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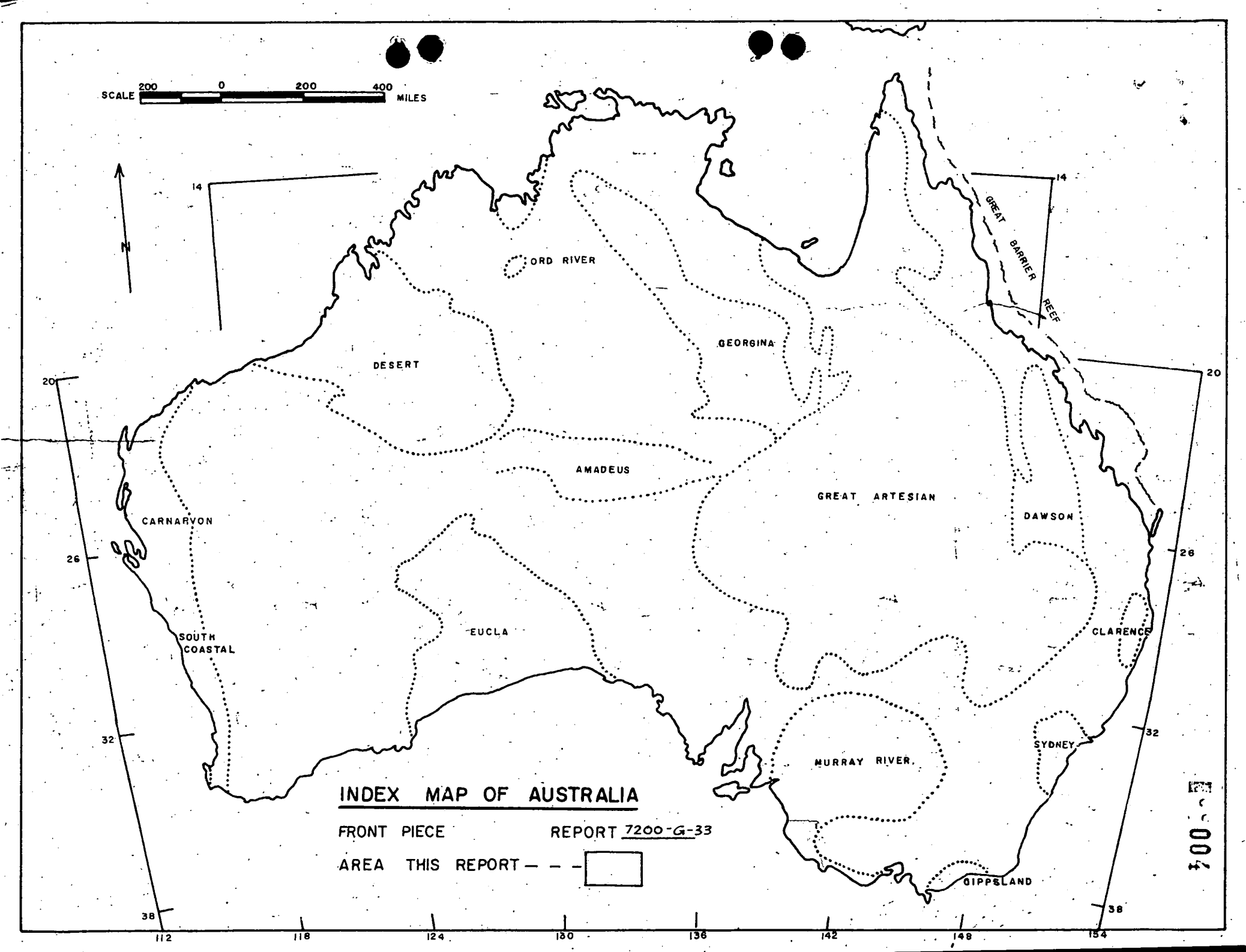
GEOLOGY OF SOUTHEAST SOUTH AUSTRALIA

by

Louis H. Dixon

Frome-Broken Hill Co. Pty. Ltd.
Melbourne.

December, 1956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GEOLOGY OF SOUTHEAST SOUTH AUSTRALIA

by

LOUIS H. DIXON

INTRODUCTION

Location

The Counties of Grey and Robe and the southern part of County MacDonnell comprise the map area and are part of an area that is locally referred to as Southeast South Australia. The town of Kingston is situated in the northwest corner of the area; Naracoorte is at the northeast margin and Mt. Gambier is located in the southern part. Adelaide, the capital of South Australia, is 289 miles by road west of Mt. Gambier. All of the area is contained within the International Map Grid J 54, Zone 6.

A bitumen highway connects Mt. Gambier with Melbourne. Also, bitumen highways extend from Mt. Gambier to Adelaide via Naracoorte and Robe.

Mt. Gambier and Naracoorte have rail connection with Melbourne and Adelaide and with spur tracks to Kingston and Beachport on the west coast.

Objective

To make a reconnaissance geological survey of Oil Exploration Licence No. 9, comprising approximately 4,600 square miles.

In the Mt. Gambier area field observations were plotted on aerial photographs and later compiled as an overlay to "(Geological Map) Mt. Gambier and Northumberland" of The Geological Survey of South Australia, scale 1 mile to one inch, see Plate 2A. Outside of this area, field observations were plotted on land maps, scale 1 inch to two miles, that were later reduced to 1 inch to four miles, see Plate 1. Cross-sections were compiled on the basis of field observations, bore logs, gravity and magnetic data, see Plate 3. Observations that were made from a moving launch on a traverse up the Glenelg River from Nelson were plotted on photo maps and later reduced and included as an insert on Plate 1.

Simultaneously with the above reconnaissance studies, a detailed geological study with the alidade and planetable was started by geologist, Jarvis Hugh O'Mara, of an area of about sixty square miles west of Mt. Schank in the Mt. Gambier area. This detailed study is in progress at present.

For this report, work was done in the field from February 20, 1956 to March 29, 1956.

Previous Investigations

Geological - Sprigg's (18) excellent publication on the geology of Southeast Province of South Australia includes a bibliography of other publications in this area. A more recent publication by Sprigg and Boutakoff (19) gives a "Summary Report on the Petroleum Possibilities of the Gambier Sunklands". Geological maps of this and adjacent parts of South Australia have been published by Sprigg et al of the South Australian Geological Survey, Department of Mines, Adelaide, (17). Ludbrook (12) of this same Department in 1955 made a report on "A Brief

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Summary of Tertiary Correlation in South Australia".

Our Company files have a number of reports by geologists of Frome-Broken Hill Co. Pty. Ltd. and its affiliates of the area of southeast South Australia and adjacent southwest Victoria. Osborne in 1932 (13) made recommendations concerning the holdings of the Western Petroleum Company. Gray and Croll (10) in 1938 made a thorough "Review of Oil Prospects of Victoria and South Australia". Reeves and Evans (14) in 1949 reported on the results of two weeks' exploratory work in the coastal belt of southwestern Victoria and southeastern South Australia. Evans (6) in May 1954 reported on the "Tertiary Structure of Mt. Gambier-Portland Area". Evans, Lyman Reed and Lehner (8) in March 1954 reported on the results of one week's "Reconnaissance of Mt. Gambier Sunklands - South Australia and Southern Victoria". Evans and Dixon (7) spent a week in May 1955 on a "Reconnaissance Trip from Melbourne to Adelaide".

The above publications and other recent ones are listed in the enclosed bibliography.

Geophysical - Boutakoff (2) and Evans (5) in 1949 reported on the results of an aeromagnetic survey of southwest Victoria and southeast South Australia that was flown by the Zinc Corporation. In 1953 Wiebenga (21) reported on "A Gravity and Magnetic Reconnaissance Survey of the South-Western Portion of Victoria" that was made by the Bureau of Mineral Resources, Geology and Geophysics in the Mt. Gambier-Portland area. Richards (15) in February 1956 completed a report on "A Correlation of B.M.R. and South Australian Mines Department Gravity Reconnaissance Surveys in Mt. Gambier - S.W. Victoria Area", Frome Report 7200, P.4.

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TABLE OF GEOLOGICAL FORMATIONS

	Estimated maximum thickness, feet
Plio-Quaternary ----------	250
Some alluvium, marine sand bars, beach and other near-shore deposits and interbedded dunes; abundant pelecypods, gastropods and algal deposits. Local interbeds of volcanic ejectamenta and basalt. Uplifted, faulted and in places slightly folded.	
Unconformity	
Gambier limestone, Miocene-Eocene?----------	800
Limestone, dolomite, bryozoal and polyzoal limestone, marl; some chert horizons. Marine.	
Unconformity	
Knight Group, Eocene-Paleocene to Cretaceous?----------	6400
Intermixed gravel, sandstone, claystone; carbonaceous. Lacustrine, estuarine - to marine.	
Unconformity	
Mesozoic, Merino Group----------	Unknown over 3000
Continental sandstone, siltstone and claystone; carbonaceous, greenish-gray.	
Unconformity	
Late Paleozoic----------	Unknown
Carboniferous glacial sediments and Devonian - Carboniferous marine sediments are known in adjacent areas, and may occur in parts sub-surface in this map area.	
Unconformity	
Early Paleozoic and Pre-Cambrian, undifferentiated -------	Unknown
Sandstone, quartzite, limestone, slate and associated igneous rocks; reported in shallow bores.	

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IGNEOUS ROCKS

Sprigg (18) reports that acid igneous rocks crop out as small inliers and occur in shallow bores on the "Padthaway horst" northeast of Kingston beyond this map area. Granite and gneiss are also reported by Stinear (16) to crop out east of this map area in and near the Glenelg River near Dergholm, Victoria. All of these occurrences are thought to be early Paleozoic in age.

A series of volcanic rocks crop out in a northwest-southeast trend through the Mt. Gambier area. Volcanic plugs, vents, explosion craters, small dykes and basalt flows are represented. In this area volcanism probably started in the Late Pliocene and continued intermittently into the Quaternary, as indicated by volcanic ejectamenta being interbedded with widespread young shallow water near-shore marine deposits and beach dunes and by near-perfect preservation of the most recent vents.

Probably during and since the close of volcanism, this area at several stages was gently uplifted and faulted. Locally the incompetent tuffaceous deposits in the area of Mt. Gambier show gentle folds, small thrust faults, drag folds, crumpling and crushing. At Mt. Schank folding in the tuffaceous beds is associated with late-stage small dykes and vents.

This volcanic activity appears to be controlled by and to extend along a series of en echelon faults that probably originate from deep seated movements in the basement. No evidence was detected that Tertiary beds were domed or arched by the igneous activity.

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STRATIGRAPHY

Paleozoic

No Upper Paleozoic rocks are known to crop out or to have been penetrated by the drill in the map area, but some of those that occur in adjacent areas may be present subsurface. Sprigg (18) reports that glacial sediments, now considered to be upper Carboniferous age, have been intersected on the "Padthaway horst" in the Alfred Flat bores (Coorong) from 510 feet down to bedrock at 924 feet. He predicts that similar conditions extend at least to Kingston. Stinear (ibid) states that no coal measures nor any marine deposits have been found at any place associated with these glacial sediments. Sprigg and Boutakoff (ibid) also report that infaulted morainic and glacigene accumulations occur near Coleraine, Victoria, to the east of the map area. Similar glacial deposits overlie marine Upper Devonian-Lower Carboniferous sediments in the nearby Grampian Mountains of Victoria. In this same general area of Victoria, Stinear (ibid) reports that acutely folded indurated slates and sandstones of Ordovician age crop out along the Glenelg River near Dergholm.

Bores on the Padthaway structurally high area just north of the map area penetrated at shallow depths sandstone, quartzite, limestone and slate of undifferentiated Paleozoic-Precambrian age, see Plate 3, Figures 3 and 4, Diagrammatical Cross-Sections.

Mesozoic

No Mesozoic sediments are known to crop out in the map area, but sediments of this age were identified on the basis of lithology in the Waterhouse 714 bore near Robe from 1,475 feet to the bottom of the hole at 4,504 feet and from bores near Comaum on the basis of pollen. East of the map area lacustrine mudstone and arkose of the Mesozoic Merino Group crop

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out in the headwaters of the Glenelg River in the Casterton-Coleraine area of Victoria. At Bacchus Marsh and Campbelltown, Victoria, small outcrops of Triassic sediments with plant remains are reported. Merino Group sediments that crop out in the Cape Otway area of Victoria have an estimated thickness of about 5,000 feet, Sprigg (ibid).

As the divisions in the Mesozoic sediments are yet in places indefinite, in some areas the age designation of "Jurassic" is loosely applied. However, Kenley (11) has divided the Merino Group near Casterton at the type section into the Lower Cretaceous Runnymeade formation and an underlying Upper Jurassic (?) Mocamboro member, separated by a disconformity. These sediments should continue in the subsurface into the map area and appear to be present in the Comaum bores, Nelson Bores, and probably in the Robe bore.

From an analysis of the reports of Glaessner (9) and Crokson (3) the section that was penetrated in the Comaum 244 HD coal bore appears to be as follows:-

Comaum 244 HD Coal Bore

Gambier limestone ---------- 0-360 feet

0-343 feet: Limestone, marly limestone, sandy limestone.
353-360: Sandy limestone with limonite pebbles.

Unconformity

Knight Group----------360-391

Unfossiliferous pebbly sandstone with coal.

Unconformity

Runnymeade formation ----------391-620

505 feet: gray clay.
567 feet: feldspathic sandstone.
619 feet and six inches - 620': pollen angiosperms occur

Lower Cretaceous or Jurassic ---------- 650-1122 (TD)

650-708 feet: High micro spore count, but no angiosperms.

Baker and Cookson (1) on the basis of pollen analysis report the presence of Upper Cretaceous fossils in the Nelson bore, Victoria, between 5782-6192 feet in marine beds. Crespin (4) however, tentatively assigns the beds in the Nelson bore below 5304 feet to the ? Paleocene.

From these occurrences it may be inferred that during the Mesozoic there were widespread lacustrine and estuarine basins of deposition in South Australia and Victoria and that a marine basin of deposition existed in Southwest Victoria and in the southeastern tip of South Australia from the Mesozoic into the Eocene.

Tertiary

Knight Group - Gravel, sandstone, siltstone and claystone comprise the Knight Group. In the limited exposures of its few outcrops in the map area these sediments are characterized by maroon, purple, grey and yellowish-brown colours. Bore logs report green, grey, brown, black and red colours and the presence of disseminated carbonaceous matter and some coal beds. In the bores relatively few marine fossils are reported, except the foraminifera Cyclammina in the Nelson bore, but the bore logs do report sharks' teeth and corals in the Robe bore between 635-645 feet; sharks' teeth in a red sandstone at 460 feet and corals at 573 feet in the Hindmarsh 195 bore near Tantanoola; lignitic sands and clays, carrying at intervals marine intercalations with fossils in the "Knight's Dome" bore No. 2; dark-grey lignitic and fossiliferous sandy clay in the Springs bore of Blanche 150; sharks' teeth and corals at 381 feet and fine carbonaceous sandstone with a molluscan and foraminifera fauna at 2,095 feet in the Associated Oil Corp. Blanche 301 bore.

In the Nelson bore a marine to brackish environment appears to have extended from the Mesozoic through the deposition of the Tertiary Knight Group and overlying Gambier limestone. In this bore the marine fossil Cyclammina occurs to depth of 5304 feet and glauconite occurs to depth of 6485 feet. Baker and Cookson (ibid) note that in this bore beneath the Gambier limestone there occurs a coarse glauconitic sandstone at 816-990 feet; Lower Eocene flora at 992-3650 feet: Lower Eocene and Paleocene affinities in the flora at 3650-4025 feet; 4225 feet Lower Eocene to Paleocene flora and from 5782-6192 feet Upper Cretaceous flora.

The 174 feet of glauconitic sandstone beneath the Gambier limestone in this bore is referred to as the Nelson sandstone by Sprigg and Boutakoff (ibid) but in South Australia the Nelson sandstone is not recognized.

Knight Group sediments have previously been reported on the surface only at the single small isolated outcrop along the fault about 6 miles northwest of Mt. Gambier. The writer tentatively includes two other exposures based on lithology at: the up-side of the MacIntyre fault and a small area on the up-side of the Bluff fault, see Plate 1. The three other small areas of Knight Group sediments that are indicated on Plate 1 are based on bore data, as the surface is covered by Quaternary sediments.

A source area for the sediments of the Knight Group probably existed to the north of the map area, where it pinches out over a basement high of rocks of undifferentiated Paleozoic and Pre-Cambrian age on the Padthaway horst. On the flanks of this and adjacent high areas various thicknesses of Knight Group sediments accumulated, see Plate 3.

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Diagrammatical Cross-Sections - On the west at the Robe bore 965 feet thickness is reported and only about 31 feet thickness appears to be present in the Comaum coal bore. Further to the east it is absent near Casterton, Victoria in the area that Sprigg (ibid) refers to as the Dundas Peninsula. To the southeast the thickness increases appreciably to over 6300 feet in the Nelson bore. In South Australia unconformities occur at the top and base of the Knight Group.

Gambier limestone - Limestone, bryozoal and polyzoal limestone, dolomite, marl and some chert comprise the Gambier limestone and reach a maximum thickness of about 800 feet in the southwest corner of the map area. In this area this formation is thickening to the southeast and reaches a thickness of more than 2265 feet drill depth in the Portland, Victoria area. Its occurrence is widespread in southeast South Australia, although a veneer of Plio-Quaternary sediments mask it over widespread areas. Where it is exposed sink holes and solution cavities are characteristic features. Marine fossils are abundant at many horizons.

In the north part of the map area only a thin veneer of Gambier limestone transgresses across and lies unconformably on basement rocks of the Padthaway horst. East of the map area in the Glenelg River cliff section this limestone overlaps and unconformably overlies Merino Group and older rocks near Casterton, Victoria, Sprigg (ibid). Also an unconformity was noted at the base of the limestone in the Mt. Gambier area at its contact with the underlying Knight Group and an unconformity also occurs at the top of the Gambier limestone, where it is in places overlain by Plio-Quaternary sediments.

The youngest beds of the Gambier limestone may be Miocene in age, but Crespin (ibid) reports that limestone beds in the Nelson bore

are Eocene in age. Late Miocene beds containing an exceedingly rich and varied marine fauna at Muddy Creek, near Hamilton, the only known locality of western Victoria, are unknown in southeast South Australia. (Sprigg and Boutakoff (ibid)).

Plio-Quaternary

Near-shore marine and beach deposits mask a large part of the map area and in places comprise several hundred feet thickness. Marine fossils are present, including abundant diminutive and well-developed gastropeds and pelecypods and algal biostromes. In places marine fossils occur in lenses of rounded cobble of quartz and chert from the Gambier limestone and locally volcanic ejectamenta is included. Current-bedding is common, some of which appears to be aeolian.

Characteristically these sediments occur as elongated narrow ridges that are in places separated by sheet deposits, which represent beach, sand bar and other near shore shallow water marine deposits that were deposited at successive stages of gentle coastal uplift. Some represent coastal sand dunes that lined the old beaches, similar to those along the present coast, and others appear to represent old sand bars and spits. In between these two the off-shore currents in places swept the Gambier limestone bedrock clean and in other places deposited their loads of quartz sand and calcarenite Gambier limestone debris in current-bedded sheet deposits. In places algal biostromes are well developed and widespread in these shallow water marine deposits and in other places the fossiliferous rounded beach cobble occurs. Weathered surfaces of these calcarenite deposits give rise to caliche, and they have been erroneously referred to in places as "calcareous sand dunes".

This type of near shore deposition started in the map area during

the Upper Pliocene Werrikooian age and extended to the present. In other adjacent areas during the Plio-Pleistocene there were isolated deeper basins of marine deposition as at Caldwell's Cliff on the Glenelg River and at the Dartmoor quarry. An unconformity occurs at the base of all these Plio-Pleistocene deposits.

These in part fossiliferous marine deposits have been elevated in places to several hundred feet above sea level and have in part been affected by faulting and some gentle folding, which started in the Late Pliocene and continued to the present.

The distribution of these Plio-Quaternary deposits is omitted on Plate 1, Geological Map...., but is shown in part on Plate 3, "Diagrammatical Cross-Sections". Sprigg (ibid) makes special reference to these deposits and he and others refer to the aeolian nature of these detrital calcareous sediments in which the writer noted abundant whole marine fossils and probably off-shore current polished and rounded fossiliferous cobble.

STRUCTURE

Regional Structure

A tentative structural pattern for southeast South Australia may be derived from limited surface observations, a few bore records, gravity and magnetic data and from previous geological interpretations. The northern part of the map area is situated on the south end of the basement high of the Padthaway horst, whereas the southern part comprises a western part of the Gambier sunklands, see Sprigg (ibid). A subsurface fault trending WNW-ESE, referred to as the Jaffa fault by Sprigg (ibid), appears to extend across the north part of the map area and to divide the horst from the sunklands.

Within the sunklands geophysical data indicates that a graben extends across the map area through the Penola-Robe area and a horst appears

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to extend through the Mt. Gambier area. Another graben appears to lie south of Mt. Gambier, whereas further to the south the basement appears to be rising towards the Port MacDonnell coastal area. As none of these features have surface expression, they appear to have been developed by faulting, and probably folding, that was initiated post-Merino Group and terminated pre-Gambier limestone.

Subsequent to the formation of these regional features, tectonic movements that can be detected on the surface have occurred periodically. The unconformity at the base of the Knight Group indicates that uplift and probably faulting occurred post-Knight Group and pre-Gambier limestone. After deposition of the Gambier limestone and prior to the Plio-Quaternary the region was again faulted and folded along northwest-south-east trends. These movements were mostly up on the north side and include the Tantanoola anticline, the zone of folding and faulting that passes west of Mt. Schank, Tartwaup fault, Nelson fault, MacIntyre fault, Allendale fault, Knight fault and others shown on Plate 1. Movement along these pre-Quaternary faults in places had a throw greater than the thickness of the Mt. Gambier limestone.

During the late Pliocene and throughout the Quaternary small scale fluctuations in the coastal belt and faulting was again active. These movements were accompanied by volcanism that continued to Late Quaternary and Sprigg (ibid) notes that fault activity in this zone has caused earthquakes in the Beachport area in historic times. Movements along the Muirhead fault, Bluff fault, Kanawinka fault and others that affected the Plio-Quaternary deposits were active at this time. These faults are <u>en echelon</u> and trend northwest-southeast. Characteristically they are up on the north side and only have throw of several hundred feet or less. Some late stage

compression accompanied the faulting and locally folded the incompetent Quaternary tuffaceous beds adjacent to Mt. Gambier. In addition to the faulting jointing is very well developed in the carbonate beds and trends principally north 20-30 west.

This structural pattern is indicated on Plate 1, Geological Map..., and more details of the fold and fault pattern of the Mt. Gambier area are shown on Plate 2, Geology of the Mt. Gambier Area.

Gambier sunklands - Quaternary and Tertiary sediments only crop out in the Gambier sunkland that lies south of the inferred Jaffa fault zone. The Knight Group has not been definitely penetrated to its total thickness in the sunklands, but bore data shows an appreciable thickening to the southeast towards the Nelson bore. From the recent observations of Baker and Cookson (ibid) that the Upper Cretaceous was reached in a marine sequence at 5782 feet drill depth in the Nelson bore, it may be inferred that a deep sedimentary basin extended from southeast South Australia into Southwest Victoria in which marine deposition of the Knight Group started in the Mesozoic and extended into the Tertiary.

Gambier limestone also reaches a known thickness of the Mt. Gambier area of about 800 feet in the Nelson bore and is present in a Portland Township bore at the total drill depth of 2265 feet, see Plate 3, Fig. 1, Diagrammatical Cross-Sections. This increase in thickness may indicate that a thick Tertiary-Mesozoic marine section occurs in the sunklands in the Nelson-Portland area of Victoria. As gravity contours rise to the south towards the Port MacDonnell coastal area, it may be inferred that the Port MacDonnell-Robe area lies outside of this deep sedimentary trough, see Plate 3, Fig. 2, Diagrammatical Cross-Sections.

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Gravity and magnetic data also indicate that the basement is low on the south down-side of the Jaffa fault in the Penola-Robe area. In the Robe bore, the relatively thin section of 1330 feet of Tertiary and the thick section of more than 3029 feet in the Merino Group may indicate that the Jaffa fault is post-Merino Group and pre-Knight Group in age and that the low Penola-Robe area may contain a thick continental Merino Group. Another gravity low lies south of Mt. Gambier.

Local Structures

Padthaway horst - Nonning Pastoral Co. Woolumbool 4? bore on the Padthaway horst penetrated Quaternary from 0-44 feet; Gambier limestone from 44-74 feet and blue, very dense quartzite and porous sandstone (Early Paleozoic?) from 74-181 feet, according to Sprigg and Boutakoff (ibid), see Plate 3, Diagrammatical Cross-Sections this report. The absence of Knight Group sediments in this bore may indicate that the horst was elevated pre-Knight Group and that the horst may have been a source area for the Tertiary clastic sediments.

In the Enterprise Oil Prospecting Co. Lacepede 442 bore near Kingston at the northwest margin of the map area, Quaternary (and Pliocene?) sediments were penetrated from 0-103 feet; Knight Group (?) from 103-402; Pre-Cambrian slate from 402-466. The absence of Gambier limestone in this bore may be explained by a post-Gambier limestone pre-Quaternary fault. It may be inferred that after Mesozoic Merino estuarine or lagoonal conditions transgressed onto this basement high, the thin sedimentary Mesozoic deposits may have been eroded after faulting and uplift.

A thin section of Tertiary sediments of about 391 feet thickness was penetrated prior to reaching the Mesozoic Merino Group in the Comaum coal bore on the east flank of the horst.

The Padthaway horst appears to end abruptly on the south by an inferred subsurface fault that Sprigg (ibid) terms the Jaffa fault zone. On the down side of this fault in the Gambier sunklands continental Mesozoic and continental-to-marine Tertiary sediments are much thicker than on the horst where the inferred original thin section of Mesozoic sediments was probably eroded prior to deposition of the Knight Group.

Folds and Faults - In addition to the inferred pre-Tertiary faults, like the Jaffa fault, Southeast Australia is cut by an en echelon series of faults, characteristically trending northwest-southeast and up on the north side. Many of these are of small magnitude, thcugh conspicuous on the surface because of the lateness of movement. The larger ones have throw greater than the thickness of the Gambier limestone and thus may expose sediments of the Knight Group.

The Knight Group is at the surface or just under the Plio-Quaternary at the three localities; along the MacIntyre fault in an estimated area of about 18 miles by four miles; along the Tartwaup fault in an area of less than 1 mile in length; along the Bluff fault in another small area of less than 1 mile in length. In addition the occurrence of the Knight Group in three bores (Forest Department Blanche 225 bore, Nangwarry 140 bore and Enterprise Oil Prospecting Co. Lacepede 442 NE bore) underlying the Quaternary may indicate that there are a number of other faults of comparable throw that are concealed under the widespread Quaternary cover in southeast South Australia.

Other faults with smaller throw, as the Kanawinka fault that passes through Naracoorte, have Gambier limestone on each side and are probably Quaternary in age. As the Gambier limestone over the Padthaway

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horst was originally probably only a few hundred feet in thickness, the throw on the Kanawinka fault is very small in this area, and probably diminishes to the northwest towards the axial part of the Padthaway horst, where there is only a veneer of Tertiary sediments. It may be noted that it is the older Padthaway horst that controls the thickness of Tertiary sediments in this area and not the young Kanawinka fault.

In the southern part of the area the Nelson fault appears to belong to the en echelon Late Tertiary fault system. As its exposure on the Nelson-Mt. Gambier road it is a normal fault that is up on the north side and trends north 45 degrees west. Its plane dips 63 degrees to the south. Drag in the limestone on the down-side at this locality dips 33 degrees to the south and as Gambier limestone is present on each side, throw is less than the 800 feet maximum thickness of this formation. Pink dolomite from the lower part of the Gambier limestone, similar to that on the crest of the Tantanoola anticline, occurs on the up-side.

Another fault, up on the north side, was noted about ¾ mile north of the Nelson fault on the west side of the Glenelg River and south of Donovan's Camp in the Gambier limestone. This fault trends north 50 degrees west and is a steep angle normal fault, whose plane dips 80 degrees to the south. Some folding is associated with this fault. The Nelson bore lies between this fault and the Nelson fault but as a Quaternary cover masks the Gambier limestone near the bore it could not be detected whether or not there is surface closure.

Folding in Gambier limestone is demonstrated in a local area of compression in the zone of en echelon faulting that lies west of Mt. Schank, see Plate 2. The individual folds extend for a length 6 miles and less and have a width of about ½ mile and less. Dips on their flanks are characteristically less than 4 degrees and others are so low that it is very difficult

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to measure dips in the surface outcrops of thick-bedded limestone. The age of folding is probably late Tertiary. The faults with which the folds are associated also appear to be of very small magnitude.

Another anticlinal fold, that is herein referred to as the "Tantanoola anticline" occurs about 2 miles east of Tantanoola in Gambier limestone and pink dolomite. The Tantanoola cave and the Hanging Rocks quarry are located on this anticline. It is about 3 miles in length and less than $\frac{1}{4}$ mile in width on the surface. There is some indication that a fault occurs on the west flank, but reversal without faulting is plainly visible on the south end. At this reversal the south plunge is 9 degrees and on the north end the plunge also appears to be about 9 degrees to the north. Gentler dips of from 5-9 degrees on the east flank and steeper dips of 15 degrees on the west flank indicate that the fold is asymmetrical and that a component of force acted from the east towards the west. The age of the fold is probably late Tertiary, although later movements also appear to have affected the Quaternary in this area.

South Australia Oil Wells Co. Hindmarsh 195 bore was drilled on the southeast flank of the Tantanoola anticline. It penetrated the Gambier limestone at 392 feet and continued in Knight Group sediments to the bottom of the hole at 1,532 feet. Apparently this location has been considered to be only a fault structure, as Sprigg (ibid) states that this bore was on the up-side of the Tartwaup fault and Stinear (ibid) and Ward (20) state that this bore was located "on the up-thrown side of the Tartwaup fault close to the fault scarp known as the Up and Down Rocks".

Concerning the Tartwaup fault, there appears to be some ambiguity. The structural trends in the area of the Tantanoola anticline show no alignment with the fault about 6 miles northwest of Mt. Gambier township that Sprigg (ibid)

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refers to as the Tartwaup fault. However, even though these two trends do not connect, they may be considered to belong to a "Tartwaup fault zone" in which individual faults are en echelon.

Three local areas of gentle folding in the Quaternary tuffaceous beds adjacent to the Mt. Gambier explosion craters were noted. Drag folding, crumpling and crushing is in part associated with the folding. On the northwest side of Mt. Schank arching and small scale folding of volcanic ejectamenta is associated with a late-stage/dyke and volcanic vents. Also a small low-angle thrust fault with throw of about 18 inches was noted in Gambier limestone under tuffaceous beds in a sink hole about two miles east-south-east of Mt. Gambier township.

OIL INDICATIONS

Since Osborne's (ibid) and Gray and Croll's (ibid) lucid summaries of alleged oil seeps and shows in southeast South Australia and southwest Victoria, Sprigg (ibid) has analysed the various alleged reports and summarised that there is probably no valid oil seep in southeast South Australia. Also alleged oil shows in bores have not been substantiated.

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"Gambier and Northumberland"; 1 mile to 1 inch.
"Penola"; 4 miles to 1 inch.
"South Australia"; 32 miles to 1 inch.
"South Australia Structural Geological Map"; 32 miles to 1 inch.

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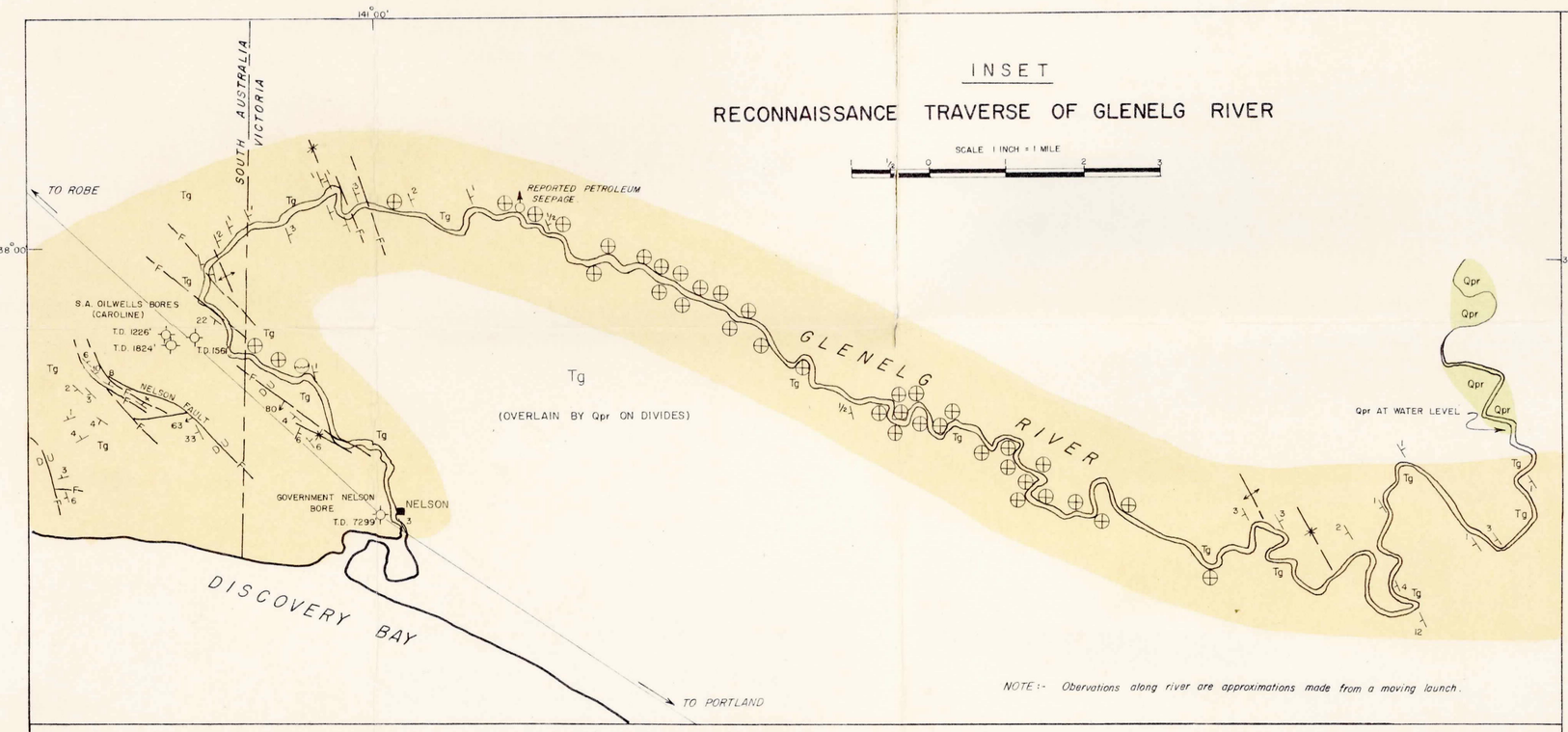
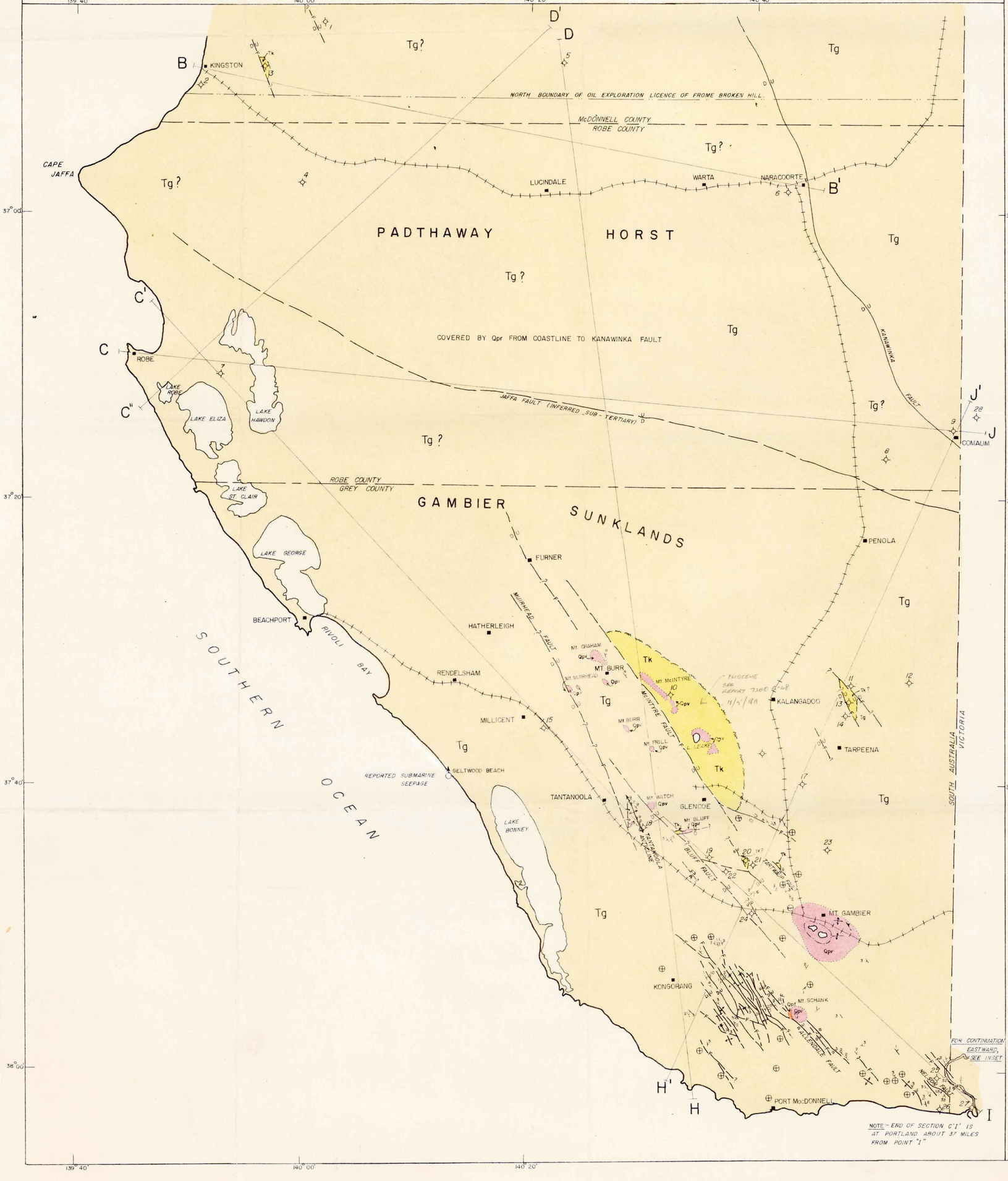
INSET

RECONNAISSANCE TRAVERSE OF GLENELG RIVER

SCALE 1 INCH = 1 MILE





LEGEND

Qpr	CALCARENITE, BEACH DEPOSITS, BARS, OTHER NEAR SHORE AND SHALLOW MARINE DEPOSITS, SOME SAND DUNES, MARINE FOSSILS, ALGAL REEFS.	PLIO - QUATERNARY
Qpv	VOLCANIC EJECTAMENTA INTERBEDDED WITH Qpr	
Qpf	BASALT, INTERBEDDED WITH AND INTERJECTED INTO ABOVE	
Tg	GAMBIER LIMESTONE. EOCENE - MIOCENE ? BRYOZOAL LIMESTONE, MARL, ALGAL REEFS, CHERT, DOLOMITE.	TERTIARY
Tk	KNIGHT FORMATION. EOCENE - PALAEOCENE, SANDSTONE, GRAVEL, SILTSTONE, CLAYSTONE, GLAUCONITIC, CONTINENTAL TO BRACKISH.	

GEOLOGICAL CONTACT
- UNCONFORMITY INFERRED
- NORMAL CONTACT

BEDDING
- STRIKE AND DIP
- HORIZONTAL
- UNDULATING AND IRREGULAR

- FAULT (63 ANGLE OF FAULT PLANE)

NORMAL FAULT
- OBSERVED
- QUESTIONABLE

- WATER BORE AND DRY OIL BORE
- THRUST FAULT (TICK POINTS UNDER UP-SIDE ANGLE OF FAULT PLANE INDICATED).
- STATE OR COUNTY BOUNDARY
- ANTICLINE
- RAILWAY
- SYNCLINE

LIST OF BORES

1 ALMALGAMATED OIL WELLS CO. MURRABINNA 108 BORE. T.D. 1363'
2 SOUTHERN OCEAN OIL CO. LACEPEDE 507. T.D. 2660'
3 ENTERPRISE OIL PROSPECTING CO. LACEPEDE 442 N.E. T.D. 466'
4 RYDER J.F. BOWAKA 195 BORE. T.D. 395'
5 NONNING PASTORAL CO. WOOLUMBOOL 4. T.D. 181'
6 NARACOORTE TOWNSHIP WATER SUPPLY BORE NO.2. T.D. 510'
7 S.A. OILWELLS "ROBE" BORE. WATERHOUSE 714. T.D. 4504'
8 S.E. DRAINAGE BOARD. COMAUM 242. T.D. 186'
9 COMAUM "COAL" BORE. T.D. 1122'
10 ADELAIDE OIL EXPLORATION CO. MT. McINTYRE BORE. RIDDOCK 9. T.D. 1045'
11 NANGUARRY 140. T.D. 115'
12 NANGUARRY 130. T.D. 121'
13 WOODS AND FORESTS DEPT. NANGUARRY 113 BORE. T.D. 70'
14 WOODS AND FORESTS DEPT. NANGUARRY 85 BORE. T.D. 55'
15 MILLICENT DAIRYING CO. BORE. T.D. 575'
16 DISMAL SWAMP BORE NO.2. T.D. 141'
17 DISMAL SWAMP BORE NO.3. T.D. 157'
18 S.A. OILWELLS BORE. HINDMARSH 195. T.D. 1532'
19 SPRING BORE. BLANCHE 150. T.D. 1160' (1230') PELICHEARS OIL CO. W.J. 6958
20 WOODS AND FORESTS DEPARTMENT BORE. T.D. 308'
21 WOODS AND FORESTS DEPARTMENT BORE. T.D. 70'
22 ASSOCIATED OIL CO. BORE. BLANCHE 301. T.D. 2110'
23 NORTH GAMBIER AERODROME BORE. T.D. 269'
24 KNIGHT DOME NO. 2 BORE. BLANCHE 170. T.D. 2013'
25 S.A. OILWELLS BORE NO. 2. (CAROLINE 336) T.D. 1824'
26 S.A. OILWELLS BORE. T.D. 839'
27 GOVERNMENT NELSON BORE. T.D. 7299'
28 PT. ADDIS OIL WELLS N.L. LAKE COOIE BORE. T.D. 1171'

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Envelope 34

GEOLOGICAL MAP, LOWER SOUTH-EAST SOUTH AUSTRALIA.

PLATE I

FROME REPORT :— Geology of Lower Southeast South Australia.
By :— L. H. DIXON, Assisted by J. H. O'MARA.

SCALE - 1 INCH = 4 MILES.

JUNE 1956

ENV 34-1

7200-G-33

35' 40' 45' 50' 55' 141°00' 05'

37°45' 50' 55' 38°00'

SPRING BORE
T.D. 1160'
(BLANCHE 150)

S.A. PRODUCER OIL BORE
T.D. 1220' (APPROX)

ASSOC. OIL CO. BORE
T.D. 2110' (APPROX)
(BLANCHE 301)

TARTWALPA FAULT

"KNIGHT DOME" NO. 2 BORE
T.D. 2013'
(BLANCHE 170)

KNIGHT FAULT

MT. GAMBIER

BLUE LAKE

VOLCANIC CONE

MT. SCHANK VOLCANIC CONE

QPV Dike

ALLENDALE FAULT

NELSON 2 FAULT

S.A. OILWELLS BORES (CAROLINE)
T.D. 1226'
T.D. 1824'
T.D. 1561'

S.A. OILWELLS BORE (APPROX)
839'

GOVERNMENT NELSON BORE
T.D. 7299'

SOUTH AUSTRALIA
VICTORIA

GLENELG RIVER

DOUGLAS POINT

PORT MacDONNELL

CAPE NORTHUMBERLAND

S O U T H E R N O C E A N

Tg

Qpv

Qpf

LEGEND

Qpr	ALLUVIUM, CALCARENITE BEACH DEPOSITS, BARS AND OTHER NEAR SHORE DEPOSITS AND SOME SAND DUNES, MARINE FOSSILS, ALGAL REEFS — OMITTED ON THIS MAP.	PLIO – QUATERNARY
Qpv	VOLCANIC EJECTAMENTA — INTERBEDDED WITH Qpr.	
Qpf	BASALT, INTERBEDDED WITH AND INJECTED INTO ABOVE.	
Tg	GAMBIER LIMESTONE. EOCENE — MIOCENE ? BRYOZOAL LIMESTONE, MARL, ALGAL REEFS, CHERT, DOLOMITE.	TERTIARY
Tk	KNIGHT FORMATION. EOCENE — PALEOCENE, SANDSTONE, GRAVEL, SILTSTONE, CLAYSTONE, GLAUCONITIC, CONTINENTAL — TO BRACKISH.	

- UNCONFORMITY INFERRED
- NORMAL CONTACT
  — GEOLOGICAL CONTACT
- VERTICAL FRACTURE
- PLANE OF FRACTURE UNKNOWN
- DIRECTION AND ANGLE OF FRACTURE PLANE
  — JOINTING
- U/D OBSERVED
- U/D QUESTIONABLE
  — NORMAL FAULT
- WATER BORE AND DRY OIL BORE
- THRUST FAULT (TICK POINTS UNDER UP-SIDE ANGLE OF FAULT PLANE INDICATED).
- STATE BOUNDARY
- ANTICLINE
- RAILWAY
- SYNCLINE
- STRIKE AND DIP
- HORIZONTAL
- UNDULATING AND IRREGULAR
  — BEDDING

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Exploration Department
Envelope 34

GEOLOGY OF THE MT. GAMBIER AREA, SOUTH AUSTRALIA.

(AN OVERLAY OF "GAMBIER & NORTHUMBERLAND" SHEET OF ONE MILE GEOLOGICAL SERIES, BY R.C. SPRIGG & G.W. COCHRANE, GEOLOGICAL SURVEY OF SOUTH AUSTRALIA, DEPARTMENT OF MINES, 1951.)

PLATE 2

FROME REPORT:- Geology of Lower Southeast South Australia
By - L.H. DIXON, Assisted by J.H. O'MARA.

SCALE = 1 INCH = 1 MILE

1 ½ 0 1 2 3

JUNE 1956

ENU 34-2

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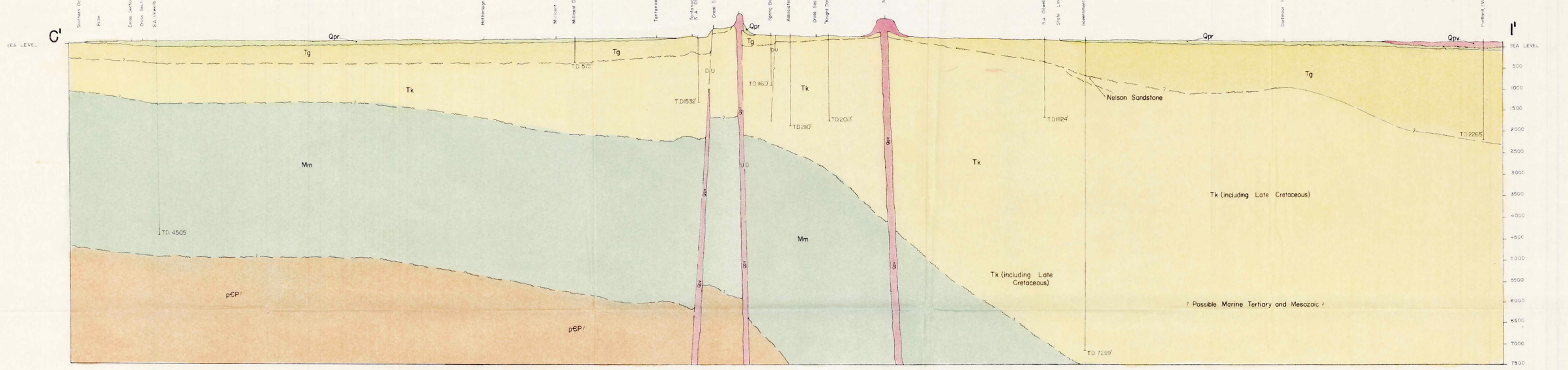
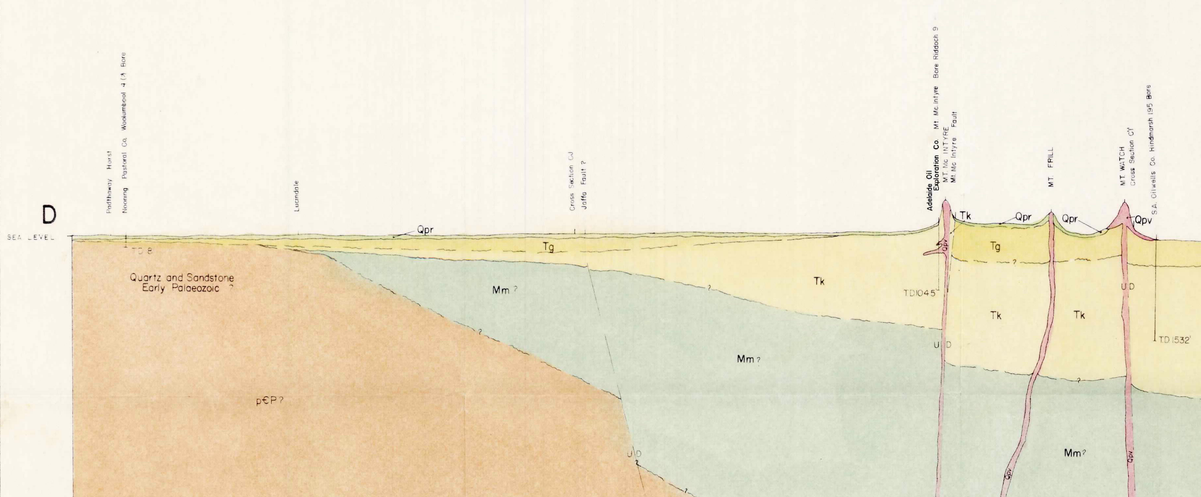
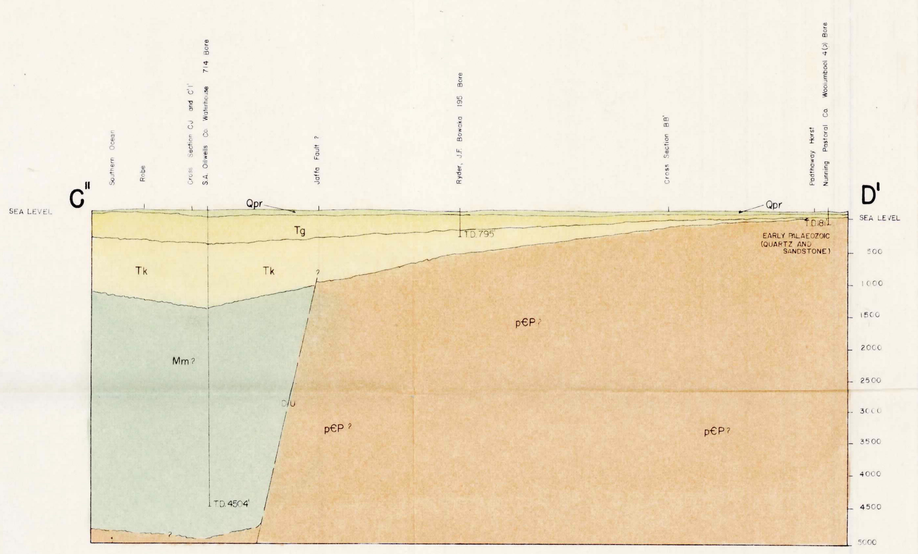


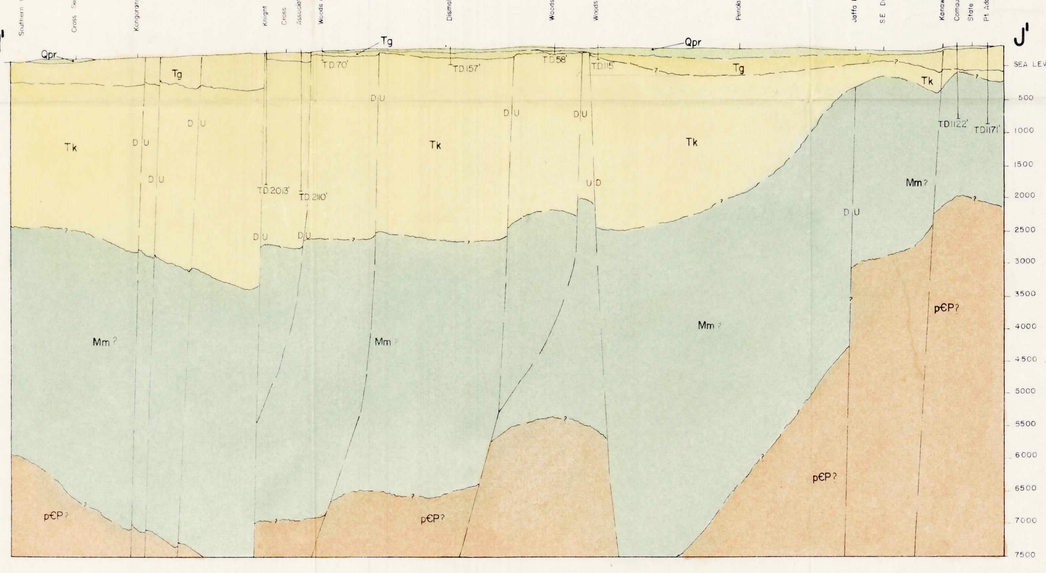
CROSS-SECTION C'I' ROBE, S.A. TO PORTLAND, VICTORIA



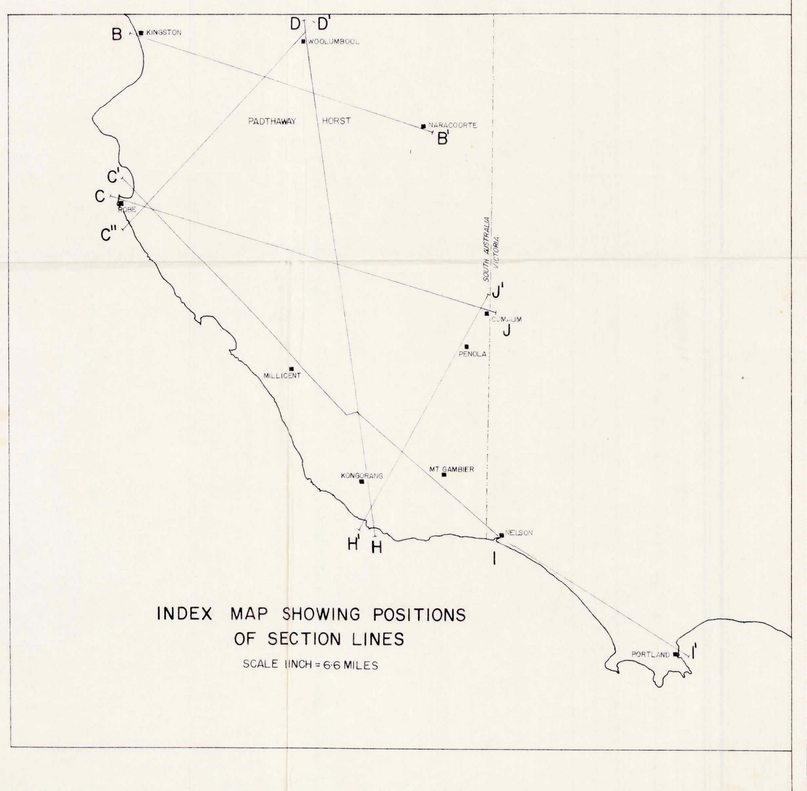
CROSS-SECTION DH PADTHAWAY HORST TO KONGORONG



CROSS-SECTION C"D' ROBE TO WOOLUMBOOL BORE

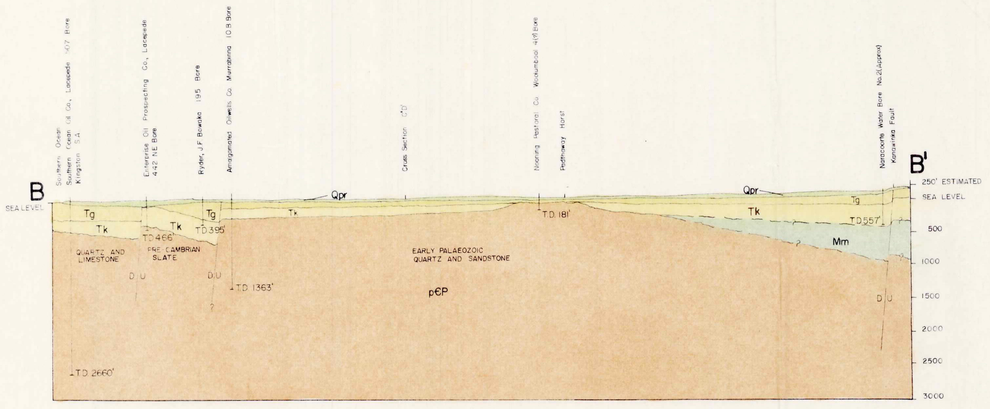


CROSS-SECTION H'J' KONGORONG TO COMAUM

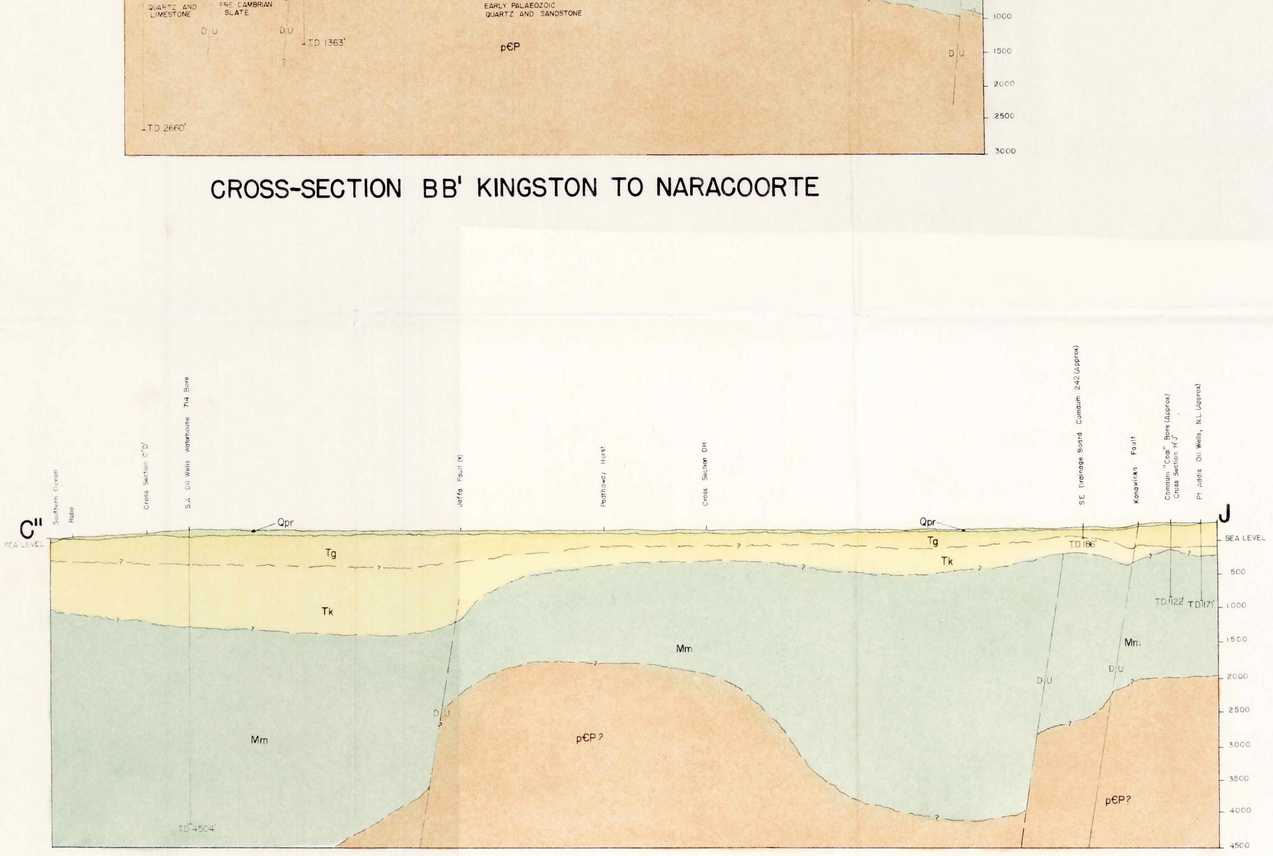


INDEX MAP SHOWING POSITIONS OF SECTION LINES

SCALE 1INCH = 6·6 MILES



CROSS-SECTION BB' KINGSTON TO NARACOORTE



CROSS-SECTION C J ROBE TO COMAUM

LEGEND

SEDIMENTARY ROCKS

Qpr — QUATERNARY - PLIOCENE — CALCARENITE, BEACH DEPOSITS, BARS AND OTHER NEAR SHORE AND SHALLOW MARINE DEPOSITS, SOME SAND DUNES, MARINE FOSSILS AND ALGAL REEFS

UNCONFORMITY

Tg — TERTIARY — GAMBIER LIMESTONE, MIOCENE - EOCENE

UNCONFORMITY

Tk — TERTIARY - MESOZOIC — KNIGHT GROUP, EOCENE - CRETACEOUS

UNCONFORMITY

Mm — MESOZOIC — MERINO GROUP

UNCONFORMITY

pEP — EARLY PALAEOZOIC AND PRE-CAMBRIAN — UNDIFFERENTIATED

VOLCANIC ROCKS

Qpv — QUATERNARY - PLIOCENE — VOLCANIC EJECTAMENTA

Qpl — QUATERNARY - PLIOCENE — LAVA

NORMAL CONTACT

UNCONFORMITY

TD — TOTAL DEPTH OF BORE

D / U — FAULT

NOTE - FOR LOCATION OF CROSS SECTION SEE INDEX MAP AND PLATE 1

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DIAGRAMMATICAL CROSS - SECTIONS SOUTHEAST SOUTH AUSTRALIA

PLATE 3

Envelope 344

FROME REPORT - GEOLOGY OF LOWER SOUTHEAST SOUTH AUSTRALIA. By - L.H. DIXON, Assisted by J.H. O'MARA.

VERTICAL SCALE 1INCH=1000 FEET
HORIZONTAL SCALE 1INCH=4 MILES

ENV 34-3.

JUNE 1956

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