

## RECORDS OF THE QUEEN VICTORIA MUSEUM, LAUNCESTON

### THE COASTAL GEOMORPHOLOGY OF KING ISLAND, BASS STRAIT, IN RELATION TO CHANGES IN THE RELATIVE LEVEL OF LAND AND SEA

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#### ABSTRACT

The solid geology and general relief of King Island are outlined as a background to a regional presentation of the coastal geomorphology from which conclusions about the physiographic history are derived. From the east coast there are rather slight indications of a 225-ft. sea-level stand and stronger evidence for one at 120-150 ft. from the same area. Whether these emergences affected the whole island uniformly cannot be determined. Later and lesser emergences did so and correlation with N.W. Tasmania suggests they may have been eustatic in character. Widespread constructional and erosional features of the Old Shoreline System give evidence of a falling sequence of levels from 65 feet down to the present level with most marked halts at 40-50 feet and 20-30 feet. They are provisionally inferred to belong to the Last Interglacial. The Old Dunes formed during this time. When the sea level stood at 30-50 feet, the climate was probably slightly warmer, but plant remains from a deltaic deposit indicate that, by the time the sea level had fallen to the present level or below it, the climate was very similar to that of today, perhaps slightly wetter or cooler. In the subsequent Last Glacial Period the former sea cliffs were degraded by subaerial weathering, probably aided by frost action. A few features point to lowered sea levels which may relate to this period. In the Holocene the New Dunes have formed, probably beginning before sea level had risen as high as the present level but continuing to form right down to today. The associated New Shoreline System is considered to relate to a Mid-Recent 10-ft. sea-level stand and the emergence from it. So far no evidence of climatic variations in the Holocene is to hand.

#### INTRODUCTION

Within an area which permits the whole shoreline to be examined conveniently, King Island possesses a good variety of coastal landforms, both erosion and constructional, though there are the drawbacks of the lack of a topographical survey of the island and the survival of thick scrub over some critical parts. In connection with black sands deposits, S. W. Carey began a study of the north-east coast between Naracoopa and Lavinia Point; in 1954 and 1955, the present writer did further work in this sector and extended it to the rest of the coastline. Certain aspects of the coastal geomorphology have already been discussed (Jennings, 1956, 1957a, 1957b). Incidental comments (Jennings (1955) have been made on the relationship of some of the constructional shorelines to available fetch, wave and wind regimes; it is clear that these need revision in relation to recent work by J. L. Davies (1959). This will not be undertaken here and only such references to these special aspects as are necessary to the present purpose will be made. That purpose is to present a general picture of the coastal physiography whereby changes in the relative level of land and sea can be assessed.

Strip maps of all significant geomorphological detail, prepared under the stereoscope from 1/15,000 vertical air photo cover, were amended in the light of field work when the whole coastline was examined on foot. These strip maps were consolidated into a six-sheet map of the whole island, using a framework of points enlarged from the Lands Department cadastral plan on a scale of two inches to one mile. The various maps illustrating this paper were reduced from this compilation.

The absence of any triangulated heights or bench marks was a serious handicap. Heights were mainly established by aneroid traverses running inland from HWM and returning to it after a short interval to enable corrections to be made. Only with the lower features close to HWM could this method give an accuracy greater than  $\pm 5$  feet. A few short traverses with hand level were made and in addition four lines, varying in length from one-third of a mile to seven miles, were levelled with a Kern GK-1 Level at critical localities. Similarly, hand borings were put down at selected important places.

Height observations were related to HWMOST because this is the datum most easily recognized on the shores of King Island; Fairbridge and Gill (1947) have advocated the use of LWMOST but this was not practicable in this study. Tidal data for King Island are meagre. Admiralty Chart 404 gives a spring rise of 3 feet for Seal Bay, Franklin Road and Councillor Island (Sea Elephant Rock); this seems rather low in relation to local observations. Records kept for several years at Currie by Mr. C. Richardson have an average range of spring tides of 5 feet. Mr. J. Skipworth is of the opinion that the same figure is applicable to City of Melbourne Bay. At Naracoopa tidal measurements kept between 15 May and 15 June, 1952, by Mr. W. Lightfoot, ranged from between 2 ft. 6 in. and 5 ft. 9 in. On this basis the tidal range for King Island generally is taken to be 5 feet at springs and 3 feet at neaps.

Collections of mollusca (Appendix II) were identified by Miss J. M. Macpherson (National Museum of Victoria); Mr. A. C. Collins examined a number of samples of foraminifera (Appendix III); Dr. S. Duigan (University of Melbourne) dealt with microflora from a deposit which also yielded wood specimens identified by Mr. H. D. Ingle of C.S.I.R.O. Forest Products Division (Appendix I); Miss I. Crespin examined a Tertiary limestone. The collaboration of these specialists is gratefully acknowledged.

Mr. E. D. Gill (National Museum of Victoria) has kindly arranged for the C-14 dating of the wood mentioned above. Dr. M. D. Garretty placed boring records and other data relating to the black sands at Sea Elephant Bay at our disposal. Many King Islanders, too numerous for all to be mentioned here, gave invaluable help in all sorts of ways. Mr. Jack Skipworth, of City of Melbourne Bay, Mr. O. H. Drake, of Pearshape, and Mr. D. Bowling, of Surprise Bay, and their families, require my particular thanks.

Finally, I must pay a special acknowledgment to Professor S. W. Carey, of the University of Tasmania, who introduced me to King Island and made available to me his mapping of the north-east coast.

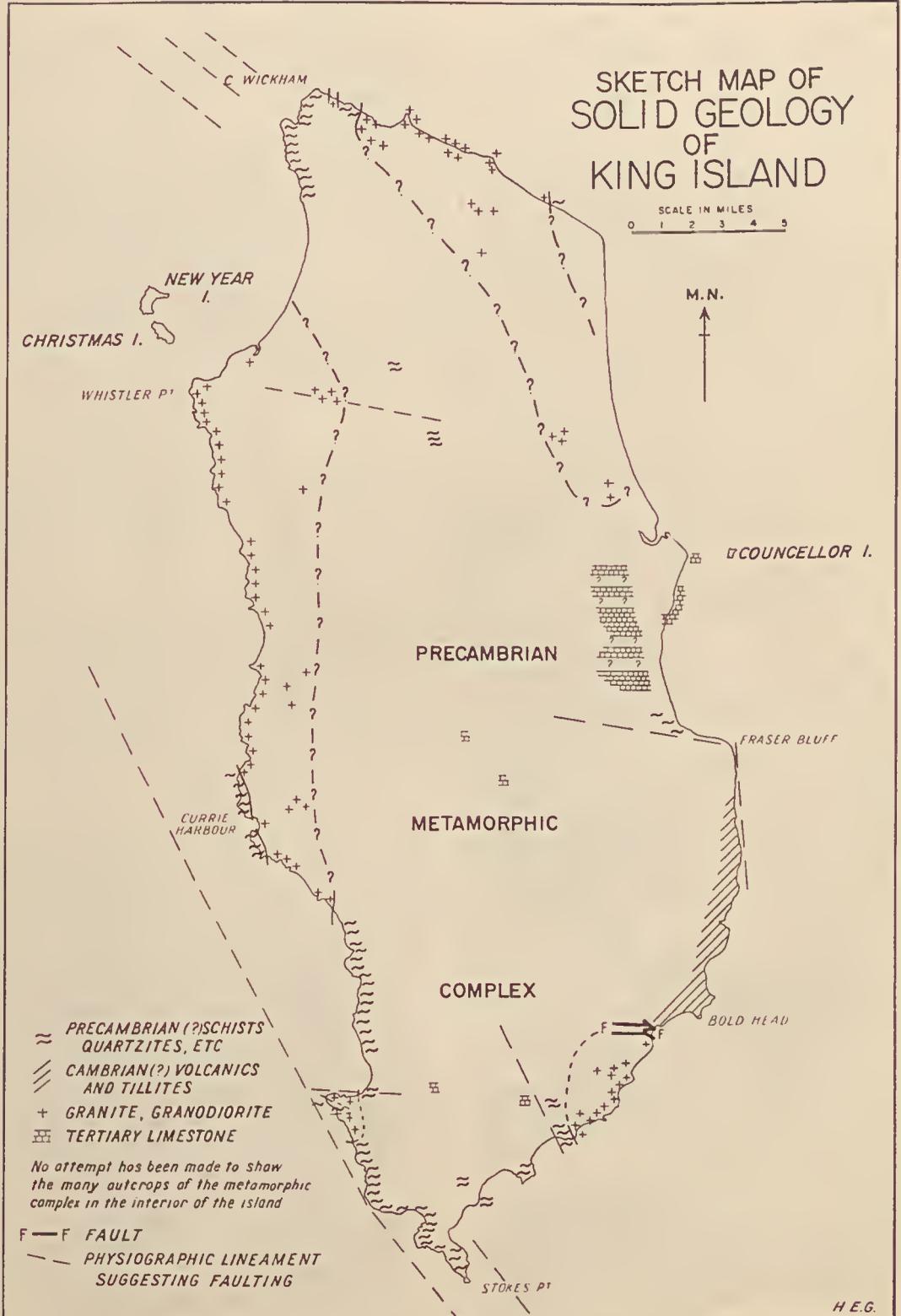


FIG. 1.—Sketch Map of Solid Geology of King Island.

### OUTLINE OF THE SOLID GEOLOGY.

Since much of the island is covered by Pleistocene and Recent superficial deposits, the solid geology is not well known. Fig. 1 is based on published material, together with some observations made during this study.

Underlying most of the island and outcropping over the high country of the centre, south-east and south-west is a folded metamorphic complex of uncertain age but generally thought to be late Precambrian (Carbine Group). Debenham (1910) lists the following rocks: quartzites, slates, phylites, various schists, granulites, porphyroids, and conglomerates. In general the dips are high and the strike never far from N-S.

Between Naracoopa and Grassy the complex passes upward into a series of glacial and volcanic rocks, dipping east at 40°. Tillite and banded dolomite occur at the base of the series and are overlain by a thick suite of lavas, with subsidiary breccia and tuff. The series is late Precambrian-Cambrian in age; Carey (1946) and Scott (1951) have suggested correlation of these volcanics with similar ones of Upper Middle Cambrian age in the Dundas Group at Zeehan. It is these rocks which give rise through contact metamorphism to the Grassy Series of hornfels, calc-flints and marble, in which occur the ore bodies of the Grassy scheelite mine (Edwards, Baker & Callow, 1955). The strike here is W-E and the dip to the south is in association with the local faulting.

Acid plutonic rocks, probably of the Tabberaberan Orogeny, intrude the basement complex. The limits of the Grassy granodiorite with much pink orthoclase and little biotite are the best known (R. Callow, personal communication). On the west coast grey biotite granite is more extensive than has been mapped previously. The Cataraque Point granite is small in area and is interrupted by a septum of metamorphics on the southern flank of the point itself. It is the southern end of a long belt of granite running from Admiral Bay to Whistler Point. Granites in Camp Creek, in bays north of Currie aerodrome, in Porky Creek, in a quarry east of Pearson's Swamp and near the North Road where it drops to the Yellow Rock R. plain, suggest that this belt is a broad one.

On the north coast, though there are gneissic granites in the basement complex farther west, the main mass of granite begins on the western side of Disappointment Bay. All outcrops of solid rock eastwards, both along the coast and in the low hills inland of the dunes are granitic until a contact is made with slates at the small headland north of Pennys Lagoon. Since granite outcrops around Mt. Counsel and at the great bend in the Sea Elephant River, it is possible that the north coast granite extends southwards as an important belt as suggested in the map.

Restricted occurrences of Tertiary limestone alone serve to tell something of the long geological history from these old rocks down to the Pleistocene. The chief outcrop known is at The Blowhole, four miles north of Naracoopa, where horizontal bryozoal limestone occurs as a shore platform, riddled by solution to give rise to small blowholes

(B. Speneer, 1888; \* Chapman, 1912). The rock can be traced a quarter of a mile up to the bed of the Blowhole Creek and half a mile northwards along the shore at LW. Seaweed patterns indicate that the limestone reaches underwater right to Cowper Point.

Superficial deposits obscure the inland extent but, running north from the Fraser River, a little behind the coast, there is a strip of country about one mile wide with a photo pattern dominated by swamp hollows of circular to oval plan. In the field these are seen to have flat peaty or clay floors depressed 2-3 feet beneath the flat sandy plain around. They seem to be sinkholes due to solution of Tertiary limestone below. The belt certainly reaches to the Sea Elephant River but beyond that there are many more dunes and these supposed sinkholes cannot be confidently distinguished in the photos from the axial hollows of old parabolic dunes. The sinkhole strip lies approximately between 50 and 90 feet above the sea.

Some way up the Sea Elephant River valley in the middle of the island, Tertiary limestone has been met in a well in the Avondale property; it has been met again in a Rural Bank Land Settlement bore nearby. Crespin (1944) attributes the first occurrence to the Balcombian (Middle Miocene). The altitudes are unknown but may be as high as 200 feet.

Debenham (1910) and Chapman (1912) reported bryozoal limestone at an unknown altitude along a tributary of Seal River less than a mile north of the Big Swamp; the fossil content did not permit dating within the Tertiary. In a well on Mr. O. H. Drake's property, about half a mile SE of Pearshape Lagoon and approximately at 250 feet, a bryozoal limestone was encountered 4 feet down; Miss I. Crespin (Bureau of Mineral Resources) reported that a sample was of Miocene age.

### GENERAL DESCRIPTION OF THE RELIEF

The relief of the island has been described in general terms already by Debenham (1910) and Stephens and Hosking (1932). Aneroid traverses along some of the roads and tracks across the island permit a rather fuller account here, necessary in the absence of a topographical survey.

In essence, King Island (fig. 2) consists of an inclined plateau of subdued relief, surrounded by a rim of coastal sand dunes. The highest part\*\* of the plateau, rising to 550 feet, is in the SE between Mt. Stanley and Naracoopa. Here the surface is gently rolling with low hills of convex profile rising above swamp flats. Its aspect conforms well with the Davisian concept of a peneplain of normal erosion but it cannot be assumed that the surface developed under humid

\* B. Spencer confused Pleistocene-Recent neolianite with Tertiary marine limestone so that not all his localities for the latter can be accepted.

\*\* Mount Stanley, lying near the track running south from the Loop Road to the Red Hut headland, rises little above the surrounding plateau. Though reputedly the highest point in the island, it is (with an approx. altitude of 500 feet) definitely lower than two more pronounced hills rising to approximately 550 feet just north of the Forestry Reserve at the southern junction of the Grassy and Loop Roads.



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temperate climatic conditions, since it carries small residual patches of lateritic ironstone (Stephens & Hosking, 1932; Hubble, 1947).

The rolling country runs north to the Pegasus road between Currie and Naracoopa, where the hills hardly reach 400 feet. East of this drainage divide, the plateau remains high right to the coast. Grassy township has a height of 430 feet within half a mile of the shore; Sullivan's Ridge, beyond Grassy Creek, is 450 feet high close to the coast and, even at Fraser Bluff, the plateau lies at 250 feet. Because of this, the creeks here are sharply incised; Grassy and Yarra Creeks for about two miles from the coast, Conglomerate Creek and Barrier Creeks for about a mile.

South of Grassy, the plateau margin runs inland to leave lower country diversified by rounded granite hills between itself and the coastal dunes. A fairly high ridge, however, runs south from the Mt. Stanley area to the granite hills near the Red Hut headland. The steep western scarp of this connecting ridge is continued north towards the northern junction of the Grassy and Loop Roads to form a marked linear western margin to the high plateau. From the northern end of this scarp, high ground at about 250 feet extends SW through Pearshape into the lower plateau behind the Cataraque Point-Surprise Point coast. This small plateau slopes gently eastward to enclose a lowland embayment between itself and the ridge to the Red Hut headland. In descending to this embayment the Seal River develops some incised meanders.

In the north-east, the high plateau ends abruptly in a steep scarp which extends some five miles west-north-west from Fraser Bluff and is markedly incised by north-north-east draining streams.

Towards the north-west and west, however, the plateau declines gently in height. As a monotonously level surface it reaches northwards to a WNW-ESE line about a mile south of the Yellow Rock River; here it is 100-150 feet high and falls off moderately steeply to the plains of Yellow Rock River and South-East Lagoon. Mount Counsel stands out from the general plateau level at its north-east corner; south to the Fraser River there is not a very clear eastern margin to the plateau.

The westerly drainage, such as the Ettrick River and Porky Creek, has not cut down much into the plateau since the latter is in fact falling in that direction.

This western flank of the plateau from Fitzmaurice Bay to Cape Whistler is buried beneath a broad belt of dunes, much of which is two to three miles wide. They are generally higher south of Currie, but this is mainly due to the greater height of the basement there. Thus, a little south of the Kentford Road, a dune was ascertained to have a height of 450 feet, but the sand thickness here was probably only about 100 feet. North of Currie it is unlikely that the dunes anywhere exceed 250 feet in absolute height; the highest ones occur just south of Pass River and at Whistler Point. Beneath the coastal dunes the plateau surface declines in height so that the bedrock is below sea level on the coast or, at

most, 20-30 feet above. There are, however, outcrops at 50-100 feet just south of Whistler Point close to the coast. These suggest that the rather high dunes of Whistler Point may have gathered around granite hills rising above the general basement of country rock. Valleys in this basement also are discernible beneath the obscuring blanket of sand, e.g., east of the Dripping Wells and along Boggy Creek (Jennings, 1956).

North of Whistler Point to Mt. Counsel, the solid rocks are almost everywhere beneath young superficial deposits and are probably below sea level over most of the area. There are the exceptions of the low granite hills arranged WNW-SSE behind the coastal dunes from Disappointment Bay to Lake Martha Lavinia. The lowest country of this northern end of the island is in the centre where there are extensive flat plains underlain by young estuarine sediments, parts of which are covered by the peaty soils of former shallow lakes and swamps—Reedy Lake, Egg Lagoon, and South-East Lagoon. This depressed interior is surrounded by a rim of coastal dunes so that one can look right across the island from the dunes of the one coast to those of the other. The west coast dunes are broader and higher, probably reaching to 250 feet west of Lake Flannigan. Elsewhere the Three Sisters, conspicuous dunes south-east of Rocky Point, are the highest and do not quite reach 200 feet, though they are of sand right down to sea level.

It is only necessary to note in general terms the effects of the coastal dune rim on the drainage of the island (see Jennings, 1957a, for details). Some rivers have maintained their courses through the dunes as these were built up and in this way "gorges of construction" have developed with steep walls of dune sand. Thus, Debenham says the Ettrick Gorge is as much as 250 feet deep. Other rivers have had their mouths deflected, most noticeably in the case of the Sea Elephant River, where it amounts to a deflection of two miles. Damming of drainage by the sand dunes has led to extensive swamps and lakes. Thus, Pearsons Swamp, an area of deep peat now drained, occupied the part of the Bungaree Creek drainage inside the dunes. The Seal River and its major tributary enter the Big Swamp behind the coastal dunes. The drainage is deflected westward into Big Lake from which the river winds deviously through the dunes to the sea. In other places surface drainage has been completely blocked and has been replaced by underground seepage through the dunes. This is best exemplified now by Lake Flannigan, but the more extensive Egg Lagoon formerly drained westward through the high dunes there, though it is now drained artificially to The Nook and Sea Elephant River.

Little can be said of the age of the major relief features of the island. Debenham regarded it as being a horst but there is still no positive evidence of young faulting to hand. However, the physiographic description given does fit in with the conception of an old peneplaned surface, fractured along two sets of trends (fig. 1) and tilted down to the north and west. Laterites of various dates are known on the Australian main-

land. Nevertheless, widespread laterization seems to have belonged to the middle or early Tertiary and the ferruginous bauxites of the Launceston district are pre-Miocene (Carey, 1947). Provisionally, the King Island surface, with its lateritic ironstones may be regarded as Mesozoic-lower Tertiary in age. If all the Tertiary limestones belong to the one Miocene formation, the occurrence of thin limestone outcrops on top of the plateau as well as on what seem to be downthrown blocks suggests that the dissection was later than this transgression. In central Tasmania, although the major Tertiary movements preceded the Miocene lacustrine sedimentation, later faulting is known (Fairbridge, 1948).

### THE DUNE SYSTEMS (Fig. 2)

A regional description of the coastal features significant for the purpose of this paper is given below, but it will facilitate that description if the dunes are considered as a whole at this stage, since they exhibit a common general pattern and the emerged shoreline features are intimately and significantly associated with them. The dunes fall clearly into two major systems designated the Old and the New Dunes.

The New Dunes form a more continuous rim around the island. Though for the most part fixed dunes, they retain everywhere a vigour and freshness of relief which betokens little change in their forms since that fixation by vegetation. For the most part they consist of parabolic or U-dunes in all stages of development ("elongate" and "windrift" dunes of Melton (1940); "transgressive" dunes of Gardner (1955)). The parabolic dunes may occur in open pattern or complexly associated, often nested one within another. Simple conical dunes occur occasionally, probably residuals from parabolic dunes. The axial trends of the parabolic dunes have been examined in relation to wind regime elsewhere (Jennings, 1957b). Suffice it to say here that on the west coast the dunes generally advanced WSW-ENE but, in accordance with varying aspects of the shore, ranged from SW-NE to WNW-ESE, whilst the general trend on the east coast was from E-W, again varying with aspect from NE-SW to SE-NW. The inland margin of the New Dunes, often lobate in consonance with parabolic dune pattern, is almost universally such a steep and continuous one that their limit is readily discerned both on the ground and in air photographs.

In constitution they exhibit a simple distribution pattern. The west coast New Dunes are predominantly calcareous, ranging from completely unconsolidated creamy-yellow shell sand with a minor proportion of quartz sand to a typical aeolianite which exhibits its usual variable degree of consolidation by secondary calcite. From Cape Wlegham to Lavinia Point the calcareous content remains high most of the way but declines as aeolianite masses cease to be seen in section, only calcareous root incrustations. Aeolianite persists from Stokes Point nearly to Grassy but eastwards the shell sand content falls off rapidly. Stephens and Hosking's Currie Sand soil type, with its poorly-developed profile, apart from some organic addition

to a surface horizon, is characteristic of the calcareous New Dunes; exceptionally, a podsol has developed on New Dunes near Currie, which have a substantial shell sand content (Stephens & Hosking, 1932, p. 26).

The east coast New Dunes are in contrast predominantly of quartz sand, slightly reddish-yellow in colour. Their soils vary from a completely undifferentiated profile to a shallow, weakly-developed podsol, which constitutes one phase of Stephens and Hosking's Naraeopa Sand soil type. Hardpans are not strongly developed and A and B horizons together are rarely deeper than 3 feet. Below is the reddish-yellow unbleached dune sand. Ferns are often dominant on these soils in contrast with the grasses, herbs and rushes of the calcareous New Dunes.

It is possible to divide up the New Dunes of particular coastal sectors into two, sometimes three, separate dune belts, each consisting of parabolic dunes in depth; these belts advanced successively inland, probably with appreciable halts between. But attempts to correlate these belts from one area to another have failed and, therefore, it is not thought that they have any general significance. It is true, however, that active blowouts, the first stage in parabolic dune development, are most common in the most seaward and latest belt immediately behind some of the larger sandy bays of the west and south-east coast. However, active blowouts occur in scattered fashion throughout those New Dunes which are intensively grazed and the detailed distribution of these blowouts in relation to gates, fences, eois, &c., indicates that they are due to grazing animals, aided by burning-off. But the most mobile areas are on the whole the only areas in the calcareous New Dunes still partly in the scrub which almost certainly covered the whole of these dunes before settlement. It seems likely then that these mobile areas were also active before settlement and clearance. In other words, the New Dunes constitute a series which has continued to develop naturally right up to the present.

The Old Dunes are much more sporadically occurring though they are found all around the island and reach farther inland. In the northern part of the island, they are found right in the middle, admittedly in small groups and as individuals there rather than covering large areas. In form they are usually subdued and rather characterless, ranging from low, gentle swells to whaleback mounds and smoothed ridges. Their limits are much less reliably and readily mapped, except, of course, where the New Dunes abut upon them. However, the characteristic parabolic dune plan is quite frequently recognizable in the air photos (less frequently on the ground) and, where clear, the inland limit of these Old Dunes shows the same lobate pattern as the New Dunes. It is evident that most of the Old Dune areas are parabolic dune systems modified by weathering and colluviation over a long time. For the most part the Old Dunes advanced inland with a direction closely comparable to that of the New Dunes of the same coastal sector. The wind regime at the time of formation of the Old Dunes cannot have been very different from the present one.

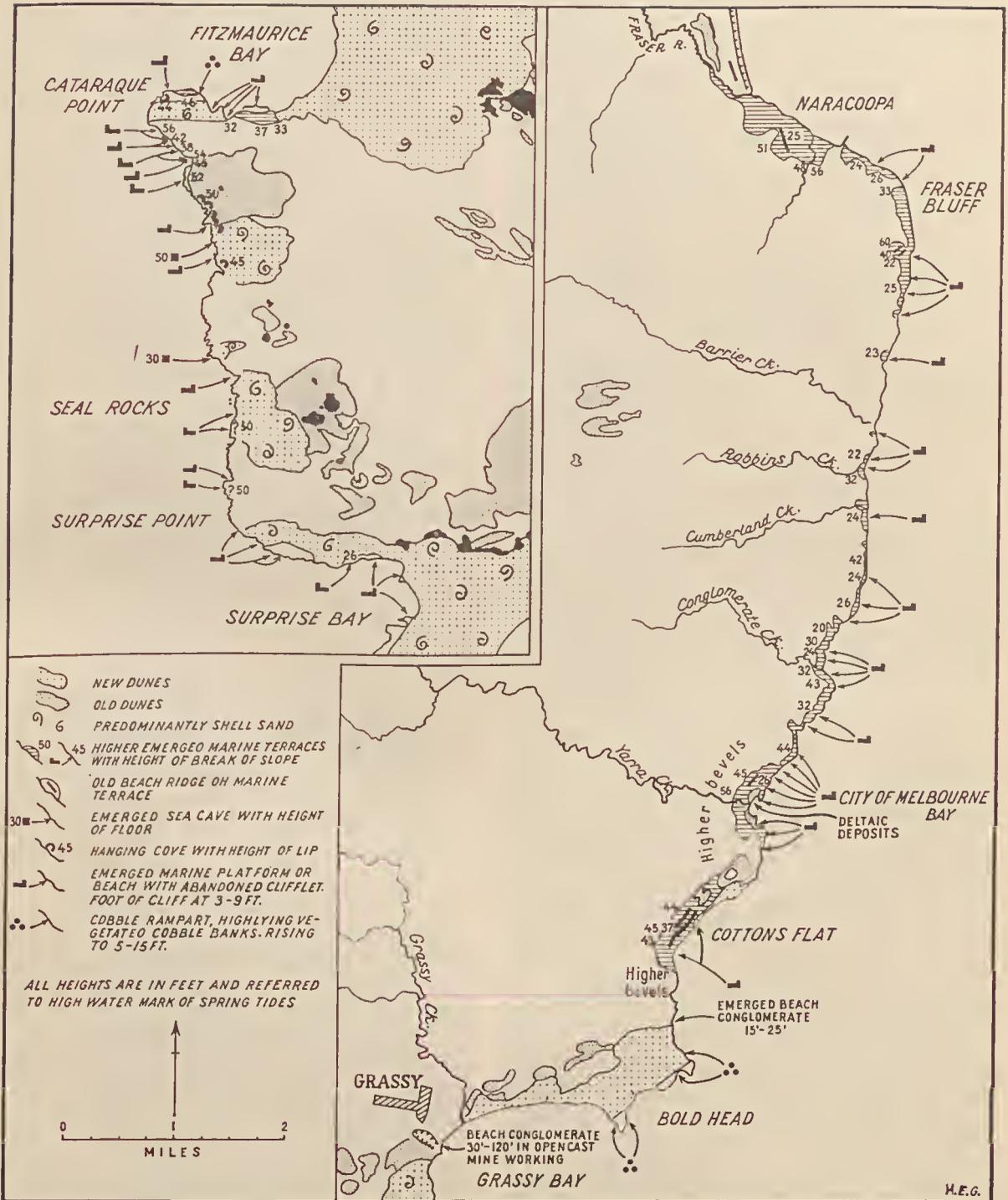


FIG. 3.—Coastal Geomorphology of S.E. and S.W. Coasts of King Island.

The constitution of the Old Dunes does differ from that of the New Dunes and is rather complex in pattern. In the first place siliceous dunes are much more widespread amongst the Old Dunes. Their quartz sands are much more deeply leached; in fact, no unleached yellow quartz sand was seen anywhere in the Old Dunes. In bores and pits dark-brown hardpans were several feet deep beneath grey-white sand and well-developed when encountered at all. In several sections, many feet of white leached sand overlay many feet of "coffee-rock", humus-bound sandrock; both layers were into the tens of feet thick in the southern side of the Grassy scheelite mine opencut. In the field these profiles were regarded as the A and B horizons of a giant podsol (cf. G. Hubble in Gill & Banks, 1956, p. 13). Recent publications by Coaldrake (1955) and McGarity (1956) show that not all sandrocks of this general type are of this origin. Further work would be necessary to substantiate this view of the King Island examples, but the rather indistinct cross-bedding seen at certain points and the fact that the Grassy opencut sand section was on a steep slope suggest that a B-horizon may be the correct interpretation of at least some of them. Stephens & Hosking map their Naracoopa Sand soil type over much of the area of the Old Dunes but here it must represent a different phase from that of the New Dune areas.

Calcareous Old Dunes are restricted to the northern half of the west coast from Currie northwards but even here they are interrupted. Near Sam Lagoon a lobate area of siliceous sands is inset between adjacent calcareous lobes and east of South-East Lagoon, some of the leached quartz dunes there have advanced from the west to interlock with others from the east coast. Also between Yellow Rock River and Bungaree Creek the sporadic Old Dunes are of quartz sand and reached inland of calcareous Old Dunes farther south in the Bungaree Creek-Pass River area.

The calcareous Old Dunes carry characteristically the Yambacona Soil type of Stephens and Hosking; this has a depth of up to 4 feet of red-brown siliceous sand, sometimes with nodular limestone layers, overlying yellow calcareous sand or aeolianite. The most likely origin of this soil type is that it is residual from the calcareous Old Dunes after much more prolonged leaching than the calcareous New Dunes have yet experienced. Despite this leaching, some of the calcareous Old Dunes have retained their original form more than the siliceous Old Dunes and in parts are still quite steep.

There does not seem to be any basis either in topography or in the nature of their sands to recognise any major subdivision of the Old Dunes in terms of successive periods of formation. Inland from Lavinia Point, however, their relationship to emerged shorelines suggests at least two phases of development (p. 16 below) comparable in status with the phases recognised in the New Dunes.

Although in certain parts the Old and the New Dunes are separated by an intervening strip of country, in general the New Dunes overlap the Old and the way in which some lobes of the New Dunes project beyond the local limits of the Old Dunes whilst nearby ones merely reflect that limit

along a more seaward line makes it likely that New Dunes must overlie the Old Dunes in parts. There is some direct evidence of this. Just north of Pennys Lagoon there is a small headland of granite breaking the long sand cliff coast from Boulder Point eastwards. The actively eroded sand cliff, which is as much as 50 feet high on either side of this headland, consists mainly of yellow New Dunes, which appear to have a significant shell sand content from the presence of calcareous root intrusions but which reveal former podsollic soil horizons up to 2 feet thick undulating laterally. But there occur also at the base of the cliff exposures of Old Dune profile 6-15 feet high, with red-brown sandrock overlain and replaced laterally by deep grey-white leached sand. Also in the floors of hollows near the eastern margin of the high calcareous dunes south of the Etrick River on the west coast there occur patches of grey leached siliceous sand, which suggest the presence of siliceous Old Dune material beneath; eastwards there is only a narrow fringe of Old Dune outside the foot of the New Dune wall.

The Old Dunes do occur right down to present sea level and it is probable that they may underlie the New Dunes quite substantially. Therefore the aeolianites exposed within the calcareous New Dunes may not always belong to that system but as yet no means of distinguishing different aeolianites has been found. This general point finds its importance in relation to fossil finds in the dunes. Bones which do not belong to the animals now living on the island are reported from blowouts in various parts of the island but only from the northern end of Stokes Point have such finds been recorded through the efforts of Mr. J. Bowling. Three collections have been described and are consolidated in the following list:—

*Dromaeus minor* Spencer (Spencer & Kershaw, 1910; Anderson, 1914). The King Island Emu was alive in the island in 1802.

*Vombatus ursinus* Shaw (Spencer & Kershaw, 1910; Anderson, 1914). This wombat is still found on Flinders Island.

*Dasyurus bowlingi* Spencer & Kershaw (Spencer & Kershaw, 1910; Anderson, 1914).

*Dasyurus? maculatus* Kerr (Anderson, 1914).

*Macropus ruficollis* Desmarest (Anderson, 1914).

*Macropus anak* Owen (Scott, 1905).

*Sthenurus atlas* Owen (Scott, 1906, 1917).

There is some discrepancy about the matrix of the finds. Spencer and Kershaw describe their finds as coming from dune sands set in motion by grazing and burning; winnowing left the bones exposed on the blowout floor and sheep bones were found along with the indigenous species. Scott's account of the matrix "soft, friable shell limestone rock of marine origin" can be safely interpreted as implying aeolianite. Certainly, there is much aeolianite exposed today in the area of the finds, the blowout now being generally fixed. But Anderson maintained that the bones occur mainly in a red-brown sandrock though some few come from overlying aeolianite which he regarded as contemporaneous. This sandrock he thought to be marine but the cross-bedding on which this idea rests could quite well be aeolian. The sandrock

seems more likely to be of Old Dune provenance, perhaps covered by New Dune aeolianite. Some of the finds thus seem to belong to the older system; there is, however, a strong likelihood that finds from very different horizons have been brought together by winnowing action in the blowout.

#### REGIONAL DESCRIPTION OF THE COASTAL GEOMORPHOLOGY

Some of the details of the coastal geomorphology will now be set out in terms of a number of sectors which possess a certain degree of homogeneity. Such a treatment will be longer than to discuss successively features at different altitudes over the island as a whole. But the local distributional relationships of features at different altitudes are significant for their interpretation; a regional treatment will make these relationships more obvious. Moreover, the validity of the interpretative synthesis which follows can be more readily assessed if the data are not presented in the framework of that synthesis. The high coastal sectors are considered before the low coasts and the east coast units before the west coast ones. On the west coast, which is the weather side of the island subject to more violent wind and wave action, features from earlier phases of the physiographic history have been more liable to obliteration by erosion or burial whereas on the leeward east coast there has been both more separation and more survival of coastal features related to different stands in the relative level of land and sea.

##### A. THE HIGH COASTS

###### 1. From Naracoopa to Grassy (fig. 3).

This is the major sector of high coast in King Island, at one time having the local name of "The Wall" (B. Spencer, 1888). Yet it is high coast only in the sense that high ground varying from 300 feet in the north to 400 feet in the south approaches very close to the shore. It is an actively cliffed coast over one mile alone of the dozen involved. A coastal terrace of varying but generally narrow width today separates the sea from the steep scarp of the plateau. The scarp typically has slopes of 30-35°, whereas the terrace varies from quite a flat surface to slopes of 5°. The terrace consists essentially of emerged marine platforms and the scarp is a degraded emerged sea cliff.

Along a little more than a mile of the coast running south from a point a mile south of Fraser Bluff modern erosion has removed the marine terraces consistently, though there are occasional interruptions of the latter elsewhere. But the modern cliff is generally only 10-20 feet high, rising at points to 30-40 feet. As a result the whole fall from the plateau to the sea here takes on the character of the "two-cycle" cliff of Cotton (1951) or the "hog-back" cliffs found in Devon and Cornwall (Balchin, 1946; Arber, 1949).

Elsewhere the break of slope between the two features, the terrace and the old cliff, which is the measure of the former stand of the sea in relation to the land, is frequently obscured by mass slumping promoted by the seaward dip of the rocks and by steep, coarse alluvial fans emerging from gullies in the scarp. Even away from these

obscuring features the old cliff-foot is somewhat rounded by vegetated talus and so it is impossible to determine the back of a platform with any degree of precision; values for a given sea level are bound to vary 5-10 feet on this count alone. Nevertheless, the range of height of the former cliff-foot from a little over 20 feet to 60 feet shows that the main terrace is composite. Moreover, subsidiary breaks of slope in the terrace can be seen at some points where fragments of higher platforms survive surrounded by lower ones. Platforms rising to 20-30 feet and 40-50 feet are most common but the marked scatter cannot be overlooked.

The terrace is generally low (20-30 feet) along the most exposed coast between Fraser Bluff and the bluff half a mile north of City of Melbourne Bay. The wider, higher terraces need further comment. Behind Naracoopa the terrace is about a quarter of a mile wide and rises generally to about 50 feet. It carries a good deal of sand arranged in steps or berms trending NW-SE and the foot of the most marked rise at least represents an old shoreline at 27 feet.

From the bluff half a mile north of Yarra Creek, for a mile and a half southwards, the old cliffline recedes a quarter to half a mile from the shore. Around City of Melbourne Bay the main coastal terrace with its back at 45-50 feet is well defined. Section, D, fig. 4, shows a levelled profile across the terrace a little north of Yarra Creek. It crosses a shallow, swampy depression, now drained, at the foot of the main scarp and which is enclosed in part of a low curving sand ridge, in part by subdued Old Dune sand and low rock projections. Here there was a small lagoon on the terrace enclosed by beach ridges. Below the sand ridges a further shoreline is traceable at 26 feet.

City of Melbourne Bay is surrounded by Old Dune ridges which are cliffed on the bayside, revealing 5-10 feet of loose, grey-white quartz sand over 8-12 feet dark-brown sandrock. Beneath this dune material are deposits at HWM to +4 feet, which are very variable, both laterally and vertically. South of the creek there are isolated small outcrops of gravel and of clay with boulders in it. North of the creek the deposit is more continuous and contact with the bedrock was visible at several points. Well rounded boulders and gravel, in parts with ferruginous matrix, lie at the contact. These pass upwards into grey silts, sandy silts or clayey sands. In these occur large timbers, abraded and *non in situ*. Where the timber is most common, the matrix is a laminated sand and peaty clay. At two points, boulders and gravel are intercalated between the driftwood layer and the overlying sandrock. All these materials can be matched in the present bed of the Yarra Creek upstream and there can be no doubt that they represent former deltaic accumulation by the creek. Sea level may well have been lower when they were deposited but could not have been higher because of the lack of any consistent bedding and absence of marine shells. In time they must have been deposited before the close of Old Dune formation and after the erosion of the marine terrace and the building of the constructional features between 38 and 22 feet.

The plant identifications from the deltaic deposit made by Dr. Duigan and Mr. Ingle are listed in Appendix I. The steep walls of the Yarra Creek gorge above are the most likely part of the drainage basin to have provided the material; the present rainfall is about 60 inches annually. The high percentage of the fern spores is not surprising; B. Spencer (1888) describes similar valleys incised into the plateau near Naracoopa as "fern gullies" and in the accompanying floral list, F. v. Mueller records a number of fern species, including the tree fern, *Dicksonia*. Tree ferns still grow on the island today, e.g., in the Seal River valley. The dominance of Celery-top Pine (*Phyllocladus aspleniifolius*) is interesting since it is often regarded as restricted to the main island of Tasmania (Curtis, 1956). It was not recorded in the collections made by Baldwin Spencer's party last century and is not known growing on the island today. Nevertheless, it seems to have been present before the disastrous forest fires of last century. An early description of the island (*Govt. Gazette*, 31 March, 1827, quoted in *Proc. Roy. Soc. Tas.*, 1873, p. 50) mentions "celery-leaved pine" growing there and during the clearance of secondary forest near the Yarra Creek as part of the Rural Bank Land Settlement Scheme a few years ago, celery-top pine logs and stumps were found to be thick on the ground in certain parts (O. H. Drake, *in litt.*). On the other hand, there is no record at all of *Nothofagus cunninghamii* (Tasmanian Beech) and *Drimys lanceolata* (Mountain Pepper) in the island now or last century. The beech is, of course, the dominant of the Tasmanian temperate rain forest and occurs sporadically in humid high altitude localities in the South Eastern Highlands on the mainland; the mountain pepper has much the same sort of discontinuous distribution. The fossil flora is thus not very different from the historical and present-day flora and there is little indication of climatic change. The Yarra Creek gorge is vegetationally near to temperate rain forest now and was then. Perhaps we can infer either slightly wetter or slightly cooler conditions, the cooler conditions making rainfall more effective.

The southern end of the recess in the old cliffline in this neighbourhood is known as Cotton's Flat, an appropriate local name since it consists of an excellent development of the main terrace with a well-defined inner margin at 45-50 feet. The northern part has an Old Dune cover but elsewhere it is gently ribbed by low sand ridges and swampy depressions.

South of Cotton's Flat the old cliff returns to the shore and is actively undercut some 10-15 feet. Here the main terrace is meagrely represented by ill-defined steps in the spurs. In one inlet a coarse conglomerate is exposed with an irregular base visible at 12-15 feet and rises at the surface to 25 feet. It is an unfossiliferous beach boulder bed, with a matrix of iron-cemented sand and seems to belong to a lower phase of the cutting of the main terrace.

The steeply-dipping volcanic rocks of Bold Head have been planed by marine erosion at higher sea levels than the present but the platforms pass under the vigorous development of New Dunes which have here climbed up the south-facing slope

of the plateau. Farther west to Grassy Creek they form a narrow belt and there is a corridor between them and the plateau scarp; the bedrock features are, however, obscured by smaller developments of Old Dune sands.

Above and below the composite main terrace there are features significant for the present purpose. At the southern end of this sector at Grassy the old cliffline runs westward with the present coast diverging southwards. The opening of the schellite mine runs along the face of the cliffline. Between the thick cover of Old Dunes and the bedrock, a boulder bed 10-15 feet thick has been exposed at various points and has been commented on several times (Nye, 1939; Nye and Knight, 1953; Edwards, Baker, and Callow, 1955). Nye speaks of the deposits as lying at heights of 120-150 feet. In 1953, when examined by R. Callow and J. N. Jennings, they were to be seen in the 90 and 70 feet mine levels and consisted of subangular to well-rounded gravel and boulders, varying from  $\frac{1}{2}$  inch to 3 feet in maximum dimension, with greenish-grey, silty clay matrix in parts. Granite, as well as the many metamorphic rocks of the mine itself, was represented. Several mineworkers stated that similar beds had been encountered at various levels as high as 120 feet and as low as 30 feet. The general disposition of these unfossiliferous beds makes it clear they are shoreline and not fluvial deposits; thus they were still visible in 1953 at the eastern end of the backwall of the cut at the 90-ft. level with no gully in the slope and virtually no catchment at all on top of the plateau. All observers agree that they are high sea level beach deposits, though the height of the associated strandline is now not closely determinable. Indeed, from the height range of the deposits, it seems likely that they related to a succession of strandlines.

However, much higher levels than those of the main terrace are involved and around the City of Melbourne Bay-Cotton's Flat recess in the old cliffline, there are certain morphological features, admittedly not well defined, which may relate to the same phase. The broad bulge in the coast between City of Melbourne Bay and Cotton's Flat is backed by ground higher than the main terrace developments north and south. This greater altitude is only partly due to the spreads of Old Dune sand and a narrower belt of sharp new parabolic dunes on the south; the bedrock also rises higher in irregular fashion to a break of slope with the old cliffline at 120-130 feet. This break of slope seems to be represented farther north by a series of flattenings in the spur profiles. These steps, though distinct, are themselves steeply inclined, and determinations of the significant break of slope are very subjective; aneroid values ranged from 144 to 127 feet. South of Cotton's Flat there were some further small steps in the old cliffline at 130-140 feet.

Three other steps at still higher levels are significant (1) on the bluff half a mile north of Yarra Creek (break at 225 feet), (2) just south of the City of Melbourne Bay road (227 feet), (3) on the bluff south of Cotton's Flat (238 feet). The first two carried patches of well-rounded gravel, 1 inch to 1 foot in size and mainly of quartz. These were unrelated to any present stream drainage and may be littoral.

The present shore of the Naracoopa-Grassy sector consists in the main of irregular rock reefs projecting a few feet above HWM. Active cliffs, even low ones as little as ten feet high, and well-developed shore platforms are few. This does not seem to be entirely due to the emergence of the main marine terrace. There are frequent and clear evidence of unattacked clifflets behind equally uneroded rock platforms, often carrying vegetated and undisturbed beach materials. The cliff foot is usually very well defined and lies a few feet above HWM, ranging from 3 to 9 feet but most commonly about 6 feet. One example is shown in Section D, fig. 4. Generally the clifflet just trims the outer edge of the main terrace but at a few points it eliminates that terrace altogether. Thus just south of Barrier Creek, the 6-foot platform is 50 yards wide, with a cover of sand, shingle and boulders, overgrown by bushes and the cliff behind also vegetated rises to a maximum height of 30 feet, pinching out the main platform. There is a similar development at the northern end of the little bay into which Conglomerate Creek debouches. Nevertheless, the general rule is for very narrow platforms and clifflets only a few feet high; they are well scattered along the coast in both exposed and sheltered positions and definitely show no sign of present-day wave attack.

At four points around Bold Head banks of weathered and vegetated beach cobbles, 0 to 20 yards wide, rise to 10-15 feet above HWM. Parts of these banks lie under thick shrubbery and, although they may grade downwards into active cobble and shingle banks, they are interpreted as belonging to the same phase which fashioned the 6-foot platforms and clifflets. The associated constructional features would, of course, rise higher than the cliff foot nip.

A further related feature is the occurrence of vegetated and unattacked shingle and cobble fills at the heads of marine erosion inlets or geos; these occur even where modern cliffing is most active, e.g., north of Barrier Creek.

Sandy shores backed by sand dunes are of restricted occurrence in this sector but do occur over short stretches. Active sand cliffs are common here but there are also some occurrences of fixed dune clifflet with vegetated sand platform in front, e.g., half a mile south of Fraser Bluff and along the shore of Cotton's Flat. These are in New Dunes but similar features in Old Dunes occur at the north-east corner of City of Melbourne Bay and just south of it. These again give a cliff-foot height within the range of the 6-foot platforms and are regarded as contemporaneous with them.

Barrier Creek leaves its gorge by a small waterfall of a few feet to enter the sand-barred lagoon at HWM. Similarly, Conglomerate Creek hangs 5-6 feet in rapids above HWM at its mouth on the shore. This lack of adjustment could be due to the small recent emergence. Grassy Creek is very different although the dam for water storage for the scheelite mine obscures the situation. Over its last quarter of a mile the steep valley walls appear to converge in a thalweg which is below the present sea level. This suggests downcutting when sea level was lower, followed by a positive movement and some aggradation.

## 2. From Surprise Bay to Fitzmaurice Bay (Fig. 3).

Though its adjoining plateau (100-190 feet) is much lower than in the case of the coast just described, the Surprise Point-Cataraque Point sector is more truly a high coast. It is broadly similar in character but the marine terraces have been largely removed and the old cliff is much more under modern attack. Active cliffing 30-60 feet in height is common and at a number of points the hogback cliff is being eroded right to the top (100-170 feet). This is particularly true of the middle section north of Seal Rocks where inlets and geos are under violent modification right to their heads which in some cases consist of vertical cliffs 150 feet high. This greater amount of present-day cliffing is readily understandable in terms of exposure to the west from which the storms mainly come. At the same time the coast has something of the character of a "plunging cliffline" for the real break of slope is not at sea level, but some 20-35 fathoms down (Jennings, 1959, in press). A plunging cliffline is usually regarded as under weakened attack because of wave reflection (Cotton, 1951).

At a number of points the old hogback cliff is not only vegetated but carries a thin skin of breccia. The angular rock fragments are cemented by a matrix of ferruginous sand, but elsewhere the consolidation is due to calcium carbonate derived from the cliff-top dunes. This would appear to be the product of subaerial weathering in different climatic conditions from the present ones, possibly periglacial (cryergic) conditions of a Pleistocene glacial period.

Evidence of former shoreline levels is not entirely lacking through more fragmentary and less clear-cut than on the high east coast. Inclined steps or "bevels" in the cliffline, very imperfect remnants of emerged marine platforms, are most frequent in the north near to Cataraque Point but some occur south of Seal Rocks. Some of these carry dune sand and thick, nearly level spreads of the breccia mentioned above. This may have been mistaken for the raised beaches, which Stephens & Hosking (1932) cite; in fact it has much more the character of periglacial "head". The backs of these "bevels" are far from clearly defined and the values given them vary from 23 feet to 59 feet, most being at 40-50 feet. To be correlated with these bevels are certain "hanging coves", small recesses in the cliffline with their lips and floors at 45-50 feet. Most do not receive any appreciable drainage from the plateau nor have they the nature of landslip scars (cf. "erosion amphitheatres" of Baker (1950); see also Edwards (1945)). The most likely origin seems to be marine erosion at a higher sea level stand. Further indication of these stands is to be seen in the high-lying sea caves in the most exposed parts of this sector. There is one square-cut, shallow cave with its floor at 50 feet in the southernmost granite headland; there are also two much deeper fissure caves, with floors at approximately 30 feet, in the strike of the schists at an extremely exposed salient north of Seal Rocks (Jennings, 1956). The details show they are unattacked and must be relict features from higher sea levels.

The short west-east reaches from Surprise Point to Surprise Bay and from Cataraque Point to Fitzmaurice Bay are less exposed than the coast between the two headlands. In consequence, the old cliffline is still set back from the modern shore. But, in the southern case, New Dunes have extended up onto the plateau from WSW and W and largely obscured the relief in the country rock. Thus, towards the west there is an irregular shelf in the rock in front of the dunes but this disappears beneath the sand with no possibility of determining the height of any former shoreline. Nearer to Surprise Bay there is a small rock shelf with part of the old degraded bedrock cliff unobscured by sand and the break of slope is about 26 feet. There are more vestiges of the lower shelf with a back at approximately 6 feet and the related vegetated clifflet is found in the solid, in aeolianite and in New Dune sand.

The Cataraque Point-Fitzmaurice Bay stretch is much less obscured, though around the two bays indenting it sand has blown over from the windward side to obscure any high terraces. But to the west and east these are preserved quite clearly; to the west the back is at 45 feet, whereas to the east 35 feet was the usual figure; the terrace here carries a very fine granite stack. Along a great deal of this northward-facing coast there are relict narrow platforms of the 6-foot level, with boulder beds and small clifflets. At two points active erosion has exposed cemented boulder beds at 10-15 feet; these must belong to the main terrace.

The evidence of this western high coast is less well preserved and on its own much less decisive than that of the Naracoopa-Grassy coast. But it reveals essentially the same story and argues against any east-west tilting during the time to which the emerged coastal features relate.

## B. THE LOW COASTS.

### 1. From Naracoopa to Lavinia Point (fig. 2).

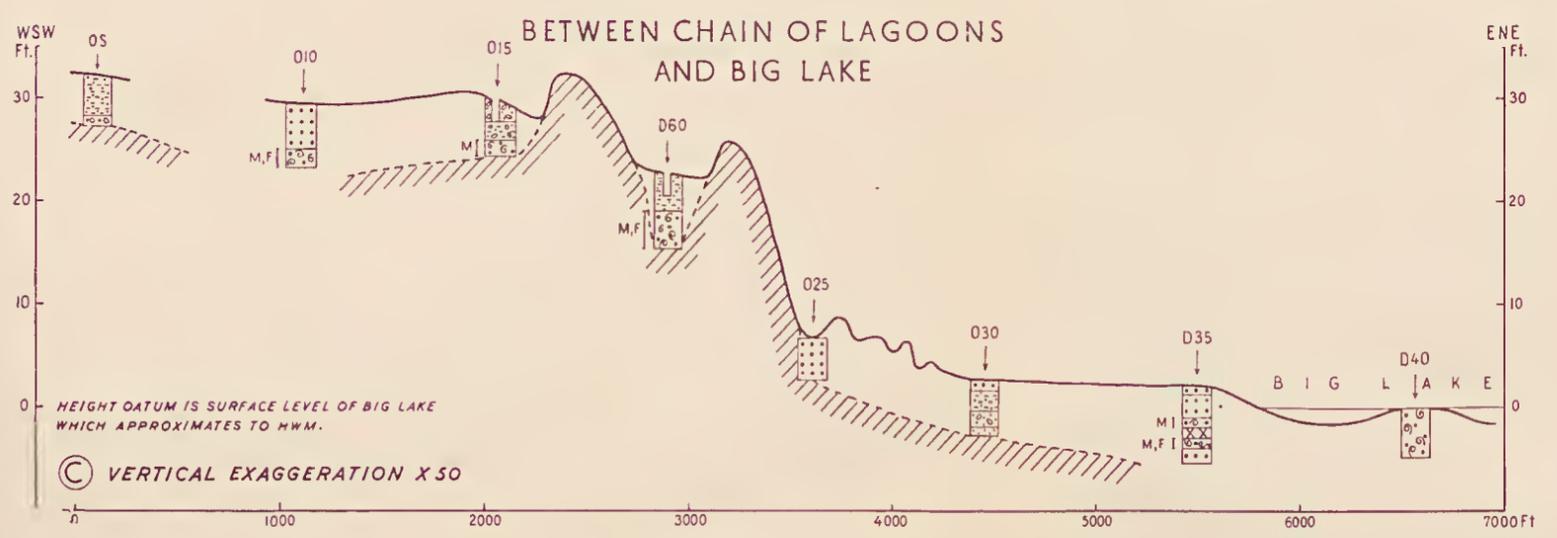
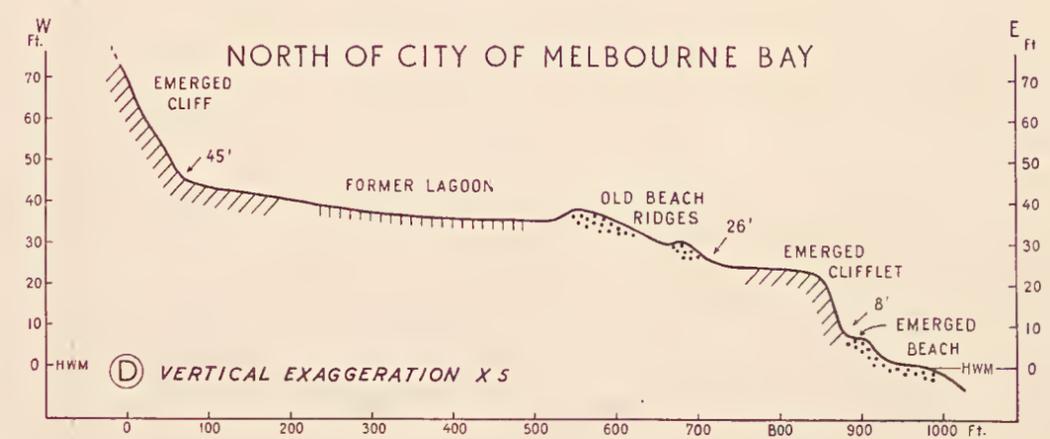
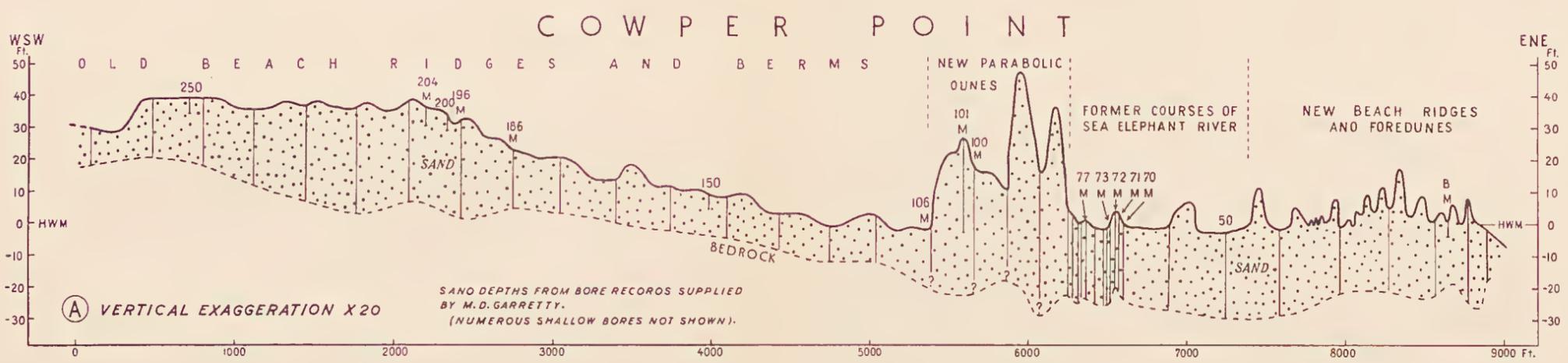
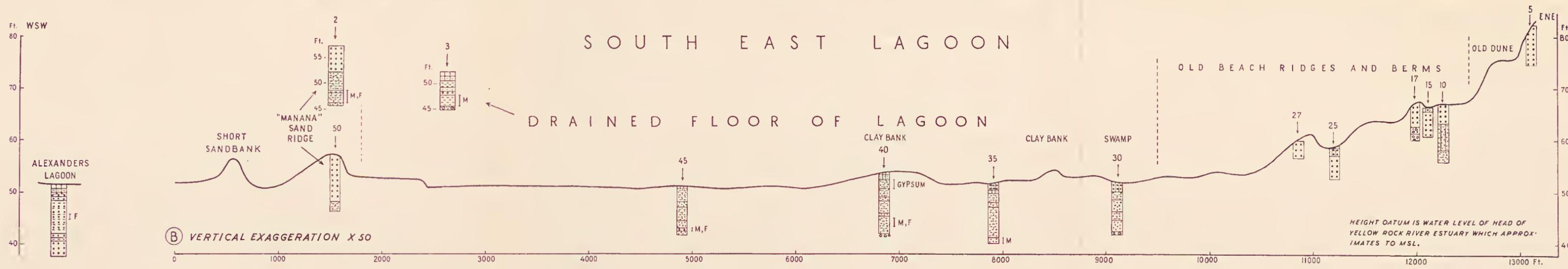
This long low coastal sector is almost entirely a sandy constructional one, with the brief exception of the Tertiary limestone of The Blowhole. It is also almost everywhere prograding at the present time. The exception is the southern side of Cowper Point where there is an active sandcliff; possibly also there is a balance between accumulation and erosion about three miles north of Cowper Point. Overall, there is an accentuation of the Sea Elephant Bay and the bay north of Cowper Point. Two sets of strandlines can be traced in almost unbroken continuity over the whole sector; the Old Shorelines are associated with the Old Dune system and the New Shorelines with the New Dunes. The relationships of the different features vary along the coast and it is necessary to discuss the sector in three parts—(a) Sea Elephant Bay, (b) Cowper Point, (c) Sea Elephant River to Lavinia Point.

(a) *Sea Elephant Bay* (fig. 2, fig. 3). Behind the symmetrical arc of sand beach is a low vegetated sand terrace, some 50 yards wide, in front of a fixed sand cliff 20-30 feet high. The cliff-foot is usually at 3-6 feet above HWM. Long low sand ridges, 3-5 feet high and as many as 4 in number,

diversify the low terrace over most of its length. Each represents a very early stage in the development of a foredune on top of a beach or berm. Davies (1957) has recently provided the most satisfactory account of Tasmanian sand ridges of this type. Together with the cliffing, these constitute the New Shorelines here and the fact that progradation succeeded retrogradation over the full length of the bay in a uniform manner is indicative of an important general change in coastal conditions such as a small emergence.

Inland from the cliff which is cut in older, deeply leached sands, there is a belt some 300 yards wide where the air photographs reveal linear patterns suggestive of further strandlines parallel to the lower features. They are clearest and most continuous behind the middle of the bay. On the ground they are seen to be low ridges or berms of leached quartz sand, separated by wetter depressions; the height difference is only a few feet and the surface rises gently as a whole inland. Where the first stream north of Fraser River cuts across this belt, the ridges bend backwards into the mouth of the valley as might be expected of shoreline features and on its southern side develop into subdued dune forms. These sand ridges appear to be degraded older equivalents of the sand ridges of the New Shoreline system. The rear margin of this higher belt of Old Shorelines was generally not well defined; it takes the form of a steeper rise, particularly where there are Old Dunes. At one of the sharpest of these breaks an aneroid height of 45 feet was obtained. Farther inland is the zone of sinkholes on Tertiary limestone with a scatter of sporadic Old Dunes, some of which exhibit parabolic form.

(b) *Cowper Point* (fig. 5). Between Blowhole Creek and Sea Elephant River, the strandline features confined farther south to a narrow belt broaden out to a depth of two miles in a fine cusped foreland. North of The Blowhole a broad swamp flat not much above mean sea level intervenes between the Old Shorelines and the New. Seaward of this flat there is a narrow New Dune belt, 50-60 feet at its highest, which broadens northwards to a big mass of parabolic dunes rising to heights of over 100 feet behind Cowper Point. Within this mass linear patterns in the air photos prove to be former clifflines frequently interrupted by later parabolic dunes advancing across them. Along the southern part of the shore from The Blowhole to Cowper Point, the front of the New Dune belt is a fixed cliff equivalent to the fixed cliff in older sands behind Sea Elephant Bay, and below this cliff are one or two low sandridges. These change northwards into a well-developed foredune with an active sandcliff. This sandcliff rises higher northwards and erosion supervenes to pinch out this last foredune. The coast is retreating and local residents report the complete disappearance of quite high dunes in the last 30 years. The other flank of Cowper Point is prograding and here is a series of narrow foredune ridges, 5-10 feet high, running NW-SE. On the southern flank of Cowper Creek, these foredunes are being truncated by erosion but on the northern flank they are successively reaching farther north-west to form a spit deflecting Sea Elephant River northwards. Between 1946, when the air photo



- ○ ○ ○ BEACH COBBLES
- ○ ○ ○ GRAVEL
- ○ ○ ○ SAND
- ○ ○ ○ SHELL SAND
- ○ ○ ○ SILT
- ○ ○ ○ CLAY
- || || PEAT
- × × × × ORGANIC MUD
- /// BEDROCK
- M MARINE SHELLS
- F FORAMINIFERA SAMPLES
- I I BOREHOLES

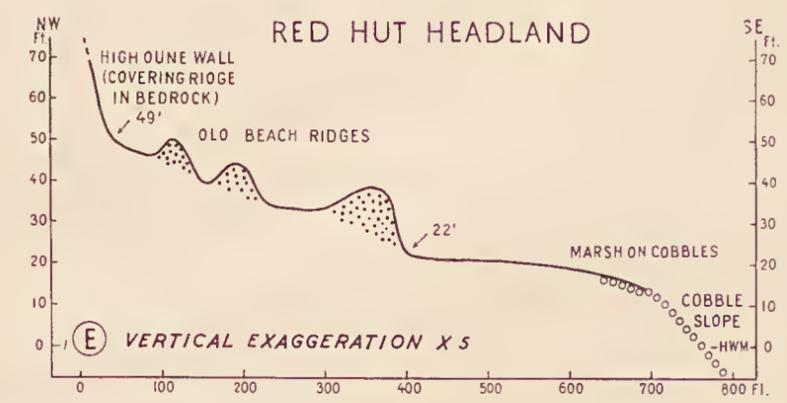


FIG. 4 (A, B, C, D) BY KERN GKI LEVEL, (E) BY ANEROID

FIG. 4.—Sections and Profiles from King Island.



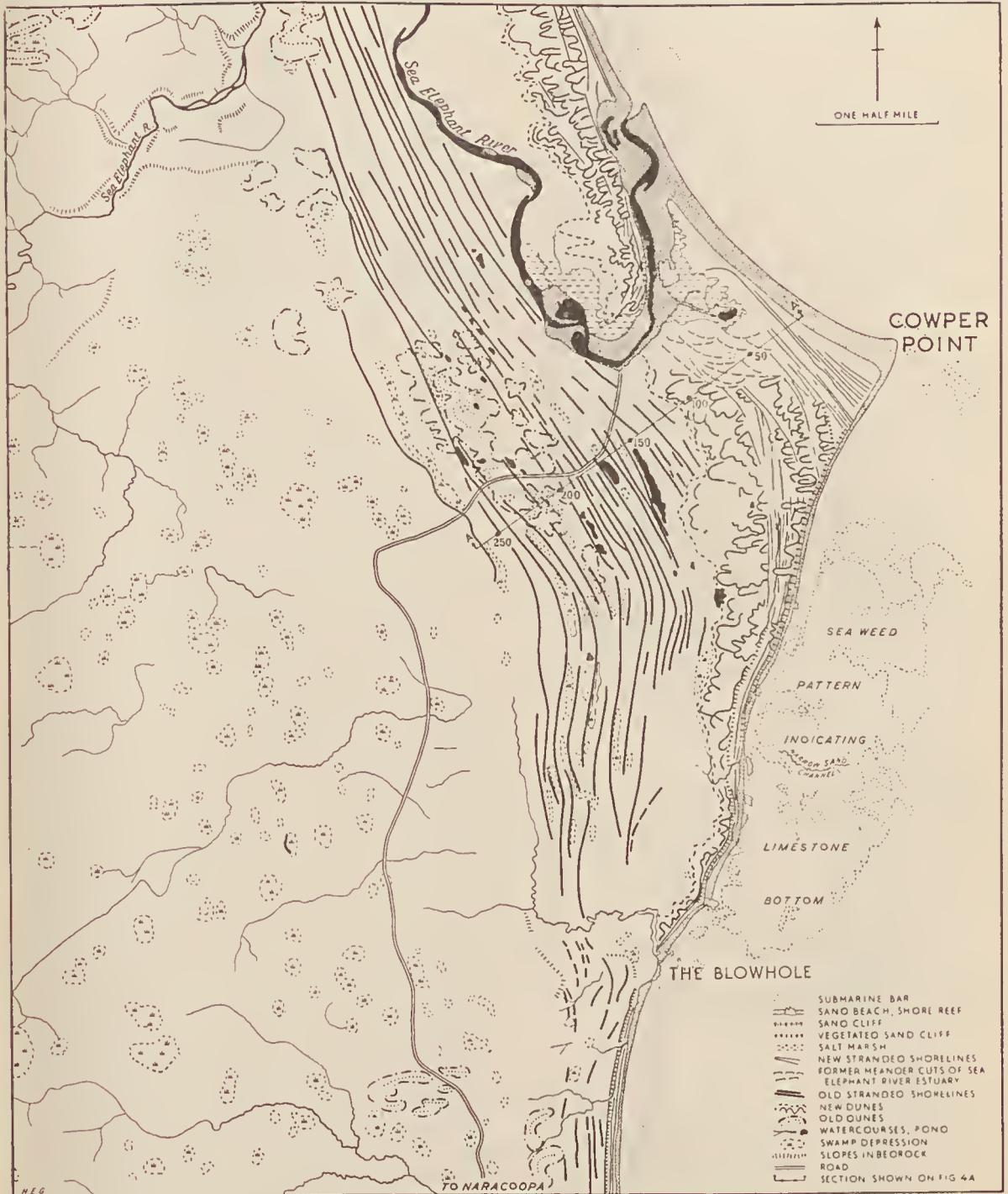


FIG. 5.—The Cuspate Foreland of Cowper Point.

cover was taken, and 1954, this spit has grown and caused the river to debouch even further to the north. Behind the spit is a protected area of salt and freshwater marsh and also a complex pattern of former meanders of the Sea Elephant River.

The New Dunes of Cowper Point encroach onto the Old Shorelines, which here reach a maximum width of a mile. These also form a blunt foreland with a nose about a mile south of Cowper Point. Section A, fig. 4, shows the general nature of the Old Shorelines here. This section was compiled from details of borings for a black sand investigation in 1952, which were kindly provided by Dr. M. D. Garretty; the levelling was done as part of the present study and shell fragments were collected from the bore spoil (see App. II.). This section crosses some of the new foredunes, former estuarine channels of the Sea Elephant River and the main new parabolic dune complex at a fairly narrow point. Behind these dunes there is a ti-tree swamp below HWM in which appears the first of the old strandlines. These consist of very low sand ridges and berms; they generally rise 2-3 feet with a maximum amplitude of 7 feet and in width vary from 10 to 65 yards. Seventeen of these features were crossed in the section line, rising steadily from just below HWM to about 40 feet above; then they remain level for the last third of a mile. Behind the last ridge there is a depression (bottom at 29 feet) which is readily traced laterally; inland there is a gradual rise into the belt of sinkholes or solution hollows. The ridges and berms consist of grey-white quartz sand, which underlies the area for 15-30 feet. The intervening hollows carry some sandy peat, at most three feet deep. They are generally swampy and may have intermittent shallow ponds, some of which are clearly due to combustion of peat at a result of burning-off practices. Very subdued, fixed Old Dunes obscure the ridge pattern in parts and a parabolic pattern is discernible in some of these low dune mounds.

From the boreline, most of the samples of mollusca (Appendix II.) came from the New Shorelines and comparatively few from the Old, but no significant differences in the assemblages are apparent. Quite a large proportion of the finds are of sandy and sandy-mud bottom dwellers but a number of intertidal rock species are present, together with submerged weed inhabitants. This suggests open beach conditions with a mixture of forms transported from different habitats, and confirms the conception of a continuously developing sand foreland with varying exposures of limestone reefs. All the species were marine with the exception of a *Salinator* speels from a swale bore in the New Shorelines; again this is consonant with the present conditions.

(c) *Sea Elephant River to Lavinia Point* (fig. 2, fig. 6).—Northwards from the estuary of the Sea Elephant River a flat depression separates the older and the newer systems of coastal features.

The New Dunes broaden and grow higher northwards and so does the belt of low foredunes, which constitute the New Shorelines here. The one or two ridges of the southern end multiply to over 20 towards Lavinia Point where they reach

half a mile inland. The seaward three are here only partly colonised by shrubs and grasses, but the others are completely fixed either by bracken or open gum woodland in accordance with the incidence of burning-off. The ridges are only a few feet higher than the hollows, though both rise gradually inland so that the innermost depressions lie at 10-15 feet above HWM.

Near Lavinia Point the New Dunes fall into three sets. Behind the full set of New Shorelines there are comparatively low parabolic dunes about half a mile wide. Then a later and higher group, reaching well over 100 feet, cut across at least eight of the New Shorelines. They eventually overlap the first set of parabolic dunes completely and cut across the head of the intervening depression to advance onto the Old Dune system. This set constitutes the main body of the New Dunes and significantly postdate the oldest of the New Shorelines. Lastly, at Lavinia Point itself, a very young and small group of parabolic dunes cuts across the ends of nearly all the remaining New Shorelines.

At their southern end the New Dunes and Shorelines have deflected the Sea Elephant River southwards and many meandering river channels, some still used at flood time, can be traced in the flat corridor behind them. In this corridor, salt marsh near the estuary gives way to freshwater marsh and north of the Sea Elephant River it becomes an elongated belt of ti-tree swamp and small lagoons known as The Nook. A bore in the dry bed of a lagoon about 1½ miles from the northern end showed grey quartz sand extremely rich in marine mollusca beneath 70 cm. of structureless dark-brown peat and organic mud. A much smaller assemblage of mollusca than at Cowper Point still ranges from intertidal rock to sandy-mud bottom forms but a high proportion of small weed-living forms are indicative of a sheltered inlet. The presence of *Salinator* and *Assimineca* also points to the transition to estuarine conditions. These sands must have been deposited after the development of the spit and New Dunes on the seaward side.

From the Cowper Point foreland the Old Shorelines reach north to the outfall of Egg Lagoon where they are cut across by Old Dunes. They decline in number and width though retaining the same character. The Sea Elephant River cuts through them down to underlying granite. They are also interrupted at several places by dune-covered projections of higher ground from the west; the recurved pattern of some of the Old Shorelines suggests shallow bays between these dune-covered headlands. At the northern end the strandlines are divided into two groups separated by a broad swampy depression; the seaward group is accompanied by Old Dune formation. On the line of "The Cords" crossing of The Nook, the mean of two aneroid traverses gave a rather unreliable height of 27 feet for the back of the highest berm of the Old Shoreline series.

The Old Dune development behind the coastal sector is meagre from Mt. Counsel southwards, but, farther north, Old Dunes reach in a broad belt right across towards South East Lagoon, where they meet other parabolic dunes blowing from the west and give rise to some special dune forms.

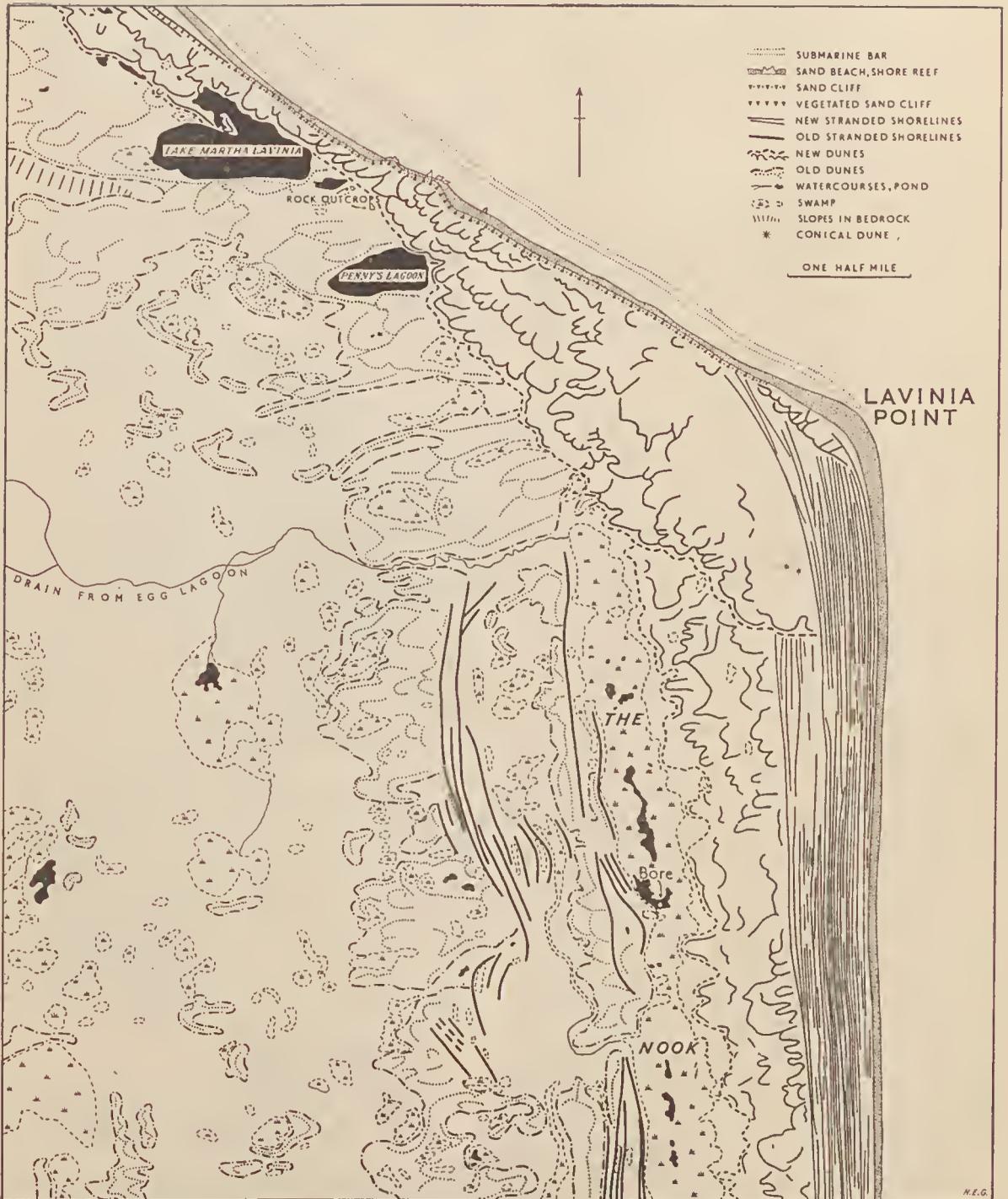


FIG. 6.—Coastal Geomorphology of Lavinia Point.

## 2. From Lavinia Point to Whistler Point (fig. 2).

This is a sandy constructional coast for the most part. The north coast is interrupted by the low rock headlands of Rocky Point, Boulder Point, and of a small outcrop north of Pennys Lagoon; then there is the longer section of low rock coast from the western side of Disappointment Bay around to the northern end of Phoques Bay.

Along the western side of Disappointment Bay, dunes are absent for half a mile, the granite hill sloping gradually down to the shore. This coast is only exposed to the north-east where the length of fetch is short and so an absence of cliffing is to be expected. Consequently, although there are some small emerged marine platforms, they are not well defined. In three places the lowest level is represented by breaks of slope at 4, 7, and 8 feet above HWM, whilst higher platforms have their backs at 22, 29 and 39 feet. A narrow foredune of deeply leached quartz sand rests on the forward part of the last one, which occupies a recess in the hill slope close to the steep wall of unleached New Dunes which has swept over from the west coast. Farther west the New Dunes reach to the rock reefs in parts; in others a fixed dune cliff leaves a rock platform in front but the cliff here cannot be surely interpreted as belonging to the 6-foot stand. Great banks of vegetated cobbles showing no sign of present-day disturbance, e.g., at Cape Wickham itself, do belong to that stand, however. Between Cape Wickham and Phoques Bay there is more active erosion, with small cliffs rising to 15 feet at a maximum to be found in places. The dunes, generally, rise immediately behind the reefs here but at a number of points the abandoned clifflet and rock platform or beach of the 6-foot level are to be seen. At one point the clifflet can be traced laterally from metamorphic basement rocks, through old spring tufa deposits into aeolianite. At three points, small sea caves, a few feet above HWM and developed at the contact of the metamorphics and tufa-cemented breccia, are no longer attacked by the sea. Beach shingle in the caves confirms marine origin; unabraded roof fall, earth, plant growth and burrows show their relict character at the present time. They are quite distinct from hollowings in the aeolianite, which are due to wind action.

The remainder of this sector needs little comment, since it consists for the most part of active sand cliff and sand beach, apart from three sections—a stretch of about one mile between Lake Martha Lavinia and Boulder Point, nearly two miles of the coast lying symmetrically between Boulder Point and Rocky Point and the projecting sand foreland west of the Yellow Rock River mouth. The first two are very similar. Grassy or shrub-covered dune cliffs, which rise to a maximum of about 100 feet, are separated from the shore by a low terrace with simple sand ridges or low shrubby foredunes. These are more numerous at the wider western end of the terrace, where active accretion and new sand ridge formation has been going on since 1946, as the air photos reveal by comparison with the 1954 position. Where the innermost foredune or ridge is not banked against the abandoned cliff, the swale bottom lies only a few feet above HWM. The Yellow Rock Foreland

also has an old fixed cliff, though much lower one, separating the main mass of parabolic dunes from low sand ridges which represent a phase of sand accumulation under different shoreline conditions. On the north of the foreland there is one low foredune in front of the cliff, whereas on the west there are four very low simple sand ridges. The features of these three localities clearly correlate with the Newer Shorelines of the Naracoopa-Lavinia Point sector.

New and Old Dune Belts almost completely ring this sector of the coast advancing from both west and east. The one break is found in the granite hills between Lake Flannigan and Disappointment Bay. Similar low granite hills lie between Egg Lagoon and the north coast, though these also are partly covered by Old Dunes. Numerous lakes occur at the contact of the dunes with the granite rises or along the boundary between the two dune systems or within the dune systems, particularly the Old Dunes; some of them have been discussed elsewhere (Jennings, 1957a) and the others belong to similar types. It is necessary, however, to consider rather more fully here certain aspects of the major drained lakes of the area. The former Reedy Lake, Egg Lagoon and South-East Lagoon all form part of a plain of young sediments enclosed by the granite rises on the north, by the west and east coast dunes to those flanks and by the northern margin of the metamorphic plateau of the island on the south. The inner part of this plain from Egg Lagoon to South-East Lagoon lies just about 50 feet above HWM; a levelled line from South-East Lagoon to the Yellow Rock River estuary shows that the plain declines gradually westward. It is still at 45 feet where it is crossed by the North Road, but it loses height rather more rapidly farther west to a level of 20-30 feet where the Yellow Rock River has incised 10-15 below it. As will be seen from evidence to be presented, this plain consists mainly of young estuarine-marine sediments overlain in parts by freshwater and swamp deposits.

Though the former relative proportions of open water and ti-tree swamp cannot now be determined, Egg Lagoon, prior to its drainage, was certainly the largest extent of lagoon and swamp in King Island. No geological records survive from the draining but Mr. H. Graves, of Three Rivers, who worked on the draining and bore-sinking, states that generally over the Lagoon floor there was about 8 feet of black clay above 8-12 feet of sand with sea shells. Mr. W. A. Steele, who, in recent years has put down fresh bores for the Rural Bank Land Settlement scheme, confirms the general occurrence of marine sands. His log on No. 1 Block, "Koreen", is typical:—

0- 2 feet	Top soil
2- 5 feet	Brown sand
5- 8 feet	Brown pug
8-24 feet	Sand
24-60 feet	Grey sand; abundant sea shells, including oyster at 40 feet
60 feet	Granite.

From a recent bore less than half a mile south of Egg Lagoon, Mr. H. Lot, the owner of the property, preserved shells from a depth of 50-60 feet; four marine specimens were identified (App. II.).



FIG. 7.—Geomorphological Features of S.E. Lagoon Neighbourhood.

Two finds of giant marsupials have been made in Egg Lagoon. Scott (1912) identified *Nototherium tasmanicum* Scott bones which he received from Mr. F. H. Stephenson, of "Yambacooona" Station. Mr. H. Graves informs me that this find was actually made in 1911 by his brother on a slightly higher islet on Plot No. 12 at the western end of Egg Lagoon. This islet is readily identifiable today and a bore was put down giving the following record:—

0- 13 cm.	Highly humified black peat
13-110 cm.	Mottled grey and buff silty clay
110-125 cm.	Brown silty clay
125-155 cm.	Black silty clay
155-180 cm.	Dark-brown silty clay with fine gravel
197-280 cm.	White gritty shell sand.

In the field the bottom deposit was estimated as an aeolianite ground up in the borcr. This is confirmed by the foraminiferal report (App. III.). Amongst the foraminifera were specimens of a *Calcarina* sp., a tropical genus not known in Bass Strait today.

The second find is recorded in detail by Keble (1945) and was made by Mr. J. G. Haynes in 1927. Teeth and jawbones of *Diprotodon australis* Owen were found scattered over a quarter of a mile of drain at the centre of Egg Lagoon in clay underlying black swamp soil. A hand bore was made within the site area during the present field work:—

0- 10 cm.	Clayey peat
10- 30 cm.	Black peaty clay
30- 70 cm.	Grey clay with fine gypsum crystals
70-125 cm.	Brown and grey silty clay with rootlets
125-340 cm.	Variably grey silty clay and green-grey clay silt, with an increasing content of fine gravel downwards.

The giant marsupials belong to the freshwater phase succeeding the previous estuarine-marine conditions. Although the modern lagoon appears to be dammed at the extreme western end by New Dunes, it cannot be assumed that the freshwater conditions did not develop till New Dune times, since the New Dunes may well overlie Old Dunes at this point. Old Dunes enclose the western part of this lagoon fairly completely otherwise, and it will be seen later that South-East Lagoon to the south must date back to Old Dune times. All that can be said, therefore, as to the age of the Egg Lagoon finds is that they may reach back to Old Dune times, but could relate to a considerably later date on present evidence.

Between Egg Lagoon and South-East Lagoon, there is flat ground a few feet higher than the lagoon floors with Old Dunes to the west and the east. This is part of the same plain of estuarine-marine sedimentation. A bore on Mr. D. Clemons' property lies close to the margin of the plain just inside the Old Dunes on the west and reached down into these sediments; only two marine mollusc species were identifiable from the bore spoil, however (Appendix II.).

The drained floor of South-East Lagoon (fig. 7) lies mainly within the "Manana" Estate, and on

the evidence of deep drains and a number of wells. Mr. J. Lewis, the manager, reports that the general sequence of deposits is as follows:—

Surface	Black Peat
	Black clay
	Fine grey sand, with cockles and mussels
— 20 feet	Grey clay, with sea shells, including oysters.

The levelled line of bores in Section B, fig. 4, confirms and elaborates this for the shallower horizons.

Between the former lagoon floor and the Old Dunes, to the east, there is interposed a series of berms and low ridges, trending NNW-SSE, but with a tendency to concavity towards the west. There are as many as seven such features with a total range in height of 51-65 feet above HWM. They are fully comparable with the Old Shorelines of the east coast, except, of course, that their gradual slopes face west and their steep slopes east. The intervening swales vary from 1-3 feet in depression and may have a couple of feet of sandy peat on top of the leached quartz sand and well-rounded fine gravel which make up the bulk of the series. In bore 10, 120 cm. of sand overlying 160 cm. of highly-humified black silty peat on top of silty clay. In this case the sand ridge has been rolled back over a previous swale swamp. Well developed podsolis occur on the ridges. There can be no doubt that these are shoreline features and their significance will be discussed later.

In front of these sand ridges are certain low broad clay banks which rise 2-3 feet above the former lagoon floor, with very gradual western slopes and steeper eastern ones. There is a good deal of gypsum in the clay. There are two such banks in the north and one in the south; the inner bank on the north runs into the outermost sand ridge of the series just described. These banks appear to define the eastern margin of the former South-East Lagoon, whereas on the west the old lake floor is bordered by a long sand ridge, some two miles long and 200-400 yards across in the form of a flat arc concave to WSW. It rises 5-6 feet above the lagoon floor and is markedly asymmetrical in cross-section, gradually sloping westwards and steeply to the east. Two bores show it to be of well-rounded, coarse sand, deeply podsolised, resting on deposits flooring the lagoon generally. This ridge reaches neither to the plateau slope on the south nor the Old Dunes on the north.

Very little peat remains on the lagoon floor, though the thicknesses of ash testify to a considerable depth in the past. Below there is generally black clay up to 3-4 feet in thickness, which includes a fair amount of plant debris. It seems likely that some at least of the finds of the surveyor, K. M. Harrison, from "a drained swamp on King Island" (Scott, 1920, 1923) came from these horizons of South-East Lagoon. The species of Harrison's interesting, but ill-documented, collection include:—

<i>Nototherium mitchelli</i> Owen
<i>N. victoriac</i> Owen
<i>Macropus anak</i> Owen
<i>Zaglossus Harrisoni</i> Scott.



Beneath the clay to the full depth of the hand bores, there was an alternation of grey silty clay and grey or brown micaceous silt. The lamination varies from less than a cm. to tens of cm. in scale. The coarser layers become preponderant downwards. Thin horizons of shell marl and organic muds were also encountered. Several bores ended in sand and fine gravel when water prevented further penetration with the available equipment.

Four foraminiferal samples (App. III) from these silts and clays were indicative of three types of conditions:—

- (a) Fully marine, with open-sea forms swept in to mingle with local quiet water species;
- (b) Brackish water, but with open sea access to allow for certain forms. A tidal estuary;
- (c) Brackish water, with only occasional incursions of salt water. A brackish lake.

Two of these samples were adjacent in the same bore, with the more marine one on top of the estuarine one. The alternations in the sediments would then seem to reflect variation in width and depth of entry from the sea into this partially enclosed bay with the physiographic vicissitudes of the spits, bars and dunes protecting it.

The marine mollusca (Appendix II.) from the hand borings and well spoil form a mixed assemblage pointing to transport of forms from different habitats as at Cowper Point. However, here there are proportionately fewer rock reef species and more small species which favour weedy areas in sheltered inlets. This agrees with the geomorphological and foraminiferal evidence, yet there is little indication of the intermittent brackish water conditions shown by the foraminifera.

West of the "Manana" sand ridge the plain was still almost entirely scrub-covered and not closely examined. Examination of two drains, one E-W and one NE-SW, showed that it consisted of clays and silts, with a few short sand ridges rising a few feet above its surface. A bore in the drained bed of Alexander's Lagoon was sampled in clays at 8 feet; few foraminifera were found in it (App. III.) and freshwater conditions probably persisted for a long time over the lagoon site.

The interpretation placed on the South-East Lagoon data can now be presented. The sand ridges east of the lagoon cannot be lacustrine, since they rise higher than anything between themselves and the sea to the west. Therefore, they are regarded as littoral features at the head of an estuary when the clays, silts and sands of estuarine-marine nature beneath the lagoon floor were being laid down. The fact that these ridges do not extend farther north than they do implies that when they were forming Old Dunes already extended some way south from the Cape Wickham granite hills, although the gap in the Old Dunes north of the main plateau was probably broader than at present.

In the middle of this estuary, the "Manana" sand ridge was built up by wave and wind action as an offshore bar (or barrier island). On emer-

gence the plain behind this ridge became a freshwater swamp and lake. Possibly the clay banks belong to an early phase of this lacustrine phase and aeolian action on the intermittently dry floor may be involved in their construction.

Old Dune formation continued after the emergence of the estuarine-marine plain at 40-50 feet because some of them lie entirely below that level. At this point it is appropriate to mention the only marine layer found interbedded in the Old Dunes of King Island. This was in the right bank of the Yellow Rock River where it is incised in the Old Dunes immediately above the disused Yellow Rock River Cheese Factory. It is a horizontal layer predominantly of shells with some sand, 1-2 feet thick, only a few feet above the contact of the dune with the underlying granite and lying at about 15 feet above sea level. This bed must register a point in the descent of sea level from the high South-East Lagoon littoral features, a descent more fully recorded by the Old Shorelines of the east coast. The mollusc assemblage (App. II.) is similar to that from South-East Lagoon, with a rather higher proportion of littoral rock species and without the small weed dwellers.

### 3. From Grassy to Surprise Bay (fig. 2, fig. 8).

This coastal sector consists of sandy bays alternating with low rocky headlands. East of the asymmetrical ridge running south from Mt. Stanley to the Red Hut headland, the plateau slopes gradually down to the coast but is diversified by granite hills well forward of it. Along here rock coast preponderates over the constructional sections; New Dune development is exiguous. West of the ridge the south-eastward slope of the plateau lies well back from the coast, much more of which consists of sandy bays; there is a broad and continuous belt of New Dunes. Old Dunes are found extensively behind the whole sector though not without interruption. Both dune systems show more pronounced variation in the direction of advance of the parabolic dunes than elsewhere; this is partly due to the more varied bedrock relief of the sector. The main characteristic is that the parabolic dunes curve in from the sandy bays laterally behind the bases of the rocky headlands. The features close to the shore will be dealt with first, from east to west and later those behind the New Dune belt will be discussed. Because of the lack of local placenames a number of the lesser headlands have been lettered on fig. 2 for convenience.

In the bay between headlands C and D there is an island which consists entirely of cobbles above HWM and these are vegetated in their central parts. On headland C there are two high-lying cobble banks completely vegetated at the rear. All these are considered relict features unadjusted to present sea level.

From headland B most of the way to headland A, there is an inactive vegetated aeolianite cliff cut in the front of the New Dune belt. Behind headland B there is a very recent low foredune in front of this cliff, but farther west this is replaced by an emerged platform in granite, with beach boulders, in various stages of overgrowth by vegetation. At one part this is 20 yards wide with

dense scrub on it. The sharp nick at the cliff-foot was determined at two points as 6 and 7 feet above HWM. The peninsula of headland A carries a detached mass of aeolianite largely bereft of any loose sand; its seaward face is abruptly cliffed above bevelled granite. Shrub-covered cobbles are banked at its foot to 10 feet above HWM. Farther seaward on the peninsula is a stack of granite with a well-marked and partly shrubbed erosional shelf on its southern side. These various features are attributed to the 6-foot sea-level stand.

The bay between headland A and the Red Hut headland has a rocky shore and is backed by the steep slope of a high granite hill. Along its middle portion the New Dunes are absent and Old Dune sand covers the granite slope. This gullied sheet of Old Dune is overlapped on the west by new parabolic dunes which have advanced from the next bay right over the top of the bedrock hills behind the Red Hut headland. A large mutton-bird rookery extends over the junction of the dune systems and the contrast in colour of the sand thrown out of the burrows, grey-white on the east and yellow on the west, is very marked. This arrangement of the New and Old Dunes here side by side in relation to the coast, is important in relation to the features of the Red Hut headland itself.

The New Dunes have an abrupt margin overlooking this low broad headland but numerous rock outcrops in this slope show that here there is a partly buried cliff in the metamorphic and granite basement (Section, E. fig. 4). The low rock platform seaward of this feature has a very low new duneline on its western side and a low granite ridge at its eastern end. Between these two extend three parallel sand ridges in rising sequence from 22 feet of the lowest to 49 feet in the swale behind the highest. These ridges are similar in character to the Old Shoreline features of the east coast north of Naracoopa but their position in relation to the New Dunes will need discussion later (p. 28). Above the present-day shore reefs of much of this headland, great banks of cobbles, up to 1-2 feet in diameter, reach to 10-15 feet above HWM. On the seaward slope they are still actively abraded, above they are first covered in lichens and obviously undisturbed, then they pass under marsh vegetation and soil for as much as 30-40 yards. These banks are thought to belong to the 6-foot sea-level stand.

Seal Point is largely dune-covered; it is necessary to note, however, several broad vegetated cobble banks on the west, a small example of unattached rock shelf and clifflet at 6 feet on the south and certain geos with vegetated cobble banks at their heads on the east.

Behind Seal Bay east of the mouth of Seal River, there is a fixed dune cliff in the New Dunes, with up to three foredunes in front. These are comparable in general nature and age to the New Shorelines of the east coast between Naracoopa and Lavinia Point, but since they are partly telescoped one against another, the swales between are very irregular in height.

Stokes Point has sand dunes right down to the shore reefs on most of its eastern side, whereas on the west there is a belt of rock exposed in front

of the dunes. This is of varying width and consists generally of rocky hummocks rising irregularly to the middle of the peninsula, with some very flat areas near the shore. The shore consists of low reefs for the most part and shows occasional small 6-foot benches and clifflets. There is a more extensive planed rock platform at the southern tip of the peninsula which includes a flat islet cut off at high tide; this emerged platform is only backed by a recognisable clifflet at its north-west corner where the break of slope is at 9 feet above HWM. More striking than these erosional features are the broad shingle ridges and cobble ramparts which line much of this western shore of the promontory. Their crests lie between 6 and 15 feet above HWM and they are generally vegetated; some of them embank ephemeral lagoons. The coarsest material is often angular and unabraded as if quite quickly thrown into the ridge and thereafter left undisturbed.

East of the Red Hut headland, the New Dunes generally abut on the Old Dunes which, in the main, advanced WNW up to the bedrock slopes. But behind the bay between headlands C and D there is a swampy depression in the rear of the New Dunes; this rises gradually to a sharp break of slope at 20-25 feet against low granite hills and Old Dunes; this appears to be an old shoreline.

West of the Red Hut headland there is a broad depression between the New Dunes and the Old Dunes. These latter take on a different character from the usual dominant pattern of subdued parabolic dunes. Here they rise from approximately sea level to between 50 and 100 feet up the south-eastern slope of the plateau in a series of SW-NE ridges, which appear to be degraded but formerly quite substantial foredunes. The depressions between are often swampy and are occupied by a number of streams which join the Seal River and its major tributaries at right angles (see fig. 7, Jennings, 1957a). Parabolic dunes are subordinate in this area. Gravel in pits by the road south of the Black Forest lie at about 50 feet behind most of these Old Dunes; they may be marine.

The Big Swamp occupies the eastern end of the depression between the two dune systems. Low sand ridges at its eastern face face its full length and relate to a phase of open water over the extent of Big Swamp which now has only small patches of open water amongst the ti-tree swamp. There is practically no gradient in Seal River between the Big Swamp and Big Lake (fig. 7). The latter is approximately at HWM since local residents relate that kelp is carried up into the lake along the Seal River from Seal Bay at very high tides. Around the northern side and eastern end of Big Lake are arranged a series of very low sand ridges, a few inches to at most 2-3 feet in height and 5-10 yards across. There is no general rise in ground level across the belt of ridges. Their disposition makes it clear that they relate to the lake and are not seashore features of the time of Old Dune formation. The assemblage registers a contraction of the lake by progradation at its present level under the influence of south and west winds. They have ceased to form since freshwater marsh vegetation now surrounds the open water. Behind the sheltered western shore there is a deeper belt of ti-tree swamp.

West of this ti-tree swamp there is gently rising cleared ground to the foot of a group of rock ridges which rise to 20-35 feet above the lake level (see Section C, fig. 4). Between these ridges and to the west as far as Mr. D. Bowling's homestead, there is level and in parts swampy ground. Beyond is the Chain of Lagoons, a series of small lakes which rise in level westwards and lie between the New Dunes on one side and on the other the plateau slopes, here partly covered by Old Dunes.

A line of bores from the Big Lake to Mr. D. Bowling's homestead, together with other scattered bores, reveals thin young sediments on the bedrock floor at levels of 15-30 feet above HWM; they are mainly sands and fine gravels, though some silty clays occur near the surface. Near the surface the sand is quartzose but lower down the proportion of shell sand increases markedly. These sands were extremely rich in marine mollusca, furnishing over 70 species (App. II.). Forms from many different habitats occur. However, intertidal rock species are much higher in proportion, sandy and sandy-mud bottom dwellers much lower than at South-East Lagoon and Cowper Point, suggesting more rock in the vicinity of this beach deposit. This corresponds closely with the geomorphological evidence. Foraminiferal samples from D10, D15 and D60 indicate open beach sands (App. III.) In D55 similar species show by their state of preservation that they accumulated in a stagnant lagoon; this site is in fact more protected from a sea to the south-east. The fossil remains, therefore, point to an open coast of rocky reefs and pocket beaches when sea level reached up to 30 feet higher than at present. The fauna is in general typical of Bass Strait today with the significant exceptions of two warmer water foraminiferal species from D60 and one further one from D55.

Below the rock ridges the sediments close to sea level have fewer mollusca (three small marine species) and the one foraminiferal sample from D35 is indicative of a marine swamp. No sea level changes are indicated but the seaward dune barrier must have been less complete than now and Big Lake must have been a salt lagoon.

#### 4. From Whistler Point to Fitzmaurice Bay.

Though this is the longest coastal sector, it has least interest for our present purpose because the massive New Dune development has covered up most evidence of earlier physiographic events. Over most of the sector these dunes abut directly on the shoreline, which mainly consists of low rock reefs, long strike ribs in the metamorphic complex, more rounded joint-controlled blocks in the granite. There are also numerous open sandy bays of varying size.

In this context of a dune cover resting on a rock basement of slight relief, which declines gently westwards to intersect with the sea at a low angle, certain types of shore profile occur which can be regarded as normal to it in the first analysis.

(a) In the sandy bays, sand beaches front active dune cliffs, where any vegetation cover suffers constant modification with the vicissitudes of wind and wave.

(b) Behind low rock reefs, an actively worked beach of sand and shingle leads to a gradual dune slope fixed or partially fixed by vegetation.

(c) At the most exposed points, the reefs are replaced by active low cliffs in the solid, 10-15 feet high, on which the dunes rest, e.g., just north of Currie Harbour and near Whistler Point.

(d) A further common coastal profile is due to the intervention of lime-rich water seepage from the dune foot at the contact with the rock. This gives rise to a strip of tufa-marsh between beach and dunes; this densely vegetated slope builds up and becomes convex through precipitation of tufa.

But, additionally, there are certain features which clearly do not relate to the present shoreline dynamics. Thus on several of the short projecting headlands small areas of exposed rock are planed off at levels 10-25 feet above HWM; similar areas occur south of Eel Creek and south of Ettrick River. They pass under gently-rising dune slopes behind. These appear to be the lower parts of marine erosional platforms, mainly still buried by the later New Dune development. At only one point is it possible to recognise a high former shoreline on this west coast sector. This is about three quarters of a mile south of the mouth of Porky Creek on Block 49/3/39 and neighbouring blocks where the very narrow New Dune belt lies in front of or banked up against an old cliffline with its foot at 35-40 feet. Behind this degraded cliff there are scattered Old Dunes.

There are also small fragments of 6-foot rock shelf and associated clifflet, colonised by plants in various degrees and showing no signs of erosion today. They are less frequent and less clearcut than those of the Naracoopa-Grassy coast. Associated with these are stretches of unattacked aeolianite cliff with narrow vegetated beach in front of them. These are very well developed south of Pass River where they are as much as 20-30 feet high. At the Dripping Wells, a mile south of the Ettrick River, a portion of such cliff has been covered by an overhanging apron of spring tufa, which creates shallow caves with stalactites and stalagmites immediately behind the beach (Jennings, 1955). In addition, the Boggy Creek tufa terraces or rimstone dams must be mentioned. These are forming between tidemarks and above HWM behind the protection of low rock reefs.

Similarly protected are a number of small patches and strips of salt marsh, e.g., near the mouth of Bungaree Creek.

A prominent feature of certain sections of this coast, e.g., on Blocks 49/3/39 and 201/3/24 south of Pork Creek and for a mile south from Currie Harbour are the wide vegetated shingle platforms at 3-10 feet above HWM. At many points these have been extensively quarried for road metal over several decades. Yet there is no evidence of refill by modern wave action; they are, indeed, colonised by various herbs and bushes, even where the pits reached right to the active beach. There are also many cobble and shingle ramparts rising to 10-15 feet above HWM; these in some cases have bushes several feet high on them. In two instances only was fresh shingle seen thrown up onto such ramparts.

At two points emerged beach deposits were seen in section. At the north-west corner of the enclosed semi-circular bay immediately south of Netherby Bay, active erosion has provided an excellent section. An exposure 25 feet long reveals a beach platform cut into and backed by semi-consolidated New Dune. The cliff-foot lies sharply at 5-6 feet above HWM. On the platform rests the beach deposit; the lower 6 inches consists of fine gravel, sand and shell fragments, above is 18-24 inches of shingle and cobbles, with some shells and sand. The mollusca numbered ten marine species, all rock reef and rock pool inhabitants (App. II.). The second occurrence is on the south side of the bay into which Three Rivers Creek flows. Below a steep dune there is a bank of beach shingle resting on a granite platform; in front are an active shingle beach and low rock reefs. Along the front of the bank erosion is exposing the stranded beach deposit at 3-5 feet above HWM over an interrupted exposure of 30-40 feet. The pebbles and occasional shells had a sandy matrix, cemented in parts by secondary calcite and in parts by iron oxide. The mollusc collection (App. II.) yielded only four species, three of which live on rocky shores between tide-marks. At both sites, the mollusca are all species of the present-day shores and no change in climatic conditions is implied; they are taken to indicate a small negative movement in the relative level of land sea.

The most striking point about this whole sector lies in the high proportion of it where there is no marked feature of erosional activity either in the form of a low rock cliff or active dune cliff. Much of the actual beach is protected by a wide belt of low rock reefs. In view of the storminess of the sea to the west, this is hard to understand except in terms of this recent small shift in the relative level of land and sea. The presence of such features as the Dripping Wells, the Boggy Creek tufa terraces and the fragments of salt marsh underlines particularly this dichotomy between the character of this shoreline and its exposure to marine attack.

South of Curric there are a number of well-enclosed, semi-circular bays; most of these seem to be due to the partial removal of a fill of beach shingle in hollows in the rock basement, protected by a slightly higher seaward rib of rock which now forms the "hammer-headed" promontories between the bays. Netherby Bay and particularly the bay immediately to its south are rather different. Their semi-circular beaches lie partly below 10-15 feet cliffs in semiconsolidated calcareous dunes; these dune cliffs have the appearance of descending below the sea level in the inner part of the bay and in these cases it seems to be the removal of calcareous dune material from hollows in the bedrock which has given rise to the bays. If this is so, a lower sea level than the present one is implied at the time of formation of the dunes.

#### DISCUSSION

The evidence for changes in the relative level of land and sea from the island can now be considered as a whole and internal difficulties considered prior to a comparison with similar data

from other parts of Australia when the question of dating can also be taken up.

#### 1. *The 225-foot Sea Level Stand.*

Waterhouse (1915) has suggested that the lower parts of the King Island plateau, usually extremely well planed, have been smoothed by marine erosion. It is true that quartz pebble gravels can be found on flat divides well away from modern stream courses; there is, for instance such an occurrence at 220 feet on the plateau top west of Fraser Bluff. In support of this idea the present study can only point to rather indecisive spur profile steps, with inner breaks of slope at about 225 feet, at three points around the City of Melbourne Bay-Cotton's Flat coastal embayment.

#### 2. *The 120-150-foot Sea Level Stand.*

Similar spur flattenings in this area suggest a sea level stand at 120-150 feet and this finds stronger support in the Grassy scheelite mine beach boulder bed, which in the earlier stages of the open cut were observed at 120-150 feet. Burial of this boulder bed by Old Dunes makes this still-stand earlier than the time of formation of this dune system.

When a topographical survey has provided a framework of fixed heights and contours, close morphological analysis of the plateau and rivers can be brought to bear on these possible stands of base level; at the present time further discussion is not warranted.

#### 3. *The Old Shorelines, 65 feet to Present Sea Level.*

From 65 feet above HWM downwards, evidence for former high sea level stands is extensive, varied and indubitable. But difficulties remain because the relevant features—emerged shell beds, estuarine-marine sediments, sand ridges and berms, marine terraces, sea cliffs and sea caves—occur at nearly every height below that figure. Some of this variation is, of course, due simply to inaccuracy of height determination, especially where the aneroid is used. Also when it is a question of estimating the level of a degraded cliff-foot, rounded by weathering and obscured by colluvium, the same shoreline at different places may be allocated several heights. Constructional littoral features can be built to varying heights above a given shoreline making estimation of the related sea level imprecise. These and many other difficulties which have been set out by D. W. Johnson (1932) make marine level correlation hazardous.

The relationship of the emerged shoreline features in this height range to the two major dune systems of the island provides the basis for an initial division.

The Old Shorelines from Naracoopa to Lavinia Point are intimately associated with the formation of the Old Dunes. The latter may have begun to form before the innermost shoreline of this series developed but they certainly continued to form during the period of falling base level registered by the sequence which here occurs continuously from about 40 feet down to present sea level. Though lying higher than this series, the Old Shorelines east of South-East Lagoon, together with the associated wide plain of estuarine-marine

sediments at 50 feet, must be correlated with them since the two series abut onto the one intervening dune system. Subsequent discussion below suggests that the difference in height of the two series is not due to subsequent tilting. Differences of tidal range between the open shore of the east and the partially enclosed waters of the west seem hardly likely to explain it and the discrepancy must await more detailed work to account for it. The marine shell bed at 15 feet in the Old Dunes at the Yellow Roek Cheese Factory corresponds to some lower point in the east coast sequence. At the southern end of the island the Old Dunes behind the Big Lake-Big Swamp depression, although of the nature of foredunes and do not allow of any precise formulation of the associated sea levels, yet do indicate once more that sea level in Old Dune times has fallen from something of the order of 50 feet down to present sea level. The shelly beach deposits on Mr. D. Bowling's farm west of Big Lake register fairly accurately sea level stands at 20-30 feet in part of this fall.

All these constructional features so far discussed and attributed to the Old Shoreline sequence lie landward of the New Dunes. There is, however, the sand ridge sequence at 22-49 feet on the Red Hut headland lying in front of the New Dunes. Nowhere else are such high sand ridges found in front of the New Dunes on the island. They cannot be features younger than the New Dunes and elevated to this abnormal altitude by local uplift, since there is no evidence for faulting in the bedrock ridge or in the New Dune system behind the headland. Moreover, New Shoreline features at their normal height also occur on the headland and as will be seen later there can be little time interval, if any, between the formation of the New Dunes and such features. The explanation already given that the New Dunes advanced from west to east across the base of the headland but failed to cross the headland itself to remove or bury these older sand ridges is regarded as the correct one, though it seems a lucky chance that the features in question survived in this way. In support of it the air photos do show a rocky bottom with little sand around this and many other headlands; the bays are the chief source of sand for dune development and this plays a large part in the directions of parabolic dune advance along this coastal sector (Jennings, 1957b).

The marine terraces in the bedrock can now be considered, first where best developed between Grassy and Naracoopa. The breaks of slope at the back of these terraces are scattered over a range from 60 feet down to 3 feet above HWM; nevertheless, they do fall into three predominant classes: (1) at 40-50 feet; (2) at 20-30 feet; (3) at 3-9 feet. The last class is very much fresher in appearance, never carries deeply leached sand either as sand ridges or true dunes but does occur quite often in front of New Dunes. All the higher terraces have a much older and degraded aspect; in certain cases they carry Old Dunes and low sand ridges and berms similar to those of the Old Shorelines of the Naracoopa-Lavinia Point sector. They are therefore correlated with the constructional Old Shorelines though the possibility that the highest

terraces, at least, may be older cannot be ruled out altogether.

Between Grassy and Little Grassy Creek a terrace at 20-25 feet occurs between the New Dunes and the Old Dunes and these higher marine terraces (22-39 feet) are also represented west of Disappointment Bay, one example carrying an Old Dune on its lower part.

On the west coast similar high terraces must generally have suffered burial because of massive dune development there. Between Cataraque Point and Surprise Point, however, the dunes are on top of the cliffs and here the terrace remnants, chiefly at 40-50 feet, associated "hanging coves" and abandoned sea caves, must also belong to the Old Shoreline system. So also does the better preserved terrace at the less frequent altitude of 35 feet east of Cataraque Point in the shelter of Fitzmaurice Bay. On the north side of Surprise Bay there is the small 26-foot terrace remnant in front of the New Dunes, the assumption being that the latter have passed right over it. This again is an exceptional case; more such cases would cast doubt on the standpoint taken here that the marine terraces from 20 feet upwards antedate the formation on the New Dunes.

It will be evident that the different levels in this older emerged shoreline sequence occur in an unsystematic fashion at the northern and southern ends of the island and on the western and eastern sides, though for reasons given they are less well represented on the western side. This unsystematic scatter at various levels argues against any tilting or other tectonic deformation of the island during or since the formation of the Older Shorelines. On the present evidence the features are regarded therefore, as belonging to a single progressive emergence which affected the island uniformly.

Climatically the evidence testifies to conditions not very different from today's. The marine fauna is close to that of the present Bass Strait, the plant remains at City of Melbourne Bay on the whole correspond with the historical Yarra Creek flora and the axial direction of the Old Dunes agree closely with those of the New Dunes and both can be shown to have close relation to the present wind regime (Jennings, 1957b). Two qualifications have to be made. The warmer water foraminifera from the 15-30 feet beds west of Big Lake indicate a slightly warmer climate, whereas the *Nothofagus* and *Drimys* from the City of Melbourne Bay deltaic deposit, which relates to a sea level at least as low as the present one and yet is covered by Old Dunes, indicate, if anything, slightly wetter or cooler conditions. Thus some climatic deterioration seems to have accompanied the fall of the sea relative to the land.

The breccia, resembling periglacial "head", on the hogback cliffs of the south-west coast may be the product of subsequent colder conditions.

#### 4. *The New Shorelines.*

The New Shorelines are best expressed between Naracoopa and Lavinia Point where, in geographical continuity, they are represented by fixed and abandoned cliffines in both New Dunes and Old Shoreline sands, by definite, though modest, fore-dunes and by low sand ridges and berms which

at best are incipient foredunes. Contemporaneity with the New Dunes is demonstrated by the relationships of the shorelines and the dunes at Lavinia Point and at Cowper Point. Moreover, the absence of New Dunes from Sea Elephant Bay south of the Blowhole is most readily explained by regarding the cutting of the cliff into the emerged slope of Old Shorelines as simultaneous with the development of New Dunes elsewhere. Only where the New Shorelines are represented by low sand ridges do the intervening swales give a good idea of the associated sea level; the innermost depression in these circumstances is usually between 3 and 9 feet above HWM.

Similar features are found in the constructional coasts of the eastern part of Seal Bay, at the Yellow Rock Foreland and to the east and west of Boulder Point.

All these occurrences could be the result of simple progradation of the coast without any change of sea level, particularly as most of them relate to the more sheltered aspects of the island's coast. But against this possibility are numerous other features all around the island which must be correlated with them. On all the rocky shores, both low and high, and on all aspects of the coast, are low clifflets a few feet high, steep and fresh, but vegetated and giving no evidence of present-day marine attack. Occasionally, they become cliffs 20-30 feet high. Bedrock, aeolianite and tufa are eliffed in this way. They lie behind narrow rock platforms or beaches, which apparently are equally inactive. In a few localities small sea caves, no longer reached by waves, are found. The cliff-foot lies between 3 and 9 feet above HWM. Though occurring sometimes in quite exposed positions, these unattacked platforms, beaches and clifflets are more frequent in protected localities, particularly so where they occur in the most exposed south-west coast.

It is clear from the facts given that these features do not fall into the category of storm-wave platforms recorded, for example, from Victoria and New South Wales, where they have occasioned vigorous discussion as to whether they are relict features of a higher sea level stand or the product of the present wave regime.

Additional in the present connection there are to be noted:—

(a) Cobble ramparts and high-lying shingle banks, between 6 and 15 feet above HWM, on some of the low rocky coasts. They show no signs of movement and are in various degrees of vegetative colonisation.

(b) Wide shingle platforms of the west coast, with old quarries unmodified by wave action.

(c) Small patches of salt marsh amongst the low reefs of the exposed west coast.

(d) The Dripping Wells tufa cliffs with their stalagmites and stalactites facing the open ocean and the Boggy Creek rimstone dams reaching below HWM.

(e) Vegetated cobble packs at the heads of geos and erosional inlets on some of the most exposed parts of the coast.

The most surprising characteristic of the King Island coast is that so much of it does not show the signs of strong marine attack; yet the storminess of its waters is well known and many of its

placenames commemorate shipwrecks. Two explanations offer—a small negative movement or a marked reduction in storminess of the surrounding seas. The fact that the phenomena concerned are very generally distributed around the whole island seems to favour the former explanation rather than the latter. A small emergence of the order of 10 feet affecting the island uniformly is the interpretation preferred here.

#### 4. Low Sea Level Stands.

A small island, liable to strong marine erosion at times of high sea level and lacking major river valleys where aggradation may bury low sea level deposits, is not favourable to determining positive movements of sea level; this is true of King Island. Four points only need to be mentioned:—

(a) The disposition of cliffed dune sand and aeolianite around two small bays on the west coast suggest that these terrestrial deposits reach below sea level.

(b) A submerged stream channel can be seen in air photos crossing the Tertiary limestone sea floor between The Blowhole and Cowper Point.

(c) The lowermost part of Grassy Creek valley seems to be incised slightly below sea level.

(d) On the southern part of the west coast there is a submarine cliff with its basal break of slope at 30-35 fathoms, which David (1923) interpreted as a Pleistocene low sea level marine cliff. It seems likely that this is a tectonic feature. However, there are offshore reefs and islets which also rise steeply from the sea floor at that level and the general evidence from Bass Strait (Jennings, 1959, in press) suggests that David's view is acceptable and not incompatible with the feature being a fault scarp also.

Where this submergence evidence fits into the emergence already discussed is not as yet determinable, but clearly the low sea level or levels must precede the formation of the New Shorelines.

#### CORRELATION AND DATING.

No direct evidence of the timing of the physiographic events described is as yet available; and attempt to date them must be based on inference and comparison with other Australian coasts.

The early work of Johnston (1877, 188) remains the best account of the Furneaux Group. Emerged beach shell beds underlie aeolianite ("Helicidae Sandstone") at 40 feet on Badger and Green Islands; similar beds at undesignated but lower heights lie beneath more recent dunes on Badger and Flinders Islands; from Arthur River valley on Flinders there is separate mention of an oyster bed at 30 feet. All these can be correlated with the Old Shorelines of King Island. Edwards (1941) quotes Johnston (1888) as recording a raised beach deposit at 100 feet on Mt. Chappel Island. This is a misreading; only aeolianite is described at this level by Johnston.

From a study of a great length of the coast of N.W. Tasmania, Edwards (1941) concludes that there are three emerged levels at 100 feet, 45-50 feet and 5-15 feet. He also mentions some coastal terraces at 30 feet. The altitudinal correlations with the King Island data are obvious.

Within this area the more detailed results of Gill and Banks (1956) come from the Duck Bay-

Mowbray Swamp area. Inland of the swamp are the Christmas Hills, old dunes with deeply leached quartz sand above sandrock; Gill and Banks regard these as two separate deposits but quote Hubble's opinion that they may constitute a giant podsol. Beneath the Mowbray Swamp peats, from the base of which come important nototherian and other vertebrate remains, there is the marine Mella Sand rising to 50 feet. Gill and Banks correlate this sand with the Rocky Cape emerged sea caves which, in their view, were formed by a 70-foot sea level. But Edwards maintains that it is necessary to allow for a very thick midden fill in the caves and that the relevant sea level lay at 50-60 feet. Gill and Banks attribute the Mella Sand to the Upper Pleistocene since a C14 date from the overlying peat is  $>33,760$  years.

The Mella Sand plain declines seawards where it carries an "Ancient Series of Sand Ridges", which, from their description, are very similar to the Old Shorelines of Cowper Point. The mapped ridges lie between 30 and 15 feet but apparently before drainage of the swamp they occurred at higher levels still. Farther seaward is a "Holocene Series of Sand Ridges" to be compared with the New Shorelines of Cowper Point. These are regarded as forming during the emergence from a Mid-Recent 10-foot sea level. The similarity of this sequence with the evidence from the north of King Island is striking and not solely altitudinal.

The correspondence between the data from the substantial area comprising King Island, Furneaux Group and N.W. Tasmania, in particular the close comparability between King Island and the Mowbray Swamp area, makes a provisional case for regarding the emergences of the Old and New Shorelines as eustatic. This is, of course, the interpretation which Edwards, Gill and Banks put on their own data.

Differing views on the origins of successive coastal dune systems have been held in Australia. Previously, following the work of Sayles on Bermudan dunes, the view was held that the coastal dune systems were formed at the time of Pleistocene glacial low sea levels when the retreating sea exposed the marine sands of the shelf floor to aeolian attack (Couison, 1940; Gill, 1943; Fairbridge, 1947; Teichert, 1947). But, from their independent studies of the coastal dune ridges of the S.E. Province of South Australia, both Hossfeld (1950) and Sprigg (1952) came to regard these dunes as forming at the high sea level stands of Pleistocene interglacials or interstadials. Sprigg related each dune ridge to a single maximum sea level, whereas Hossfeld thought some related to maxima and others to halts in the falls from these maxima. Moreover, Teichert and Fairbridge (1952) revised their earlier views in the light of studies of soil horizons within the West Australian aeolian dunes. They also came to the conclusion that beach conditions similar to present ones were sufficient for dune formation and that dune belts could form during any halt in the Pleistocene glacioeustatic oscillations. Unless tectonic movements are involved, the dunes on the land surface will belong to interglacials or interstadials, whereas any dunes of glacial periods will be found submerged on the continental shelf.

The King Island evidence shows clearly the association of the dune systems with high sea level shorelines and supports the second standpoint.

The immaturity of soil profile development on the New Dunes of King Island and their freshness of form precludes their having survived a glacial low sea level period even if that were only the final advance of the Last Glaciation. They belong to the Holocene. The pronounced degradation of form and greater maturity of soil profile presumes a much greater age on the part of the Old Dunes and the intervention of a glaciation or a glacial stadium between the formation of the two systems. It is logical, therefore, to attribute the Old Dunes to either the last interstadial or the Last Interglacial. Reasons will follow for preferring the latter alternative.

Claims for a 10-foot Mid-Holocene eustatic high sea level come from such widely-scattered localities around Australia and are based on such diverse shoreline features that they are not easily set aside. From West Australia there are Teichert's and Fairbridge's studies of benches in aeolianite and coral reefs; from Victoria, Couison and Gill have employed emerged shell beds; from the black sand seams of the coasts of New South Wales and Queensland, Beasley and Gardner independently derived a 10-foot Recent level. The New Shoreline features of King Island are therefore regarded as a further expression of this Recent 10-foot stillstand and of the succeeding emergence.

According to Gill (1956) evidence for a 25-foot level stand is the most widespread higher level in Victoria. Through Carbon-14 dating this is attributed to the Last Interglacial; mollusca and foraminifera suggest a warmer climate. Baker (1950) mentions briefly marine terraces and notches at 40 feet and 60-70 feet from W. Victoria.

Teichert and Fairbridge (1952) ascribe the Cowaramup Bay Conglomerate and other deposits in West Australia at 5-15 feet to the last Wurm II/III interstadial. The Peppermint Grove Formation of Perth is regarded as indicating a 25-foot sea level stand of the earlier Wurm I/II interstadial. These attributions are based mainly on the unsatisfactory basis of altitude correlation with England and N. Africa. Moreover, the Guildford Clay is correlated with the Peppermint Grove Formation and as the former is described as rising to 50 feet, it upsets the altitude correlation in any case. Gardner (1955) finds evidence for high sea levels of 20 feet and 45 feet along the north N.S.W. coast; the former belongs in his view to the last Wurm interstadial and the latter to the Riss-Wurm Interglacial, with the earlier Wurm interstadial unrepresented.

In this context any correlation of the King Island Old Shorelines is uncertain but the closest correspondence is with the Mowbray Swamp sequence. This sequence has the advantage of a C-14 dating. On this basis, the Old Shoreline sequence of King Island with its range of erosional and constructional features from over 60 feet down to sea level, but with more important halts at 40-50 feet and 20-30 feet is provisionally attributed as a whole to the Last Interglacial. A Carbon-14 dating of the wood from the City of Melbourne Bay deltaic deposit will provide a useful test of this correlation.

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APPENDIX I.—PLANT REMAINS FROM DELTAIC DEPOSIT EXPOSED IN CLIFF OF CITY OF MELBOURNE BAY

Fossil Wood (Identified by Mr. H. D. Ingle, C.S.I.R.O. Division of Forest Products)

*Eucalyptus* sp.

*Nothofagus* sp.

Hardwood, not either of the above.

Fossil Pollen and Spores (Identified by Dr. S. Duigan, University of Melbourne)

POLLEN

<i>Phyllocladus aspleniifolius</i>	91.5 %	Expressed as % of total pollen count
<i>Drimys lanceolata</i>	4.5 %	Expressed as % of total pollen count
<i>Nothofagus cunninghamii</i>	1.0 %	Expressed as % of total pollen count
Myrtaceae	0.5 %	Expressed as % of total pollen count
Unknown dicotyledons	2.5 %	Expressed as % of total pollen count

SPORES

Unknown ferns including <i>Dicksonia</i> ? sp. & <i>Todea</i> ? sp.)	17.5 %	Expressed as % of total pollen count
<i>Cyathca</i> sp.	2.5 %	Expressed as % of total pollen count
<i>Polypodium</i> sp.	1.0 %	Expressed as % of total pollen count

## APPENDIX II.—MOLLUSCA FROM KING ISLAND.

J. Hope Macpherson  
(National Museum of Victoria)

+ denotes species present.  
J denotes juveniles only of species present.  
? denotes uncertain identification.

## COWPER POINT:

Bore No. .. ..	Sample No. 15 .. ..	New Shorelines and Dunes										Old Shorelines		
		S	70	71	72	73	77	100	101	106	186	196	204	
		A	B	C	D	E	F	G	H	J	K	L	M	
<i>Clanculus floridus</i> Philippi .. ..		..	..	..	..	..	+	..	..	..	..	..	..	..
<i>Austrocochlea adelaidae</i> Philippi .. ..		+	..	..	..	..	..	..	..	+	+	+	..	..
<i>A. constricta</i> Lamarck .. ..		+	..	..	..	..	..	..	..	..	..	..	..	..
<i>A. odontis</i> Wood .. ..		..	..	+	..	..	..	..	+	..	..	..	..	..
<i>Cantharidus ramburi</i> Crosse .. ..		..	..	..	..	..	..	..	..	..	..	+	..	..
<i>Subnivalia undulata</i> Solander .. ..		+	+	+	..	+	+	..	..	..	..	+	..	+
<i>Micrastraea aurea</i> Jonas .. ..		+	..	..	..	..	..	..	..	..	..	..	..	..
<i>Phasianella</i> sp. .. ..		..	..	..	..	..	..	..	..	..	..	..	?	..
<i>P. ventricosa</i> Swainson .. ..		..	..	+	..	..	..	..	..	+	..	..	..	..
<i>Sigapatella calyptraeformis</i> Lamarck .. ..		..	..	..	..	..	..	..	..	..	..	+	..	..
<i>Hippopsis</i> sp. .. ..		..	..	..	..	..	..	..	..	..	?	..	..	..
<i>H. conica</i> Schumacher .. ..		+	+	..	..	..	..	..	..	..	..	..	+	..
<i>Zeacumantus cerithium</i> Q. and G. .. ..		+	..	+	..	+	+	..	+	..	..	..	..	..
<i>Turritella</i> sp. .. ..		..	..	+	..	..	..	..	..	..	..	..	..	..
<i>Turbonilla mariae</i> T. Woods .. ..		..	..	..	..	..	..	..	..	..	..	..	+	..
<i>Ellatirivia merces</i> Iredale. . . .		+	..	..	..	..	..	..	..	..	..	..	..	..
<i>Zemitrella semiconvexa</i> Lamarck .. ..		..	..	..	..	..	..	..	..	..	..	..	+	..
<i>Cominella lineolata</i> Lamarck .. ..		+	..	..	..	..	..	..	..	..	?	..	..	..
<i>Alocospira marginata</i> Lamarck .. ..		..	..	..	..	..	..	..	..	..	?	..	..	..
<i>A. pellerdi</i> Tate .. ..		..	..	..	..	..	..	..	..	..	..	..	+	..
<i>Marginella</i> sp. .. ..		..	..	..	..	..	..	..	..	..	+	..	..	..
<i>M. fornicula</i> Lamarck .. ..		..	..	..	..	..	..	..	..	..	..	..	+	..
<i>Marita metralis</i> Adams and Angus .. ..		..	..	..	..	..	..	..	..	..	..	..	+	..
<i>Floraconus anemone</i> Lamarck .. ..		..	..	..	..	..	..	..	+	..	..	..	..	..
<i>Salinator fragilis</i> Lamarck .. ..		+	..	..	..	..	..	..	..	..	..	..	..	..
<i>Glycymeris</i> sp. .. ..		..	..	..	?	..	..	..	..	..	..	..	?	?
<i>G. radians</i> Lamarck .. ..		?	?	?	..	..	..	..	+	..	?	..	..	..
<i>G. striatularis</i> Lamarck .. ..		..	..	..	..	..	..	..	..	+	..	..	..	..
<i>Ostrea angasi</i> Sowerby .. ..		..	..	..	..	..	..	..	..	+	..	..	..	..
<i>Venericardia calva</i> Tate .. ..		..	..	..	..	..	..	..	..	..	..	?	..	..
<i>Codakia crassilirata</i> Tate .. ..		..	..	..	..	..	..	..	+	..	..	..	..	..
<i>C. tatei</i> Angus .. ..		..	+	..	..	..	..	..	..	..	..	..	..	..
<i>Cardium</i> sp. .. ..		..	?	..	..	..	..	..	..	?	..	..	..	..
<i>Gomphina undulosa</i> Lamarck .. ..		+	+	..	+	+	+	..	?	..	..	..	..	..
<i>Katylsia</i> sp. .. ..		..	..	..	..	..	..	..	..	..	..	?	..	..
<i>K. peroni</i> Lamarck .. ..		..	..	..	?	..	..	..	..	..	..	..	..	..
<i>K. scalarina</i> Lamarck .. ..		+	+	+	+	+	+	..	+	..	..	..	..	..
<i>K. rhytiphora</i> Lamy .. ..		+	+	+	+	+	+	+	+	..	..	..	+	..
<i>Tawera galinula</i> Lamarck .. ..		..	..	..	+	+	+	..	+	..	+	+	+	..
<i>T. spissa</i> Deshayes .. ..		..	..	..	..	..	..	..	..	..	..	..	+	..
<i>Notospisula trigonella</i> Lamarck .. ..		..	..	+	..	..	..	..	..	..	..	..	..	..
<i>Mesodesma angusta</i> Reeve .. ..		..	..	..	..	..	..	..	+	+	..	..	..	..



## YELLOW ROCK CHEESE FACTORY: Sample No. 56.

<i>Amblychilepas javanicensis</i> Lamarek .. .. +	<i>Glycymeris radians</i> Lamarek .. .. +
<i>Sophsimalepas oblonga</i> Menke .. .. +	<i>G. striatularis</i> Lamarek .. .. +
<i>Haliotis</i> sp. .. .. ?	<i>Ostrea angasi</i> Sowerby .. .. +
<i>Cellana tramoserica</i> Sowerby .. .. +	<i>Cardium</i> sp. .. .. ?
<i>Micrastrea aurea</i> Jonas .. .. +	<i>Gomphina undulosa</i> Lamarek .. .. +
<i>Hipponix conica</i> Schumacher .. .. +	<i>Tawera gallinula</i> Lamarek .. .. +
<i>Pleuroploca australasiae</i> Perry .. .. +	<i>Notispisula trigonella</i> Lamarek .. .. +
<i>Floraconus anemone</i> Lamarek .. .. +	<i>Mesodesma angusta</i> Reeve .. .. +

## D. BOWLING'S FARM (between Chain of Lagoons and Big Lake).

Bore No.	Higher Sediments							Lower Sediments		
	well	D10 1.5- 1.9m.	D15	D15 1.45- 1.6m.	D20 1.75- 2.45m.	D55 1.15- 1.36m.	D55	D60 1.05- 1.6m.	D35 1.55- 1.65m.	D35 1.7- 1.8m.
Sample No.	40	47	49	52	58	41	55	38	44	37
<i>Sophsimalepas crucis</i> Beddoone .. ..	..	..	..	..	..	+	..	..	..	..
<i>S. oblonga</i> Menke .. ..	+	..	..	..	..	..	..	..	..	..
<i>Macrochisma tasmaniac</i> Sowerby .. ..	..	..	..	..	..	+	..	..	..	..
<i>Haliotis raei</i> Gray .. ..	..	..	..	..	..	..	+	..	..	..
<i>H. ruber</i> Leach .. ..	..	..	+	..	..	..	..	+	..	..
<i>Clanculus aloysii</i> T. Wood .. ..	..	..	..	..	..	..	..	+	..	..
<i>C. plebejus</i> Philippi .. ..	+	..	..	..	..	+	..	+	..	..
<i>Gibbula</i> sp. .. ..	..	..	..	..	..	..	..	+	..	..
<i>Herpetopoma aspersa</i> Philippi .. ..	..	..	..	..	..	+	..	..	..	..
<i>Phasianotrochus</i> sp. .. ..	..	..	?	..	..	?	..	..	..	..
<i>P. crinus</i> Perry .. ..	+	..	..	..	..	..	..	?	..	..
<i>Bankia fasciata</i> Menke .. ..	..	..	..	..	..	+	..	..	+	..
<i>Cantharidus ramburi</i> Crosse .. ..	+	..	..	..	..	..	..	+	..	..
<i>Austrocochlea adelaidae</i> Philippi .. ..	..	..	+	+	+	+	..	..	..	..
<i>A. constricta</i> Lamarek .. ..	+	..	+	..	..	..	..	..	..	..
<i>A. odantis</i> Wood .. ..	+	..	+	+	..	+	..	+	..	..
<i>Hypotrochus monachus</i> C. and F. .. ..	..	..	+	+	..	+	+	+	..	..
<i>Calliotrochus</i> sp. .. ..	..	..	?	..	..	..	..	+	..	..
<i>Subinella undulata</i> Solander .. ..	+	..	..	..	..	..	..	..	..	..
<i>Micrastrea aurea</i> Jonas .. ..	..	..	+	+	..	+	..	..	..	..
<i>Phasianella</i> sp. .. ..	..	..	..	..	..	+	+	..	..	..
<i>P. ventricosa</i> Swainson .. ..	..	..	+	+	+	..	..	..	..	..
<i>Munditia subquadrata</i> T. Woods .. ..	..	..	..	..	..	..	+	+	..	..
<i>Elachorbis harriettae</i> Petterd .. ..	..	..	..	..	..	..	..	..	..	..
<i>Actinoleuca calamus</i> C. and F. .. ..	..	..	..	..	..	?	..	..	..	..
<i>Cellana solida</i> Blainville .. ..	..	..	+	..	..	..	..	+	..	..
<i>Chiazamaea</i> sp. .. ..	..	..	..	..	..	..	..	..	..	..
<i>Patelloida alticostata</i> Angas .. ..	..	..	..	..	..	?	..	?	..	..
<i>Laevilitorina mariae</i> T. Woods .. ..	..	..	..	..	..	+	..	..	..	..
<i>Pseudorissoina tasmanica</i> T. Woods .. ..	..	..	..	..	..	..	..	..	+	+
<i>Sigapatella calyptraeformis</i> Lamarek .. ..	..	..	..	..	..	..	..	..	..	+
<i>Antisabia foliacea</i> Q. and G. .. ..	+	..	+	..	..	..	..	+	..	..
<i>Hipponix conica</i> Schumacher .. ..	..	..	..	..	+	?	..	+	..	..
<i>Ataxocerithium serotinum</i> A. Adams .. ..	+	..	+	..	..	..	+	..	..	..
<i>Zeacumnantus cerithium</i> Q. and G. .. ..	..	..	..	..	..	..	..	+	..	..
<i>Triphora angasi</i> Crosse and Fischer .. ..	..	..	..	..	+	..	..	..	..	..
<i>Fossarina petterdi</i> Crosse .. ..	..	..	..	..	..	..	..	?	..	..
<i>Turbonilla lofmani</i> Angas .. ..	..	..	..	..	..	..	..	+	..	..
<i>T. mariae</i> T. Woods .. ..	..	..	..	..	..	+	..	..	..	..
<i>Eulina cori</i> Pilsbry .. ..	..	..	..	..	..	..	..	+	..	..
<i>Cymatiella lescuri</i> Iredale .. ..	+	..	..	..	..	+	..	..	..	..
<i>C. verrucosa</i> Reeve .. ..	+	..	..	+	..	..	..	+	..	..
<i>Notocypraea angustata</i> Gmelin .. ..	..	..	..	+	..	+	..	+	..	..
<i>Ellatrivia merces</i> Iredale .. ..	..	..	+	..	..	..	..	..	..	..

D. BOWLING'S FARM: *continued*—

Bore No. .. ..	Higher Sediments								Lower Sediments	
	well	D10 1.5- 1.9m.	D15	D15 1.45- 1.6m.	D20 1.75- 2.45m.	D55 1.15- 1.36m.	D55	D60	D35 1.55- 1.65m.	D35 1.7- 1.8m.
Depth .. ..										
Sample No. .. ..	40	47	49	52	58	41	55	38	44	37
<i>Litozamia brazieri</i> T. Woods .. ..	..	..	..	..	..	+	..	+	..	..
<i>Lepsiella reticulata</i> Blainville .. ..	..	..	..	+	..	..	?	..	..	..
<i>Zemitrella austrina</i> Gaskoin .. ..	..	..	..	+	..	..	..	..	..	..
<i>Z. semiconvexa</i> Lamarek .. ..	+	+	+	+	+	+	..	..	..	..
<i>Z. tenebrica</i> Reeve .. ..	..	..	..	+	..	..	..	..	..	..
<i>Retiunassa mobilis</i> Hedley and May .. ..	..	..	..	..	..	..	..	+	..	..
<i>Tavanioflia tasmanica</i> T. Woods .. ..	..	..	..	..	+	..	..	+	..	..
<i>Cominella eburnea</i> Reeve .. ..	..	..	..	..	+	..	..	..	..	..
<i>C. lincolata</i> Lamarek .. ..	..	..	+	..	..	+	..	..	..	..
<i>Alocospira lineata</i> Kiener .. ..	..	..	..	..	+	..	..	..	..	..
<i>A. marginata</i> Lamarek .. ..	+	..	+	..	..	..	?	..	..	..
<i>A. petterdi</i> Tate .. ..	..	..	..	..	..	+	..	..	..	..
<i>Marginella</i> sp. .. ..	..	..	?	..	?	..	..	..	..	..
<i>M. formicula</i> Lamarek .. ..	..	..	..	+	+	..	..	+	..	..
<i>M. inconspicua</i> Sowerby .. ..	..	..	..	..	+	..	..	..	..	..
<i>M. ovulum</i> Sowerby .. ..	..	..	..	..	..	+	..	..	..	..
<i>M. pygmaea</i> Sowerby .. ..	..	..	..	?	..	+	..	+	..	..
<i>Austromitra angasi</i> Brazier .. ..	..	..	..	..	..	+	..	..	..	..
<i>Floraconus</i> sp. .. ..	..	..	..	..	?	..	..	..	..	..
<i>F. anemone</i> Lamarek .. ..	..	..	+	..	..	..	..	..	..	..
<i>Pseudodaphnella modesta</i> Angas .. ..	..	..	..	..	..	?	..	..	..	..
<i>Terebra ustulata</i> Deshayes .. ..	..	..	..	..	..	..	..	+	..	..
<i>Siptonaria diemensis</i> Q. and G. .. ..	..	..	..	..	..	+	..	+	..	..
<i>Glycymeris</i> sp. .. ..	..	..	..	..	..	?	..	..	..	..
<i>Arca pistachia</i> Lamarek .. ..	..	..	+	..	..	..	..	..	..	..
<i>Mytilus</i> sp. .. ..	..	..	..	..	..	..	?	..	..	..
<i>Modiolus pulex</i> Lamarek .. ..	..	..	..	..	..	..	..	+	..	..
<i>Cardita calyculata</i> Linne .. ..	..	..	..	..	..	..	..	+	..	..
<i>Meliteryx helmsi</i> Hedley .. ..	..	..	..	..	..	..	..	..	+	..
<i>Mysella donaciformis</i> Angas .. ..	..	..	+	..	..	..	..	..	..	..
<i>Tawera gallinula</i> Lamarek .. ..	..	..	..	..	..	+	+	..	..	..
<i>T. spissa</i> Deshayes .. ..	..	..	..	..	..	..	..	+	..	..
<i>Hiatella australis</i> Lamarek .. ..	..	..	..	..	..	+	..	..	..	..

THREE RIVERS: Sample 31.

<i>Austrocochlea</i> sp. .. .. ?	<i>Micrastraea aurea</i> Jonas .. .. +
<i>Cellana solida</i> Blainville .. .. +	<i>Pleuroploca australasiae</i> Perry .. .. +

BAY SOUTH OF NETHERBY BAY: Sample 16.

<i>Austrocochlea adelaidae</i> Philippi .. .. +	<i>P. victoriana</i> (Singleton) .. .. +
<i>A. constricta</i> Lamarek .. .. +	<i>Patellanax proni</i> Blainville .. .. +
<i>A. odontis</i> Wood .. .. +	<i>Dicathais tortiliosa</i> Lamarek .. .. +
<i>Subinnella undulata</i> Solander .. .. +	<i>Zemitrella semiconvexa</i> Lamarek .. .. ?
<i>Patelloida alticostata</i> Ongas .. .. +	<i>Cominella lineolata</i> Lamarek .. .. +

## APPENDIX III.—REPORT ON FORAMINIFERAL SAMPLES FROM KING ISLAND, TASMANIA

A. C. Collins

*Bowling's Farm, Surprise Bay.*

Sample 38, Bore D60. Dark-grey shell and quartz sand, 105-160 cm.

Residue after washing is almost entirely calcareous; bryozoan fragments are dominant; there are also small mollusca, echinoid spines, sponge spicules, worm tubes, ostracoda. Many foraminifera are present, over 100 spp. Some small sharp-edged quartz grains occur.

Floatingly mostly consist of the lighter bryozoan fragments with foraminifera, ostracoda and gastropod molluscs. The foraminiferal assemblage is that of an open-sea beach sand as found on the mainland at places like Torquay with the exception of two species. *Quinqueloculina monynensis* has so far been recorded only from the warm-water Pleistocene shell-beds of Port Fairy. *Poroepionides lateralis* is a tropical species. One specimen only was found, poorly developed, but otherwise typical.

Sample 41, Bore D55. Grey shell sand, 115-136 cm.

Residue after washing and floating similar to those of sample 38. The foraminiferal assemblage of about 70 spp. is that of an open-sea beach sand in composition but not in preservation. Many of the miliolid tests are stained grey or black, in some cases the whole test being a polished jet-black. This suggests deposition under reducing conditions, e.g., material derived from adjacent shallow-water being carried by waves or high tides into a stagnant lagoon.

Two specimens of the foraminifera, *Fabularia* sp. c.f. *lata* Collins were found in this material, both black-stained like other miliolids. The only previous record for *F. lata* is from warm-water Pleistocene shell beds at Port Fairy, Vic., while a closely-similar, if not identical, form has been recorded from shallow water off Kingston, South Australia. The genus has in general been recorded from warm-water deposits from the Eocene onward. This record suggests rather warmer climatic conditions at the time of deposition than at present.

Sample 47, Bore D10. Shell and quartz sand, 150-190 cm.

Residue after washing consists of clear quartz sand, grains well rounded, with a good deal of shell debris, echinoid spines, bryozoan fragments, foraminifera, &c.

Floatingly consist mainly of foraminifera, about 80 spp., of recent shallow-water Bass Strait facies; also there are the lighter fragments of bryozoa, ostracoda and small mollusca. The material is a typical open-sea beach sand.

Sample 38, Bore D35. Grey quartz sand and gravel with occasional shell fragments, 170-180 cm.

Residue after washing consists mainly of quartz sand, larger grains rounded, smaller angular, also some larger fragments of greenish fine-grained rock. A good deal of carbonaceous matter is present, adhering to the sand grains and giving the material its dark colour.

Floatingly contain a fair number of foraminifera, of about 55 spp. and a normal shallow-water Bass Strait facies. Specimens are mostly rather small, with surfaces dulled or eroded and in some cases dark-stained. Other organisms include discoidal diatom tests, sponge spicules, ostracoda and coxiellid gastropods.

Foraminiferal and other evidence suggests conditions of normal salinity but somewhat sapropelic bottom conditions, not very favourable to the growth or preservation of foraminifera, e.g., a marine swamp.

*South-East Lagoon.*

Sample 34, Alexander's Lagoon. Grey clay, 92-96 in.

Residue is mostly sharp clear quartz grains. Floatingly consist mainly of a matted accumulation of a bright-green stellate desmid alga. One specimen of a foraminifera was found—*Fissurina* sp., in poor condition, possibly adventitious.

Evidence is negative only; the deposit is presumably freshwater.

Sample 35, Bore 2. Dark-grey silty clay, with shells, 58-52 in.

Residue after washing is mostly shell debris with fibrous carbonaceous matter; there are some fine quartz grains and a good deal of mica.

Floatingly include small mollusca, with many coxiellids, ostracoda, and very many specimens of a species of the foraminiferal genus *Streblus*, so common as to make up about a quarter of the entire float. Five spp. of the genus *Elphidium* were present, the remaining 19 spp. being all such as are found in the shallow waters of Bass Strait, with no arenaceous miliolid forms.

The preponderance in numbers of the species of *Streblus* and *Elphidium*, genera known to have species tolerant of low salinities, combined with the paucity of other species, suggests brackish-water tidal conditions, as in an estuary.

Sample 36, Bore 2. Green-yellow clay-gyttja, with shells, 44-48 in.

Residue after washing consist mainly of molluscan shell-fragments, clean and well preserved, with ostracoda, echinoid spines, &c., and a good deal of mica. Some fairly large quartz grains are subangular or sharply faceted.

Floatingly consist largely of small foraminifera, well preserved and unstained, with a strong element of large specimens of *Elphidium* sp. sf.

*crispum* (L.). There are also some large specimens of *Streblus* sp., but they are not common. The smaller species are of similar facies to sample 35.

This is an assemblage which almost suggests two separate provenances—a local quiet-water marine element consisting of the larger species, and a current-transported assemblage of the smaller and lighter forms from an open-sea source. Corio Bay, Vic., has shore-sand assemblages dominated by this species of *Elphidium*. There does not seem to be any strong evidence of low salinity. Mineral contents suggest short travel of the quartz and mica fraction. The development and good preservation of the larger foraminiferal and molluscan shells seems to be at variance with sapropelic bottom conditions as suggested by the identification of the deposit as clay-gyttja.

Sample 50, Bore 40. Grey clay-silt, with shells, 270-310 cm.

Residue after washing is a fine-grained calcareous sand, with shell debris, foraminifera, ostracoda, small mollusca, echinoid spines, sponge spicules and some clear quartz grains.

*Streblus* sp. is dominant in the floatings, which also contained coxiellid gasteropods. Other foraminifera, about 50 spp., were of shallow-water open sea facies, with some grey-staining and erosion. The foraminiferal and other evidence suggests brackish-water conditions with open sea access, e.g., tidal estuaries.

Sample 53, Bore 45. Grey silt with shells, 255-268 cm.

Residue after washing is mostly of angular quartz grains with mica flakes.

Floatings consist almost entirely of coxiellid shells, with a few foraminifera dominated by

*Streblus* sp., grey-stained and eroded. The evidence suggests brackish-water lake conditions with occasional access by the sea.

#### Egg Lagoon.

Sample 54. White shell sand, 197-260 cm. Bore at *Nototherium* site (whereas all above are estuarine-marine sediments, this may be an aeolianite mashed up in the auger).

The material consists mostly of calcareous fragments with some quartz grains, rather angular. Shell fragments and foraminifera have a rather "frosted" appearance, including those which are naturally glassy and translucent. The material compares rather closely with an aeolianite from Cape Grim, Tas. (coll. E. D. Gill), and is probably of similar provenance. There are about 60 spp. of foraminifera, all Bass Strait forms, with the exception of *Calcarina* sp. cf. *calcar* d'Orb. *Calcarina* as a genus is tropical in distribution. Specimens found are not well preserved but are rather like a form found in Western Australian and Barrier Reef waters. Genus was recorded also from the Pleistocene of Port Fairy. It is not known as recent in Bass Strait.

The ecological indications vary from probable fresh-water deposits to marine beach-sand. The only evidence of climatic difference is given in the occurrence of *Quinqueloculina moynensis* and *Poroponides lateralis* in Sample 38, of *Fabularia* sp. cf. *lata* in Sample 41, and of *Calcarina* sp. in Sample 54. These invite comparisons with the climate of the last Pleistocene warm period. They also, indirectly, give some age evidence, since to the best of my knowledge these species do not occur in the Bass Strait area in the recent state. Otherwise all species appear to be of recent Bass Strait facies.



	SAMPLES									
	38	41	47	37	35	36	50	53	54	
<i>G. regina</i> (Brady, Parker and Jones) .. .. .	+	+	+	..	..	..	+	..	..	
<i>Globulina gibba</i> d'Orbigny .. .. .	+	+	..	+	..	..	..	..	..	
<i>Polymorphina howchini</i> Cushman and Ozawa .. .. .	..	+	..	..	..	..	..	..	..	
<i>Sigmoidella kagaensis</i> C. and O. .. .. .	..	..	..	..	..	..	..	..	+	
<i>S. elegantissima</i> Parker and Jones .. .. .	+	+	+	..	..	..	..	..	+	
<i>Bolivina folium</i> (P. and J.) .. .. .	..	..	..	..	..	..	..	..	+	
<i>Buliminella madagascariensis</i> d'Orbigny .. .. .	..	..	+	..	..	+	..	..	+	
<i>Bulimina marginata</i> d'Orbigny .. .. .	+	+	+	+	..	..	..	..	+	
<i>B. sp. aff. elongata</i> d'Orb .. .. .	..	..	..	..	+	+	..	..	..	
<i>Virgulina sp. aff. pauciloculata</i> Brady .. .. .	..	..	..	..	+	+	..	..	..	
<i>Reussella sp. aff. simplex</i> Cushman .. .. .	+	+	+	+	..	..	..	..	+	
<i>Bolivina compacta</i> Sidebottom .. .. .	..	..	+	..	+	+	+	..	..	
<i>B. pseudoplicata</i> Heron-Allen and Earland .. .. .	+	..	+	+	+	+	+	..	+	
<i>Uvigerina bassensis</i> Parr .. .. .	+	+	+	+	..	..	+	..	+	
<i>Siphogenerina raphanus</i> (P. and J.) .. .. .	..	+	+	+	..	..	..	..	..	
<i>Angulogenerina angulosa</i> (Will.) .. .. .	+	+	..	+	..	..	..	..	..	
<i>Trifarina bradyi</i> Cushman .. .. .	..	..	..	..	..	..	..	..	+	
<i>Cassidulina delicata</i> Cushman .. .. .	..	..	+	..	..	..	..	..	..	
<i>Spirillina inaequalis</i> Brady .. .. .	..	..	..	..	..	..	+	..	..	
<i>S. denticulata</i> Brady .. .. .	..	..	..	+	..	..	..	+	..	
<i>Patellina corrugata</i> Williamson .. .. .	..	..	..	..	+	..	..	..	..	
<i>Patellinella inconspicua</i> (Brady) .. .. .	..	..	+	+	..	..	..	..	..	
" <i>Discorbis</i> " <i>williamsoni</i> Chapm. and Parr .. .. .	+	+	..	..	..	..	..	..	..	
" <i>D.</i> " <i>rarescens</i> (Brady) .. .. .	+	..	+	..	..	+	..	..	..	
" <i>D.</i> " <i>globularis</i> (d'Orbigny) .. .. .	+	..	+	..	+	+	..	..	..	
" <i>D.</i> " <i>australensis</i> H-A. and E. .. .. .	..	+	+	+	..	..	+	..	..	
" <i>D.</i> " <i>pulvinatus</i> (Brady) .. .. .	+	..	+	..	..	..	..	..	+	
" <i>D.</i> " <i>patelliformis</i> (Brady) .. .. .	..	..	..	..	..	..	..	..	+	
" <i>D.</i> " <i>dimidiatus</i> Parker and Jones .. .. .	+	+	+	+	..	..	+	..	+	
<i>Discorbinella biconcava</i> (P. and J.) .. .. .	+	+	+	+	..	..	+	..	+	
<i>D. disparilis</i> (Sidebottom) .. .. .	+	+	+	+	..	..	..	..	+	
<i>Heronallenia lingulata</i> (B. and H.) .. .. .	..	..	..	+	..	..	..	..	..	
<i>H. translucens</i> Parr .. .. .	..	+	..	..	..	..	..	..	+	
<i>Porocponides lateralis</i> (Terquem) .. .. .	..	..	..	..	..	..	..	..	..	
<i>Valvulincra collinsi</i> (Parr) .. .. .	..	+	..	..	..	..	..	..	..	
<i>Streblus sp. (?)</i> .. .. .	..	+	..	+	..	+	..	+	..	
<i>Calcarina sp. cf. calcar</i> d'Orb. .. .. .	..	..	..	..	≈	+	≈	+	+	
<i>Globigerina bulloides</i> d'Orb. .. .. .	..	+	+	+	..	+	..	..	+	
<i>Globigerinoides conglobatus</i> (Brady) .. .. .	..	+	+	+	..	..	+	..	..	
<i>Orbulina universa</i> d'Orbigny .. .. .	..	+	+	+	..	..	..	..	..	
<i>Sphaeroidina bulloides</i> d'Orb. .. .. .	..	..	..	+	..	..	..	..	..	
<i>Globorotalia crassula</i> Cushman and Stewart .. .. .	..	+	+	+	+	..	+	..	+	
<i>Truncorotalia truncatulinoides</i> (d'Orbigny) .. .. .	..	+	+	+	..	..	..	..	+	
<i>Tretomphalus concinnus</i> (Brady) .. .. .	..	+	..	..	..	..	..	..	..	
<i>Cibicides lobatulus</i> (W. and J.) .. .. .	..	+	..	..	+	..	+	..	..	
<i>C. psuedoungerianus</i> Cushman .. .. .	..	..	+	..	..	..	..	..	..	
<i>Dyocibicides laevis</i> Parr .. .. .	..	+	+	+	..	..	..	..	..	
<i>Planorbulina rubra</i> d'Orb. .. .. .	..	+	+	..	..	..	..	..	..	
<i>Acervulina inhaerens</i> (Schultze) .. .. .	..	+	+	..	..	..	..	..	..	
<i>Gypsinia vesicularis</i> P. and J. .. .. .	..	..	+	+	..	..	+	..	+	
<i>Elphidium sculpturatum</i> Cushman .. .. .	..	+	..	+	..	..	..	..	+	
<i>E. macellum</i> (Fichtel and Moll) .. .. .	..	+	..	..	..	..	..	..	+	
<i>E. macellum</i> var. <i>limbatum</i> (Chapman) .. .. .	..	..	..	..	+	..	..	..	..	
<i>E. crispum</i> (Linne) .. .. .	..	..	..	..	+	≈	..	..	..	
<i>E. sp. aff. articulatum</i> (d'Orb.) .. .. .	..	..	..	..	+	..	..	..	..	
<i>E. argenteum</i> Parr .. .. .	+	+	+	..	..	+	+	..	+	

+ denotes species present.

≈ denotes dominant species.