COMMONWEALTH OF AUSTRALIA

DEPARTMENT OF NATIONAL DEVELOPMENT

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

Report No. 12

STRATIGRAPHY AND MICROPALAEONTOLOGY OF THE MARINE TERTIARY ROCKS BETWEEN ADELAIDE AND ALDINGA, SOUTH AUSTRALIA

By

I. CRESPIN

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Issued Under The Authority Of Senator the Hon. W. H. Spooner, M.M.,
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LIST OF REPORTS

1. Preliminary Report on the Geophysical Survey of the Collie Coal Basin-N.G. Chamberlain, 1948.

2. Observations on the Stratigraphy and Palaeontology of Devonian, Western Portion of Kimberley Division, Western Australia-Curt Teichert, 1949.

3. Preliminary Report on Geology and Coal Resources of Oaklands-Coorabin Coalfield, New South Wales-E. K. Sturmfels, 1950

4. Geology of the Nerrima Dome, Kimberley Division, Western Australia-D. J. Guppy, J. O. Cuthbert and A. W. Lindner, 1950

5. Observations of Terrestrial Magnetism at Heard, Kerguelen and Macquarie Island, 1947-1948. (Carried out in co-operation with the Australian National Research Expedition, 1947-1948). N. G. Chamberlain, 1952.

6. Geology of New Occidental, New Cobar and Chesney Mines, Cobar, New South Wales -C. J. Sullivan, 1951.

7. Mount Chalmers Copper and Gold Mine, Queensland-N. H. Fisher and H. B. Owen, 1952.

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11. The Nelson Bore, South-Western Victoria; micro-palaeontology and stratigraphical succession-I. Crespin,

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Secretary - H. G. Raggatt, C.B.E.

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

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This Report gives the results of a detailed examination of the foraminifera found in the surface and subsurface marine Tertiary deposits between Adelaide and Aldinga, South Australia. The outcrops occur chiefly in the cliffs along the eastern shores of St. Vincent Gulf, between Hallett Cove and Aldinga, at Hackham and along the banks of the Onkaparinga River at Noarlunga. Samples of the subsurface rocks came from 37 bores in the Adelaide Basin.

Five lithologically distinct formational units, the Maslin Sandstone, Blanche Point Limestone, Aldinga Limestone, Oaklands Limestone, and Hallett Cove Sandstone, have been recognised, the Oaklands Limestone only in subsurface sections. The formational boundaries coincide approximately with characteristic foraminiferal assemblages.

Beneath the Adelaide Plains is a wide-spread deposit of calcareous sandstone, referred to in literature as the "Adelaidean". This deposit is regarded by the writer as the equivalent of the Hallett Cove Sandstone, and will be referred to in this Report as the lower Pliocene sandstone of the Adelaide Basin.

The foraminifera indicate that beds of upper Eocene age, of "f_1" stage (lower Miocene) of Indo-Pacific Tertiary subdivision, and of lower Pliocene age, exist in the area. The upper Eocene beds most probably represent the Janjukian Stage of south-eastern Australian Tertiary stratigraphy. The "f_1" stage beds are most probably the equivalent of the Balcombian Stage, and the lower Pliocene of the Kalimnan Stage.

1. INTRODUCTION

Considerable information has been gathered during recent years on the stratigraphy and microfaunal content of the Tertiary sediments around Adelaide and along the east coast of St. Vincent's Gulf south of the Aldinga cliffs at Port Willunga (Plate 1). In

1936 Sir Douglas Mawson accompanied the author on a visit to Hallett Cove, Maslin Beach, and Aldinga, where fairly large collections of fossiliferous material were made. Since that date, Sir Douglas has made several small collections from the Aldinga section with the hope that the author would later prepare a detailed account of the stratigraphy and micro-palaeontology of the area. A short account of the microfauna of the Aldinga section was published in 1946 (Crespin, 1946).

Since 1946 a large amount of subsurface material has been available for detailed micropalaeontological investigation from the Adelaide Basin, because of the intensive drilling programme that has been undertaken by the South Australian Department of Mines in its effort to assess the underground water supply that exists in the beds underlying the Adelaide Plains. During 1946 and 1947, Mr. B. C. Cotton and the author, at the request of the Director of Mines, examined samples from thirty-seven bores in the area; Mr. Cotton investigated the mega-fossils and the writer the micro-fossils. Much of the information obtained has been incorporated in a report on the water possibilities of the Adelaide Basin by K. R. Miles (1951). Since then the author has extended the area of investigations to include the coastal section as far south of Adelaide as Aldinga.

Detailed results of the microfaunal examination of the samples from the bores recently drilled in the Adelaide Basin have been sent to the Director of Mines. The majority of the bores were drilled under department supervision and the material systematically collected. The others were drilled under private contract and samples carefully taken. Most of the bores finished in the calcareous sandstone which is the main aquifer and which is lower Pliocene in age. Others penetrated the underlying "f_1" stage (lower Miocene) deposits, in which a second aquifer exists, and a few reached the upper Eocene sediments. Earlier bores, such as the Metropolitan Abattoirs Bore and the Salisbury, Croydon, and Kent Town Bores, are referred to only incidentally, as samples were collected from them in rather an unsatisfactory manner.

Since the bores of the Adelaide Basin were examined and reported upon, considerable detailed stratigraphical work has been carried out on the Tertiary section between Torquay and Eastern View, southern Victoria, by Dr. H. G. Raggatt and the writer, with the result that drastic changes have become necessary regarding the age of the beds referred to as "Janjukian" (Raggatt and Crespin, 1952). Furthermore, detailed investigations have been made into the application of the "letter classification" of East Indian Tertiary stratigraphy to Australian Miocene deposits (Schneeberger, 1952), and the results of this research are applied in this Report to the South Australian deposits.

HISTORICAL NOTES

Little literature is available on the micro-palaeontology and stratigraphical sequence of the Tertiary deposits around Adelaide and south to Aldinga, but different opinions have been held regarding their age. This aspect has been discussed in detail by Singleton (1941), and will be referred to only briefly in this section, chiefly in relation to the stratigraphy of the area.

The earliest reference to fossiliferous beds around Adelaide was made by J. Tenison Woods in 1865 when he presented a paper before the Philosophical Society of Adelaide entitled "Tertiary Geology of South Australia", in which he placed the deposits near Adelaide and in the Government House Quarry in the "Newer Pliocene" (Woods, 1867).

Professor Ralph Tate was a prolific writer on the fossil fauna in the Adelaide and Aldinga deposits, the bulk of this work being descriptions of new species of Tertiary molluscs. However, his contributions to the Tertiary stratigraphy of the area are basic works.

In 1879 Tate divided the Aldinga deposits into an upper and a lower bed which he considered to be Miocene and Eocene respectively. He also regarded the Hallett Cove fossiliferous beds as equivalent in age to the upper Aldinga horizon. This correlation has been confirmed, but the age is regarded as lower Pliocene rather than Miocene. The lower bed is referable to the upper Eocene.

In 1882, Tate discussed the Tertiary strata underlying the Adelaide Basin, basing his comments on his examination of fossils from a bore at the Waterworks Yards at Kent Town near Adelaide. He combined the general features of the section in the bore with those exposed in the coastal cliffs at Aldinga and suggested the following sequence for the "Older Tertiaries" in the Adelaide Basin:

Top of Section.

A. Estuarine or Lacustrine clay, exceeding 50 feet.

B. Marine - total thickness, 197 feet.
  (a) Calciferous sandstone, with oyster banks.
  (b) Sandy and calcareous clays with argillaceous limestones, chiefly in the lower part.
  (c) Glauconitic limestones and sands, etc.

C. Lacustrine and estuarine clays and sands, with carbonaceous debris - total thickness, 142 feet.

In 1890 Tate suggested a classification of the beds when he considered the sequence in a bore at the Australian Smelting Company's works at Dry Creek, near Adelaide. He referred the topmost 120 feet of unfossiliferous sands to the "Pliocene or Mammaliferous Drift", and the fossiliferous sands from 320 feet down to 410 feet he considered to be the first record in Australia of "marine deposits of Pliocene age". He included a list of 10 species of foraminifera determined by Howchin, who commented that the list was "more characteristic of the Upper Bed (Miocene of Muddy Creek) than the Lower (Eocene)".

Later in 1890, he gave an account of the sequence in No. 2 Bore, Croydon, three and a half miles from Adelaide, down to the depth of 800 feet, and in 1898, on completion of the bore, the recorded depth of which was 2,296 feet, he gave the following sequence of beds:-

	Thickness in feet
Mammaliferous Drift	395
Older Pliocene (marine)	320
Eocene? (marine)	45
Eocene (marine)	921
Eocene (unfossiliferous)	1,54[illegible]

Professor W. Howchin made considerable contributions to the knowledge of the stratigraphical sequence in the Adelaide Basin and south to Aldinga. In 1891 he recorded the foraminifera from No. 2 Bore, Kent Town, which Tate described in 1882. He gave no precise depth for the samples from which he listed the foraminifera but stated that the most important fossiliferous horizon occurs at the base of the marine rocks, which consist of brown and green clayey sands 23 feet in thickness. The majority of foraminifera recorded are referred to Recent species, but one which he described as "Truncatulina margaritifera Brady var. adelaidensis var. nov." occurs only in the green glauconitic limestones of Eocene age at Christie's Beach, Port Noarlunga, and Maslin Beach north of Blanche Point. He makes a comparison of the assemblage with that found at Muddy Creek near Hamilton, Victoria. Apparently the Kent Town Bore passed through the lowest richly fossiliferous beds exposed at Maslin Beach and Christie's Beach.

In 1923, Howchin gave a detailed account of all the Sections on the east side of the Gulf of St. Vincent, from Brighton to Sellick's Hill, and this work has been invaluable in the preparation of this Report.

In 1935 and 1936 Howchin discussed the sequence of several bore sections in the vicinity of Adelaide and in 1938, in collaboration with the late W.J. Parr, he described many typical foraminifera from the Pliocene and Miocene beds in these bores. Most of these species were recorded in recent investigations by the author.

In 1940 R. W. Segnit published the results of his detailed work in the Hallett Cove district. He gave special attention to the relationship of the unfossiliferous sandstone ("glacial till") and the overlying fossiliferous calcareous sandstone of Hallett Cove.

Different views on the age of the beds in the Adelaide Basin and down to Aldinga have been put forward by Tate (1879), Tate and Dennant (1896), Tate (1899), Hall and Pritchard (1902), Dennant and Kitson (1903), Chapman (1914), Chapman and Singleton (1925), Woods (1931), Cotton and Woods (1935), Chapman and Crespin (1935), Singleton (1938, 1941), Howchin and Parr (1938), Ludbrook (née Woods) (1938, 1941), Crespin (1946), and Glaessner (1951).

Chapman (1935) described some plant remains from two blocks of "pipe-clay" underlying the glauconitic limestone near Blanche Point, Aldinga. He regarded their age as lower Oligocene. These plant beds have not been studied in this investigation but it is most probable that they are of middle Eocene age, since they presumably underlie the fossiliferous upper Eocene of Blanche Point.

DESCRIPTIONS OF FORMATIONS

Striking differences in lithology are apparent in the beds exposed in surface sections throughout the area under disccussion and it is possible to recognise four distinct formational units. At the same time it has been necessary to institute a new formational name for a distinctive lithology in subsurface section. The suggested names for these Formations are given below and are arranged in descending stratigraphical sequence:

Hallett Cove Sandstone
Oaklands Limestone
Aldinga Limestone
Blanche Point Limestone
Maslin Sandstone

The Maslin Sandstone is the sandstone containing brown-stained quartz grains and abundant polished ovoid limonitic pellets, at the base of the cliff section in the central and southern portions of Maslin beach, immediately north of Blanche Point.

The Blanche Point Limestone is represented by cream to pinkish fossiliferous limestone, green glauconitic chalky limestone, greyish argillaceous limestone with abundant Turritella, and cream chalky limestone,exposed in the cliff section in the central and southern portion of Maslin Beach between Blanche Point and the steps leading down to the beach near Uncle Tom's Cabin.

The Aldinga Limestone consists of the sandy limestones, yellowish glauconitic sandy limestone, and bryozoal chalky limestone, which outcrop in the cliff sections of Blanche Point around Aldinga Bay to Snapper Point.

The Oaklands Limestone is represented by beds of bryozoal limestone and sandy limestone that are found, as far as is known, only in subsurface sections in the Adelaide Basin.

The Hallett Cove Sandstone refers to the calcareous quartz sandstone exposed at Hallett Cove, Christie's Beach and Port Noarlunga, and in the cliff sections around Aldinga Bay. Beds of similar lithology occur extensively in subsurface sections in the Adelaide Basin and are referred to as the lower Pliocene sandstone of the Adelaide Basin.

Maslin Sandstone

The term "Maslin Sandstone" has been applied to friable dark brown to greenish coarse limonitic sand with limonitic ovoid pellets, and the firm coarsely current-bedded coarse limonitic sandstone exposed in the lower part of the cliff section along the southern and central shores of Maslin Bay, Hundred of Willunga, immediately north of Blanche Point, which is a bold headland, 140 feet high, separating Maslin Bay from Aldinga Bay (Plate 3).

Tate (1882) described "an unfossiliferous ironshot sand of unknown thickness, but which to the north of Blanche Point gradually rises in the section until it attains a level above that of the Upper Aldinga Series and is seen reposing at a considerable inclination against the old slate rock". This description undoubtedly refers to the Maslin Sandstone.

The Maslin Sandstone consists of highly polished grains of quartz, stained brown, and of flat to ovoid polished pellets of limonite. It is most probable that the limonite represents an alteration product of glauconite. This deposit was regarded by Howchin (1923) as of freshwater origin, but the presence of tests of foraminifera and fragments of bryozoa that have been replaced with limonite suggest a marine origin.

The Formation has an irregular surface and is overlain unconformably by the Blanche Point Limestone from Blanche Point north to the steps leading down the cliff face to Maslin Beach near Uncle Tom's Cabin, and by travertines and mottled clays of Pleistocene age from these steps to Bennett Creek, the first creek north of Blanche Point and about one mile from it. The junction with the "old slate rocks" mentioned by Tate (1882) has been covered by talus and the base of the sequence is not visible.

Blanche Point Limestone

The Blanche Point Limestone is exposed in the cliff section in the central and southern portion of Maslin Beach, from the steps leading down the cliff to the beach in the vicinity of Uncle Tom's Cabin southward to Blanche Point, which is a bold headland 140 feet high separating Maslin Bay from Aldinga Bay. The greatest thickness of the Formation is at Blanche Point where at least 40 feet of sediments are exposed in the vertical cliff face. The Formation unconformably overlies the irregular surface of the Maslin Sandstone, and different beds of the Blanche Point Limestone overlap the Maslin Sandstone as they thin out to the north from Blanche Point, and the Maslin sandstone thickens. It is unconformably overlain by the Hallett Cove Sandstone.

The Blanche Point Limestone is composed of cream and pinkish fossiliferous clastic limestone, clastic limestone containing abundant megafossils - especially echinoids and brachiopods -, glauconitic fossiliferous clastic limestone with abundant Turritella, and cream clastic limestone.

The lowest bed of the Formation is about 3 feet thick and is exposed towards the southern portion of the section; it disappears under the sea at the southern end of Maslin Beach. It consists of a cream to pinkish bryozoal clastic limestone with many brown polished limonitic pellets similar to those found in the underlying Maslin Sandstone. This bed is overlain by a cream clastic limestone about 4 feet thick and containing numerous small grains of green glauconite and abundant large echinoids and brachiopods. This bed overlaps the Maslin Sandstone in the direction of the steps.

This limestone, in turn, is overlain by a moderately hard glauconitic fossiliferous limestone, in which casts of Turritella aldingae are very abundant. This glauconitic limestone, which is about 2 feet thick, can be followed with the eye for the extent of the section from above Uncle Tom's Cabin to Blanche Point. To the north near the steps it overlaps the Maslin Sandstone. In the direction of Blanche Point it is overlain by a dark-grey argillaceous limestone about 30 feet thick and containing abundant well-preserved Turritella aldingae. This limestone bed disappears beneath the sea on the southern side of Blanche Point where at very low tide it forms a wide platform.

This dark-grey argillaceous limestone does not occur in the section down the steps. Instead the glauconitic deposit is overlain by a thin bed of cream chalky limestone which, in turn, is overlain unconformably by the Hallett Sandstone.

Outcrops of limestone which are regarded as part of the Blanche Point Limestone occur at Christie's Beach, Port Noarlunga; in the cliff section, near the mouth of the Onkaparinga River, south of Port Noarlunga; at Hackham; and in the cliffs along the Onkaparinga River at Noarlunga.

Aldinga Limestone

Aldinga Limestone is the name given to the bryozoal sandy limestone, yellowish-green glauconitic sandy limestone, greenish sandy marls, and bryozoal clastic limestone, in the cliff section around Aldinga Bay south from Blanche Point to Snapper Point (pl.4, fig.2). The Formation includes the well-known section which Tate referred to as the "Lower Aldinga Series" (1879, 1899).

The Aldinga Limestone disconformably overlies the Blanche Point Limestone, as far as can be seen, in the vicinity of Blanche Point, but at one locality between Blanche Point and Aldinga Creek it rests on a reddish sandstone which most probably represents the Maslin Sandstone. The base of the Formation is not visible south of Aldinga Creek. It is unconformably overlain by the Hallett Cove Sandstone, and dips gently to the south-west and disappears under the sea immediately north of Snapper Point.

In the section from the north side of Aldinga Creek to the south side of Blanche Point, a 12-foot thickness of Aldinga Limestone is exposed. The basal bed of the Formation occurs in this part of the section and consists of a yellowish-grey glauconitic sandy limestone 2 feet thick. This is overlain by a friable to hard bryozoal sandy limestone which is current-bedded and is five feet thick. This bed in turn is covered by a pale buff-coloured bryozoal limestone about 5 feet thick, and the highest bed in the section north of Aldinga Creek is a green glauconitic clastic limestone.

Approximately 35 feet of Aldinga Limestone is exposed in the cliff section south from Aldinga Creek to Snapper Point. The basal bed in this portion of the section is a light-brown bryozoal chalky limestone. This is followed by green glauconitic sandstone about two feet thick. Then follows approximately nine feet of buff to ochreous bryozoal limestone and sandy limestone, Then a section of twenty feet of the Aldinga Limestone is exposed in a cutting leading down to the Port Willunga Jetty. The rocks consist of greenish-white bryozoal marly limestone, below whitish bryozoal marly limestone, with a fawn to red bryozoal marl forming the topmost bed; this is unconformably overlain by the Hallett Cove Sandstone.

Oaklands Limestone

The name "Oaklands Limestone" is applied to a sequence of limestones and sandy limestones which occur, as far as is known, only in subsurface sections in the Adelaide Basin. Bore No. 36, Oaklands Railway Station, south-west corner of Section 154, Hundred of Noarlunga, about 10 miles south of Adelaide, between the depths of 218 feet and 400 feet, has been selected as the type section for the Formation (Plate 2). It is realised that a subsurface section is not a satisfactory one for the recognition of a formation; but should a similar lithological sequence of beds be found in outcrop, it can readily displace the subsurface section as the type.

The sequence of beds in Bore No. 36, Oaklands Railway Station, is as follows:-

218-220 feet	Moderately hard grey limestone with glauconite.
220-226 feet	Moderately hard grey limestone with glauconite.
226-260 feet	Bryozoal limestone with glauconite.
260-270 feet	Cream limestone.
270-310 feet	Dark grey sandy limestone.
310-312 feet	Cream sandy limestone.
312-350 feet	Cream bryozoal sandy limestone.
350-380 feet	Greyish sandy limestone.
380-400 feet	Yellowish bryozoal sandy limestone, with glauconite.

The Oaklands Limestone is overlain disconformably by the lower Pliocene sandstone of the Adelaide Basin. In Nathan Brewery Bore, Southwark, north-east corner of Section 1, Hundred of Adelaide, the following lithological sequence occurs:

350-364 feet	Ochreous sandstone.
364-447 feet	Grey calcareous sandstone.
447-500 feet	No sample.
500-509 feet	Hard yellowish bryozoal limestone.

The stratigraphical break between the two formations occurs between 447 and 500 feet. Unfortunately none of the recent bores drilled in the Adelaide Basin passed through the Oaklands Limestone into an underlying Formation.

The characteristic lithology of the Oaklands Limestone is recorded from the following bores in the Adelaide Basin:

Bore No. 29, Marion Road, Harcourt Gardens, west boundary of Section 88, Hundred of Adelaide, between the depths of

153 feet 6 inches and 200 feet.

Bore No. 36, Oaklands Railway Station, south-west corner of Section 154, Hundred of Noarlunga, between the depths of

218 feet and 260 feet.

Bore No. 58, Railway Station, Hove, west side of Brighton Road, Section 238, Hundred of Noarlunga, between the depths of

208 feet and 311 feet.

Bore No. 63, Wolseley Plantation, Port Road, south-west boundary of Section 375, Hundred of Yatala, between the depths of

600 feet and 620 feet.

Bore at Nathan Brewery Southwark, north-east corner of Section 1, Hundred of Adelaide, between the depths of

500 feet and 555 feet.

Bore on A.E. Amber's Property, Netley, near west boundary, south-west corner of Section 106, Hundred of Adelaide, between the depths of

271 feet and 461 feet.

Bore No. 1, A.H. Kinnish's Property, Direk, Section 3078, Hundred of Munno Para, between the depths of

280 feet and 318 feet.

Bore No. 2, A.H. Kinnish's Property, Direk, Section 3076, Hundred of Munno Para, between the depths of 265 feet and 365 feet.

The thickness of the Oaklands Limestone met with in the bores ranges from 20 feet in Bore No. 65, Wolseley Plantation, to 190 feet in Amber's Bore, Netley, but in no case has the true thickness been proved. This lack of evidence as to the true thickness is due to the positions of the bores in which it is recorded. Bores Nos. 29 and 36 are in the southern part of the Adelaide Basin and on the south side of a fault line striking north-east which brings the Formation close to the surface. Amber's Bore is to the north of Bores Nos. 29 and 36 and between two parallel fault lines. Bore No. 65 and Nathan Brewery Bore are on the northern side of the more northerly fault. No. 65 Bore is to the north-west of the Nathan Brewery Bore and in the deeper part of the basin, where the Hallett Cove Sandstone is well developed (Plate 2). The Kinnish Bores at Direk are situated in the northern part of the Adelaide Basin.

Hallett Cove Sandstone

The term "Hallett Cove Sandstone" is given to the well-known deposit of fossiliferous calcareous quartz sandstone which outcrops at a locality half a mile south of Hallett Cove railway station, Section 562, Hundred of Noarlunga, and 14 miles south of Adelaide (Plate 5). This sandstone is composed of coarse angular to sub-angular quartz grains, is richly fossiliferous, and is about four feet thick. It unconformably overlies a white fine-grained sandstone most probably of Lower Cretaceous age. It is disconformably overlain by unfossiliferous Pleistocene sands and clays, which in turn are covered by concretionary travertine probably Recent in age. (See Segnit, 1940, p. 17, text figure 1).

Segnit (1940, p. 36) under the heading "Cainozoic-Lower Pliocene" informally referred to the beds at Hallett Cove as a formation and said "One of the most important formations present in the region under review is the very thin bed of fossiliferous sandstone and unfossiliferous sandy-limestone which has been deposited unconformably upon the (eroded?) surface of the younger till". He suggested that the age of the "younger till" was Lower Cretaceous. The writer is inclined to agree with Segnit about the age of the "younger till", for, although no fossil evidence is present to support this idea, the lithology is similar to that found in the strata underlying the marine Tertiary at Christie's Beach, Port Noarlunga, in which Lower Cretaceous foraminifera were recently found.

Segnit concluded that the "Hallett Cove Sandstone" had been subjected to considerable erosion, which was evidenced by the smooth, gently eroded and weathered, surface upon which the Pleistocene mottled clays were deposited. He considered that the area had been subjected to considerable faulting and that the fossiliferous rocks which overlay the "younger till" did not extend beyond the northern and southern limits of the till in the area he examined.

Outcrops of the Hallett Cove Sandstone occur at various points in the cliff sections on the eastern shores of St. Vincent Gulf, and these have been described in detail by Howchin (1923) and Segnit (1940). In the Hallett Cove area they are exposed near the top of the cliff sections from Black Cliff south to Field River. The cliffs rise to a height of more than 200 feet above sea level at the northern end, where the Hallett Cove Sandstone has an approximate thickness of 12 feet. At the southern end, at a distance of a little more than half a mile from Hallett Cove railway station and at the type locality for the formation, it is only four feet thick. It is present at the top of the marine beds in the cliff sections at Port Noarlunga and Maslin Beach, where it unconformably overlies the Blanche Point Limestone, and at Aldinga Bay where it unconformably overlies the Aldinga Limestone. In the road cutting leading down to the Port Willunga Jetty, the Hallett Cove Sandstone is approximately 20 feet thick.

<u>Lower Pliocene sandstone of the Adelaide Basin</u>

Extensive deposits of richly fossiliferous calcareous sandstones have been proved by borings in the Adelaide Basin and comments by the writer on these beds and their microfaunal content are given in the publication on the underground water resources of the Adelaide Basin (Miles, 1951). The lithology of these rocks closely resembles that of the Hallett Cove Sandstone, with which they are at least equivalent in age. The subsurface deposits have been widely referred to as the "Adelaidean" and "Adelaidean Stage", a name proposed by Howchin in 1928 (see Singleton, 1941, p.22). This name can easily be confused with the term "Adelaide Series" of Pre-Cambrian age.* Glaessner (1951, p.280) introduced the term "Dry Creek Sands" for the "fossiliferous strata first observed in the Dry Creek Bore from 320 feet to 410 feet". This name is unsatisfactory because hundreds of water-courses throughout Australia are called "Dry Creek".

Samples from twenty-seven bores in the Adelaide Basin, which were drilled through the lower Pliocene sandstone or bottomed in it, were examined for microfaunae. Consequently a unique opportunity was given to study it in considerable detail. The bores were as follows:

No.	18b.	Fulham Reserve	426-530	✓
No.	19	Holbrook's Bridge, Underdale	420-490	✓
No.	20	Findon Road, Findon	393-440	✓
No.	21	Torrens Outlet	340-487	✓
No.	27a	Welland	390-410	✓
No.	28	Woodville Grove	360-410	✓
No.	29	Harcourt Gardens	135-140	
No.	30	Cambden North	229-250	✓
No.	31	Keele Bridge, Lociley's	378-380	✓
No.	37	Frogmore	343-460	✓
No.	38	Torrensville	410-440	✓
No.	39	Flinders Park	403-456	✓
No.	40	Fremanton	384-475	✓
No.	41	St. James Park	384-424	✓
No.	56	Woodville Oval	320-360	✓
No.	65	Wolseley Plantation	385-568	
No.	66	Kilkenny Plantation	331-440	✓
No.	67	Beverley Reserve	391-443	✓
No.	69	Royal Park	301-365	✓
No.	75	Southwark	339-396	✓

✓ Denotes the last bore sample received for examination

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* The most appropriate name would be "Adelaide Sandstone" for these subsurface deposits in the Adelaide Basin because of their wide distribution and almost complete uniformity of lithology within the Basin. This usage, however, because of probable confusion with the "Adelaide Series" of Pre-Cambrian age, would be possible only if the "Adelaide Series", which actually outcrops only around the margins of the Adelaide Area and is typically developed in the Mt. Lofty Ranges, were renamed.

No. 80	M.T.T. Viaduct, Fulham	344-485 ⌿
No. 83	Twickenham-Netley	385-475 ⌿
T. Bamber's, Seaton Gardens		347-457 ⌿
A. E. Pape's, Fulham Gardens		368-467 ⌿
K. R. Weymouth's, West Beach		320-450 ⌿
B. Hann's, Flinders Park		320-492 ⌿
Nathan Brewery, Southmark		350-447 ⌿

⌿ Denotes the last bore sample received for examination.

The detailed examination of samples from the bores showed that two characteristic lithological types are present:

(i) A thin upper bed of ochreous, calcareous sandstone rather thinner in texture than the lower bed. The thickness ranges from 2 feet in Bore No. 41 at St. James Park to 49 feet in Bore No. 21 at Torrens Outlet Channel, Fulham. This bed is overlain by sands of Pleistocene age.

(ii) A thicker lower bed of coarse grey clacareous sandstone which is uniform in texture throughout the portion of the Basin which contains the bores listed above.

The greatest thickness of lower Pliocene sandstone is in Bore No. 65, Wolseley Plantation, Port Road, where 183 feet of fossiliferous sandstone were examined before the bore passed into the underlying Oaklands Limestone.

Table 1

Distribution of new and described species of foraminifera from different localities for the Blanche Point Limestone and Aldinga Limestone and from bores in the Adelaide Basin; and the age and country of the described species.

1. Christie's Beach, Port Noarlunga
2. Cliff at mouth of Onkaparinga River, Port Noarlunga
3. Maslin Beach, north of Blanche Point
4. *Turritella* Bed, Blanche Point
5. Aldinga Section, north and south of Port Wilunga Jetty
6. Four bores in the Adelaide Basin from which Upper Eocene species have been determined (See Section 5 for individual bores).

Foraminifera	1	2	3	4	5	6	Age and country of described species
Alabamina obtusa (B&H) var. *westraliensis* Parr	-	-	x	x	-	-	u. Eocene, W.Aust.
Angulogerina subangularis Parr	-	x	x	-	x	-	u. Eocene, W.Aust.
Angulogerina sp. 1	-	-	x	-	-	-	
Angulogerina sp. 2	x	-	x	x	x	-	
Angulogerina sp. 3	-	-	x	-	-	-	
Angulogerina sp. 4	-	-	x	-	-	-	
Angulogerina sp. 5	x	-	x	-	-	-	
Angulogerina sp. 6	x	-	x	x	-	-	
Angulogerina sp. 7	x	-	x	-	-	-	
Angulogerina sp. 8	x	-	x	-	-	-	
Anomalina perthensis Parr	x	x	x	x	x	x	u. Eocene, W.Aust.
Anomalina westraliensis Parr	x	-	x	x	-	-	u. Eocene, W.Aust.
Asterigerina adelaidensis (Howch.)	x	-	x	x	-	-	u. Eocene, S.Aust.
Asterigerina cyclops Dorreen	-	-	-	-	x	x	u. Eocene, N.Z.
Asterigerina sp.nov.	-	-	x	-	-	-	
Astrononion sp.nov.	x	-	x	-	-	-	
Baggatella sp.nov.	-	x	-	-	-	-	(genus) Eocene, U.S.
Bolivina carinata Terquem	x	-	-	-	-	-	m. Eocene, France
Bolivina gardnerae Cushman	-	-	x	x	x	-	u. Eocene, U.S.A.
Bolivina nobilis Hantken	-	-	x	-	-	-	u. Eocene, Hungary
Bolivina reticulata Hantken	x	-	-	-	-	-	u. Eocene, Hungary
Bolivina victoriana Cushman	-	-	-	-	x	x	u. Eocene, Victoria
Bolivinella alata Cush. & Bermudez	-	-	-	-	-	x	Eocene, Cuba
Bolivinita selmenensis Cushman	-	-	x	-	-	-	U. Cretaceous, U.S.A.
Bulimina cf. *jacksonensis* Cushman	-	-	-	x	x	-	u. Eocene, U.S.A.
Bulimina pupula Stache	-	-	-	x	-	-	Eocene, N.Z.

Foraminifera	1	2	3	4	5	6	Age and country of described species
Buliminella westraliensis Parr	-	x	-	-	x	x	u. Eocene, W.Aust.
Buliminella sp.nov.	-	x	-	-	-	-	
Calcarina sp.nov.aff. C. mackayi Karrer	-	x	x	-	-	-	
Cassidulina armosa Bandy	x	-	-	-	-	-	u. Eocene, California
Cassidulina diversa Cush. & Stone	x	-	-	-	-	-	Oligo, Hungary
Cassidulina globosa Hantken	x	-	-	-	-	-	Oligo, Hungary
Cibicides perforatus (Karrer) var. notocenicus Dorreen	-	x	-	-	x	x	u. Eocene, N.Z.
Cibicides perlucida Nuttall	-	x	x	-	-	-	l. Oligo., Mexico
Cibicides cf. praecursorius (Schw.)	-	-	x	-	-	-	m. Eocene, Egypt
Cibicides pseudoconvexus Parr	x	x	x	x	x	x	u. Eocene, W.Aust.
Cibicides pseudowuellerstorfi (Schwager)	-	x	-	-	-	-	Eocene, U.S.A.
Cibicides umbonifer Parr	x	x	x	x	x	x	u. Eocene, W. Aust.
Cibicides vortex Dorreen	-	-	-	-	x	x	u. Eocene, N.Z.
Cibicides, sp. 1	x	x	x	x	x	x	
Cibicides, sp. 3	x	-	x	-	-	-	
Cibicides, sp. 4	-	-	-	-	x	-	
Cornuspira byramensis Cushman	-	-	-	x	-	x	l. Oligo., U.S.A.
Crespinella sp.nov.	-	-	x	-	-	x	
Dentalina fissicostata Gumbel	-	-	-	-	-	x	Eocene, Germany
Dentalina soluta Reuss	x	-	-	-	-	-	Eocene, Germany
Dentalina subcostata Chapman	x	-	x	-	-	x	u. Eocene, N.Z.
Discorbinella sp. nov.	-	-	-	-	x	-	
Discorbis assulatus Cushman	-	x	x	-	x	-	u. Eocene, U.S.A.
Discorbis sp. 2	-	-	-	x	-	-	
Dorothia subglabra (Gumbel)	-	x	-	-	x	-	l. Eocene, Bavaria
Elphidium omotoensis Dorreen	-	-	-	-	x	x	u. Eocene, N.Z.
Eoannularia sp.nov.	-	x	-	-	-	x	(genus) m. Eocene, Cuba
Eponides repandus (F.&M.) var.nov.	x	-	-	x	x	x	
Eponides cf. toulmini Brotzen	x	-	x	-	x	-	Palaeocene, Sweden
Eponides sp.nov.	-	-	-	x	x	x	
Frondicularia tenuissima Hantk	-	-	x	-	-	-	l. Oligo., Hungary
Frondicularia sp.nov.aff. F. midwayensis Cushman	-	-	-	-	-	x	

Foraminifera	1	2	3	4	5	6	Age and country of described species
Glabratella crassa Dorreen	-	x	-	-	-	-	u. Eocene, N.Z.
Glabratella petalifera (Howe)	-	x	-	-	x	-	u. Eocene, U.S.A.
Glabratella sp. 1	-	x	-	-	x	-	
Glabratella sp. 2	-	x	-	-	-	-	
Globigerina mexicana Cushman	x	x	x	x	x	x	u. Eocene, Mexico
Globigerina triloculinoides Plummer	x	-	x	-	-	-	Palaeocene, U.S.A.
Globigerina sp.nov.	-	-	x	-	-	-	
Globorotalia chapmani Parr	x	-	-	-	x	-	u. Eocene, W.Aust.
Globorotalia sp.nov.	-	-	-	-	x	-	
Globulina sp.nov.	-	x	-	-	-	-	
Guttulina hantkeni Cush. & Ozawa	-	-	x	-	-	x	Eocene, Hungary
Guttulina spicaeformic (Roemer)	-	-	x	-	-	x	l. Oligo., Germany
Gyroidina soldanii (d'Orb.) var. octocamerata Cush. & Hanna	x	-	x	-	-	-	u. Eocene, U.S.A.
Hantkenina alabamensis Cushman subsp. compressa Parr	-	-	x	-	-	-	u. Eocene, Victoria
Heronallenia pusilla Parr	-	-	x	-	-	-	u. Eocene, W. Aust.
Heronallenia vicksburgensis. Cush.	x	x	x	-	x	-	l. Oligo., U.S.A.
Heronallenia sp.nov.aff. lingulata (B. & H.)	-	-	-	-	x	-	
Lagena fenestrissima Howe & Ellis	-	-	x	-	-	-	Eocene, U.S.A.
Lagena perthensis Parr	x	x	x	-	-	x	u. Eocene, W.Aust.
Lagena scarenaensis Hantken var. glabrata Selli	x	-	x	-	-	-	m. Eocene, Italy
Marginulina subbullata Hantken	-	x	-	-	-	-	l. Oligo., Hungary
Massilina torquayensis (Chapman)	-	-	-	-	x	x	u. Eocene, Victoria
Miliola cf. jacksonensis (Cushman)	-	-	-	-	-	x	Eocene, U.S.A.
Nonionella crassipunctata Cush.	-	-	x	-	-	-	l. Oligo., U.S.A.
Nonionella hantkeni (Cush. & Applin)	-	-	-	-	-	x	Eocene, U.S.A.
Notorotalia stachei Finlay	-	-	-	-	x	-	Eocene, N.Z.
Notorotalia sp. 1	-	-	-	-	x	-	
Patellina sp. nov.	-	x	-	-	-	-	
Pavoninoides sp.nov.	-	x	-	-	-	-	(genus) Oligo., Panama
Planorbulina macphersoni Finlay	-	x	x	-	x	-	Eocene, N.Z.
Pseudobulimina glaessneri Howe & Roberts	x	x	-	-	-	-	Eocene, U.S.A.
Pseudoglandulina clarkei Parr	-	-	x	-	x	x	u. Eocene, W.Aust.
Pseudopolymorphina rutila (Cush.) var. parri Cushman & Ozawa	-	-	-	-	-	x	u. Eocene, Victoria
Pullenia eocenica Cush. & Siegfus	x	x	x	-	-	-	Eocene, U.S.A.

Foraminifera	1 2 3 4 5 6	Age and country of described species
Quinqueloculina moodeysensis Cushman & Todd	- - - - - x	Eocene, U.S.A.
Quinqueloculina ornithopetra Crespin	- - - - - x	u. Eocene, Victoria
Quinqueloculina cf. whitei Beck	- - - - - x	u. Eocene, U.S.A.
Reussella finlayi Dorreen	- x - - x x	u. Eocene, N.Z.
Reussella limbata (Terquem)	- x - - - -	Eocene, France
Reussella oberburgensis (Freyer)	- x - - - -	Eocene, Germany
Reussella révurvata (Halkyard)	- x - - - -	Eocene, France
Robulus alato-limbosus (Gumbel)	- - x - - -	Eocene, Austria
Robulus inornatus (d'Orb.)	- - x - - -	Eocene, Austria
Robulus limbosus (Reuss)	- - x - - -	Eocene, Austria
Robulus limbosus var. hockleyensis Cushman	- - x - - -	Eocene, U.S.A.
Robulus gyroscalprum (Stache)	x - x - - -	Eocene, N.Z.
Robulus pseudovortex Cole	- - - x - -	Eocene, Mexico
Rotorbinella finlayi (Dorreen)	- x - - x x	u. Eocene, N.Z.
Sherbornina atkinsoni Chapman	- x - x x x	u. Eocene, Tasmania
Sigmoidella plummerae Cush. & Ozawa	- - - - x x	Eocene, U.S.A.
Sigmomorphina jacksonensis C. & O.	- - x - - x	Eocene, U.S.A.
Sigmomorphina vaughani C. & O.	- x x - - x	Eocene, U.S.A.
Sigmomorphina wilcoxensis Cushman and Ponton	- x - - - -	Eocene, U.S.A.
Spiroplectammina mississippiensis (Cushman)	x x - - - -	l. Oligo., U.S.A.
Spiroplectammina mississippiensis var. álabamensis Cushman	- x - - x -	l. Oligo., U.S.A.
Spiroplectemmina wilcoxensis Cushman and Ponton	x - - - - -	Eocene, U.S.A.
Stomatorbina torrei (Cush. & Bermudez)	- x x x - x	Eocene, Cuba
Textularia adalta Cushman	- x x - - -	Eocene, U.S.A.
Vaginulina subplumoides Parr	- - - - x -	u. Eocene, W. Aust.
Victoriella plecte Chapman	- - x - - -	u. Eocene, Victoria

FORAMINIFERAL ASSEMBLAGES OF THE FORMATIONS

Foraminifera are abundant in the Blanche Point Limestone but are not so abundant in the Aldinga Limestone, Oaklands Limestone, Hallett Cove Sandstone, and its equivalent, the lower Pliocene sandstone of the Adelaide Basin. Characteristic assemblages are present in each of them; these are discussed below. The distribution of many described species found in the Blanche Point Limestone and the Aldinga Limestone and in samples from bores which penetrated beds of upper Eocene age, together with the country in which these species were described, is given in Table 1.

Maslin Sandstone

Fossils are difficult to recognise in the Maslin Sandstone because of their replacement by limonite, most probably after glauconite. The recognizable forms include foraminifera, echinoid spines, bryozoa, and small mollusca. The foraminifera which could be determined are:

Globulina gibba
Quinqueloculina sp.
Spirillina cf. *decorata*

Blanche Point Limestone

A rich and distinctive assemblage of foraminifera is present in the glauconitic limestone composing the Blanche Point Limestone at the type locality at Maslin Beach, at Christie's Beach, Port Noarlunga, and in the cliff near the mouth of the Onkaparinga River south of Port Noarlunga. The assemblage contains species described by Parr from upper Eocene deposits in the King's Park Bore, Perth, (1938), and by American and European workers from various Eocene deposits elsewhere. The late W.J. Parr in a personal communication to the writer indicated his discovery of the Eocene genus *Hantkenina* in the limestone immediately overlying the Maslin Sandstone at Maslin Beach. However, the writer has been unable to find this important zonal form in the considerable amount of material examined from the bed indicated by Sir Douglas Mawson as being the one from which Parr had collected his sample. Mr. A.C. Collins kindly permitted the examination of the specimen collected by Parr.

In the Maslin Beach material, several species described from the Eocene of Western Australia, New Zealand, America, and Europe are present. They include Alabamina obtusa var. westraliensis, Angulogerina subangularis, Anomalina perthensis, Asterigerina cyclops, A. adelaidensis, Bolivina carinata, B. nobilis, B. reticulata, Cibicides pseudoconvexus, C. umbonifer, C. vortex, Globigerina mexicana, Heronallenia pusilla, Hantkenina alabamensis subsp. compressa, Lagena perthensis, Pseudoglandula clarkei, Planorbulina macphersoni, Pullenia eocenica, and Stomatorbina torrei. A new species of Crespinella is a persistent form at Maslin Beach, and the restricted upper Eocene species Victoriella plecte is also present.

In the glauconitic limestones at Christie's Beach and in the cliff section at the mouth of the Onkaparinga River, Port Noarlunga, many Eocene species are present. The assemblage includes many new species of Angulogerina which are also found at Maslin Beach and which have affinities with American Eocene and lower Oligocene species. Many of the species listed above from the Maslin Beach section are present in the assemblage as well as Cassidulina armosa, C. diversa, Cibicides pseudowuellerstorfi, Dorothia subglabra, Glabratella crassa, G. cf. petalifera, Globorotalia chapmani, Pseudobulimina glaessneri, Reussella finlayi, R. recurvata, Rotorbinella finlayi, Sherbornina atkinsoni, and Sigmomorphina wilcoxensis. The genus Eoannularia, which is also present, has been described from the middle Eocene of Cuba.

Aldinga Limestone

The foraminiferal assemblage in the beds of the Aldinga Limestone contains species already listed from the underlying Blanche Point Limestone. A complete list of species is given in Table I. However, genera are not so varied nor are species so numerous as in the underlying Formation. This is probably owing to the character of the sediments of the Aldinga Limestone, which contain more bryozoa, and which, in some places, are more sandy than those in the beds constituting the Blanche Point Limestone.

Upper Eocene species in the Aldinga Limestone previously recorded from the Blanche Point Limestone include Angulogerina subangularis, Anomalina perthensis, Cibicides umbonifer, C. pseudoconvexus, Discorbis assulatus, Glabratella petalifera, Globigerina mexicana, Globorotalia chapmani, Massilina torquayensis, Pseudoglandulina clarkei, Rotorbinella finlayi, Reussella finlayi, and Sherbornina atkinsoni.

The dominant form is Sherbornina atkinsoni, which is found with Victoriella plecte, Hantkenina alabamensis subsp. compressa, and Massilina torquayensis at Bird Rock, Torquay, Victoria. All samples collected between the southern side of Blanche Point and south of Port Willunga Jetty contained this species. However, Asterigerina adelaidensis and Crespinella sp.nov. were not recorded from beds of the Aldinga Limestone.

Assemblage of Foraminifera in Samples from Bores in the southern part of the Adelaide Basin

An assemblage of foraminifera similar to those found in the Blanche Point Limestone and Aldinga Limestone was present at shallow depths in four bores examined from the southern part of the Adelaide Basin, namely:

Bore No. 25, Marion Road, Vermont, west boundary of Section 91, Hundred of Adelaide, between the depths of 150 feet and 254 feet.

Bore No. 47, Glendore, centre of north end of Section 51, Hundred of Adelaide, between the depths of 124 feet and 240 feet.

Bore on Ackland's property, Glendore, Section 52, Hundred of Adelaide, between the depths of 155 feet and 160 feet.

Bore on Ivimey's property, Warradale, north-west corner, Section 140, Hundred of Noarlunga, between the depths of 206 feet and 270 feet.

The richest assemblage of species was in Bore No. 47, but many of the forms recorded from the Blanche Point Limestone and Aldinga Limestone were present in samples from other bores. The assemblage in the subsurface deposits include Anomalina perthensis, Asterigerina cyclops, Cibicides pseudoconvexus, C.vortex, C.umbonifer, Buliminella westraliensis, Eoannularia sp.nov., Massilina torquayensis, Rotorbinella finlayi, Sherbornina atkinsoni, Stomatorbina torrei, Lagena perthensis, and Quinqueloculina ornithopetra.

Oaklands Limestone

The foraminiferal assemblage in the rocks composing the Oaklands Limestone, which has its type section in Bore No. 36, Oaklands Railway Station, 10 miles south of Adelaide, between the depths of 218 feet and 400 feet, has up to the present only been found in subsurface deposits. The distinctive feature of the assemblage is the presence of species of foraminifera which are regarded as characteristic of "f_1" stage (lower Miocene) deposits both in south-eastern and north-western Australia (see Section 6). The assemblage includes the following species:

Austrotrillina howchini (Schlumberger)
Calcarina verriculata (Howchin and Parr)
Cibicides victoriensis Chapman, Parr & Collins
Crespinella umbonifera (Howchin & Parr)
Elphidium adelaidense Howchin & Parr
Gypsina howchini Chapman
Marginopora vertebralis (Quoy & Gaimard)
Operculina victoriensis Chapman & Parr
Rotorbinella cycloclypeus (Howchin & Parr)
Sigmomorphina subregularis Howchin & Parr

In Victoria A.howchini, C.verriculata, C.umbonifera, G.howchini, and O.victoriensis are usually associated with Lepidocyclina; A.howchini and G.howchini are described from Lepidocyclina limestones at Hamilton and Batesford respectively. O.victoriensis was described from beds in Victoria without Lepidocyclina but of equivalent age. C.verriculata, C.umbonifera, and S.subregularis were described by Howchin and Parr (1938) from limestones in the Metropolitan Abattoirs Bore, Adelaide, which are now regarded as part of the Oaklands Limestone; they are found in the Lepidocyclina limestones at Hamilton and Batesford. The association of Austrotrillina howchini and Marginopora vertebralis occurs not only in the

Oaklands Limestone, but also in bores in the Mallee and Wimmera Districts of north-western Victoria and in limestones in North-West Australia.

Also present in the microfauna of the Oaklands Limestone are Elphidium adelaidensis, Epistomaria polystomelloides, and Rotorbinella cycloclypeus, which, together with M.vertebralis, are prominent in the assemblage in the overlying lower Pliocene sandstone. All but the last species were described by Howchin and Parr (1938) from the lower Pliocene deposits in the Adelaide Plains.

A description of the foraminiferal content of samples from Bore No. 36, Oaklands Railway Station, between the depths of 218 feet and 400 feet, - which is the type subsurface section for the Oaklands Limestone -, is given in detail.

218-226 feet. Moderately hard grey limestone with glauconite, foraminifera, and poorly preserved bryozoa.

Austrotrillina howchini
Marginopora vertebralis
Operculina victoriensis

220-226 feet. Moderately hard grey limestone with glauconite, numerous foraminifera, and a few ostracoda.

Acervulina inhaerens
Amphistegina lessonii
Anomalina glabrata
Austrotrillina howchini
Cibicides victoriensis
Dentalina fissicostata
Dorothia parri
Elphidium adelaidense
Eponides repandus
Glandulina laevigata
Guttulina irregularis
Guttulina regina
Gypsina howchini
Marginopora vertebralis
Miniacina minuta
Nonion depressulus
Operculina victoriensis
Quinqueloculina vulgaris
Sigmoidella kagaensis
Spirillina decorata

226-260 feet. Bryozoal limestone, with numerous glauconite grains, foraminifera, poorly preserved bryozoa, and ostracoda.

Amphistegina lessonii	Guttulina regina
Austrotrillina howchini	Marginopora vertebralis
Carpenteria proteiformis	Quinqueloculina ammophila
Cibicides victoriensis	Quinqueloculina lamarckina
Dorothia parri	Quinqueloculina vulgaris
Elphidium adelaidense	Rotorbinella cycloclypeus
Elphidium parri	Sigmoidella elegantissima
Globulina gibba	Sigmoidella victoriensis
	Triloculina tricarinata

260-270 feet. Cream limestone with fossil remains (including foraminifera) almost completely recrystallised.

Elphidium chapmani
Gypsina howchini
Operculina victoriensis

280-310 feet. Dark grey sandy limestone with a few foraminifera and ostracoda.

Anomalina subnonionoides	Guttulina (Sigmoidina) silvestrii
Calcarina verriculata	Lagena marginata
Cassidulina subglobosa	Liebusella antipodum
Cibicides refulgens	Lagena favosopunctata
Cibicides victoriensis	Planorbulina mediterranensis
Dorothia parri	Planulina wuellerstorfi
Elphidium crassatum	Pseudopolymorphina rutila var. parri
Elphidium parri	Sherbornina atkinsoni
Eponides scabriculus	Sigmoidina victoriensis
Frondicularia lorifera	Sphaeroidina bulloides
Gaudryina collinsi	Spirillina decorata
Glandulina laevigata	Trifarina bradyi
Guttulina irregularis	Triloculina tricarinata
Guttulina lactea	

310-312 feet. Cream sandy limestone with foraminifera (Operculina victoriensis common).

Anomalina glabrata	Elphidium parri
Astrononion australe	Globigerinoides trilobus
Bolivina sp.	Gypsina howchini
Calcarina verriculata	Operculins victoriensis
Carpenteria rotaliformis	Operculina victoriensis var.nov.

Cibicides sp.nov.
Dentalina obliqua
Elphidium adelaidense
Rotorbinella balcombensis
Sherbornina sp.nov.
Sigmoidella elegantissima
Textularia sagittula

312-350 feet. Cream bryozoal sandy limestone with foraminifera. (Calcarina verriculata and Crespinella umbonifera common).

Calcarina verriculata
Cibicides victoriensis
Clavulinoides szaboi var. victoriensis
Crespinella umbonifera
Guttulina regina var. crassicostata
Guttulina (Sigmoidina)silvestri
Gypsina howchini
Miniacina minuta
Operculina victoriensis
Quinqueloculina vulgaris
Rotorbinella balcombensis
Sigmomorphina subregularis

350-380 feet. Greyish sandy limestone with foraminifera and ostracoda.

Anomalina subnonionoides
Austrotrillina howchini
Calcarina verriculata
Carpenteria rotaliformis
Clavulinoides szaboi var. victoriensis
Cibicides sp.nov.
Discorbis cycloclypeus
Elphidium adelaidense
Elphidium crassatum
Eponides scabriculus
Glandulina laevigata
Gypsina howchini
Lagena hexagona
Marginulina costata
Massilina lapidigera
Miniacina minuta
Operculina victoriensis
Sherbornina atkinsoni
Sigmoidella elegantissima

380-400 feet. Yellowish bryozoal sandy limestone with foraminifera and abundant glauconite.

Anomalina glabrata
Anomalina subnonionoides
Calcarina verriculata
Cibicides victoriensis
Clavulinoides szaboi var. victoriensis
Crespinella umbonifera
Discorbis bertheloti
Dorothia parri
Elphidium parri
Eponides scabriculus
Sherbornina sp.nov.
Sigmoidella elagantissima

From 218 feet down to 270 feet the foraminiferal assemblage is dominated by Austrotrillina howchini and Marginopora vertebralis. From 270 feet down to the bottom of the bore at 400 feet, the lithology changes from limestone to sandy limestone in which Marginopora is not recorded. However, A.howchini is present at 350-380 feet and other typical Miocene species such as Crespinella umbonifera and Calcarina verriculata persist down to the last sample at 400 feet. Two species of Sherbornina are also present in some samples. One species is new, and has already been collected, but not yet described, from "f_1" stage limestones in Victoria. The other closely resembles S.atkinsoni, which is common in the Aldinga Limestone.

Hallett Cove Sandstone

The beds composing the Hallett Cove Sandstone contain an assemblage of fossils which is also found in the lower Pliocene sandstone of the Adelaide Basin and which is distinctive in the Tertiary deposits of south-eastern Australia. The assemblage includes calcareous algae, foraminifera, corals, echinoids, mollusca and ostracods.

Howchin determined only one species of foraminifera from the type locality for the Hallett Cove Sandstone, which is situated near the top of the cliff about half a mile south of Hallett Railway Station, about 14 miles south of Adelaide. The species was Marginopora vertebralis which is common in the hard calcareous sandstone - some of the tests have a diameter of 25 mm. Examination of material collected at this locality has yielded twenty-six species of foraminifera and the assemblage is typical of that found in subsurface deposits in the Adelaide Basin. The species recognised are as follows:

Clavulina multicamerata Chapman,
Cribrobulimina polystoma (Parker & Jones)
Discorbis acervulinoides Parr
Elphidium adelaidense Howchin & Parr
Elphidium crispum (Linné)
Epistomaria polystomelloides (Parker & Jones)
Guttulina problema (d'Orbigny)
Marginopora vertebralis Quoy & Gaimard

Nubecularia lucifuga Defr.var. lapidea Wiesner
Peneroplis pertusus (Forskal)
Pyrgo sp.
Quinqueloculina boueana d'Orbigny
Quinqueloculina vulgaris d'Orbigny
Reophax scorpiurus Montfort var.testacea Wiesner
Rotalia beccarii (Linné)
Rotorbinella cycloclypeus (Howchin & Parr)
Sigmoidella elegantissima (d'Orbigny)
Sigmoilina australis (Parr)
Sorites marginalis (Lamarck)
Triloculina tricarinata d'Orbigny
Triloculina trigonula (Lamarck)
Triloculinella bucculenta (Brady)
Triloculinella oblonga (Montford)
Valvulina davidiana Chapman
Valvulina fusca(Williamson)

Lower Pliocene sandstone of the Adelaide Basin

Howchin (1928) stated that the fauna in the subsurface deposits in the Adelaide Basin represented "a geological stage in the Newer Tertiaries that is purely local and limited to the Adelaide Basin". He apparently did not recognise this fauna as being similar to that found in the exposed deposit at Hallett Cove. Singleton (1941) similarly referred to these beds as "known only in borings beneath the Adelaide Plains".

Eighty-one species of foraminifera have been determined from the bores in the lower Pliocene sandstone of the Adelaide Basin. Fifty-one of these have a stratigraphical range from Miocene up to Recent and consequently are of little age value. The most striking feature of the assemblage is the uniformity of occurrence of certain species in almost every sample examined. Several of the species were described by Howchin and Parr (1938) from the Metropolitan Abattoirs Bore, Adelaide.

The characteristic species of the assemblage are:

Clavulina multicamerata Chapman
Cribrobulimina polystoma (Parker & Jones)
Discorbis acervulinoides Parr
Discorbis dimidiatus (Parker & Jones)
Elphidium adelaidense Howchin & Parr
Elphidium rotatus Howchin & Parr
Epistomaria polystomelloides (Parker & Jones)
Flintina triquetra (Brady)
Flintina intermedia Howchin
Guttulina regina (Parker & Jones)
Marginopora vertebralis Quoy & Gaimard
Nubecularia lucifuga Defr, var. lapidea Wiesner
Peneroplis pertusus (Forskal)
Quinqueloculina adelaidensis Howchin & Parr
Quinqueloculina ammophila Parr
Rotalia beccarii (Linné)
Rotorbinella cycloclypeus (Howchin & Parr)
Sorites marginalis (Lamarck)
Valvulina davidiana Chapman
Valvulina fusca (Williamson)

The assemblage is dominated by Recent species typical of warm to tropical waters; these include Marginopora vertebralis, Sorites marginalis, Peneroplis pertusus, Valvulina davidiana, and V. fusca. All these forms are found in the vicinity of coral reefs in the Indian and Pacific Oceans. Commonly associated with this assemblage are several species of the Miliolidae such as Quinqueloculina lamarckiana, Q. polygona, Q. disparilis, Q. boueana, Triloculina tricarinata, Spiroloculina antillarum, and two species of the Polymorphinidae, Sigmoidella elegantissima and S. kagaensis.

AGE OF THE FORMATIONS AND CORRELATIONS OF THE FORAMINIFERAL ASSEMBLAGES WITH SIMILAR ONES ELSEWHERE IN AUSTRALIA

Table 2 below shows the stratigraphical sequence, age, and foraminiferal assemblages found in the beds of the different formations in the Adelaide-Aldinga area. The formational boundaries coincide with the upper and lower limits of the foraminifera assemblages found in the beds composing the Blanche Point Limestone, Aldinga Limestone, Oaklands Limestone, and Hallett Cove Sandstone.

The lower Pliocene sandstone of the Adelaide Basin must be considered with the Hallett Cove Sandstone because of their similarity in age and foraminiferal assemblage. Certain zonal species are indicative of age and the foraminiferal assemblages represent well-known stages in Victorian Tertiary stratigraphy. Definite determination has been made possible by recent detailed work on measured sections at Bird Rock, Torquay, Victoria (Raggatt and Crespin, 1952) and in the North-West Basin, Western Australia (Crespin, 1950; Schneeberger, 1952). The discovery of Hantkenina alabamensis subsp. compressa in the basal strata at Bird Rock has definitely placed the beds belonging to the Janjukian Stage in that area as upper Eocene. Previous records of the occurrence of Hantkenina in the Victorian Tertiaries were made by Parr (1947) from Brown's Creek coastal section and Hamilton Creek in the Otway area.

The stratigraphical range of Austrotrillina howchini, the important Miocene ("f_1" stage) zonal species in the Indo-Pacific region, has been fairly definitely established by detailed work on measured stratigraphical sections in North-West Australia. However, the upper limit of the species in south-eastern Australia is not yet satisfactorily determined, and it may range slightly higher there than in Western Australia and the Indo-Pacific generally. This point will only be proved by more detailed work on measured sections in Victoria.

The leaf-bearing beds north of Blanche Point (Chapman, 1935) are not included in this sequence because of their stratigraphical position has not been definitely determined in relationship to the Maslin Beach section. It is quite probable that they are middle Eocene in age.

Two important features, one relating to stratigraphy and the other to faunal assemblages, are illustrated in Table 2.

1. Two major stratigraphical breaks have been proved -
   (a) Between the upper Eocene and lower Miocene ("f_1" stage)
   (b) Between the lower Miocene ("f_1" stage) and the overlying lower Pliocene.

Table 2

Succession, age, probable stage correlation, and foraminiferal assemblages of the Formations

Epoch	Stage		Formation	Foraminiferal Assemblages
	Victoria	Indo-Pacific		
Lower Pliocene	Kalimnan	-	Hallett Cove Sandstone and equivalent subsurface sandstone (Adelaide Basin)	Marginopora vertebralis, Peneroplis pertusus, Flintina intermedia, F. triquetra, Elphidium adelaidense, E. rotatum, Epistomaria polystomelloides, Discorbis acervulinoides, Rotalia beccarii, Rotorbinella cycloclypeus, Valvulina davidiana, V. fusca.
Lower Miocene	Balcombian	"f_1"	Oaklands Limestone	Austrotrillina howchini, Marginopora vertebralis, Gypsina howchini, Calcarina verriculata, Crespinella umbonifera, Operculina victoriensis, Shernbornina sp. nov.
Upper Eocene	Janjukian	-	Aldinga Limestone	Sherbornina atkinsoni, Massilina torquayensis, Pseudopolymorphina rutila var. parri, Asterigerina cyclops, Cibicides vortex, C. umbonifer, Rotorbinella finlayi.
			Blanche Point Limestone	Asterigerina adelaidensis, Crespinella, sp. nov., Stomatorbina torrei, Eoannularia sp. nov., Hantkenina alabamensis subsp. compressa, Glabratella, Pseudobulimina glaessneri.
? Eocene-Palaeocene			Maslin Sandstone	No zonal species

2. Four characteristic assemblages can be correlated with similar assemblages elsewhere -
   (a) The upper Eocene assemblage is composed of small species which are found in Eocene - chiefly upper Eocene - deposits of Western Australia, New Zealand, America, and Europe.
   (b) The "f_1" stage (lower Miocene) and lower Pliocene assemblages contain species characteristic of deposits of those ages throughout the Indo-Pacific region.

1 (a) The stratigraphical break between the upper Eocene and lower Miocene is apparently a widespread feature. It has been found in parts of the North-West Basin, Western Australia (Crespin, 1950), and in other countries in the Indo-Pacific region (van Bemmelen, 1949). It is known in Western India and Pakistan (Eames, 1952), and along the west coast of California (Laiming, 1940).

1 (b) The stratigraphical break between the lower Miocene and the overlying lower Pliocene which is found in the subsurface deposits of the Adelaide Basin is apparently also widespread. A similar break is present in the Exmouth Gulf area, Western Australia, where the lower Pliocene beds unconformably overlie beds assigned to "f_1" stage.

2. In discussing the distinct foraminiferal assemblages found in the different formations and their relationships with similar assemblages elsewhere, it is necessary to discuss each formation individually.

(a) Upper Eocene Assemblages
Blanche Point Limestone

The age of the beds composing the Blanche Point Limestone is based on the discovery by the late W.J. Parr (personal communication) of the typical upper Eocene species *Hantkenina alabamensis* subsp. *compressa* in the basal limestone at Maslin Beach, north of Blanche Point, Aldinga; on the discovery by the writer, in the beds at the mouth of the Onkaparinga River, Port Noarlunga, of *Eoannularia*, a genus described by Cole and Bermudez (1944) from the middle Eocene of Cuba; and on the presence of certain species at Christie's Beach, Port Noarlunga, in the cliff section at the mount of the Onkaparinga River, south of Port Noarlunga, and at Maslin Beach, which are similar to forms found in the Eocene deposits of America, Europe and New Zealand. The genus Angulogerina, which is characteristic of the Eocene and lower Oligocene of America and Europe, is represented by several new species, which have close affinities with those described from overseas deposits. Furthermore, several species described by Parr (1938) from the King's Park Bore, Perth, and referred by him to the upper Eocene, are also present. Coleman (1952) supports Parr's determination of an upper Eocene age for the Perth beds. The foraminiferal assemblage in the Blanche Point Limestone suggests correlation with the Janjukian Stage of Victorian Tertiary stratigraphy.

Aldinga Limestone

The foraminiferal assemblage in the beds of the Aldinga Limestone is also referred to the upper Eocene. Recorded species include some of those described from the upper Eocene of the Perth bores (Parr, 1939) such as Cibicides pseudoconvexus, C.umbonifer, Globorotalia chapmani, Anomalina perthensis, Buliminella westraliensis, and Vaginulina subplumoides; of New Zealand (Finlay, 1947; Dorreen, 1948) such as Asterigerina cyclops, Cibicides vortex, Rotorbinella finlayi, Notorotalia stachei; and of south-western Victoria and Tasmania (Chapman, 1921, 1922) such as Massilina torquayensis and Sherbornina atkinsoni. M.torquayensis is a characteristic species of the basal part of the Bird Rock section, Torquay, where it occurs in a very restricted zone. S.atkinsoni, is associated with that species in the same section (Raggatt and Crespin, 1952). It is also found in the Blanche Point Limestone.

Upper Eocene beds in bores in the Adelaide Basin

Samples at certain depths in four bores in the southern part of the Adelaide Basin must now be regarded as of upper Eocene age rather than lower Miocene (Crespin in Miles, 1951). The bores and the depths between which upper Eocene foraminifera were found are:

Bore No. 25, Marion Road, Vermont, west boundary of Section 91, Hundred of Adelaide, between 150 feet and 254 feet.

Bore No. 47, Glendore, centre of north end of section 51, Hundred of Adelaide, between 125 feet and 240 feet.

Bore on Ackland's property, Glendore, Section 52, Hundred of Adelaide, between 155 feet and 160 feet.

Bore of S.A. Ivimey's property, Warradale, N.W. corner, Section 140, Hundred of Noarlunga, between 206 feet and 270 feet.

Further material from the samples was washed and additional species were found. The upper Eocene species include Asterigerina cyclops, Anomalina perthensis, Bulimina westraliensis, Cibicides vortex, C. pseudoconvexus, C. umbonifer, Eoannularia sp.nov., Massilina torquayensis, Quinqueloculina ornithopetra, and Sherbornina atkinsoni.

Asterigerina adelaidensis, described by Howchin (1882) as "Truncatulina margaritifera Brady var. Adelaidensis nov." from the old Kent Town Bore near Adelaide, is possibly an important zonal for beds of the Blanche Point Limestone. The occurrence of this species associated with other widely distributed Eocene species supports the view that beds of Eocene age exist at considerable depth north of the four bores listed above.

(b) "f_1" stage (lower Miocene) and lower Pliocene Assemblages

(i) Oaklands Limestone

The foraminiferal assemblage in the beds of the Oaklands Limestone is characteristic of "f_1" stage (lower Miocene) of the Indo-Pacific Tertiary "letter classification" and of the Lepidocyclina horizon in the Victorian Tertiary (Crespin, 1948). Since the writer published the work on the Lepidocyclinae of Victoria, further evidence has been available which suggests that the beds containing Lepidocyclina belong to "f_1" stage rather than to "f_2-f_2" stage (Crespin, 1943). The assemblage in the beds of the Oakland Limestone is dominated by Austrotrillina howchini (Schlumberger) together with Crespinella umbonifera (Howchin and Parr) and

Gypsina howchini Chapman and other species listed on p. 17-20 and in Crespin, (1936). Limestones in North-West Australia containing Austrotrillina howchini as well as other species listed on p. 17-20 and in Crespin (1936) have been assigned to "f_1" stage. Similar assemblages have been found in bores in western Victoria, as in the Dimboola Bore (Crespin in Gloe , 1947) and in some of the Mallee Bores (Chapman, 1916).

2. Hallett Cove Sandstone and lower Pliocene Sandstone of the Adelaide Basin

The age of the subsurface fossiliferous sandstone in the Adelaide Basin, which has been referred to as the "Adelaidean" stage, has been under discussion for many years. Amongst the more recent suggestions regarding age are those put forward by Howchin and Parr (1938, p.289) who based their conclusion of an upper Pliocene age on the foraminifera; by N.H. Ludbrook (née Woods) who, on evidence of the mollusca said firstly that the beds were lower Pliocene (in Segnit, 1940 p.38) and later (Ludbrook, 1941, p.80) that they should be classified as "Lower-Middle Pliocene"; and by Singleton (1941,p.60 and Table), who placed them in middle Pliocene, again on evidence of the mollusca. The writer considers the age of the Hallett Cove Sandstone and the subsurface sandstone of the Adelaide Basin to be lower Pliocene.

Workers on Pliocene foraminiferal and molluscan faunas in the Indo-Pacific region found considerable difficulty in dividing the Pliocene into upper, middle, and lower (van Bemmelen, 1949); and there is little doubt that the age determination must be based on the evidence of the mollusca rather than the foraminifera. Cotton and the writer (in Miles, 1951), in their investigations into the mega- and micro-faunas respectively from 27 bores in the Adelaide Basin, concluded that the subsurface fossiliferous sandstones there should be referred to the lower Pliocene.

Cotton (in Miles, 1951) gave the following percentage of ranging species of the mollusca he determined:

Range of Species	Per Cent
Miocene to Recent	0
Miocene to "Adelaidean"	32
Characteristic of Kalimnan (lower Pliocene) in "Adelaidean"	14
Kalimnan (lower Pliocene) to Recent	1
"Adelaidean" to Recent	9
Restricted to "Adelaidean"	44
Total	100

Crespin gave the following resume of range of foraminifera:

Range of Species	Per Cent
Miocene to Recent	62
Miocene to "Adelaidean"	8
Restricted to Kalimnan (lower Pliocene)	1
"Adelaidean" to Recent	19
Restricted to "Adelaidean"	2
Total	100

Certain species of foraminifera such as Marginopora vertebralis, which have a stratigraphical range from Miocene to Recent, are characteristic of warm waters in Recent seas. It is suggested that the micro- and megafaunal assemblage in the Hallett Cove Sandstone and in the lower Pliocene sandstone of the Adelaide Basin is the result of a change in facies from the fine-grained sandstone of the lower Pliocene deposits of south-eastern Victoria, which were deposited in shallow temperate waters, to coarse-grained to fine-grained sandstones of the Adelaide-Aldinga area, which were deposited in shallow warm to subtropical waters from the Indo-Pacific region which invaded that part of southern Australia during Upper Tertiary times. Lithological conditions and the micro-faunal content of the sediments shown in 27 bores in the Adelaide Basin and in outcrops at Hallett Cove and southward to Aldinga are uniform in character. Similar conditions and faunas have been found east of this area, in the Murray cliffs at Mannum, and elsewhere along the Murray River, in South Australia (Cotton, 1947), and in central western Victoria, where evidence of the eastern limit of the old "Murray Gulf" is to be found (Crespin in Gloe, 1947).

NOTES ON SOME OF THE FORAMINIFERAL SPECIES

No new species are formally described in this Report, but a few comments are made on some of the more important described species as well as on some of the rarer undescribed forms which have been found during this investigation. Some of the described species are figured on Plates 6 and 7. The order of the genera is based on the Cushman Classification of 1948.

Genus VALVULINA d'Orbigny, 1826

Valvulina davidiana Chapman (Pl.6, fig.5)

Valvulina davidiana Chapman, 1900, p.9, pl.1, fig.4

This species was described from Funafuti Atoll, Ellice Group. It closely resembles V.triangularis d'Orb., from the Eocene of the Paris Basin; but it seems certain that the present species, which is found in the calcareous sandstone at Hallett Cove and in the lower Pliocene sandstone of the Adelaide Basin, is referable to the Recent form from the subtropical waters of the Pacific. The figured specimen comes from Bore No.69, Royal Park, Old Port Road, Adelaide, at 352-365 feet.

Valvulina fusca (Williamson) (Pl.6, fig.6)

Rotalina fusca Williamson, 1858, p.55,pl.5, figs.114-115

Valvulina fusca Brady, 1884, p.392, pl.49, figs.13,14; Cushman, 1921, p.143,pl.28, figs.1a,b.

This recent species is another that is typical of the assemblage in the Hallett Cove Sandstone and in the lower Pliocene sandstone of the Adelaide Basin and this record of its occurrence in the lower Pliocene deposits is apparently the first one of the species as a fossil in the southern Australian Tertiaries. It has been found in limestone of similar age in the North-West Basin, Western Australia. The figured specimen comes from Bore No.69, Royal Park, Old Port Road, Adelaide, at 352-365 feet.

Genus CRIBROBULIMINA Cushman, 1927

Cribrobulimina polystoma (Parker and Jones) (Pl.6, fig.4)

Valvulina sp. Parker & Jones in Carpenter, 1862, p.147, pl.1 figs. 19-21, 24-26

Valvulina polystoma Parker & Jones, 1865, pp.437,438

Cribrobulimina mixta Cushman, 1927, p.80, pl.11, figs.1-5

Cribrobulimina polystoma Parr, 1932, p.6, text-fig.1, pl.1, figs. 7a-b

This shallow-water form is a persistent species in the Hallett Cove Sandstone and in the lower Pliocene sandstone of the Adelaide Basin. It is also found in the shore sands just off shore west of Cape Nelson and across the Great Australian Bight (Parr, 1932). The figured specimens come from Bore No.69, Royal Park, Old Port Road, Adelaide, at 352-365 feet.

Genus QUINQUELOCULINA d'Orbigny, 1826

Quinqueloculina adelaidensis Howchin and Parr (pl.6, fig.3)

Quinqueloculina adelaidensis Howchin & Parr, 1938, p.293, pl.15, figs. 5,7

Howchin and Parr described this species from the Metropolitan Abattoirs Bore, Adelaide, where they found several specimens between the depths of 341 feet and 500 feet. It occurs at Hallett Cove but is scarce in the samples examined from bores in the Adelaide Basin. Q.adelaidensis is apparently restricted to the lower Pliocene deposits. The figured specimen comes from the Salisbury Bore, near Adelaide, at the depth of 330 feet.

Quinqueloculina ornithopetra Crespin

Quinqueloculina ornithopetra Crespin, 1950a, p.73, pl.10, figs. 7a, b.

This species was found in Bore No. 47, Glendore, Hundred of Adelaide between 174 and 240 feet. It was described from upper Eocene beds at the base of Bird Rock, Torquay, Victoria. It is apparently restricted to sediments of this age.

Genus MASSILINA Schlumberger, 1893

Massilina torquayensis (Chapman) (Pl.7, fig.13)

Spiroloculina torquayensis Chapman, 1921, p.320,pl.51, figs.1,2.

Massilina torquayensis Crespin, 1950a, p.73,pl.10, fig.8.

Chapman described this species from a bore near Bird Rock, Torquay, from the depth of 13 feet 3 inches down to 14 feet 3 inches, and it seems to be restricted to the lower part of the Janjukian Stage, which is upper Eocene. It is recorded from the Aldinga Limestone at the type locality for the Formation at Aldinga and from subsurface beds of equivalent age in the following bores in the Adelaide Basin: Ivimey's Bore, Warradale, between 206 and 226 feet; Bore No.25, Vermont, between 200 and 254 feet; Bore No.47, Glendore, between 159 and 240 feet, and Ackland's Bore, Glendore, between 155 and 160 feet. The figured specimen comes from Bore No.47, Glendore, between 174 and 240 feet.

Genus AUSTROTRILLINA Parr, 1942

Austrotrillina howchini (Schlumberger) (Pl.7, fig.14)

Trillina howchini Schlumberger, 1893, p.119, woodcut fig.1 and Pl.3, fig.6; Chapman, 1907, p.753,pl.34, fig.7-9; 1913, p.169,pl.16, fig.4; Crespin, 1936, pl.6,pl.1, figs.1,2.

Austrotrillina howchini Parr, 1942, p.361, figs.1-3.

Austrotrillina howchini is a prominent species in the beds composing the Oaklands Limestone and has only been found in the subsurface deposits in the Adelaide Basin. It is common in Bore No.36, Oaklands Railway Station, between the depths of 218 feet and 260 feet, and also in the Kinnish Bores Nos. 1 and 2, Direk, between the depths of 280 feet and 318 feet in No.1 Bore, and 265 feet and 365 feet in No.2 Bore. It is also present in Amber's Bore, Netley, between 294 feet and 334 feet. The figured specimen comes from Kinnish Bore No.1, Direk, between 280 and 318 feet.

Genus FLINTINA Schubert, 1911

Flintina intermedia (Howchin) (Pl.6, Fig.1)

Hauerina intermedia Howchin, 1889, p.4, pl.1, figs. 6a,b.
Flintina intermedia Parr, 1939, p.70, figs.24a, b.

Howchin described this species from lower Pliocene deposits (Kalimnan Stage) at Hamilton, Western Victoria. Its discovery in the calcareous sandstone in Bore No.69, Royal Park, Old Port Road, at the depth of 352-365 feet, is interesting because its presence gives support to the assignment of a lower Pliocene age for the subsurface calcareous sandstones in the Adelaide Basin. The figured specimen comes from Bore No.69, Royal Park at the depth of 352-365 feet.

Flintina triquetra (Brady) Pl.6, fig. 2

Miliolina triquetra Brady, 1879, p.268; 1884,p.181, pl.8, figs.8-10.

Flintina triquetra Chapman & Parr, 1935, p.4, pl.1, figs.2a,b; Howchin & Parr, 1938, p.295,pl.15, figs.11-13.

Howchin and Parr made the first record of this Recent species as a fossil when they found it in the lower Pliocene sandstone of the Adelaide Basin in the Metropolitan Abattoirs Bore. It is understood that Howchin found it at Hallett Cove but he made no record of this discovery. It was also found there during the present investigation. The figured specimen comes from the Salisbury Bore, near Adelaide, at 330 feet.

Genus FRONDICULARIA Defrance, 1826

Frondicularia tenuissima Hantken

Frondicularia tenuissima Hantken, 1875, p.43,pl.13, figs.11a,b.

A typical specimen of this beautiful species was found in the topmost bed of the Blanche Point Limestone in the Maslin Beach section near the steps leading down to the beach. It was described by Hantken from the lower Oligocene of Hungary.

Genus SIGMOMORPHINA Cushman and Ozawa, 1928

Sigmomorphina subregularis Howchin and Parr (Pl.7, fig.19)

Sigmomorphina subregularis Howchin & Parr, 1938, p.308,pl.18, figs. 2,11.

This species was described from the Metropolitan Abattoirs Bore, Adelaide, between 509 and 620 feet, in beds equivalent to the Oaklands Limestone. It occurs in samples from Bore No.36, Oaklands Railway Station, the type subsurface section for the Formation. It has also been recorded from "f_1" stage (lower Miocene) beds in No.1 Bore, Dimboola, in the Wimmera district of Victoria. The figured specimen comes from Nathan Brewery Bore, Southwark, Adelaide, at 509-524 feet.

Genus PSEUDOPOLYMORPHINA Cushman and Ozawa, 1928

Pseudopolymorphina doanei (Galloway and Wissler) (Pl.6, fig.7)

Polymorphina doanei Galloway & Wissler, 1927, p.54,pl.9, fig.8

Pseudopolymorphina doanei Cushman & Ozawa, 1930, p.95, pl.24, figs. 5a,b; Parr & Collins, 1937, p.200, pl.14, figs.2a-c.

This species is represented by several specimens in the bores in the Adelaide Basin which penetrated the lower Pliocene sandstone. It has been recorded from several localities in the lower Pliocene (Kalimnan Stage) of Victoria. The original specimen was from the Pliocene of San Pedro, California. The figured form comes from Bore No.83, Twickenham-Netley, at 410 feet.

Pseudopolymorphina rutila (Cushman) var.*parri*, Cushman & Ozawa, (Pl.7, fig.16.)

Pseudopolymorphina rutila (Cushman) var.*parri*, Cushman & Ozawa, 1930, p.100; Parr & Collins, 1937, p.201,pl 14,figs.4a-c.

The type specimen came from the upper Eocene (Janjukian Stage) beds at Rocky Point, near Bell's Headland, west of Torquay, not from Point Danger as stated by Cushman and Ozawa. The species occurs in Bore No.25, Vermont, Hundred of Adelaide, where it is associated with *Sherbornina atkinsoni* and *Massilina torquayensis* in the sample at 200-254 feet; in Bore No.47, Glendore, Hundred of Adelaide, between 174 and 340 feet; and in Ackland's Bore, Glendore, at the depth of 160 feet. The species is also found in "f_1" stage beds (lower Miocene) in Bore No.36, Oaklands Railway Station. The figured specimen comes from the depth of 270-310 feet in that bore.

Genus PENEROPLIS Montford, 1808

Peneroplis pertusus (Forskal) (Pl.6, fig.10)

Nautilus pertusus Forskal, 1775, p.125, No.65.

Peneroplis pertusus Jones, Parker & Brady, 1865, p.19; Brady, 1884, p.204, pl.13, figs.16,17; Cushman, 1917, p.86, pl.36, fig.1; pl.37, figs.1,2,6; Hofker, 1951, p.345, text figs. 23-28.

This species is present in the calcareous sandstone at Hallett Cove and is common in some of the bores in the lower Pliocene sandstone of the Adelaide Basin. It is a warm water form and flourishes in Recent seas in the Indo-Pacific region. The figured specimen comes from Bore No.37, Frogmore, Adelaide, at 405 feet.

Genus OPERCULINA d'Orbigny, 1826

Operculina victoriensis Chapman and Parr (Pl.7, fig.22)

Operculina bartschi Crespin, 1936 (non Cushman), pl.1, fig.12

Operculina victoriensis Chapman & Parr, 1938, p.284, pl.16, figs.3-8, text-fig.2; Howchin & Parr, 1938, p.309, pl.18, fig.10.

Operculina victoriensis was described from lower Miocene deposits at Red Bluff, Shelford, Victoria, and is a common form in the Lepidocyclina horizon throughout Victoria. It is also common in Bore No.36, Oakland Railway Station, Hundred of Adelaide, especially at the depth of 310-312 feet. The figured specimen comes from Nathan Brewery Bore, Southwark, at 535-555 feet.

Genus BOLIVINELLA Cushman, 1934

Bolivinella alata Cushman and Bermudez

Bolivinella alata Cushman & Bermudez, 1937, p.12, pl.1, fig.4.

This species was described from the Eocene of Cuba. The flattened spines on each side of the test and towards the base are a distinctive feature. It was found in the upper Eocene beds in Bore No.47, Glendore, at the depth of 174-240 feet.

Genus PSEUDOBULIMINA Earland, 1934

Pseudobulimina glaessneri Howe and Roberts, 1933, p.81, pl.11, figs. 9-11.

This interesting species was found in the limestone from the cliff at the mouth of the Onkaparinga River, south of Port Noarlunga. It was described from the upper Eocene of Cook Mountain, Louisiana.

Genus PAVONINOIDES Bermudez, 1949

Pavoninoides sp.

A typical specimen of this genus was found in the cliff section near the mouth of the Onkaparinga River, south of Port Noarlunga. Bermudez described it from the middle Oligocene, Madden Lake, Panama Canal Zone.

Genus ROTORBINELLA Bandy, 1944

Rotorbinella cycloclypeus (Howchin and Parr) (Pl.6, fig.9)
Discorbis cycloclypeus Howchin & Parr, 1938, p.302, pl.16, fig.11; pl.18, figs.5,12; pl.19, fig.13.

This species is placed in the new genus created by Bandy for the Discorbis-like forms which have a coarsely perforated test, an umbilical plug, and channelled sutures in the ventral surface. R.cycloclypeus was described from the lower Pliocene sandstone in the Cowandilla Bore, Adelaide Basin. It occurs at Hallett Cove and is common in many of the bores examined in the Adelaide Basin. It is also found in the lower Pliocene (Kalimnan Stage) at Muddy Creek, Hamilton, western Victoria, and in bores in the Adelaide Basin which penetrated the Oaklands Limestone ("f_1" stage), and in rocks of similar age in North-West Australia. The figured specimen comes from Bore No.31, Keele Bridge, Lockleys, near Adelaide, at 450 feet.

Rotorbinella finlayi (Dorreen)
Discorbis finlayi Dorreen, 1948, p.293, pl.38, figs.12a-c.

Dorreen, in describing D.finlayi from the upper Eocene of New Zealand, stated that it was with some hesitation that he placed the species in the genus Discorbis. He noted the coarsely perforated test, the channelled sutures on the ventral surface and the umbilical plug. He apparently did not know of Bandy's new genus Rotorbinella, R. finlayi, which is closely allied to the small Miocene species "Discorbis" balcombensis described by Chapman, Parr and Collins (1934) from the Balcombe Bay deposits, Mornington Peninsula, Victoria. There seems little doubt that it should be referred to this new genus. R. finlayi has been recorded from the upper Eocene deposits at the mouth of the Onkaparinga River, south of Port Noarlunga, and from the Aldinga Limestone at Aldinga.

Genus GLABRATELLA Dorreen, 1948

Glabratella crassa Dorreen

Glabratella crassa Dorreen, 1948, p.294, pl.39, figs.1a-d

Dorreen described this species from the upper Eocene of New Zealand. The genus is characterised by the simple round aperture in the centre of the ventral face; the test is inflated with the dorsal surface slightly roughened and the ventral surface smooth with fine radial striae. The present species comes from the upper Eocene limestones near the mouth of the Onkaparinga River, south of Port Noarlunga. Two new species of this genus also occur at this locality. Another form which is also found at that locality and in the Aldinga section seems referable to "Bulimina?" petalifera Howe described from the upper Eocene of Cook Mountain, Louisiana.

Genus EPISTOMARIA Galloway, 1933

Epistomaria polystomelloides (Parker and Jones) (Pl.6, fig.8)

Discorbis polystomelloides Parker & Jones, 1865, p.421, pl.19, figs.8a-c; Heron-Allen and Earland, 1915, p.698, pl.52, figs.19-23.

(?) Epistomaria polystomelloides Howchin & Parr, 1938, p.303, pl.17, figs.5-7, 11-13.

This species, described from Recent deposits, is a well-known one in Recent and Pliocene Indo-Pacific assemblages. It is well represented in the lower Pliocene sandstone of the Adelaide Basin and occurs at Hallett Cove. However, it makes an early appearance in the upper part of the Oaklands Limestone ("f_1" stage) where it is associated with Austrotrillina howchini. A specimen from Bore No.65, Wolseley Plantation, Port Road, has a diameter of 5 mm. The figured specimen comes from Bore No.69, Royal Park, Old Port Road, at the depth of 352-365 feet.

Genus CRESPINELLA Parr, 1942

Crespinella umbonifera (Howchin and Parr) (Pl.7, fig.21)

(?) Operculina umbonifera Howchin and Parr, 1938, p.309, pl.18, figs.3,4,13,14.

Crespinella umbonifera Parr, 1942, p.361, figs.4,5.

This form was described from "f_1" stage beds on the Metropolitan Abattoirs Bore, Adelaide, from the depth of 575-620 feet, and is a common species in the type subsurface section for the Oaklands Limestone, in Bore No.36, Oaklands Railway Station, especially in the sample at 312-350 feet. It is widely distributed in "f_1" limestone on the Nullarbor Plains, especially at Balladonia, Western Australia, and it has been found in limestones of similar age in the North-West Basin, Western Australia. It is recorded from No.1 Bore, Dimboola, north-western Victoria, where it is associated with Austrotrillina and Marginopora. It occurs rather commonly in the limestone immediately underlying the Lepidocyclina beds in the new quarry at Batesford. However, it is exceedingly scarce in the Miocene beds east of Batesford and it seems typical of assemblages which thrive in warm shallow waters such as existed in the Indo-Pacific region in Miocene times.

Crespinella sp.nov.

A form which is common in the Blanche Point Limestone at Maslin Beach is tentatively referred to the genus Crespinella. The surface is usually coarsely papillate, but the shape of the test and the position and shape of the aperture suggest affinities with this genus. The form has also been found in upper Eocene limestones in Western Australia.

Genus STOMATORBINA Dorreen, 1948

Stomatorbina torrei (Cushman and Bermudez)

Lamarckina torrei Cushman and Bermudez, 1937, p.21, pl.2, figs. 24-26.

Stomatorbina torrei Dorreen, 1948, p.226, pl.39, figs.4a-c.

The genus Stomatorbina was created by Dorreen to include many references to the species Pulvinulina concentrica or Eponides concentricus of Brady and allied species which have been recorded from the Indo-Pacific, Australia, and Europe. Dorreen found that the genus is characterised by a supplementary aperture or clear space on each ventral chamber. There is little doubt that the species recorded from the Blanche Point Limestone and the Aldinga Limestone is referable to that described by Cushman and Bermudez under the name "Lamarckina torrei" from the Eocene of Cuba, which Dorreen records from the upper Eocene of New Zealand. The species is also common in the upper Eocene deposits at Bird Rock, Torquay.

Genus ASTERIGERINA d'Orbigny, 1839

Asterigerina adelaidensis (Howchin) (Pl.7, fig.20)

Truncatulina margaritifera Brady var. adelaidensis Howchin, 1891, p.352, pl.13, figs.11-13.

This form described by Howchin has the characteristic angular supplementary chambers between the regular series of chambers that form a stellate pattern on the ventral surface of the genus Asterigerina. The type specimen came from the lowest beds in No.2 Bore, Kent Town near Adelaide, which was drilled for water (Tate,1882). The species occurs in the glauconitic limestone at Christie's Beach, Port Noarlunga, and it has recently been found in the upper Eocene beds between Brown's Creek and Johanna River, south-western Victoria. A.adelaidensis should be an important upper Eocene index species. The figured specimen comes from the glauconitic limestone (Blanche Point Limestone) at Maslin Beach, 12 feet above the top of the Maslin Sandstone, near the steps leading down to the beach near Uncle Tom's Cabin.

Asterigerina cyclops Dorreen

Asterigerina cyclops Dorreen, 1948, p.297, pl.40, figs.5a-c.

This species was described by Dorreen from the upper Eocene of New Zealand. Specimens were found in the southern part of the Adelaide Basin in beds regarded as upper Eocene in age. The bores are Ackland's Bore, Glendore, at the depth of 155-160 feet, and Bore No.47, Glendore, at 174-240 feet.

Genus CALCARINA d'Orbigny, 1826

Calcarina verriculata (Howchin and Parr)(Pl.7, fig.19)

Rotalia calcar Chapman (non d'Orbigny) 1910, p.289, pl.3, fig.2.

Rotalia verriculata Howchin & Parr, 1938, p.310, pl.19, figs. 8,9,11,15.

Calcarina verriculata Crespin, 1943, in lists.

C.verriculata was described from "f_1" stage limestones (equivalent to the Oaklands Limestone) in the Metropolitan Abattoirs Bore at the depth of 710-775 feet. It is common in Bore. No.36, Oaklands Railway Station, between 310 and 350 feet, and in Amber's Bore, Netley, between 362 and 435 feet. It is abundant in Victoria in the Lepidocyclina-bearing rocks at Batesford and Flinders, and in the Hamilton Bore, western Victoria. It also occurs in rocks of similar age in North-West Australia. The figured specimen comes from Amber's Bore, at 362-400 feet.

Genus HANTKENINA Cushman, 1924

Hantkenina alabamensis Cushman subsp.compressa Parr

Hantkenina alabamensis Cushman subsp.compressa Parr,1947, p.45, text-figs.1-6.

Hantkenina alabamensis Bronnimann, 1950, p.414, pl.56, figs.10, 14-16.

Hantkenina alabamensis subsp.compressa, Raggatt & Crespin, 1952, p.145.

This important upper Eocene form was found by the late W.J.Parr shortly before his death in 1949, in beds of the Blanche Point Limestone immediately overlying the Maslin Sandstone and immediately north of Blanche Point at Maslin Beach. Parr described his subspecies from Brown's Creek, Otway area, south-western Victoria. He also recorded it from Hamilton Creek, 6 miles east of Brown's Creek. It has recently been found in the basal beds at Bird Rock, Torquay.

Genus SHERBORNINA Chapman, 1922

Sherbornina atkinsoni Chapman (Pl.7, fig.17)

Sherbornina atkinsoni Chapman, 1922, p.501, pl.23, figs.1-5; Crespin, 1950, p.74, pl.10, fig.4; Glaessner, 1951, p.278; Raggatt & Crespin, 1952, p.146.

This species was described by Chapman from the Crassatellites bed at Wynyard near Table Cape, Tasmania. It is common in the beds of the Aldinga Limestone at the type locality for the Formation. It also occurs in the cliff section at the mouth of the Onkaparinga River, south of Port Noarlunga, and in the upper Eocene beds in some of the bores in the Adelaide Basin, where it is associated with Massilina torquayensis. It is associated with Victoriella plecte and Hantkenina alabamensis subsp. compressa at the type locality for the Janjukian Stage at Bird Rock, Torquay. A specimen was also found in the lower part of the Oaklands Limestone in Bore No.36, Oaklands Railway Station, 10 miles south of Adelaide. The figured specimen comes from the Aldinga Bay section between Port Willunga Jetty and Aldinga Creek.

Genus EOANNULARIA Cole and Bermudez, 1944

Eoannularia sp.

One specimen of this Eocene genus was found in the upper Eocene cliff section at the mouth of the Onkaparinga River and another in a sample from a bore on S.A. Ivimey's property, Warradale, Hundred of Noarlunga, at the depth of 268-270 feet. Numerous specimens of the genus were found in bore samples from Moorlands coalfield, eastern South Australia, and it is also present in the upper Eocene beds at Castle Cove and Johanna River, south-western Victoria.

Genus GYPSINA Carter, 1877

Gypsina howchini Chapman, (Pl.7, fig.15)

Gypsina howchini, Chapman, 1910, p.291, pl.52, figs.4a,b; pl.53, figs.3-5; Crespin, 1936, pl.1, figs.7,8.

Chapman described this species from the Lepidocyclina limestone at Batesford and it is typical of this horizon. It occurs in Bore No.36, Oaklands Railway Station, and in Amber's Bore, Netley, Although not a common species, it has a wide distribution in "f_1" stage limestones throughout the Indo-Pacific region. The figured specimen comes from Amber's Bore, Netley, at 362-400 feet.

PALAEOECOLOGY OF THE MARINE TERTIARY DEPOSITS BETWEEN ADELAIDE AND ALDINGA, BASED ON EVIDENCE OF THE FORAMINIFERA

The most distinctive feature of the lithology of the marine Tertiary deposits in the area under discussion are:

1. The polished brown ovoid limonitic pellets and brown-stained quartz grains of the Maslin Sandstone, at Maslin Beach.

2. The yellowish to dark-green glauconitic clastic limestone of the Blanche Point Limestone at Christie's Beach, Port Noarlunga, at Hackham, and at Maslin Beach.

3. The uniform lithology of the Hallett Cove Sandstone and of the lower Pliocene sandstone in bores examined in the Adelaide Basin.

Little comment is given regarding the origin of the Maslin Sandstone, with its polished brown ovoid limonitic pellets and its brown-stained quartz grains, as no attempt has been made to solve this problem in this investigation; but it does appear that the pellets, which may once have been glauconitic or coprolitic mud, have been replaced by limonite during diagenesis.

A little more information is available about the possible origin of the glauconite in the beds of the Blanche Point

Limestone. The study of the origin of glauconite has received the attention of many workers, such as Galliher (1935), Takahashi and Yagi (1929), and Shepard (1948). The Committee on a Treatise of Marine Geology and Paleoecology, Washington, D.C., headed by H.Ladd, has added to the ideas of the origin of this mineral. One of the contributors, Christina Lochman (1949), states that one of the main points brought out by her study of glauconite in Lower Palaeozoic sediments is "that glauconite, in itself, does not indicate any definite temperature or water depth". It is generally admitted that turbid and agitated waters are necessary for the process of glauconitization, and that sedimentation must be very slow.

The importance of the derivation of sediments from land areas, where crystalline rocks containing biotite are exposed, has been stressed by Galliher (1935), who proved that glauconite in the deposits in Monterey Bay, California, was formed from brown and green biotite. However, Shepard (1948) suggests that glauconitization has its origin in mud. He does not regard biotite as the most important source because of the abundance of glauconite-filled tests of foraminifera. He thinks that, as glauconite points to slow sedimentation, it is certainly an indication of the failure of sediments to cover the numerous organisms during the time of sedimentation. Murray and Renard (1891) concluded that glauconite was derived from mud and that decaying organic matter played a large part in the transformation. The Blanche Point Limestone contained an abundant and varied fauna, and therefore conditions should have been favourable for the conversion of mud or other suitably reactive mineral matter to glauconite.

Some investigations on the probable origin of the glauconite in the Blanche Point Limestone at Maslin Beach were undertaken for the writer by W.B. Dallwitz of the Bureau of Mineral Resources, Geology, and Geophysics, and the results tend to support the ideas put forward by Shepard that the main source of origin is in mud. Dallwitz noted the low refractive indices of the mineral in some samples from this locality. Indices as low as 1.557 were recorded, whereas the lowest index usually quoted for glauconite proper is 1.590. In a subsequent publication (Dallwitz, 1952) it was suggested that the low refractive indices were due to the richness of the mineral in alumina; in ordinary glauconite there is a marked excess of ferric oxide over alumina. A feature of the Maslin Bay glauconite, even that found by analysis to be rich in ferric oxide, is its very light colour, which lies between moderate greenish-yellow and pale olive. Examination of thin sections of the limestone showed that finely-divided glauconite is distributed more or less evenly throughout the calcite cement; it also occurs as fillings of the tests of organisms (foraminifera, echinoid plates and spines, and bryozoa) and as coatings up to 1 mm. thick on internal casts and external moulds of brachiopod and molluscan shells. It was concluded that mud is the probable progenitor of glauconite in these rocks.

The foraminiferal assemblage in the beds of the Blanche Point Limestone is characterised by numerous genera and species of such families as the Lagenidae, Polymorphinidae, Rotaliidae and Buliminidae. The abundance of different genera and species varies with the lithology. The assemblage throughout is dominated by such genera as Lagena, Dentalina, Robulus, Guttulina, Globulina, Sigmomorphina, Cibicides, Anomalina and Angulogerina, the last genus being the most prominent in the glauconitic clastic limestones. The environment for such an assemblage is between the mid-continental shelf (mid-neritic zone) and the upper part of the continental slope (inner bathyal of Lowman, 1949), that is between the depths of 150 feet and 600 feet, where the sea bottom is muddy.

Fewer genera and species of foraminifera are found in the Aldinga Limestone than in the Blanche Point Limestone. Bryozoal fragments constitute the major part of the faunal assemblage in the Aldinga Limestone, and the conditions under which bryozoa thrive are not suitable for the existence of certain foraminiferal genera.

The foraminiferal assemblage in the Oaklands Limestone indicates a change, not only in depth of the water, but also in temperature, from the environment under which the beds of the Blanche Point Limestone and Aldinga Limestone were deposited The change was to warm, sub-tropical moderately shallow clear water conditions. The assemblage in this Formation is marked by the presence of the warm-water Indo-Pacific form Austrotrillina howchini, in association with the sub-tropical to tropical form Marginopora vertebralis. Marginopora thrives in Recent seas in warm shallow water in the vicinity of coral reefs and at depths of not more than 100 fathoms. Other sub-tropical genera are Gypsina, Planorbulinella, Calcarina, Crespinella, Carpenteria, Operculina and Amphistegina. Conditions which suited the above assemblage extended into central western Victoria.

The calcareous sandstone which composes the Hallett Cove Sandstone and the lower Pliocene sandstone of the Adelaide Basin presents a further marked contrast in conditions of deposition. The foraminiferal assemblages in these rocks is dominated by shallow-water forms such as Rotalia beccarii, Elphidium adelaidense, Rotorbinella cycloclypeus, Discorbis dimidiata, and several species of the Miliolidae, which are characteristic of near-shore faunas of the inner nertic zone. Typical species occur in abundance between the depths of 100 feet and 150 feet and prefer a sandy sea bottom. The presence of Marginopora, Peneroplis, and Sorites indicates that the waters were shallow and moderately warm during deposition of the Hallett Cove Sandstone and the lower Pliocene of the Adelaide Basin. These three forms are found living in seas with sandy bottoms, around the coral reefs. The writer observed such an environment at Dongara, south of Geraldton, on the west coast of Western Australia, where Recent shore sands represent ecological conditions such as probably existed at the time of deposition of the Hallett Cove Sandstone and the lower Pliocene sandstone of the Adelaide Basin. The coarse sandy lithology of the South Australian deposits is possibly the result of deposition of coarse sands by the ancestors of the Torrens River and streams to the south as far as Aldinga.

BEARING OF MICROFAUNAL ZONES ON STRUCTURE OF THE ADELAIDE BASIN

Although it is generally known that the portion of the Adelaide Basin under review has been subjected to faulting (Segnit, 1940; Sprigg, 1945), the evidence for such faulting has not been previously shown by means of subsurface contours based on foraminiferal evidence (Plate 2). The key horizon in the lower Pliocene sandstone in the Adelaide Basin is the top calcareous sandstone, which contains a characteristic foraminiferal assemblage accompanied by a rich and equally characteristic molluscan fauna. Two horizons can be recognised in the "f_1" stage of the Oaklands Limestone and one in the upper Eocene.

The bores, in which the grey calcareous lower Pliocene sandstones, which contain the main aquifer in the Adelaide Basin, were proved, are situated along the banks of, and chiefly north of, the Torrens River, which flows in a more or less westerly direction from Nathan Brewery Bore at Southwark to its outlet at Fulham on St. Vincent Gulf. Unfortunately samples from only seven bores on the south side of the fault were available for examination, and these were situated at intervals ranging from half a mile to two miles.

It will be seen from Plate 2 that the fault-lines trend south-west. The northern line runs south of Nathan Brewery Bore at Southwark and Bore No.83 at Twickenham, and the southern line north of Bores No. 25 at Vermont, No.47 at Glendore, and Ackland's at Glendora. A broad synclinal structure whose axis trends slightly south of west from Bore No.69 at Royal Park to St. Vincent Gulf is suggested by the contours in the area which has Bore No.69 at Royal Park as the northern point, Bore No.37 at Frogmore and Bore No.83 at Twickenham as the southern limit, and Nathan Brewery Bore at Southwark and Bore No.80 at M.T.T. Viaduct, Fulham, as the eastern and western points. Shallow rolls within the syncline are indicated in Bore No.41 at St. James Park and in Bore No.21 at Fulham near the Torrens Outlet.

In Bore No.80, at the entrance to the viaduct which gives the Torrens River an outlet to St. Vincent Gulf, the lower Pliocene sandstone of the Adelaide Basin was penetrated at a much greater depth than in the surrounding bores; this depression was possibly caused by erosion prior to the deposition of the lower Pliocene sandstone. Two other slight depressions occur in the vicinity of Bore No.19 at Holbrook Bridge along the Torrens Valley and of Bore No.67 at Beverley, a mile and a half to the north.

The small amount of faunal evidence available from bores on the south side of the fault suggests a dip in a north-westerly direction.

A further fault-line north of the area under discussion is revealed by micro-examination of two bores at Direk, where the Oaklands Limestone was penetrated at the depth of 265 feet and 280 feet.

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APPENDIX

Notes on Stratigraphical Nomenclature

by M. A. Condon

The stratigraphical nomenclature used in this report was submitted to and approved by the South Australian Committee on Stratigraphic Nomenclature in 1951. Unavoidable delays, including the fire which destroyed the Bureau premises in April, 1953, have held up publication; and in the meantime Reynolds (1953) has described the same sequence with a different nomenclature, also apparently approved by the South Australian Committee on Stratigraphic Nomenclature. Reynolds did not know about Miss Crespin's work until after he had completed his manuscript (Reynolds, 1953, p. 119).

Rather than have Miss Crespin's paper completely re-written in terms of Reynolds' nomenclature, it has been decided to publish it in its original form. This short note explains the reason for the nomenclature and indicates the comparison between Reynolds' and Miss Crespin's names.

There are some differences between Reynolds' and Crespin's reports of the sequence which can be reconciled only by re-examination of the cliff section: Crespin suggests a disconformity between her "Blanche Point Limestone" and "Aldinga Limestone"; no disconformity is indicated by Reynolds at this boundary (between his Blanche Point Marl and Chinamens Gully Beds) although he describes the Chinamens Gully Beds as non-marine; Reynolds has a thickness of 62 feet between Blanche Point and Aldinga Creek, Crespin 12 feet; Crespin mentions Maslin Sandstone as cropping out below the "Aldinga Limestone" at one place between Blanche Point and Aldinga Creek; Reynolds makes his Port Willunga Beds between Aldinga Creek and Snapper Point 80 feet thick, whereas Crespin describes this part of her "Aldinga Limestone" as about 35 feet thick.

The accompanying text figure indicates the sequence as described by Reynolds and Crespin respectively. Equivalent beds about which there is little doubt are indicated by joining lines.

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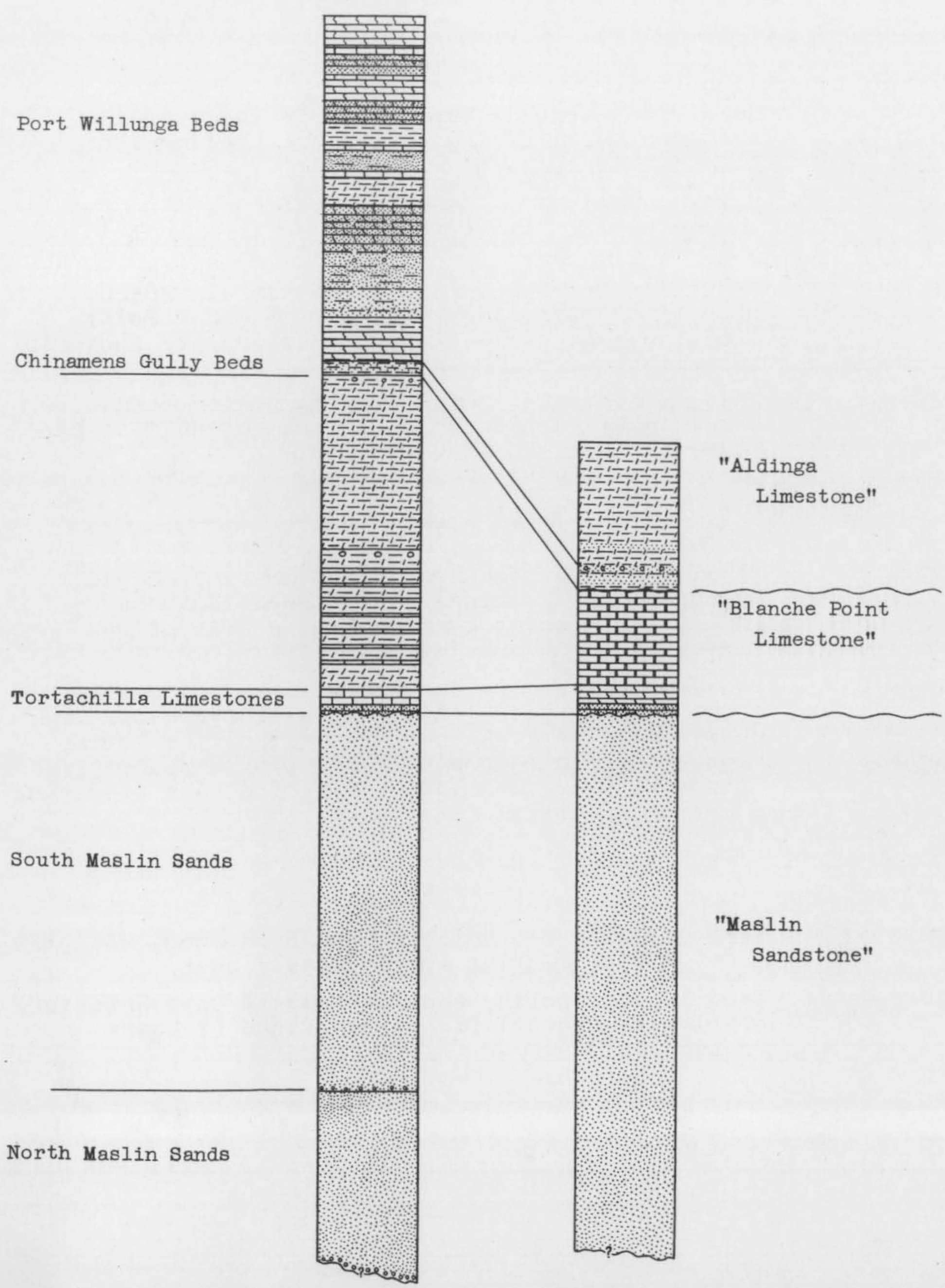
Reynolds, 1953 Crespin, this Report



EXPLANATION OF ILLUSTRATIONS

Plate 1

Sketch Geological Map, Adelaide-Aldinga Area. To face Introduction.

Plate 2

Subsurface Contour Map of the Adelaide Basin, based on Foraminiferal Zones and showing localities of Bores.

Plate 3

Figure 1 — Type Section, Maslin Sandstone, Maslin Beach, exposed by landslide. Beds of Blanche Point Limestone and Hallett Cove Sandstone are shown in top right corner.

Figure 2 — Section at Maslin Beach showing Maslin Sandstone overlain by Blanche Point Limestone, Hallett Sandstone and Pleistocene clays.

Plate 4

Figure 1 — Type locality, Blanche Point Limestone, Maslin Beach. View looking south towards Blanche Point, and showing gently dipping beds of the Formation.

Figure 2 — Portion of the type section for the Aldinga Limestone looking south from Port Willunga Jetty and showing gentle south-westerly dip of the Formation. A thin bed of Hallett Cove Sandstone occurs between the Aldinga Limestone and overlying Pleistocene clays.

Plate 5

Figure 1 — Type locality for Hallett Cove Sandstone, Hallett Cove. View looking approximately east.

Figure 2 — View looking north, showing Hallett Cove Sandstone overlying unfossiliferous sandstone (? Lower Cretaceous).

Plate 6

Foraminifera from the Hallett Sandstone.

Figure 1 — Flintina intermedia (Howchin). Bore No. 69, Royal Park, at 352-365 feet. Lower Pliocene sandstone. a. dorsal view; b. peripheral view. x 40.

Figure 2 — Flintina triquetra (Brady). Salisbury Bore at 330 feet. Lower Pliocene sandstone. x 40.

Figure 3 — Quinqueloculina adelaidensis Howchin and Parr. Salisbury Bore at 330 feet. Lower Pliocene sandstone. x 75.

Figure 4 — Cribrobulimina polystoma (Parker and Jones). Bore No.69, Royal Park, at 352-365 feet. Lower Pliocene sandstone. x 40.

Figure 5 — Valvulina davidiana Chapman. Bore No.69, Royal Park, at 352-365 feet. Lower Pliocene sandstone. x 40.

Figure 6 — Valvulina fusca(Williamson.) Bore No. 69, Royal Park, at 352-365 feet. Lower Pliocene sandstone. x 40.

Figure 7 — Pseudopolymorphina doanei (Galloway and Wissler). Bore No.83, Twickenham-Netley, at 410 feet. Lower Pliocene sandstone. x 40.

Figure 8 — Epistomaria polystomelloides (Parker and Jones) Bore No.69, Royal Park, at 352-365 feet. Lower Pliocene sandstone. a. dorsal view; b. ventral view. x 40.

Figure 9 — Rotorbinella cycloclypeus (Howchin and Parr). Bore No. 31, Keele Bridge, Lockleys,at 450 feet. Lower Pliocene sandstone. a. dorsal view; b. ventral view. x 40.

Figure 10 — Peneroplis pertusus (Foskal). Bore No. 37, Frogmore, at 405 feet. Lower Pliocene sandstone. x 40.

Figure 11 — Elphidium adelaidense Howchin and Parr. Hallett Cove Sandstone, overlying Aldinga Limestone in road cutting leading down to Port Willunga Jetty, Aldinga Bay. Lower Pliocene. x 40.

Figure 12 — Elphidium rotatum Howchin and Parr. Bore No.69, Royal Park, at 352-365 feet. Lower Pliocene sandstone. x 40.

Plate 7

Foraminifera from Oaklands Limestone, Aldinga Limestone, Noarlunga Limestone.

Figure 13 — Massilina torquayensis (Chapman). Bore No.47, Glendore, at 174-240 feet. Upper Eocene. x 40.

Figure 14 — Austrotrillina howchini (Schlumberger). Kinnish's Bore No. 1, Direk, at 280-310 feet. Oaklands Limestone. "f_1" stage. Surface worn, showing alveoli. x 40.

Plate 7 (contd.)

Figure 15 — Gypsina howchini Chapman. Amber's Bore, Netley, at 362-400 feet. Oaklands Limestone. "f_1" stage. x 10.

Figure 16 — Pseudopolymorphina rutila (Cushman) var. parri Cushman and Ozawa. Ackland's Bore, Glendore, at 155-160 feet. Upper Eocene. x 100.

Figure 17 — Sherbornina atkinsoni Chapman. Aldinga Bay section between Port Willunga Jetty and Aldinga Creek. Aldinga Limestone. Upper Eocene. x 100.

Figure 18 — Sigmomorphina subregularis Howchin and Parr. Nathan Brewery Bore, Southwark, at 509-524 feet. Oaklands Limestone. "f_1" stage. x 40.

Figure 19 — Calcarina verriculata (Howchin and Parr). Amber's Bore, Netley, at 362-400 feet. Oaklands Limestone. "f_1" stage. a. dorsal view; b. ventral view. x 40.

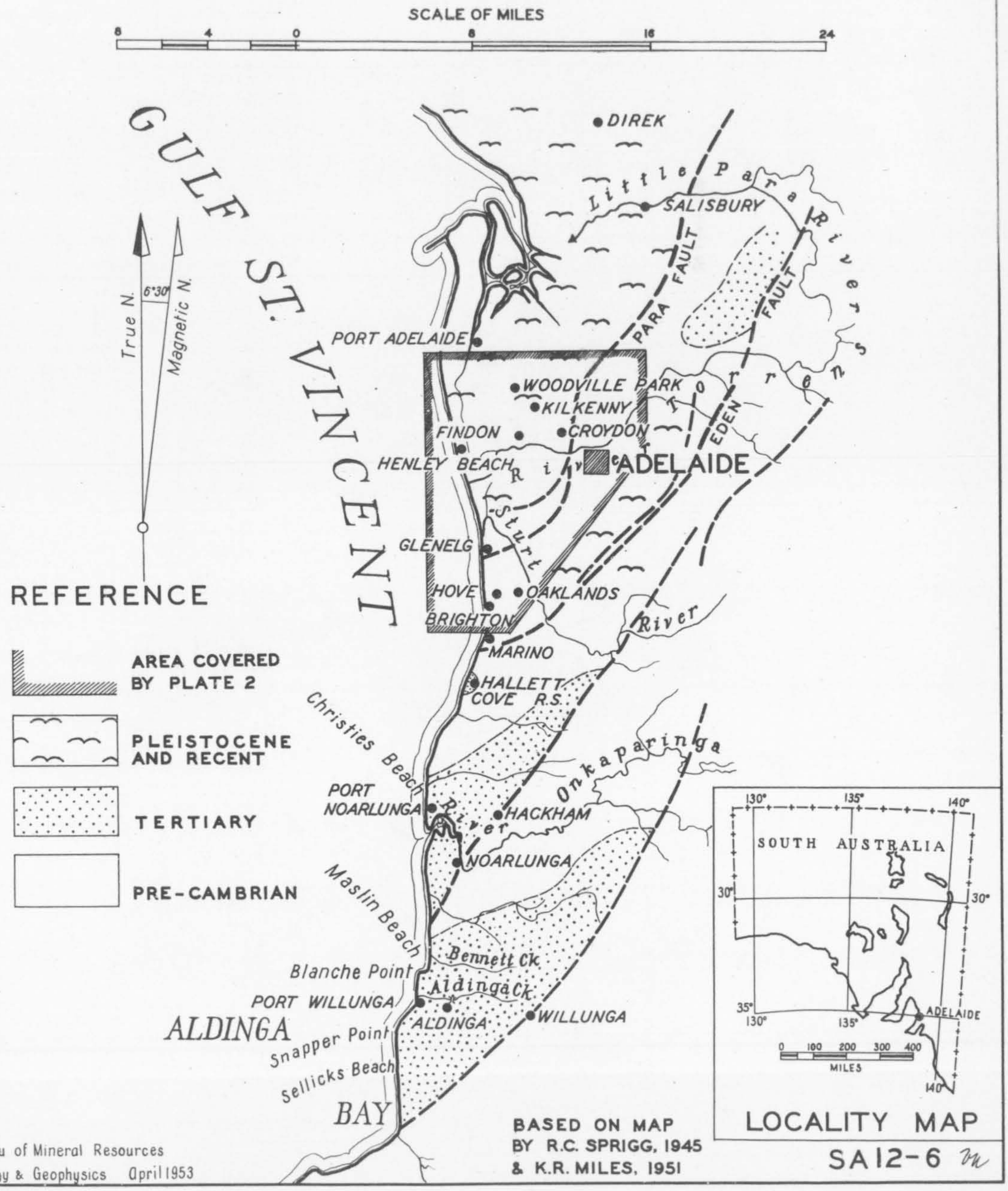
Figure 20 — Asterigerina adelaidensis (Howchin). Glauconitic clastic limestone, Maslin Beach, Blanche Point Limestone. Upper Eocene. a. dorsal view; b. ventral view showing typical stellate pattern of chambers. x 60.

Figure 21 — Crespinella umbonifera (Howchin and Parr). Kinnish's Bore No. 1, Direk at 280-31 feet. Oaklands Limestone. "f_1 stage". a. dorsal view; b. peripheral view. x 40.

Figure 22 — Operculina victoriensis Chapman and Parr. Nathan Brewery Bore, Southwark, at 535-555 feet. Oaklands Limestone. "f_1" stage. x 10.

PLATE I

GEOLOGICAL SKETCH MAP
ADELAIDE - ALDINGA AREA
SOUTH AUSTRALIA



Bureau of Mineral Resources
Geology & Geophysics April 1953

BASED ON MAP
BY R.C. SPRIGG, 1945
& K.R. MILES, 1951

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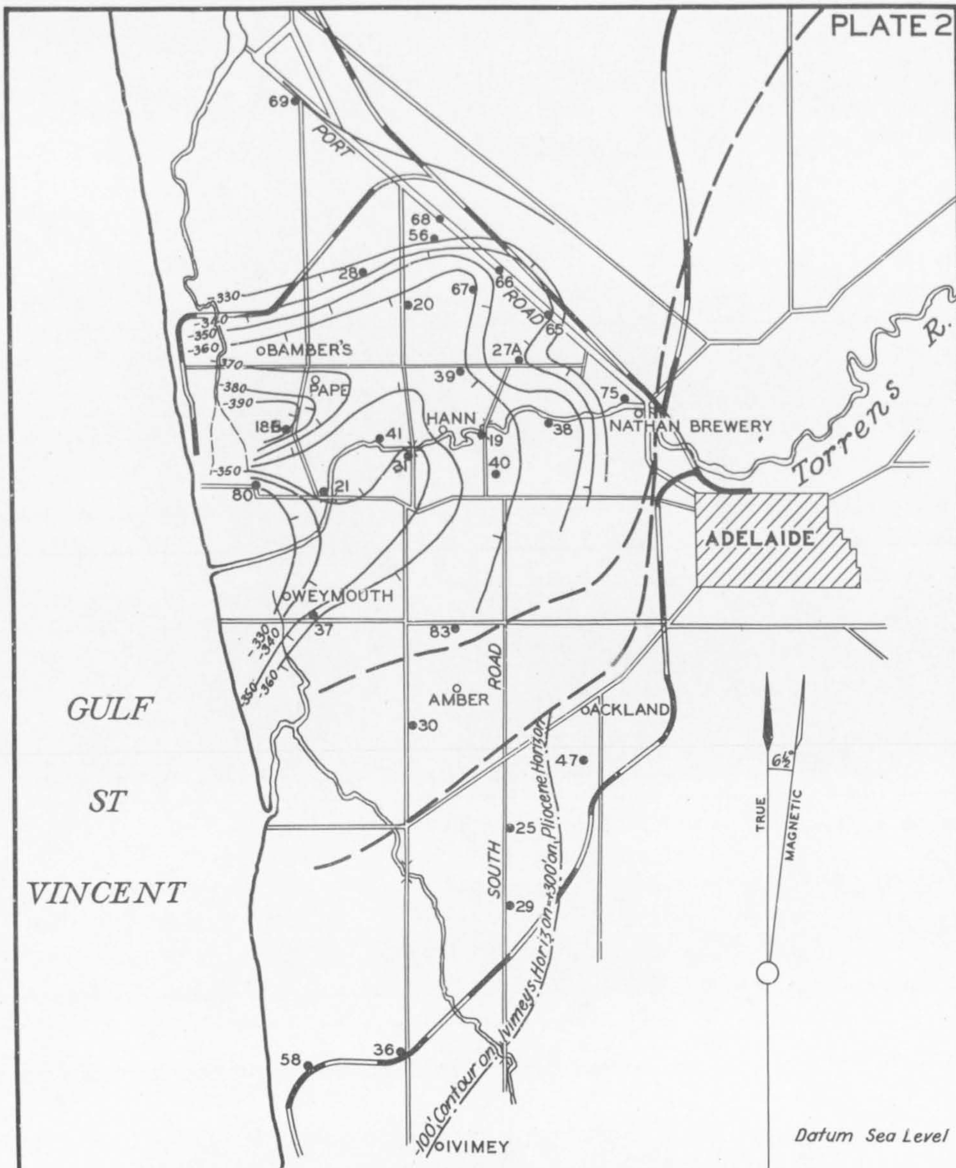

REFERENCE

——— *Contours in vicinity of Torrens River are based on highest rich fossiliferous horizon in the Hallett Sandstone (Pliocene)*

—·— *The contour extending from near Ackland's bore to Ivimey's bore is based on lowest foraminiferal horizon in Aldinga Limestone (Miocene)*

o *Private bores.* • *Mines Department bores.* ═══ *Railway.*

BORES AND STRUCTURAL CONTOURS IN PART OF THE

ADELAIDE BASIN

SOUTH AUSTRALIA

SCALE

1 0 1 2 3 MILES

BUREAU OF MINERAL RESOURCES GEOLOGY AND GEOPHYSICS FEBUARY 1951.

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Fig. 1. Type Section, Maslin Sandstone, Maslin Beach.

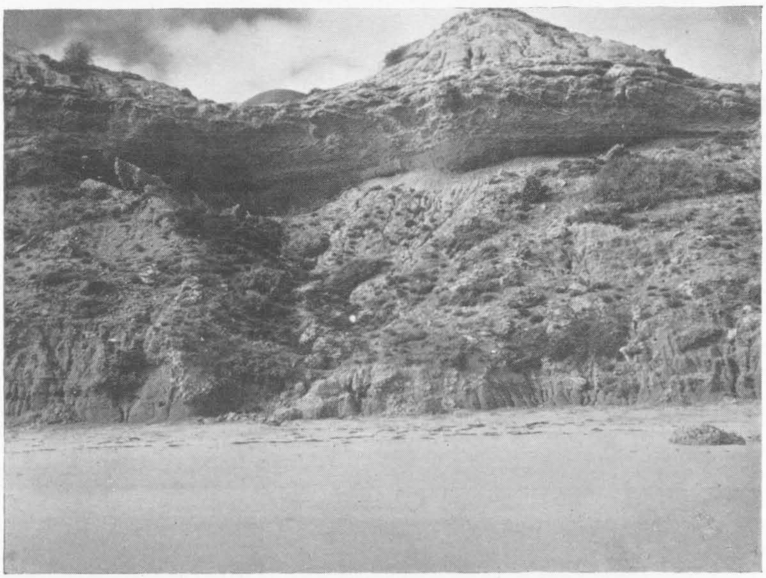


Fig.2. Maslin Sandstone, and Noarlunga Limestone, Maslin Beach

Fig. 1. Type section, Noarlunga Limestone, Maslin Beach.

Fig. 2. Southern portion of type section, Aldinga Limestone, Port Willunga.

Fig. 1. Type section, Hallett Sandstone, Hallett Cove, looking east.

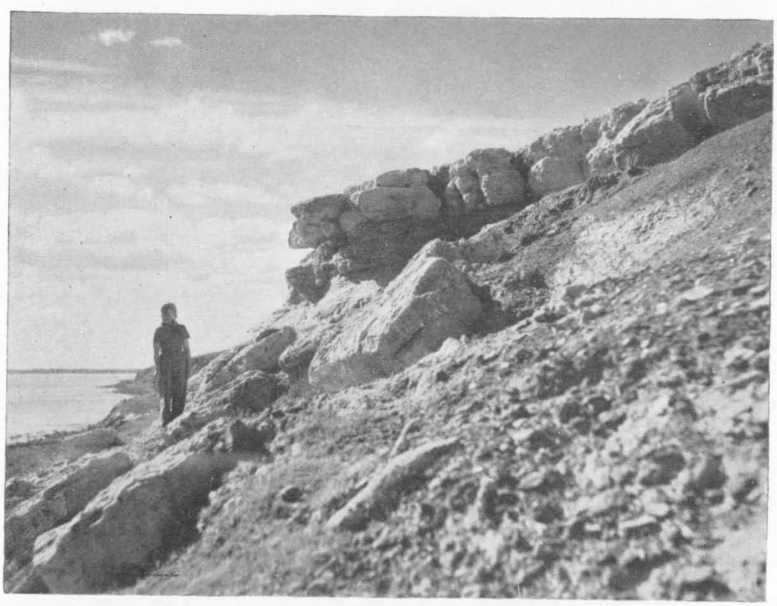
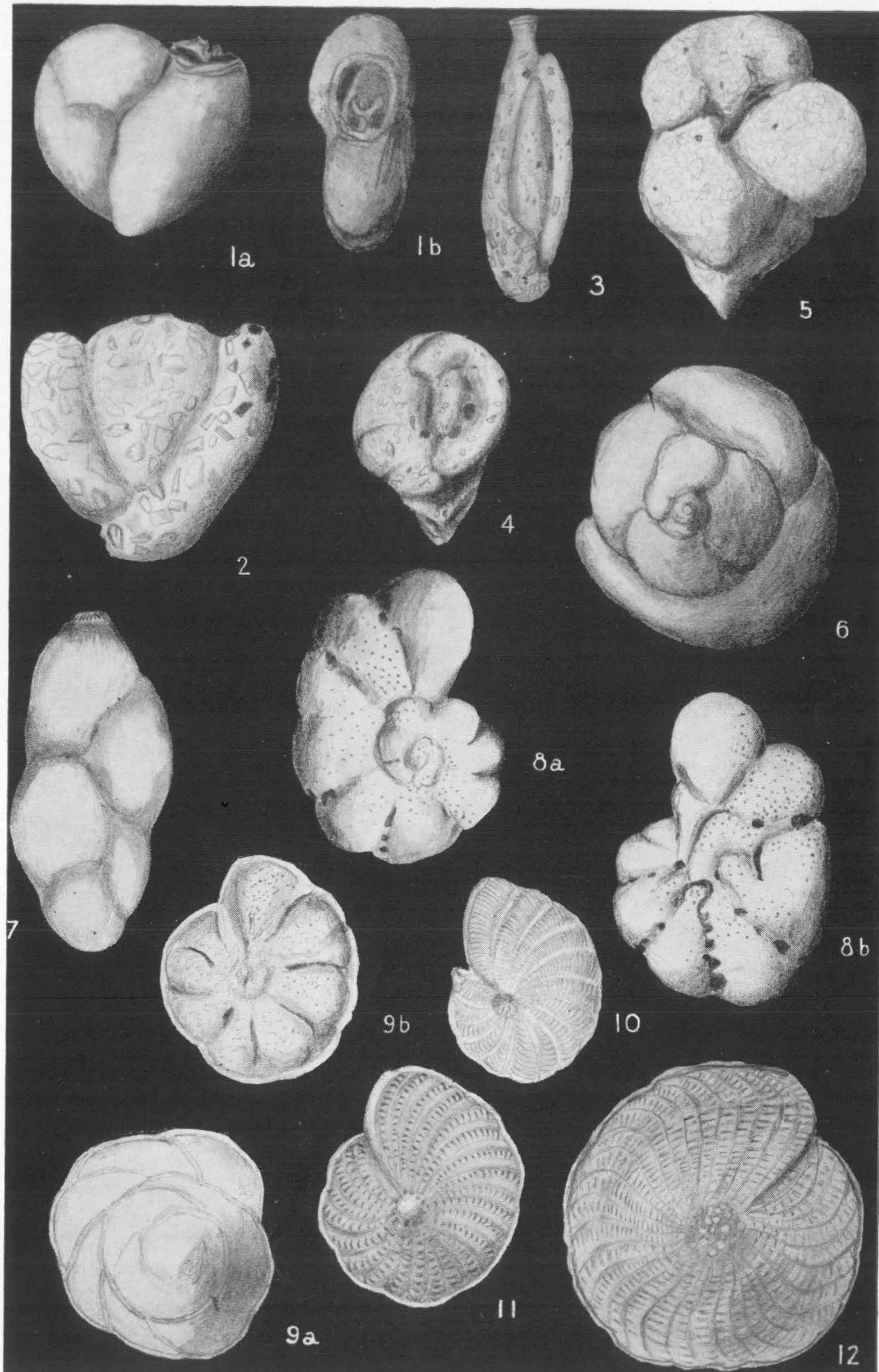
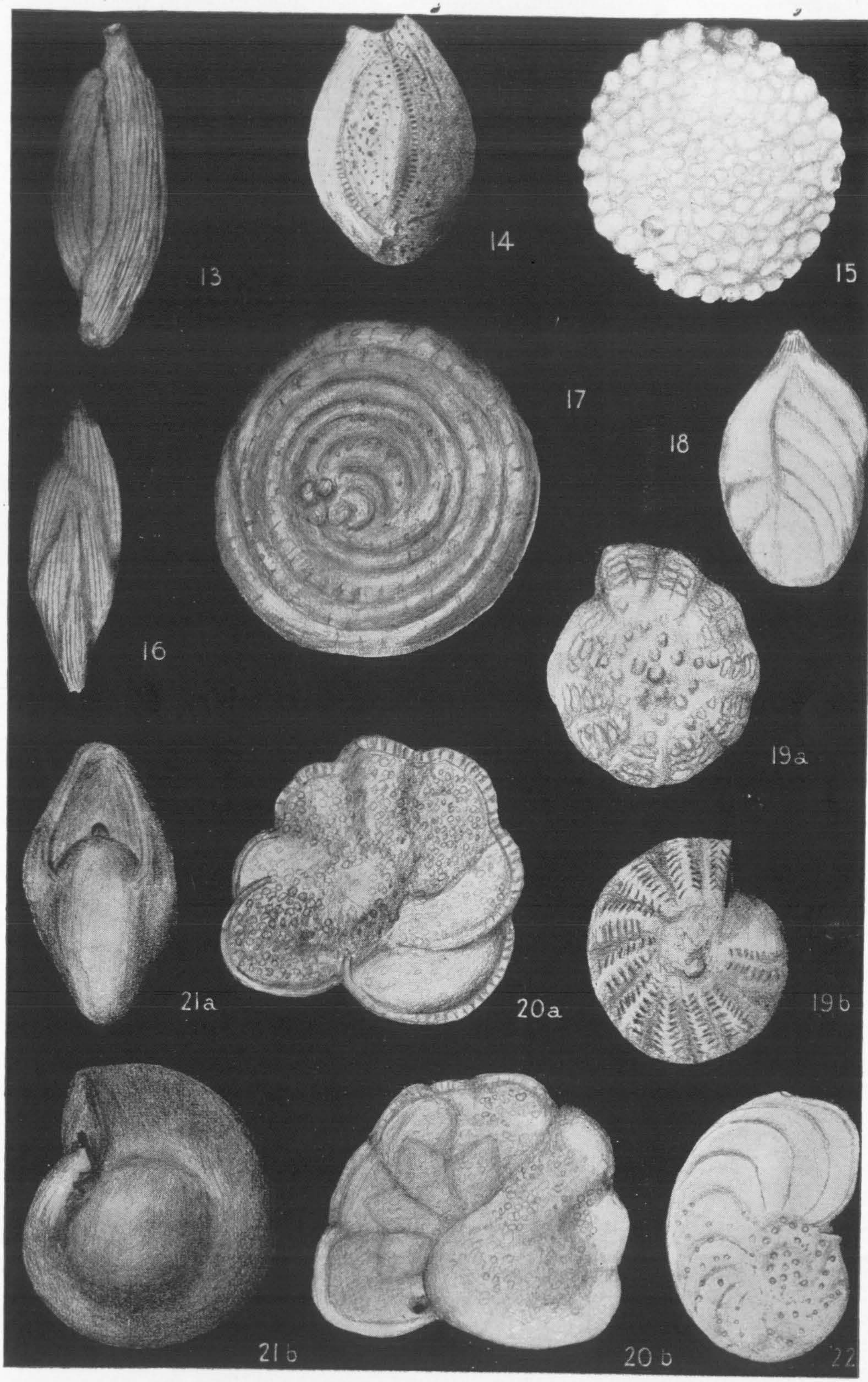


Fig. 2. Type section, Hallett Sandstone, Hallett Cove. looking north.



Foraminifera from the Hallett Sandstone



Foraminifera from Oaklands Limestone, Aldinga Limestone, Noarlunga Limestone