Troubridge Island Well (100ft.). It consists of cream crystalline glauconitic limestone, with pseudopolymorphina sp., Gyroidina octocamerata and Lamarckina airensis.

The Journal of the Geological Society of Australia Vol. 5 Part 2 states that the fauna of the Tortachilla limestone generally includes the mollusc Notostrea and the "Eocene cephalopods Aturia clarkei attenuata and Cimoma felix. The echinoids Salenia tertiaria and Australanthus longianus are restricted to the Eocene, but many others are long-ranging. Bryozoa form the framework of the rock. The foraminifera Globigerinoides index, Globigerinella micra and Asterigerina adelaidenses are present in the microfauna which is dominated by species of Cibicides and Angulogerina (Créspin, 1954). The sands and the basal portion of the limestones contain pebbles and blocks of ironstone with worm burrows. In the overlying transitional marl beds which grade upwards into the fine grained Blanche Point Marls, Hantkenina alabamensis compressa, Gumbelina and Créspinina kingscotensis enter the foraminiferal fauna."

Blanche Point Marls.

The Blanche Point Marls are at the top of the Eocene sequence.

In the Croydon Bore the Blanche Point Marls are 191ft. thick. The upper part (the soft marls) consist of pale grey, clayey and sandy, calcareous siltstone with a well preserved planktonic microfauna with Turritella and the Scaphopod Dentalium. The underlying "banded marl" section consists of calcareous clays with hard bands of light grey siliceous and calcareous siltstones. The siltstones near the base are more glauconitic. The base of the Blanche Point marl section (the "transitional marls") consists mainly of brownish grey glaucon-

The surrounding area was fairly flat during this period, as the tectonism which produced the present topography did not reach its climax until later. The edges of St. Vincent's Gulf may have been a complex of swamps and estuaries with river deltas reaching far out into the Gulf. The sea connection was probably through Backstairs Passage between Kangaroo Island and the Fleurieu Peninsula, through the Permian glacial fiords or valleys in this area. Geophysics also suggests the deeper part of the Tertiary basin is along the east part of Gulf St. Vincent towards Backstairs Passage. There is little evidence to suggest a Tertiary seaward connection through Investigator Strait.

Upper Eocene.

In the St. Vincent's basin, the Upper Eocene is made up of 3 units. From the top down these are the Blanche Point Marls, Tortachilla limestone and South Maslin sands.

South Maslin Sands:

The South Maslin glauconitic sands represent a marine phase, overlying the continental North Maslin sands on the south east side of the gulf. They are succeeded by the richly fossiliferous marine glauconitic Tortachilla limestone. The Tortachilla limestone is overlain by the fossiliferous Blanche Point Marls.

In the Adelaide plains the South Maslin sands are grey or dark grey and may be carbonaceous. Interbedded clays have been referred to as the Mulloowurtie clays, and included with the underlying North Maslin sands by some workers.

In the 97A bore about 13 miles north west of the Light No. 1 well, in the Wild Horse Plains area near the northern part of the gulf, a clearcut section of the South Maslin sands was encountered. Here it consists of grey-brown, silty fine grained, micaceous, carbonaceous, slightly glauconitic and pyritic sand 15 ft thick, containing rare forams, sponge spicules and gastropod fragments.

In the Croydon bore, the South Maslin sands are 135 ft. thick, in the Grange bore 130 ft. thick, and in the Elizabeth Oval bore 37 ft. thick.

The Croydon bore sequence consists of carbonaceous, micaceous, slightly pyritic and glauconitic clayey sands.

The Grange No. 1 sequence consists of sands and clays which are slightly glauconitic near the top and very slightly calcareous. The sandstones and clays are micaceous, carbonaceous and pyritic and range from pale grey to black in colour. Some of the clay sections have been referred to as the Mulloowurtie clays, which have been included elsewhere with the underlying North Maslin sands.

In the Elizabeth Oval bore the South Maslin sands consist of slightly glauconitic, pyritic, carbonaceous, lignitic and poorly fossiliferous, partly gravelly sands with some overlying interbeds of dark brownish grey sandy clays. These clays have been referred to the Mulloowurtie clays but elsewhere the term has been used for clays at the base of the south Maslin sands as well as for clays within the Middle Eocene North Maslin sands.

In the Light No. 1 well the South Maslin sands are not present.

Port Willunga beds are also present overlying Permian tillites in the Myponga Valley, and in the Myponga Bore.

On Kangaroo Island, in the Kingscote-Cygnnet area, bryozoal limestones, apparently equivalent to the Port Willunga beds, occur in small outcrops.

On Yorke Peninsula bryozoal limestones are present, some containing Lithothamnium and Lepidocyclina gippslandica.

The Port Willunga beds onlap over the preTertiary beds inland around the margins of the St. Vincent's basin. They represent the widest transgression of the Tertiary sea. If the Tertiary sea connected with other basins it was probably at this time through widened Permian glacial valleys and fjords.

Depositional History - Port Willunga Beds.

The Port Willunga beds represent a sustained marine transgression which apparently persisted from Late Eocene to possibly Middle Miocene times, although there may have been a minor regression in the Oligocene. Sedimentation covered a more extensive area than any of the other Tertiary units, and represented the maximum transgression of the Tertiary sea. Deposition apparently was partly related to further movement on old Palaeozoic faults marginal to the St. Vincent's Basin. A shallow sea covered the area in which calcareous sediments built up, as well as clastic material from the surrounding area.

Apart from fault movement during deposition there may have been some slight midTertiary folding in this period, which is apparently evident in the coastal cliffs, and which would be important as a tectonic event to oil exploration elsewhere. It is possible that the folding could have been accompanied by some erosion prior to Late Tertiary deposition.

During the period of the Port Willunga beds marine transgression, the Nullarbor limestones were being deposited in the Eucla Basin, and limestones were being deposited at Fishery Bay south west of Port Lincoln.

Pliocene.

The Pliocene sequence consists of two units, the Dry Creek sands and the underlying Hallett Cove sandstone. The maximum thickness is probably around 200ft. although it is generally considerably less. Pliocene is present in numerous shallow bores drilled in the Adelaide plains and elsewhere, and it outcrops along the east side of St. Vincent's Gulf, and also on Yorke Peninsula. In outcrop it is in places as much as 250ft. above present sea level. It contains a rich mollusc fauna with abundant oysters (Ostrea arenicola), large forams, bryozoa and crab claws.

The lithology ranges from sand to alternately hard fossiliferous limestones and sand.

Depositional History

The Pliocene sea occupied a rather large area of St. Vincent

Unit (A) appears to be largely indistinguishable lithologically from the Upper Blanche Point "soft marls", and the base is related to the extinction level of Turborotalia inconspicua aculeata.

In this part of the type section at Port Willunga, the sequence consists of a "thin basal gravelly sand followed by cream cross-bedded bryozoal sands and sandstones, green grey clays and brownish impure calcarenitic limestones, silts and clays".

Unit (B) has been recognized lithologically in the Adelaide Plains area as well as at the type section at Port Willunga, and may be found to be elsewhere on detailed lithological examination. It consists of hard, grey, siliceous, cherty, calcareous siltstone, sandstone or limestone. Thicknesses appear to generally range from 25 to about 220ft. At the Port Willunga beds type section this unit is 50ft. thick and consists of calcarenitic impure limestones, marls, silts and sands with prominent bands of cherty nodules. As well as being a reasonably distinct unit lithologically the base of the member is related to the lowest occurrence of Guembelitria stavensis.

Unit (C) consists of softer, marly greenish and glauconitic limestones, calcareous sandstones and siltstones. At the type section the sequence is 12ft. thick and consists of glauconitic, bryozoal beds including marly limestones, silty sands and calcarenitic sands. Distinctive forams make their appearance as the top of the Unit C is encountered. These are Victoriella conoidea, Gyroidinoides sp., Massilina torquayensis, Guembelitria stavensis and Bolivinospis sp. The first appearance of any of these forams can be taken as top of Unit (C).

Unit (D) ranges in thickness from 45 to 280ft. in the Adelaide Plains, and consists of pale grey to brown calcarenitic limestone, calcareous sands, silts and marls, often softer and more glauconitic with depth.

Unit (E) has a maximum known thickness of 31 ft. and is known to be present in the Southern Adelaide Plains. The best documented section is in the Grange Well where there are interbeds of dark grey clay and light brown limestone.

Unit (F) consists of sandy limestone, and is known to be present in the southern Adelaide Plains.

A comprehensive, recent, discussion of the microfauna of the Port Willunga beds is given in Lindsay (1967).

The total thickness of the Port Willunga beds are:
Elizabeth Oval Bore No. 1 - 547ft; Croydon Bore - 874ft; Grange No.1 Bore - 720ft; Light No. 1 Bore - 260ft; Hallion's No. 2 Bore - 300?ft.

In the Troubridge Shoal No. 1 Well a thickness of 610ft. of Port Willunga beds was encountered. The sequence has not been subdivided like the Adelaide plains sequence, but the forams present would suggest affinities with (D), (E) and (F) Lower Miocene units, indicating a thickened Lower Miocene sequence. The upper 190ft. consisted of cream white recrystallized limestone, which was chalky and bryozoal near the base, and the bottom 60ft. consisted of greenish-cream marly limestone.

The Minlaton No. 1 Bore on the Yorke Peninsula encountered no Port Willunga beds over the Permian section, but the Stansbury No. 1 encountered 119ft. of fossiliferous calcareous sandstone, and sandy bryozoal limestone. These are apparently of Oligocene age, possibly equivalent to Units (B) and (C).

alent section is possibly present as far north as the Croydon Bore. The age and significance of these beds is not certain, but they may be near the Eocene-Oligocene boundary.

Upper Eocene Depositional History

After the continental Middle Eocene beds were laid down, a marine transgression resulted in the deposition of the glauconitic South Maslin sands. This marine transgression may have been related to renewed movement on old Palaeozoic faults along the margin on the basement, increasing the rate of subsidence. The continental influence was still very strong, however. Marine fossils are not abundant, and carbonaceous and lignitic material is commonly present. It was not until Tortachilla times that full marine conditions were attained, and the richly fossiliferous Tortachilla limestone was deposited in a warm shallow sea in the southern part of the Gulf (Troubridge Island-Willunga-Noarlunga-Kangaroo Island area). To the north the limestone becomes marly, silty, and grades to marine sandstone near the head of the gulf.

The Blanche Point marls have a higher argillaceous content than the Tortachilla, but are still essentially a marine unit over some of the area. The Upper Eocene sea appears to have contracted, as the Noarlunga and Willunga areas in which the Tortachilla was so richly fossiliferous, now exhibits a continental facies of the Blanche Point marls. The marine Blanche Point marls are also missing under the northern part of the Adelaide Plains, and exhibit rather continental or brackish water characteristics in the Cape Yorke Peninsula area.

It is probable that while the Upper Eocene sediments were being deposited in St. Vincent's Gulf that the very stable shallow warm water marine Wilson's Bluff limestones were being deposited in the Eucla Basin. While the Eucla Basin was a very broad area with little influx of terrestrial material, the St. Vincent Basin was more enclosed, and a greater amount of clastic material was contributed to the sequence.

Miocene-Oligocene-Upper Eocene

Port Willunga Beds:

Recent work (Lindsay 1967) has shown that the Port Willunga beds, previously considered to be Miocene, now appear to span a larger time interval, from the Upper Eocene to the Middle Miocene. This makes following of the earlier literature rather difficult. His contribution is of considerable importance to offshore oil exploration, since it increases the length of time during which Port Willunga sedimentation occurred, and consequently also the expectation of thicker Tertiary sequences offshore.

The Port Willunga beds are divided, over this period, into the following units:

- (F) Middle Miocene? Port Willunga beds above Munno-Para clay
- (E) Lower Miocene Munno-Para clay
- (D) Lower Miocene Port Willunga beds below Munno-Para clay
- (C) Oligocene "Upper Janjukian member"
- (B) Oligocene "Siliceous member"
- (A) Upper Eocene "Aldingan" member.

As the above terminology is rather unwieldy, the units have been designated (A), (B), etc. from the base up.

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itic silty limestone and dark brownish grey saccharoidal glauconitic and sandy limestone, and are the equivalent of the Tortachilla limestone.

In the Grange No. 1 Well the Blanche Point marls are again divided into the upper "soft marls" - 220ft. thick, and the "middle banded marls" - 60ft. thick. The lithologies are generally rather similar to those in the Croydon well. The "lower transitional marls" are the equivalent of the Tortachilla limestone.

In the Elizabeth Oval Bore the total thickness is 216ft. The "soft marl" and the "banded marl" sections are both present at this well. The "soft marl" section is 65ft. thick and consists of grey, calcareous, silty sands and clays containing a few forams, as well as carbonaceous and lignitic material. The "banded marls" contain hard bands of siliceous, sandy, calcareous siltstones.

In the Light No. 1 Bore the Blanche Point marl has transitional boundaries, and the total thickness is probably about 60ft. The unit consists of dark brownish grey to black, siltstones, mudstones, clays and marls, which are more pyritic, glauconitic and lignitic towards the base. The marls are fossiliferous and include forams and Dentalium.

In the Hallion's No. 2 Bore the upper 223+ft. of the Blanche Point is possibly present. 53ft.+ of "banded marls" is present at the bottom of the hole and consists of calcareous, clayey siltstones and clays.

The Blanche Point marls contain abundant sponge spicules, and the mollusc Turritella aldingae is common. The foraminiferal fauna is dominated by Lagenids with Asterigerina adelaidensis and Globeferinoides index being very common. Bones of an extinct penguin, Palaeudyptes cf. Antarcticus have been found in the Blanche marls.

In the Noarlunga and Willunga areas on the south-east side of St. Vincent's Gulf the Blanche Point marls have changed facies to silts, sands and some lignites, but siliceous bands, rich in Turritella are common.

In the Cape Yorke area, the equivalents of the Blanche Point marls consist of clays with brackish water forams, plant bearing quartzites, and siliceous bands containing Turritella. It would appear that a less marine, more marginal environment is represented in this area.

The Troubridge Island Well is in this area and encountered 140ft. of dark grey carbonaceous marl, sand and silt, equivalent to the Blanche Point. Turritella aldingae and Corbula pixidata are present.

The marine Blanche Point marls are apparently absent under the northern part of the Adelaide Plains, and also on the far eastern side of the basin generally.

In addition to this, more continental facies are evident in the Noarlunga and Willunga areas, and also on Cape Yorke, suggesting that the Blanche Point sea occupied considerably less area than the overall depositional area.

A thin unconformable sequence about 5ft. thick of red and green clays and sands is present in a few places above the Blanche Point marls on the eastern side of St. Vincent's Gulf. Some equiv-

basin and the sediments were laid down in tropical marine conditions in an epineritic to littoral environment. In Late Pliocene or Early Pleistocene times tectonic activity increased. Considerable uplift occurred in the ranges to the east, and gentle folding is evident in the Tertiary strata. Some volcanic activity is also evident during this period on the northern part of Kangaroo Island.

Plio-Pleistocene, Pleistocene and Recent Sediments.

These consist of thin sections of mostly continental sands, gravels and alluvial clays, and are of no interest from an oil exploration point of view.

Additional Tertiary Information.

The Tertiary around St. Vincent's Gulf is relatively well documented, probably largely due to its proximity to population centres. No well, however, has been drilled in the Gulf itself, in the deeper part of the basin, so the ultimate thickness and deeper basin lithology of the Tertiary can only be inferred.

In addition to the bores covered in the preceeding Tertiary discussions there are others in the St. Vincent's Gulf area with varying degrees of documentation. It must be remembered that most of the bores were drilled for water, not oil, and the diligence of the officers of the Mines Department is to be commended for the information available on them.

Further information could be obtained, particularly regarding shallow Tertiary units on large number of water bores dealt with in the Department of Mines Summary Reports on Adelaide Plains Stratigraphy, by Lindsay (1965, 1966 and 1967.). Undifferentiated, or partly differentiated, Tertiary sections are also present in the Myponga, Kingscote, S.A.R.E.T., Mallata, Clinton, Black Point and Adelaide Oil No. 1 bores. Although little information is available on most of these bores, some have significant thicknesses of Tertiary, and could warrant a further search for information.

Some bores which did not encounter any Tertiary over Palaeozoic or older rocks, are useful in delineating the limit of the Tertiary. These include Black Swamp Bore, Minlaton Oil No. 1 and Peninsula Oil No. 1.

WANILLA-CUMMINGS BASINS.

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Distribution of Tertiary.

These basins are located on the Eyre Peninsula. The outline of the combined area is shown on Plate 9. There appears to be a possible maximum of about 500 ft. of Tertiary present on the land portion of these basins, which are treated jointly in this report.

Stratigraphy of Tertiary.

The sequence is as follows:

Pliocene:	Limestones, laterites
Miocene:	Limestones
Eocene:	Carbonaceous and lignitic sands.

In the Wanilla-Cummings basin the Tertiary sequence begins with Eocene lenticular carbonaceous, lignitic, silty sands, grits and gravels. The presence of small planktonic forams suggests estuarine or lagoonal conditions of deposition, at least at times. The age of these beds has not been precisely determined, but the forams are "similar to those occurring in Upper Eocene sediments elsewhere in South Australia" and pollens present are "characteristic of Middle or Upper Eocene deposits in Southern Australia."

It is possible that the Eocene beds are related in age to the Pidinga lignitic clays and sands of the Eucla Basin. In the Wanilla-Cummings Basin they have a maximum known thickness at present of 380 ft.

The Miocene limestones outcrop at Fishery Bay, about 16 miles south west of Port Lincoln. They consist of bryozoal, buff coloured, gritty, marine Miocene limestones, containing abundant shell casts and boulders of bedrock gneisses. They contain large pelecypods, suggesting a shallow water "bay head" environment. The outcrops are apparently very limited, and it would seem that the Miocene sea made a very limited incursion into the present land area. The small outcrops are important, however, as providing a clue to the type of offshore Miocene section which could be expected..

The Pliocene sediments, apart from marine littoral limestones overlying the Miocene limestone in the Fishery Bay area, and the sub-surface section in the Sleaford areas are presumably limited to high level laterites, lateritic gravels and conglomerates. These are assumed to have formed during periods of high rainfall in the Pliocene.

The thickness of the marine Pliocene outcrop is not documented, but is presumably fairly thin. The limestone is conglomeratic and contains large pelecypods including Fulvia tenuicostata, Vasticardium submaculosum, Miltha hova, and an undescribed Anodontia. Like the Miocene sea, the Pliocene sea made only a limited incursion into the area. The Pliocene laterites, on the other hand, are quite extensive.

A few bores have been put down in the area, but these are generally poorly documented. It would seem that the Sleaford No. 1 well encountered about 325 ft. of Tertiary section, of which 105 ft. may have been Eocene. The Sleaford No. 2 well apparently encountered 446 ft. of Tertiary, of which the upper 265 ft. may have been Pliocene. The Mallata No. 1 and Mallee Park No. 1 wells are useful in that they have passed directly from Pleistocene into Archean without encountering

any Tertiary section. The Eyre Peninsula No. 3 Bore encountered only 50ft. of undifferentiated Quaternary or Tertiary above the Pre Cambrian.

Depositional History.

It is reasonable to assume that the paralic, lagoonal, estuarine and lignitic swamp deposits of the Pidinga sequence in the Eucla Basin, the North Maslin sands in the St. Vincent's Basin, and similar Eocene sediments in the Wanilla-Canning Basin were deposited about the same time. Remnants of Miocene limestones previously referred to, represent later incursions of the sea, which may have been related in time to the deposition of part of the Port Willunga beds in the St. Vincent's Basin, and the Nullarbor limestone in the Eucla Basin.

POLDA BASIN.

Stratigraphy.

The Poldas Basin is located east of Elliston on the Eyre Peninsula. Its configuration is very vague as only one well of any depth (Polda No. 1 - 565ft. deep) has been drilled in the area. A large number of very shallow water wells have been drilled which produce water from a calcareous sand capped by travertine limestone. It appears that the sand is of Quaternary age. The Tertiary sequence in the Poldas No. 1 Well is 119ft. thick, and appears to be made up entirely of Middle Eocene carbonaceous and lignitic sands, carbonaceous silts and occasional lignites. The sands are generally dark brown to black, and consist of fine, medium and coarse grained quartz grains, as well as carbonaceous and micaceous material. Light brown or dark brown, carbonaceous, lignitic, clays and silts are also present. The lignite is dark brown and occurs in two seams 14ft. and 4ft. thick respectively. Some of the lignite is sandy and marcasitic.

The outline of the basin shown on Plate 9 is only that suggested by the presently drilled area of the Quaternary water sand basin and may have little or no relationship to the size of the Tertiary basin.

Depositional History

It is apparent that the continental lagoonal and swamp environments of Middle Eocene times in the St. Vincent's Gulf, Wanilla-Cummings basin and the eastern portion of the Eucla basin were also present in the Poldas area at about the same time. The Poldas basin is interesting because the Tertiary sequence is underlain by Jurassic sediments, unlike the known areas of the Wanilla-Cummings and St. Vincent's Gulf basins.

STREAKY BAY AREA.

There is a small area about 200 sq. miles extent, south east of Streaky Bay (See Plate 9) in which a Quaternary water sand basin similar to that in Poldas basin is present. Although it appears that the sand generally overlies the Pre Cambrian, one can, by drawing a parallel to the Poldas Basin speculate that a small area of Tertiary may be present, or that Tertiary may be present in the adjacent area offshore. There is a small lobe from the Anxious Bay Aeromag "thick" trending in this direction.

HYDROCARBON PROSPECTS OF ST. VINCENT'S BASIN AND EYRE PENINSULA TERTIARY.

The Tertiary sequence in St. Vincent's Basin probably does not exceed 2,500 ft. in thickness. The sequence is one of alternating marine and continental sediments, an alternation which suggests that an attractive combination of source and reservoir beds may be present in thicker offshore Tertiary sections. It is doubtful if there was a marine connection from St. Vincent's basin through Investigator Strait, to the area west of Kangaroo Island, but rather that the Tertiary is related to the Wanilla-Cummings Tertiary basin.

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The open sea connection for the St. Vincent's basin was probably through Backstairs Passage. In spite of this, the detailed knowledge of the Tertiary in St. Vincent's Basin is an aid in postulating the nature of Tertiary sedimentation west of Kangaroo Island.

The Wanilla-Cummings Basin on the tip of Eyre Peninsula is unfortunately a relatively poorly documented area, but it is known that continental, or estuarine Eocene beds are present, and that marine Miocene and Pliocene limestones are also present.

The Marine Miocene beds are present at Fishery Bay, about 16 miles south west of Port Lincoln. The outcrop is small, but very important, as it indicates that marine Miocene deposition almost certainly occurred offshore.

Pliocene marine beds are also present in this area, and 220 and 265 ft. thicknesses have also been reported in the Sleaford 1 and 2 bores.

If the Tertiary thickens considerably offshore, it must be credited at the present time with good prospects, and with a likely alternation of source and reservoir beds. The presence of mid-Tertiary and late Tertiary folding in the St. Vincent's Basin, in encouraging, and possibly increases the chances for such folding being offshore.

RECOMMENDATIONS FOR FIELD WORK.

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These recommendations are set out in a geographical, rather than a geological order to facilitate sequential field examinations of the areas mentioned.

Plate 12 indicates the general locations suggested for examination, listed alphabetically, generally from east to west, but is not meant to be a precise guide map. The field geologist should refer to the 4 mile = 1" topo maps, and the various geological references for precise locations, tracks etc. The author will assist the field geologist with directions in areas of which he has personal knowledge, and also information on applicable maps and references. The field geologist should be fully equipped for survival and vehicle breakdown in the Nullarbor region, and should attempt to obtain first hand information from geologists and speleologists who have worked in the area, as well as from the local residents. Good photo mosaics are available on the West Australian portion of the Eucla Basin.

The areas are briefly described below:

- A. Area of boulder and pebble beds of unknown age north west of Cleve. These should be examined, and sampled, in particular for any evidence of glacial origin (faceting, striations, assorted lithologies, etc.) Generally thought to be Cambrian, without any evidence. May possibly be Permian.
- B. Blue Hills area. Ditto as for A.
- C. Any cliffs in the coastal area should be examined for outcrops of possible Permian.
- D. Small outcrops are present at Fishery Bay of Pliocene and Miocene limestone. These are very important, as they imply that marine Tertiary is present offshore. All such outcrops should be carefully logged and sampled for laboratory lithological and micro-palaentological examination.
- E. A small outcrop of conglomerate and sandstone is reported in the Talia area. This should be examined as it could possibly be a Permian exposure.
- F. The "Talia Caves" should be examined as (1) some idea of the Quaternary sequence may be useful, in view of the Poldia Tertiary and Jurassic basin, which is currently outlined only on Quaternary water sand drilling. (2) Any Tertiary found in the base of the caves would be a useful addition to the knowledge of the shape of the Poldia basin.
- G. Mount Wedge. Ditto as for A and B
- H. Any cliffs along the coast in this area should be examined for outcrop, either Tertiary or possible Palaeozoic.
- I. The Streaky Bay area to the north, has a small Quaternary basin which may open seaward near this estuary. Examination should be made on any cliffs for Tertiary outcrops.
- J. The edge of the Tertiary basin probably meets the sea coast south west of Penong. An examination could be made of the area for any exposures of Pidinga type clays, sands or lignites, or limestone, which would delineate this edge of the Eucla basin. Ideally K should be visited before attempting J.

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- K. Outcrop of Pidinga silts, clays and lignites of Eocene age.
- L. Outcrop section of Nullarbor limestone on sea cliff. Better sections are of difficult access, - more accessible sections are partly dune covered.
- M. Koonalda Cave. Section of Nullarbor limestone, un-named Oligocene - Eocene section, and Wilson's Bluff limestone. Should be sampled.
- N. Warbla Cave. Ditto as for M.
- O. Wilson's Bluff. Type section of Wilson's Bluff limestone. May be preferable to visit and sample this, prior to M and N.
- P. Weebubbie Cave. Ditto as for M.
- Q. Abrakurrie Cave. Ditto as for M. Un-named unit known to be present here.
- R. Hampton Scarp. A periodic examination of this scarp along its length, particularly where it has not been severely degraded, may reveal information on the lithology of the Wilson's Bluff limestone, the Oligocene-Eocene un-named unit, the Nullarbor limestone and their contacts.
- S. Cliff section as in R. There is a small cave on the Roe Plains south of Madura, bottoming in unknown lithology, possibly either Pleistocene or Wilson's Bluff limestone. Should be sampled.
- T. Cocklebidy Cave. Ditto as for Q.
- U. An examination, and sample collection should be made of the Cambrian succession on Kangaroo Island, with the object of determining their source rock and reservoir potential.

The airphoto mosaics of the western part of the Eucla basin, show linear and curving trends of different types of solution features, of varying densities and sizes. A photogeological study may be warranted, in case the solution features, which may be related to jointing, have any deeper significance relevant to basin configuration, structure etc.

The most important requirement for additional study, however, is in the Wanilla-Cummings basin. Any sample material on the deeper bores in the area should be examined and logged, and a thorough search for information through geologists familiar with the area, should be made. Examination and logging of outcrop sections should be undertaken, and a search made for any evidence of Tertiary folding in the area. The Wanilla-Cummings basin probably represents the small landward portion of a larger offshore Tertiary basin west of Kangaroo Island, and may provide important additional clues to offshore sedimentation.

SUMMARY.

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This report involves a review of the available literature relevant to the onshore geology between Kangaroo Island and the western portion of the Great Australian Bight. Isopach and structure maps have been compiled on various units and horizons, along with appropriate cross sections. A discussion of each formation is included, with attention to its distribution, lithology, fauna, depositional history, and hydrocarbon prospects. Well data sheets have been compiled summarizing the basic information on 90 bores and wells, and recommendations have been made regarding field work in the area.



J. R. Cundill.

REFERENCES

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|-----------------------------------|------|---|
| ALLIANCE PETROLEUM AUSTRALIA N.L. | 1964 | Alliance Eucla No. 1 Well Completion Report. |
| AUSTRALIAN OIL EXPLORATION LTD. | 1955 | Geological Investigations - Permits to explore 39H, 40H, 41H, Eucla Basin. |
| BEACH PETROLEUM N.L. | 1967 | Stansbury Town No. 1 Well Completion Report. |
| COMMONWEALTH RAILWAYS | | Plan and Section of Bores Kalgoorlie-Port Augusta. |
| CORNISH, B.E. | 1964 | Light No. 1 Well Completion Report, S.A. Dept. of Mines 875/64 Pet.4/64 |
| CRAWFORD, A.R. | 1965 | The Geology of Yorke Peninsula Geol.Surv.of S.A. Bull No. 39. |
| CUNDILL, MEYERS & ASSOC. | 1966 | Stansbury West No. 1 Well Completion Report. |
| CUNDILL, MEYERS & ASSOC. | 1967 | Beach Petroleum N.L. Edithburgh No.1 Well Completion Report. |
| DAILY B. | 1967 | Preliminary Report on Stansbury West No.1 and Edithburgh No. 1 Wells. Subsurface Stratigraphy and Palaeontology of the Cambrian Sequence. University of Adelaide. |
| EVANS, H.J. | | Memorandum on Structure of Eucla Coastal Area. Private Paper. |
| GEOLOGICAL SOCY. OF AUSTRALIA | 1958 | The Geology of S.A. Journ. of the Geological Socy.of Aust.Vol.5 Pt.2. |
| GEOSURVEYS OF AUSTRALIA LTD. | 1963 | Completion Report for Beach Petroleum N.L. Troubridge Island No. 1 Stratigraphic Well. O.E.L.24 S.A. |
| HARRIS W.K. | 1965 | Palynological Observations on Eocene Sediments from two Bores in the N.Adelaide Plains. S.A.Mines Dept. 1737/57, Pal.Report 2/65. |
| HARRIS W.K. | 1964 | Mesozoic Sediments of the Polda Basin, Eyre Peninsula. Quarterly Notes, Geol.Surv.S.A. No. 12 |
| HAWKINS, HENNION, NAFE & DOYLE | 1965 | Marine Seismic Refraction Studies on the Continental Margin to the South of Australia. Deep Sea Research Vol. 12 |
| JENNINGS J.N. | 1963 | Some Geomorphological Problems of the Nullarbor Plain. Trans. Royal Socy.S.A. Vol. 87. |
| JOHNS R.K. | 1961 | Geology and Mineral Resources of Southern Eyre Peninsula. Geol. Surv. of S.A. Bull No. 37. |

JOHNSON J.E.	1963	Basal Sediments of the North Side of the Officer Basin. Quarterly Notes Geol. Surv. of S.A. No. 6.
JOHNSON W.	1956	Preliminary Report on Ground Water Investigations. County Hopetown, S.A. Dept. Mines 1674/55 Hyd. 217
KENDALL G.W.	1965	Report on Reconnaissance Seismic Refraction Survey in the South Australian portion of the Eucla Basin. Geol. Surv. S.Aust. D.M. 1413/64.
LINDSAY D.	1893	Elder Scientific Exploring Expedition 1891-92. Trans. Royal Geog. Socy. of S.A. Vol. XVI.
LINDSAY J.M.	1965	Stratigraphy and Micropalaeontology of Three Deep Bores, Hundred of Port Gawler. S.A. Dept. of Mines 1408/62 Pal. Rept. 4/65
LINDSAY J.M.	1965	Adelaide Plains Sub-Basin Stratigraphy Summary Report No. 1. Hundred of Port Adelaide. S.A. Dept. Mines 1937/65, Pal. Rept. 16/65
LINDSAY J.M.	1966	Adelaide Plains Sub-Basin Stratigraphy Summary Report No. 2. Hundred of Yatlala. S.A. Dept. Mines 1937/65 Pal. Rept. 1/66
LINDSAY J.M.	1966	Adelaide Plains Sub-Basin Stratigraphy Summary Report No. 3. Hundred of Munno Para, Mudla Wirra and Port Gawler. S.A. Dept. Mines 1937/65 Pal. Rept. 2/66
LINDSAY J.M.	1967	Adelaide Plains Sub-Basin Stratigraphy and Micropalaeontology. Summary Report No. 4. S.A. Dept. Mines 27.67 Pal. Rept. 1/67
LOWRY D.C.	1964	The Development of Cocklebidy Cave Eucla Basin, W.A. Helictite Vol. 3 No. 1
LUDBROOK N.H.	1957	Palaeontological Examination of Bores in the Western Portion of the Eucla Basin. S.A. Dept. Mines Pal. Rept. 8/57.
LUDBROOK N.H.	1958	The Stratigraphic Sequence in the Western Portion of the Eucla Basin.
LUDBROOK N.H.	1958	The Subsurface Stratigraphy of the Maralinga Area. S.A. Dept. Mines 1127/57 Pal. Rept. 7/58.
LUDBROOK N.H.	1960	Exoil Pty. Ltd., Eyre No. 1 and Grainbanga No. 1 Wells. Subsurface Stratigraphy and Micropalaeontological Study. S.A. Dept. Mines Pal. Rept. 11/60
LUDBROOK N.H.	1961	Minlaton and Stansbury Stratigraphic Bores, Subsurface Stratigraphy and Micropalaeontology. S.A. Dept. Mines Pal. Rept. 7/61.

- | | | |
|--|------|--|
| LUDBROOK N.H. | 1963 | Beach Petroleum N.L. Troubridge Shoal No. 1 Stratigraphic Well. Subsurface Stratigraphy. S.A. Dept.Mines Pal. Rept. 7/63. |
| LUDBROOK N.H. | 1963 | Correlation of the Tertiary Rocks of South Australia. Trans. Rgy. Soc. S.Aust. Vol. 87 |
| LUDBROOK N.H. | 1966 | Hughes-Denman Stratigraphic Drilling Projects of Outback Oil Co. N.L. Subsurface Stratigraphic and Micro-palaeontological Study S.A. Dept. Mines Pal. Rept. 10/66. |
| OUTBACK OIL CO. N.L. | | Aeromagnetic Survey Subsidy Application. Eucla Basin Offshore Shelf. |
| PATTERSON G.W. & MOON R.E. | 1954 | Reconnaissance of Southern Part of the Eucla Basin. Private report. |
| REED L.C. & EVANS H.J. | | Geological Reconnaissance of the Eucla Basin. Private Paper. |
| SHELL DEVELOPMENT (AUSTRALIA) PTY.LTD. | 1967 | Final Report South Australian Shelf R-1 Marine Seismic Survey O.E.L. No. 38 S.D.A. Rept. 68. |
| S.A. MINES DEPARTMENT | | Well Reference List. |
| S.A. MINES DEPARTMENT | 1959 | Groundwater Handbook |
| S.A. MINES DEPARTMENT | | Logs of Bores in Western Eucla Basin Ref. DM 2082/55 |
| SPRIGG R.C. & CAMPANA B. | 1953 | The Age and Facies of the Kanmantoo Group. Aust. J.S. Vol.16 No.1.ppl2-14 |
| SPRIGG R.C. | 1955 | The Point Marsden Cambrian Beds Kangaroo Island, S.A. Trans.Roy.Soc.of S.A.Vol 78 ppl65-168 |
| SPRIGG R.C. | 1961 | Petroleum Prospects of the Mesozoic-Tertiary Basins of South Eastern Australia (Based on 1961 ANZAAS paper). |
| SPRIGG R.C. & STACKLER W.F. | 1965 | Submarine Gravity Surveys in St. Vincent's Gulf and Investigator Strait, S.A., in relation to Oil Search, A.P.E.A. Jour. 1965. |
| SPRIGG R.C. | | Oil & Gas Possibilities of St.Vincent Gulf Graben and Adjacent Areas. Unpub. Rept. |
| SPRIGG R.C. | 1966 | Palaeogeography of the Australian Permian in Relation to Oil Search A.P.E.A. Jour. 1966. |
| THOMSON B.P. | 1963 | Regional Structures Southern Fleurieu Peninsula. Quarterly Notes. Geol.Surv. of S.A. No. 6. |
| THOMSON B.P. | 1966 | Stratigraphic Relationships between Sediments of Marinoan Age. Adelaide Region. G.S.S.A. Quart.Notes No. 20. |

- | | | |
|-------------------|------|--|
| THOMSON B.P. | 1966 | The Lower Boundary of the Adelaide System and Older Basement Relationships in S.A. Jour. Geol. Socy. Aust Vol. 13, pt.1, pp 203-228. |
| TURNER A.R. | 1964 | Petrological Examination and Report. Nullarbor Nos. 6, 7, 8 Bores, Guinewarra Bore, S.A. Dept. Mines Rept. from Amdel MP 1043-65 |
| W.A.P.E.T. | 1961 | Exoil Eyre No. 1 and Gainsbanga No.1 Well Completion Reports. |
| WARD L.K. | 1944 | The Search for Oil in S.A. Geol. Surv. of S.A. Bull. No. 22 |
| WARD L.K. | 1946 | The Occurrence, Composition, Testing and Utilization of Underground Water in S.A., and the search for further Supplies. Geol. Surv. of S.A. Bull No. 23. |
| WOOLLEY & FRANKEN | 1964 | Oil Prospects of the St. Vincent's Gulf - Private Report. |

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SHEET 1
WESTERN & CENTRAL EUCLA BASIN
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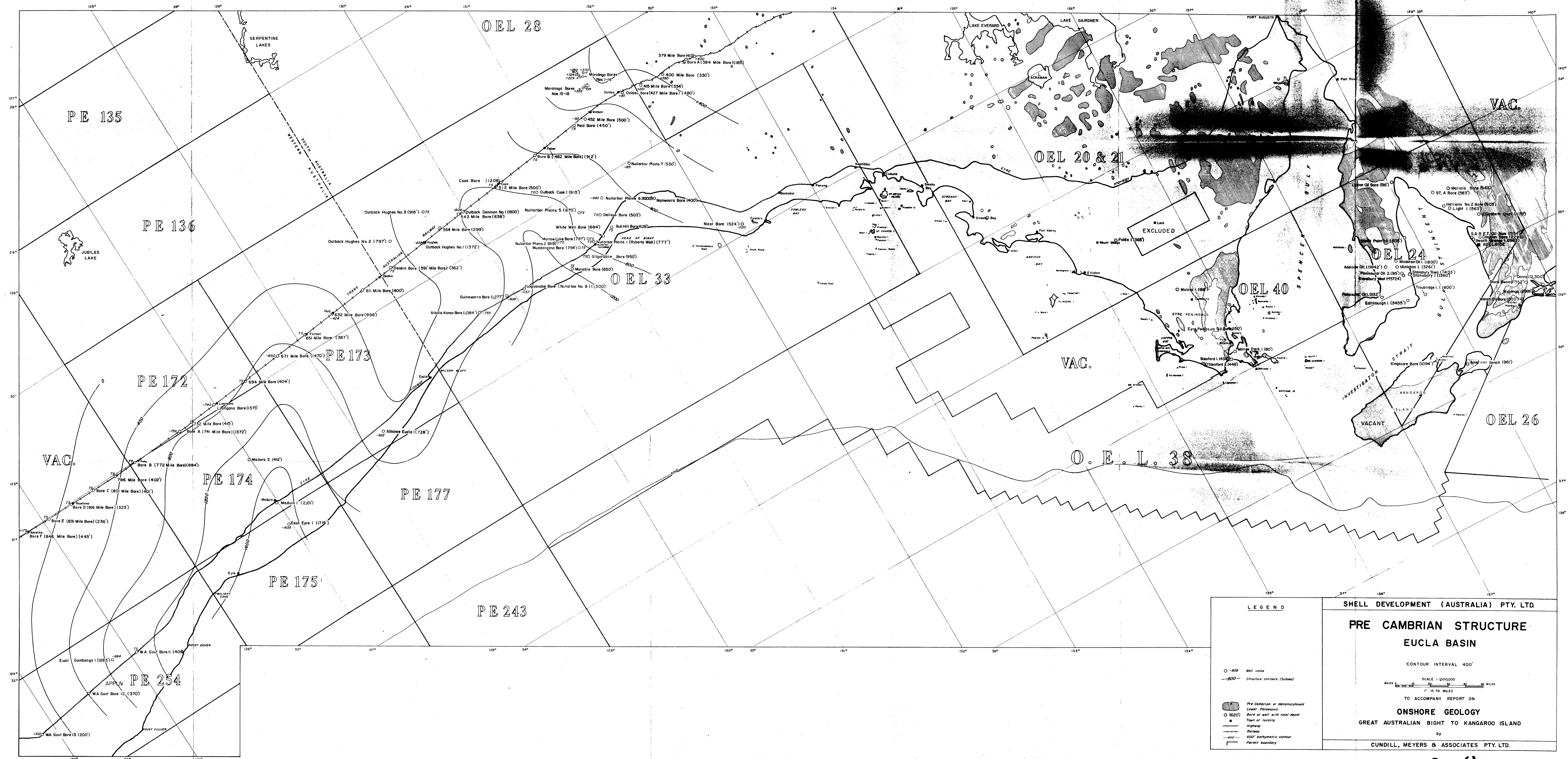
Qn 2 (f) 1

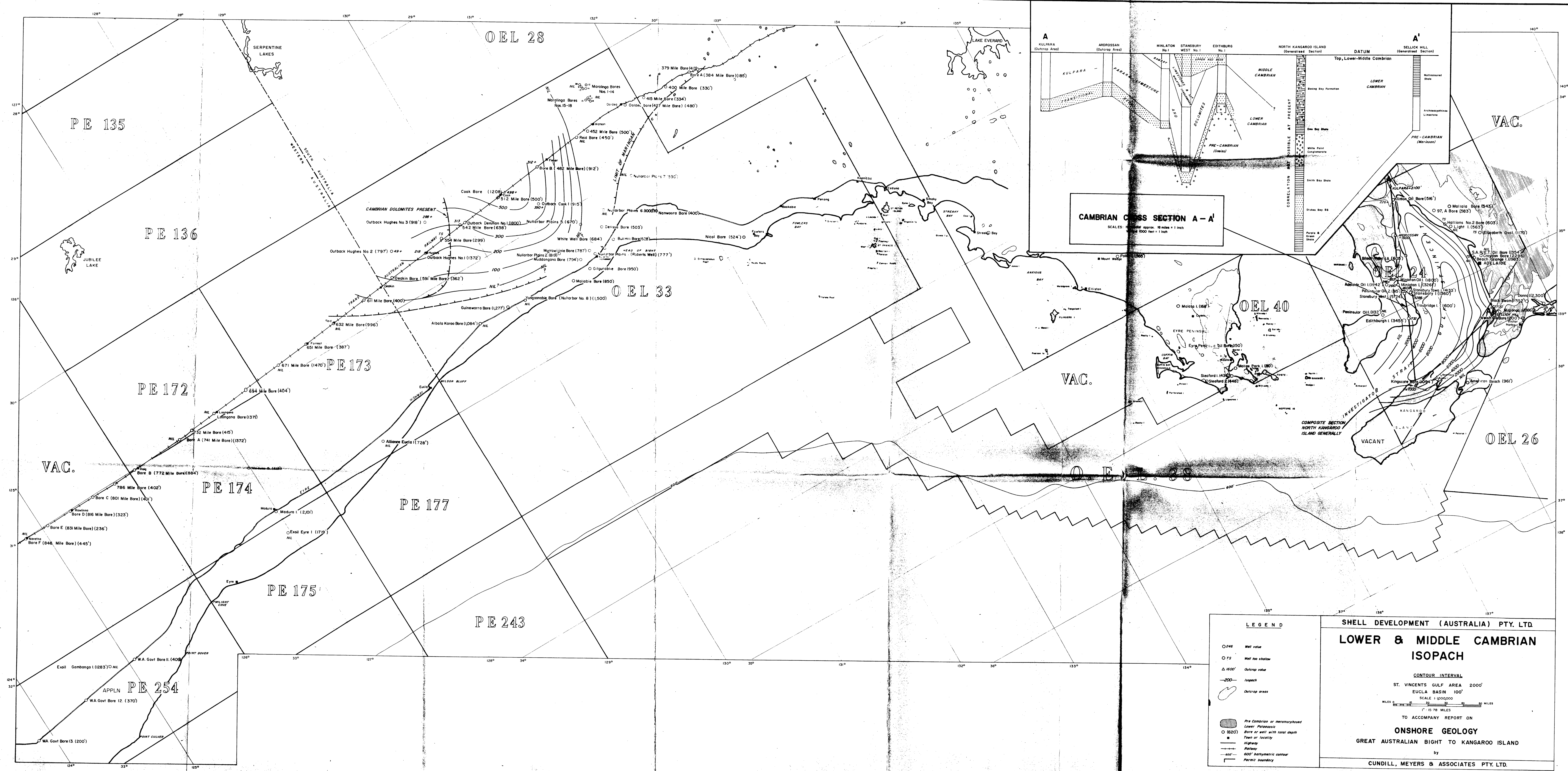
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WELL & WATER BORE INFORMATION
SHEET 2
(EASTERN EUCLA BASIN)
CUNDILL MEYERS & ASSOCIATES PTY. LTD.

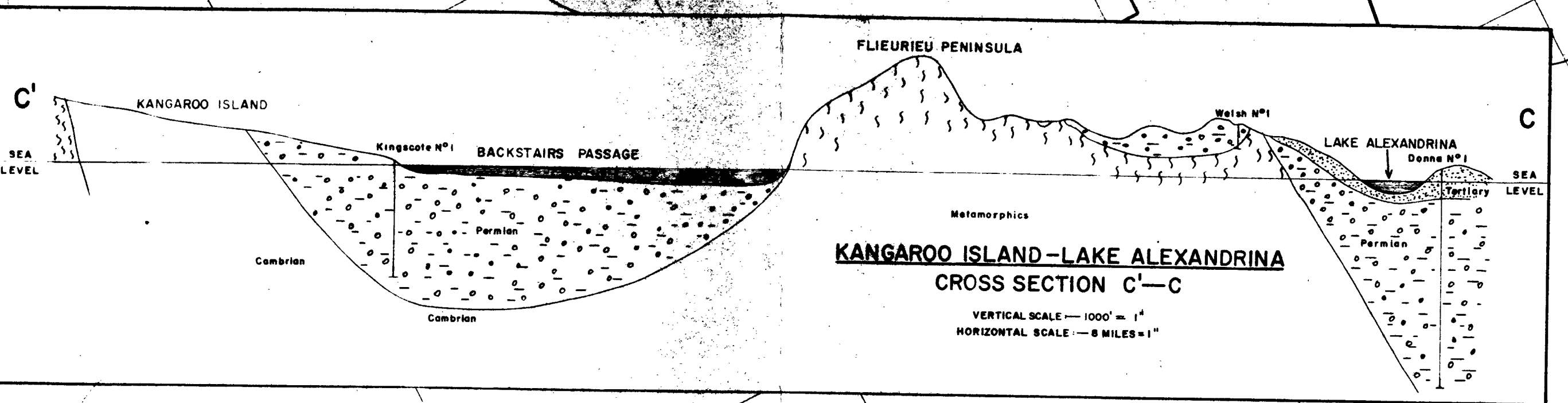
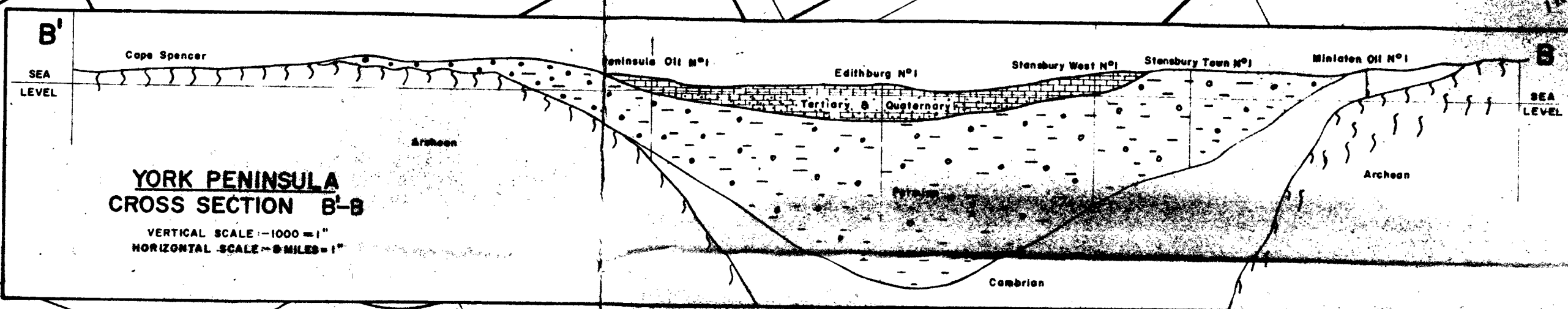
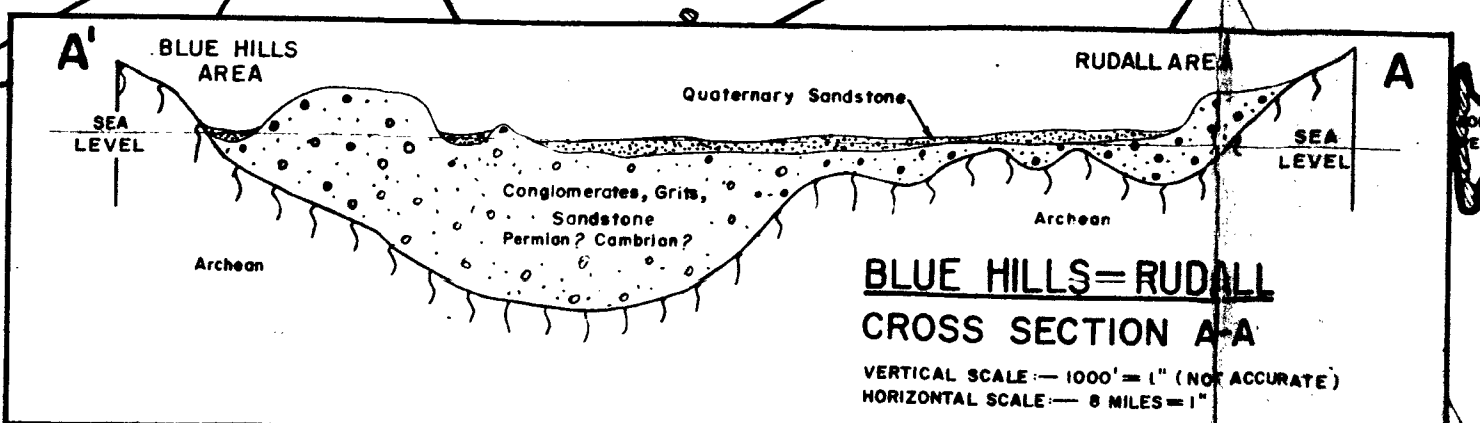
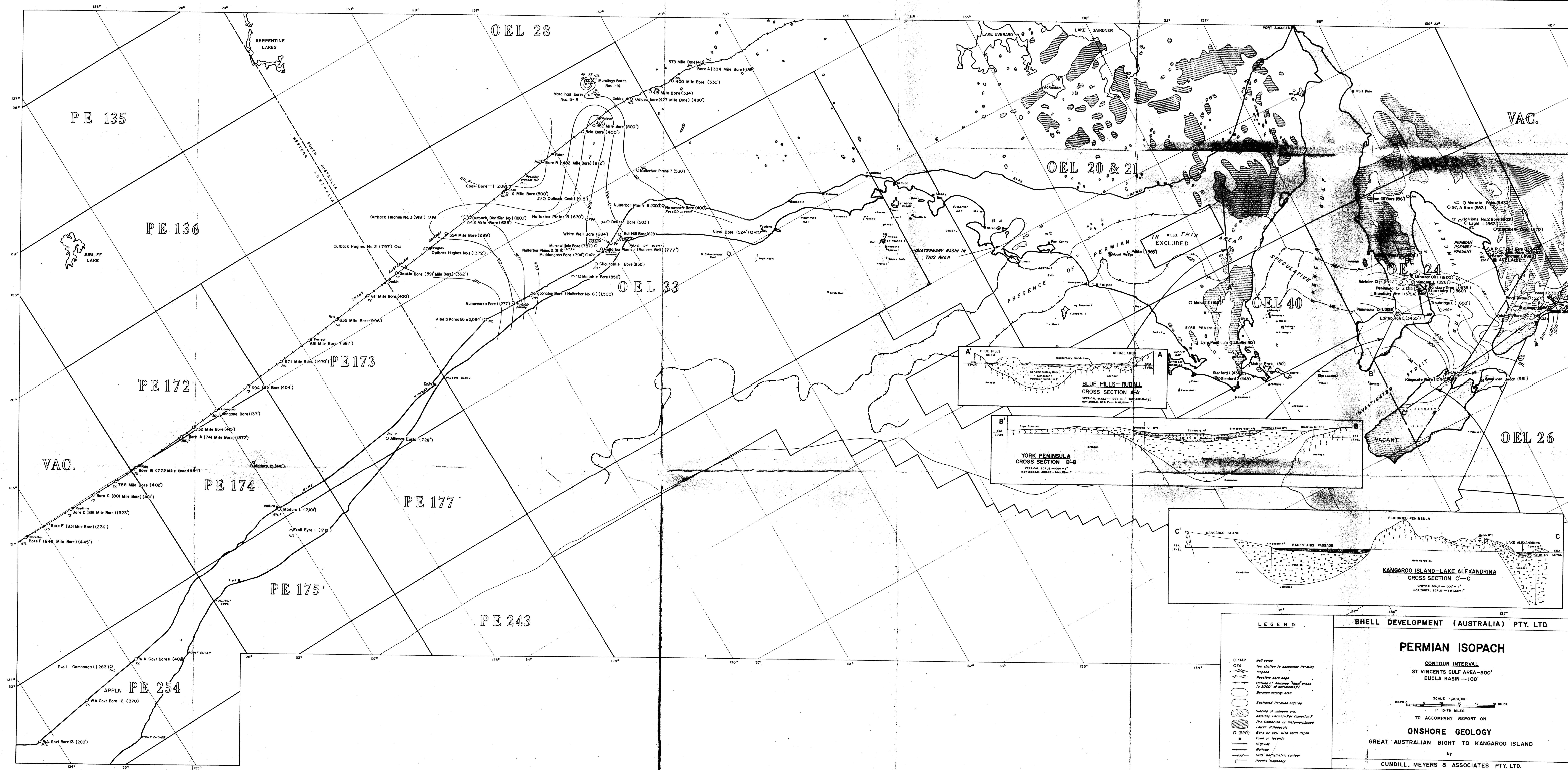
WELL NAME		32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	
OPERATOR		DENMAN N°1	MALLABIE BORE	GILGURABIE BORE	NULLARBOR PLAINS N°2	MURRUMBIDGE BORE	MURRUMBIDGE BORE (CAME SHAF? + BORE)	NULLARBOR PLAINS 2 (ROBERTS WELL)	WHITE WELL BORE	NULLARBOR PLAINS N°3	OUTBACK OIL CO. N°1	512 MILE BORE	COOK BORE	BORE 8 (482 MILE BORE)	BULLS HILL BORE	DELISSA BORE	NULLARBOR PLAINS 6	NULLARBOR PLAINS 7	Red N°4 Bore	452 MILE BORE	MARALINGA BORE 15	MARALINGA BORE 13	MARALINGA BORE 12	MARALINGA BORE 8	MARALINGA BORE 5	GOOLWA BORE (427 MI BORE)	415 MILE BORE	400 MILE BORE	BORE 4 (364 MI BORE)	379 MILE BORE	NANWOOD BORE	IRCOL BORE	
T. D.		1800'	850'	850'	818'	794'	787'	777'	684'	670'	916'	500'	1208'	92'	628'	503'	1000'	530'	450'	500'	402'	300'	903'	800'	600'	480'	334'	330'	185'	415'	400'	524'	
LOCATION		30° 59' 10" 129° 58' 43"	4 Miles SW of Mallabie Tanks			9 Miles NW of Nullarbor Station		27 Miles NW of head of light			30° 50' 30" 130° 41' 00"	512 Mile peg C'wealth Rlys	Cook Rly Stn	482 Mile peg C'wealth Rlys	7 Miles ENE of White Well				Red Rly Stn	452 Mile peg C'wealth Rlys						427 Mile peg C'wealth Rlys	415 Mile peg C'wealth Rlys	400 Mile peg C'wealth Rlys	364 Mile peg C'wealth Rlys	379 Mile peg C'wealth Rlys	36 Miles East of White Well	31° 55' 152° 14'	
DATE		1966	1920	1915		1925	1915		?	1893	1966	1914-15?	?	1914-15?	?			?									1914-15?	1914-15?	1914-15?	1914-15?	1914-15?	Nil	Nil
LOGS RUN		?	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	?	Nil	Nil	Nil	Nil	?	1954	1954	1954	1954	1954	1954	1914-15?	1914-15?	1914-15?	1914-15?	Nil	Nil	
K. B.		461	200'	7200'	300'	210'	234'	200'	7197	300'	330'	400'	400'	400'	?	1910	?	2.50	170'	36.5'	470'	812'	814'	915'	570'	585'	445'	560'	570'	?	400'	?	
MAIN SOURCES OF INFORMATION (SEE TEXT FOR NUMBER CODE)		20, 34A	35A, 30, 37	30,	30, 24, 37	30, 34, 37	35A, 18	35A, 30, 24, 37	35A, 37	35A, 30, 24, 37	31A,	35A	24, 12, 37	30, 37	1, 31A	46, 15, 31A	2, 12, 33, 35A, 37	2, 35A, 37	31A	15, 37		15	15	15	15	87	87	87	37	31A	11	31A	
FORMATIONS/UNITS																																	
SUBSEA THICKNESS																																	
RECENT/QUATERNARY																																	
PLIOCENE																																	
</																																	

SHELL DEVELOPMENT (AUST.) PTY. LTD.
WELL & WATER BORE INFORMATION SHEET 3 (EYRE PENINSULA & ST. VINCENT'S BASIN)
CUNDILL MEYERS & ASSOCIATES PTY. LTD.

[illegible]







- LEGEND**
- 1259 Well value
 - 1500 Too shallow to encounter Permian
 - 1500 Possible zero edge
 - 1500 Outline of assumed 'thick' areas (> 2000' of sediments?)
 - 1500 Permian outcrop area
 - 1500 Scattered Permian outcrop
 - 1500 Outcrop of unknown age, possibly Permian/Pre-Cambrian?
 - 1500 Pre-Cambrian or metamorphosed
 - 1500 Lower Palaeozoic
 - 1500 Bore or well with total depth
 - 1500 Town or locality
 - 1500 Highway
 - 1500 Railway
 - 1500 600' bathymetric contour
 - 1500 Permian boundary

SHELL DEVELOPMENT (AUSTRALIA) PTY. LTD.

PERMANIAN ISOPACH

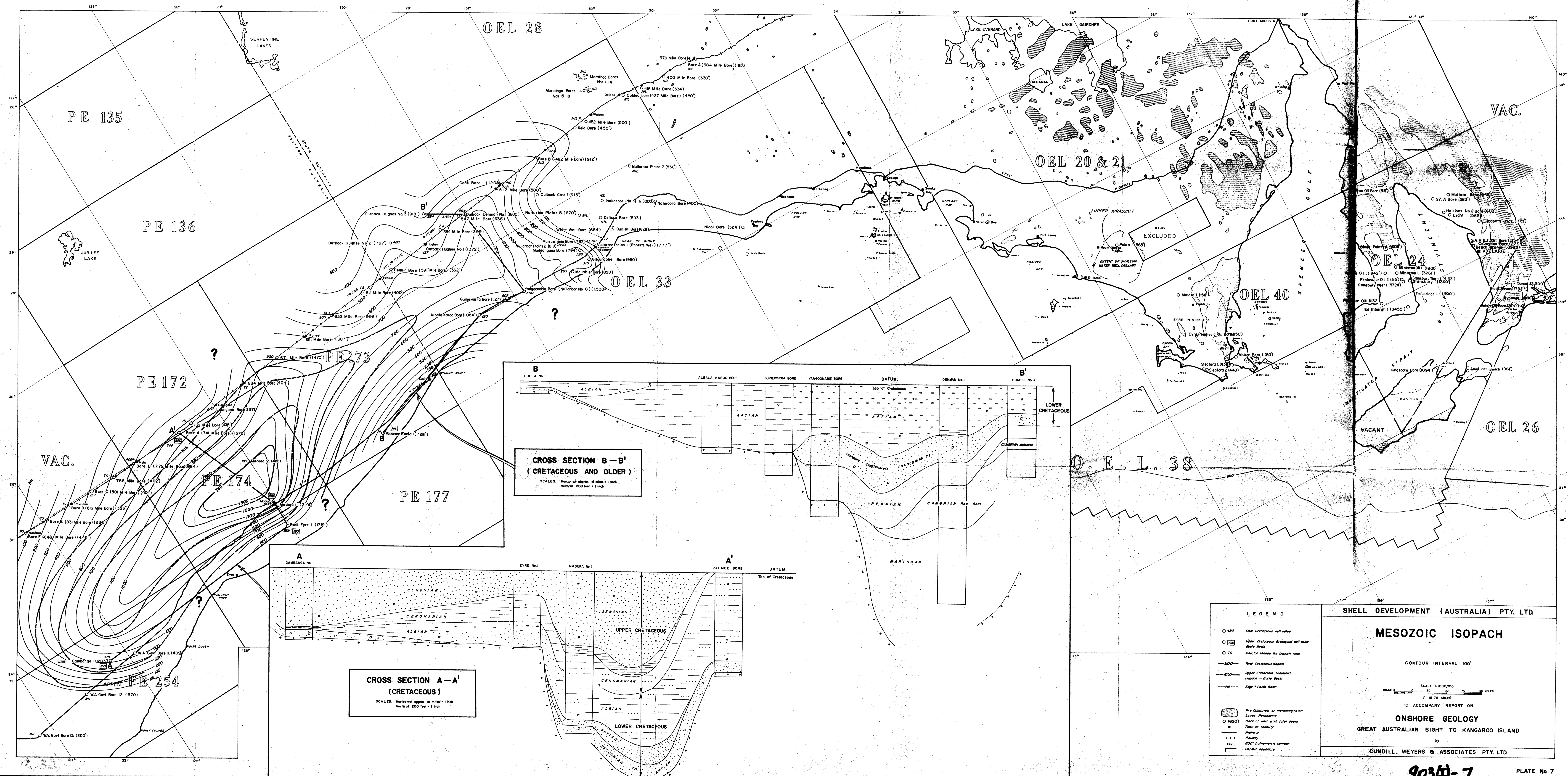
CONTOUR INTERVAL
ST. VINCENT'S GULF AREA—500'
EUCLA BASIN—100'

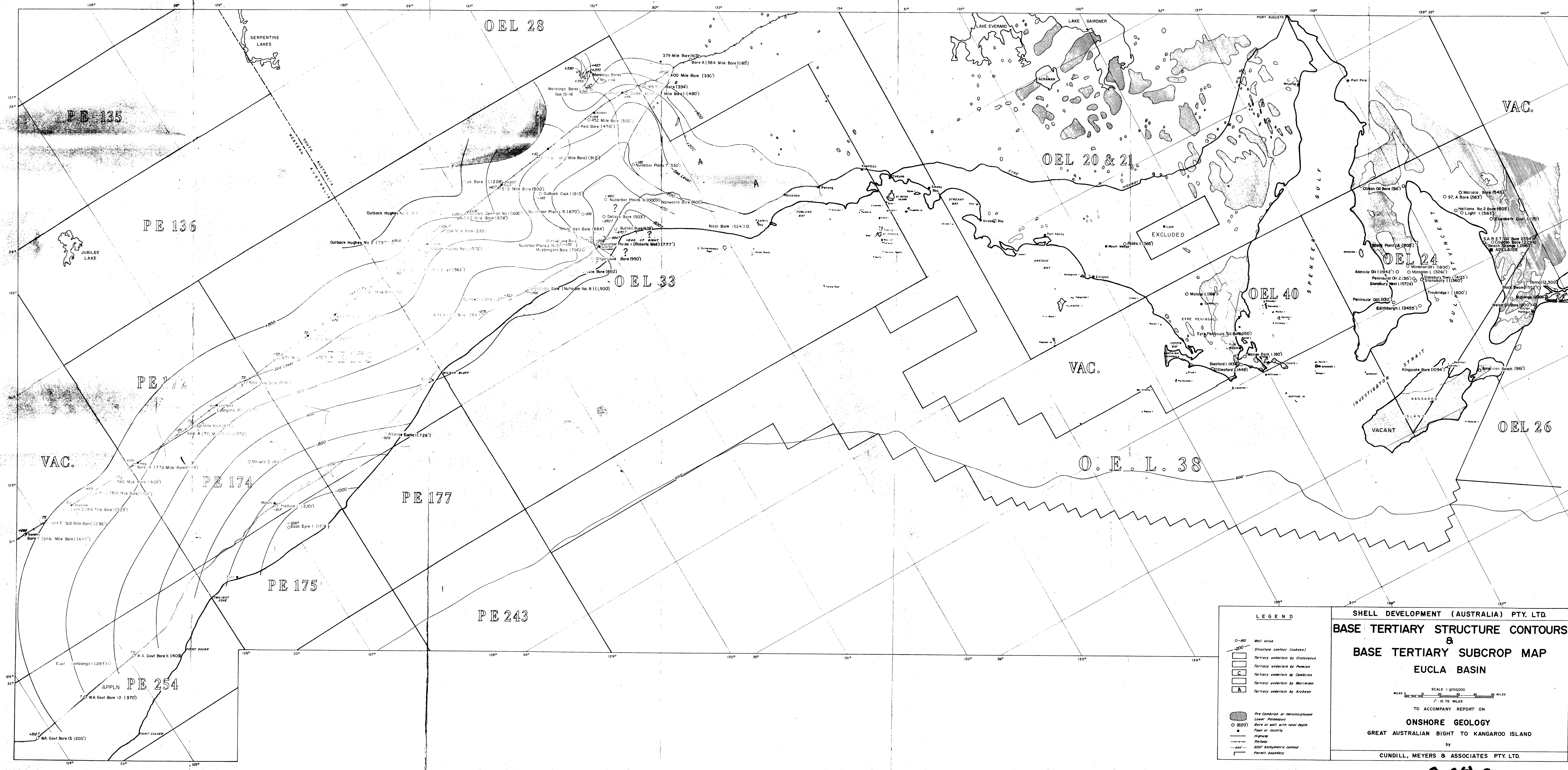
SCALE 1:100,000
1" = 10 MILES

TO ACCOMPANY REPORT ON

ONSHORE GEOLOGY
GREAT AUSTRALIAN BIGHT TO KANGAROO ISLAND

by
CUNDILL, MEYERS & ASSOCIATES PTY. LTD.





LEGEND

- O-185 Well value
- 200 Structure contour (subsea)
- Tertiary underlain by Cretaceous
- Tertiary underlain by Permian
- Tertiary underlain by Cambrian
- Tertiary underlain by Morrimoon
- Tertiary underlain by Archean
- Pre Cambrian or metamorphosed
- Lower Palaeozoic
- Bore or well with total depth
- Town or locality
- Highway
- 400' bathymetric contour
- Permit boundary

SHELL DEVELOPMENT (AUSTRALIA) PTY. LTD.

BASE TERTIARY STRUCTURE CONTOURS

BASE TERTIARY SUBCROP MAP

EUCLA BASIN

SCALE 1:100,000

TO ACCOMPANY REPORT ON

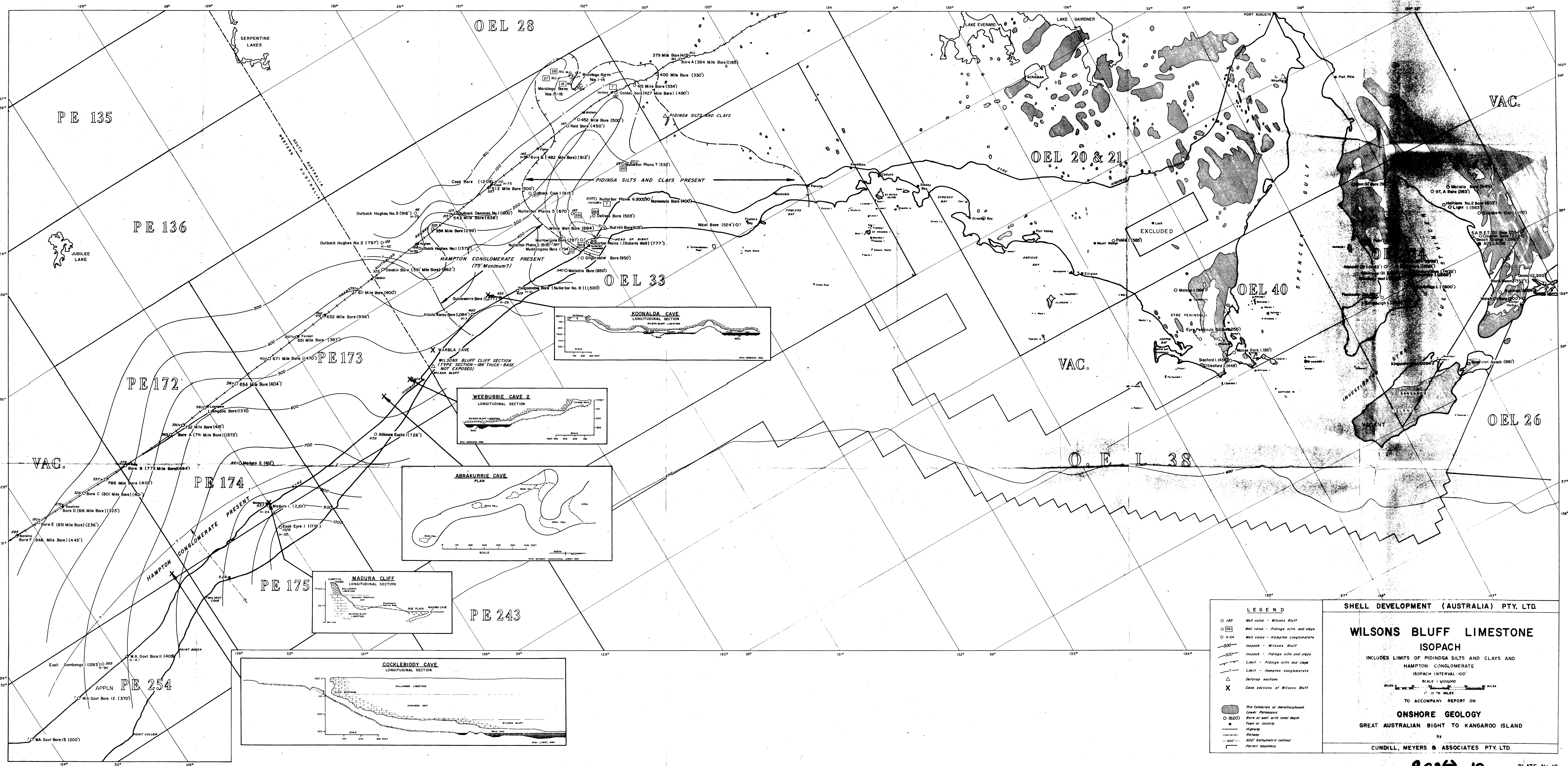
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LEGEND

- 185 Well value - Wilsons Bluff
- 261 Well value - Pidinga silts and clays
- H-24 Well value - Hampton conglomerate
- 300 Isopach - Wilsons Bluff
- 300 Isopach - Pidinga silts and clays
- 300 Isopach - Hampton conglomerate
- 300 Limit - Pidinga silts and clays
- 300 Limit - Hampton conglomerate
- △ Outcrop sections
- X Cave sections of Wilsons Bluff
- Pre Cambrian or metamorphosed
- Lower Palaeozoic
- (620) Bore or well with total depth
- Town or locality
- Highway
- Railway
- 600' bathymetric contour
- Permit boundary

SHELL DEVELOPMENT (AUSTRALIA) PTY. LTD.

WILSONS BLUFF LIMESTONE ISOPACH

INCLUDES LIMITS OF PIDINGA SILTS AND CLAYS AND HAMPTON CONGLOMERATE ISOPACH INTERVAL 100'

SCALE 1:500,000

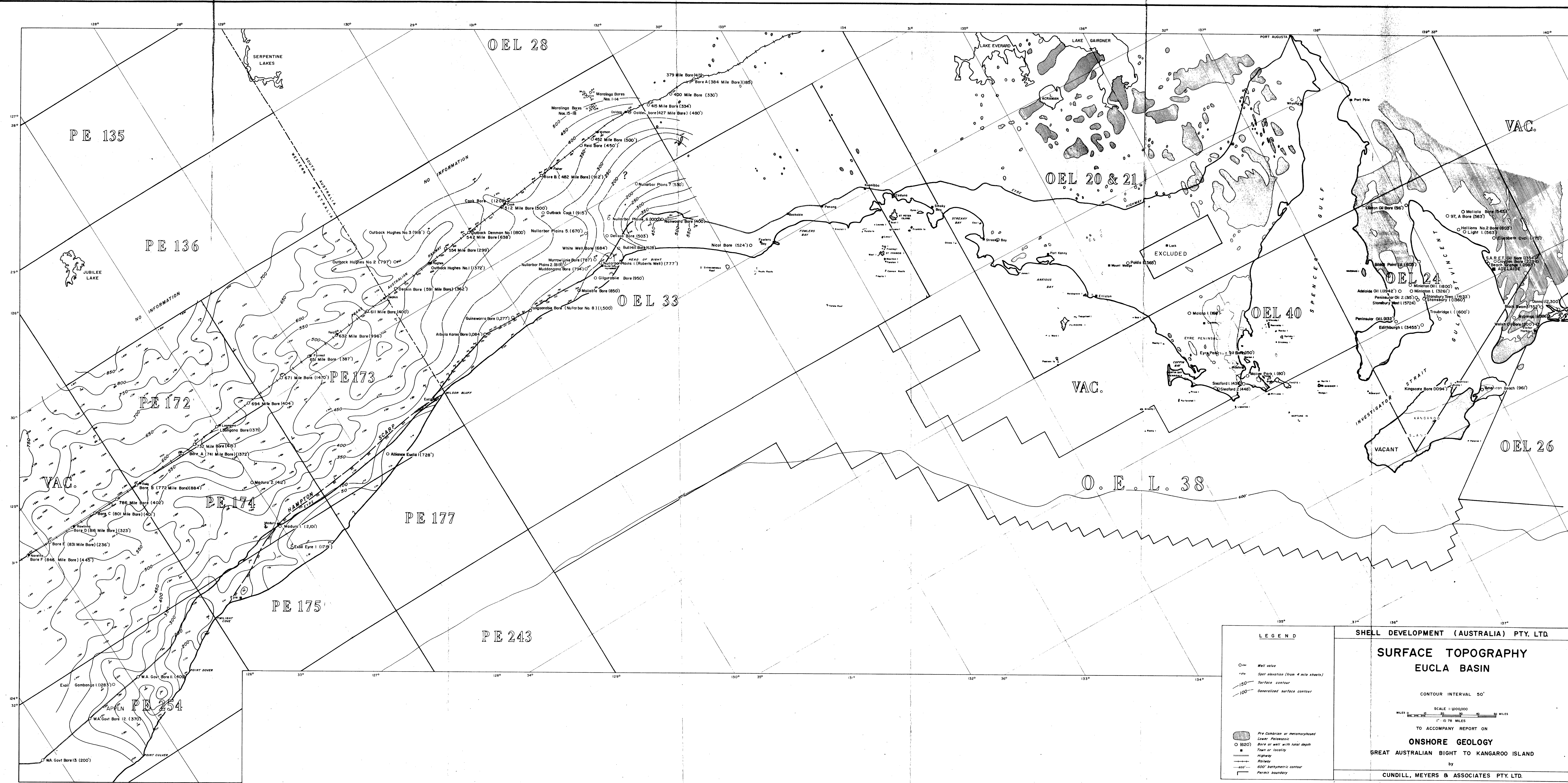
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LEGEND

- Well value
- Spot elevation (from 4 mile sheets)
- Surface contour
- Generalized surface contour
- Pre Cambrian or metamorphosed
- Lower Palaeozoic
- Bore or well with total depth
- Town or locality
- Highway
- Railway
- 600' bathymetric contour
- Permit boundary

SHELL DEVELOPMENT (AUSTRALIA) PTY. LTD.

SURFACE TOPOGRAPHY
EUCLA BASIN

CONTOUR INTERVAL 50'

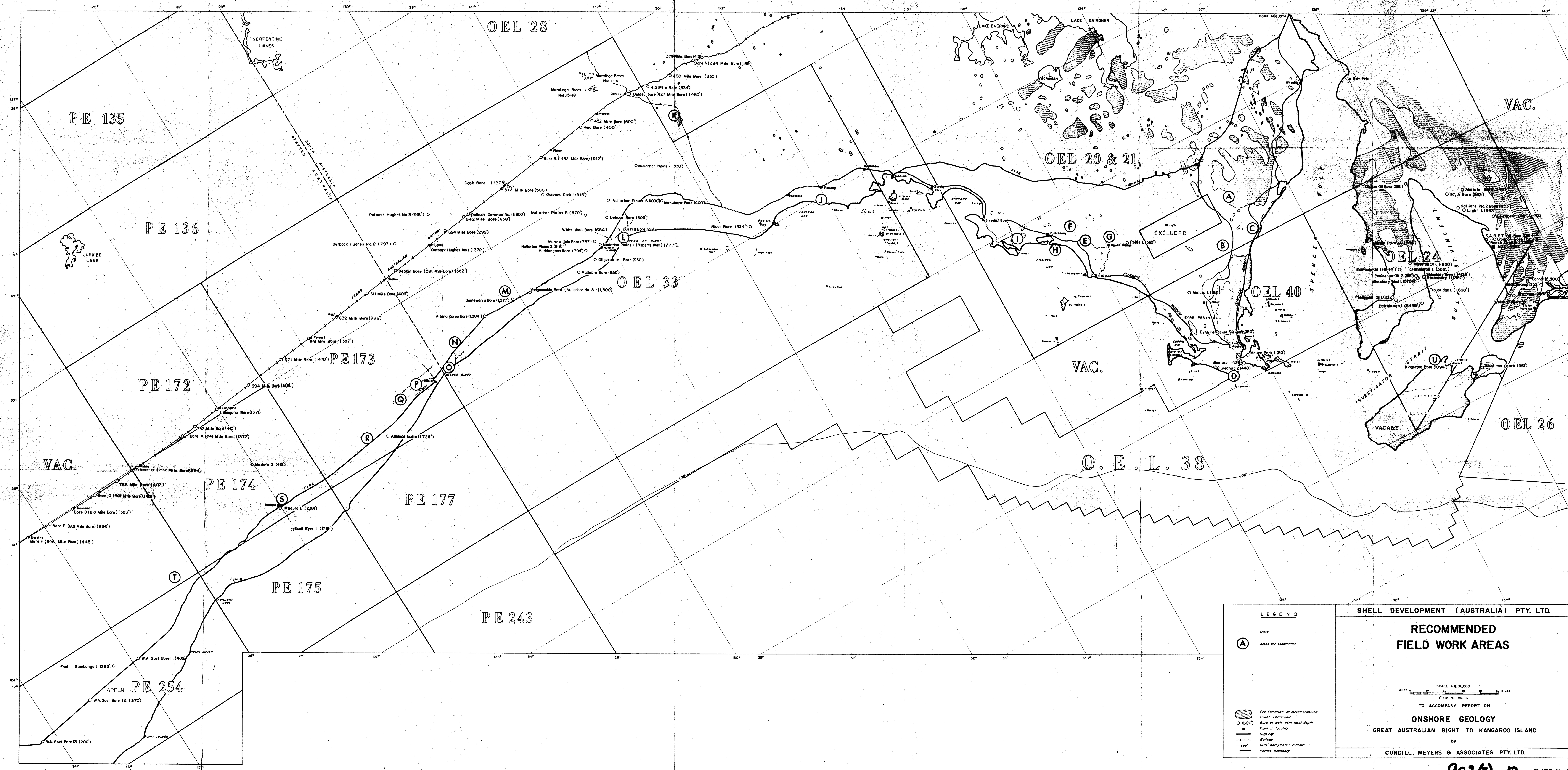
SCALE 1:100,000
1" = 15.78 MILES

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LEGEND

Track

Area for examination

Pre Cambrian or metamorphosed

Lower Palaeozoic

Bore or well with total depth

Town or locality

Highway

600' bathymetric contour

Permit boundary

SHELL DEVELOPMENT (AUSTRALIA) PTY. LTD.

**RECOMMENDED
FIELD WORK AREAS**

SCALE 1:100,000

1" = 15.78 MILES

TO ACCOMPANY REPORT ON

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