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THE GEOLOGY AND PHYSIOGRAPHY OF NORTH STRADBROKE ISLAND.

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SOUTHPORT. 31st December, 1948.

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THE GEOLOGY AND PHYSIOGRAPHY OF NORTH STRADBROKE ISLAND.

SUMMARY.

Altimeter traverses of the island made during January and February, 1948.

Valuable information was gained from the field logs of bores put down by Zinc Corporation Ltd., and from aerial photographs of the island.

Except for small areas of Mesozoic sandstone at Dunwich and rhyolite at Point Lookout, and a very small outcrop of early Palaeozoic greenstones on the west coast, the island consists of sand dunes and swamps, or swamp deposits. These range in age from mid-Pleistocene to Recent. The Eighteen Mile Swamp and the dune area adjacent to the ocean beach are Recent in age. The higher dunes west of the Swamp are of Pleistocene age. The oldest dunes occur in the north-western part of the island, while exceptionally high dunes of a slightly later period form the central part of the island. The youngest of the Pleistocene dunes appear on the eastern flanks of the latter dunes, and form the greater part of the southern portion of the island. Deposits of fine-grained sand, cemented and discoloured by organic material crop out beneath Pleistocene dunes at elevations of 90 to 110 and 40 to 60 feet. These appear to be fossil swamps, which may have formed during interglacial stages of the Pleistocene glaciation when the level of the sea was 100 feet and 50 feet above its present level.

The latest of the Pleistocene dunes from 3 miles to 13 miles south of Point Lookout contain about 2 per cent by volume of heavy minerals. Deposits of heavy minerals occur below the Recent dunes and swamp just south of the Point Lookout rhyolites, and along the present ocean beach.

The building of the sandy portions of the island is thought to have commenced in early upper Pleistocene times during the recession of the sea from the maximum level attained during the Mindel-Riss interglacial stage. During this recession, the fossil swamp deposits at 90 to 110 feet above sea level, the dunes in the north-western portion of the island, and high central dunes were deposited in succession. In the subsequent recession of the sea, during the Riss-Wurm interglacial stage, the fossil swamp deposits at 40 to 60 feet above sea level, and the latest Pleistocene dunes containing an appreciable concentration of heavy minerals were, in turn, deposited. The Recent swamps and dunes, with underlying deposits of heavy minerals, formed during and after the final (sub-Recent) fall in sea level.

I. INTRODUCTION.

A. The Scope and Conduct of the Field Work - For the purpose of obtaining a general understanding of the geology of North Stradbroke Island, field work was carried out on the island from January 8th to February 17th, 1948. Altimeter traverses were made from Dunwich, Amity, Point Lookout and Blue Lake, and from the connecting roads. The southern portion was covered from landing points on the west coast near Russel Island. The results of observations were plotted on to Military Map Queensland Zone 8, No. 182 (Brisbane Valley). Altimeter readings were corrected from the readings of a weekly barograph stationed at Dunwich, on the western side of the island. These corrections were not always satisfactory, as it was found that whenever a strong sea breeze was blowing a considerable variation in the diurnal pressure changes existed between the eastern and western sides of the island.

B. Location and Access. The localities referred to below are shown on the locality plan (Plate I) which accompanies this report:

North Stradbroke Island lies about twenty five miles east of Brisbane. The island is twenty three miles in length from north to south, and varies in width from about seven miles at the northern end to between two and three miles at the southern end. The island has an area of approximately one hundred square miles. The eastern margin, which is bounded by the Pacific Ocean, consists of an almost straight line of beach and low dunes extending in a north easterly direction. The western side of the island faces Moreton Bay and consists of several relatively small headlands and bays. Bay islands such as Russel, Macleay, Lamb and Peel islands lie adjacent to the west coast of North Stradbroke Island. Directly to the north of North Stradbroke is Moreton Island and to the south is South Stradbroke Island.

A motor launch company, Hayles' Cruises Ltd., conducts a tri-weekly service from Brisbane to North Stradbroke, the journey taking about five hours. Vehicles may be transported to the island by this service. The disembarking points on the island are Amity Point and Dunwich.

A daily ferry service operates between Dunwich and Cleveland on the mainland which is connected by rail to Brisbane. This route from Brisbane takes about three hours travelling. Vehicles cannot be shipped to the island by the Cleveland ferry service.

At present vehicular traffic on the island is restricted because of the lack of good tracks and because of the fact that most of the island consists of high and steep sand dunes, with swampy areas, in places densely vegetated. A rough vehicular track runs from Point Lookout to Amity Point (see Locality Map)(Plate I) along the northern end of the island. Amity Point is connected with Blue Lake by a fairly good sandy road which follows the north-westerly trend of the dunes for about fifteen miles. A rough track about ten miles in length connects Blue Lake with Dunwich. A second track runs three miles southwards from Dunwich, winds around the northern end of Kounpee Swamp and connects with a series of tracks which extend some three miles southwards from Blue Lake. These tracks run to various bore lines laid out by The Zinc Corporation which has been testing the heavy mineral sand deposits of the island.

Vehicles can travel the entire length of the Ocean Beach at low tide. Access to the main body of the island from the ocean beach is practicable only between the northern end of the swamp and Point Lookout, a distance of about four miles, and by way of a "catwalk" across the swamp about three miles from its northern end opposite Blue Lake. The northern beach can also be used at low tide.

A rough track follows the telegraph line from Dunwich to Amity Point but washouts have made this unusable for vehicles in some places.

Access to the southern part of the island is by foot from Dunwich or Blue Lake. Landings from a boat can be made on the west coast opposite the north-east tip of Russel Island, at a point three miles further south, and at the Stockyard which is about two miles north of the southern end of the island.

Some parts of the island, particularly to the west of the Amity-Blue Lake road, are almost bare of vegetation apart from scattered grass-trees and gorse. Most of the island is covered with fairly open eucalypt forest and bracken but in some areas, such as immediately north west of Swan Bay and in places bordering the Eighteen Mile Swamp, the scrub is thick.

The principal sources of fresh water on the island are the Eighteen Mile Swamp and Blue Lake. Small springs occur at Point Lookout, Dunwich, Capembah Creek and Flying Fox Creek. Elsewhere on the island watercourses are non-perennial but water is always obtainable from the swamps and lagoons.

II. PHYSIOGRAPHY.

The physiographic units of the island are shown on Plate 2. Reference should also be made to the 1-mile Military Maps, Queensland Zone 8, No. 182 (Brisbane Valley), Zone 8 No. 183 (Brisbane) and No. 193 (Beenleigh 1 Mile Series).

Apart from a small area of sandstone at Dunwich, one of rhyolite at Point Lookout, and a very small area of greenstone in Canaipa Passage, the island is composed of sandhills and swamps. Four areas which make up the greater part of the island are distinguished from one another by the heights of the dunes and the trends of the dune lines. These areas are :-

A. The Western Area, which is a narrow, northerly trending fixed-dune area adjacent to the west coast, commencing near Dunwich and extending in a southerly direction to about the southern end of Black Snake Lagoon. The outlines of individual dunes are not apparemt, and the northerly trend applies to the area, and not to actual dunes. This region of dunes has areas of solid rock at its northern and southern extremities, the sandstone at Dunwich and the greenstone in Canaipa Passage.

B. A Central and a North-Western Area of high, fixed, north-westerly trending dunes. The Central Area is bounded on the east by the Eighteen Mile Swamp. Towards the southwest the Central Area is divided from the lower-lying Southern Area by a scarp which runs in a south-easterly direction from about a mile north of Lake Kounpee to the southern apex of the area, about 5½ miles south of Blue Lake. Towards the north-west the high dunes of the Central Area terminate along an irregular or serrated line which runs from about 3 miles north-east of Dunwich to Rocky Point on the North coast. Lower dunes continue beyond this serrated boundary in a north-westerly direction and make up the main part of the North-Western Area. In the middle part of the Central Area, the dunes rise to a height of 700 feet. The average altitude of the area is about 400 feet. In the North-Western Area, the average altitude is nearer 250 feet.

C. The Southern Area embraces that portion of the island, south of the Central Area, which has been transgressed by long north-westerly-trending dunes. These dunes, though attaining heights of 400 to 500 feet in portions of the Southern Area, e.g. Mt. Wiles, Mt. Hutton, Mt. Scott, and South Hill, are in general much lower than those of the Central Area. The high-dune portions are separated by wide valleys or comparatively low-lying tracts, such as the north-westerly trending areas which enclose Horseshoe Swamp, Native Companion Lagoon and Duck Lagoon. The Southern Area is separated from the Western Area by the Western Chain of Lagoons and Swamps. This includes Lake Kounpee and Kounpee Swamp, Blakesley Lagoon, Shag Lagoon, Black Snake Lagoon and Ibis Lagoon.

D. The Eastern Area is a narrow strip of low dunes adjacent to the ocean beach on the east coast, and separated from the Central Area by the Eighteen Mile Swamp. The dunes, which reach a maximum height of 50 feet, appear to have an original northerly-trend, which is being destroyed by wind erosion, and the development of active north-westerly trending dunes. North-westerly "Blowouts" cut through the existing dunes and adjacent to the blowouts, dunes are building up, and moving in the direction of the prevailing winds. These dunes have encroached on the Eighteen Mile Swamp over distances ranging up to half a mile. The north-westerly trend of the blowout dunes is similar to that of the fixed dunes of the Central, North-Western and Southern Areas.

E. Swamps. Swamps cover about thirty-five to forty square miles of the island. These may be divided into three groups :-

1. The Eighteen Mile Swamp and the swamp running between Amity and Point Lookout. These are about ten feet above sea-level, are up to a mile wide, and are separated from the ocean by lines of relatively low active dunes and by the beach.

2. Fringing mangrove swamps cover most of the western shore line and extend around the southern end of the island.

3. Relatively small isolated patches of swamp occur inland. These include the Western Chain of Lagoons and Swamps, and the swamps of the Southern Area, mentioned in Section C above.

III. GEOLOGY

The localities mentioned in this section are shown in Plate 3 accompanying this report.

A. General. The complete geological structure of the island is difficult to determine because so much of the island is covered by dune sand.

The oldest rocks are greenstones of the Brisbane Schist Series, which outcrop in a small area about ten miles south of Dunwich on the western side of the island.

Mesozoic sandstone and grit form the headland at Dunwich, and sandstone floaters found just north of Blue Lake may also belong to this period.

Point Lookout, the north-east tip of the island, is composed of fluidal rhyolite which L.C. Ball (1930) regarded as being of Mesozoic Age.

The remainder of the island consists mainly of sand dunes. In places in these dunes, particularly along the border of the Eighteen Mile Swamp, are outcrops of organically cemented sand of tentatively Pleistocene Age. There appar to be three distinct horizons on which these organically cemented sands appear, viz., between 150-250 feet above sea level, between 90-110 feet and between 30-60 feet.

The sand dunes which form the major part of the island fall broadly into two groups: (a) old dunes lying to the west of the Eighteen Mile Swamp, and (b) young dunes lying between the Eighteen Mile Swamp and the ocean beach. The latest of these dunes are active. The older dunes rise to a maximum height of 720 feet (Mt. Hardgrave) with a mean elevation of 300 feet, they are fixed and are for the most part heavily vegetated. The younger dunes have an average elevation of 30 feet, reaching in places to small peaks of 50 feet. Vegetation on these dunes is sparse, and is gradually being covered by fresh sand blown up from the ocean beach.

B. Palaeozoic.

Greenstones of the Brisbane Schist Series occur in a small area on the west coast about ten miles south of Dunwich. At the time of examination the outcrops extended intermittently for about three hundred yards along the shore line; the lateral extent being obscured by deep water on one side and dune sand on the other. The greenstones are visible at low tide and stike 6° west of north; the dip is almost vertical.

The variation of textural types (Denmead 1928) in this rather confined area is striking. Porphyritic Massive, Finegrained, and Porphyroblastic Schistose greenstones occur in close proximity.

Greenstones have been reported to occur near Dunwich but no sign of them was seen in that locality.

C. Mesozoic.

1. Sandstone at Dunwich.

The coarsegrained sandstone and grit which form the Dunwich headland was traced for an area of about half a square mile but a definite limit to its extent could not be fixed because of the sand dunes which rise to 350 feet within a mile of the shore. No outcrop was found in depressions immediately to the east of these dunes.

The Dunwich sandstone is extensively cross-bedded and contains small pebble bands. Fairly strong limonite staining is an overall feature, and there is also a north-south, east-west network of limonite veins which probably indicates a system of jointing. The apparent general dip of these beds is in a north-westerly direction at a low angle.

In lithological characteristics, limonitisation and current bedding, the Dunwich sandstone resembles the sandstone on Peel and Goat Islands, about two miles west of Dunwich. A species of Thinnfeldia (details unknown) has been found in the sandstones on these islands. Because of this the sandstones have been regarded as equivalent to the Mesozoic Ipswich Series. In the absence of palaeontological evidence from the Dunwich sandstone a tentative correlation on lithological grounds has been made with the Ipswich Series by way of the Peel and Goat Island sandstones.

2. Sandstone North of Blue Lake.

Floaters of quartz sandstone found on the south eastern end of the second dune north of Blue Lake, immediately above the edge of the Eighteen Mile Swamp were also regarded as being of Mesozoic Age although no fossil evidence was found. No outcrop of this sandstone could be found in the vicinity, most of the floaters being about thirty feet above present swamp level.

Some of the floaters measure up to two feet square and about six inches in thickness. Bedding planes are well developed. The quartz grains are larger and more angular than grains in the dune sand or in the semi-consolidated sandrock occurring in the area. The cementing material is calcareous. As none of the features such as current-bedding, limonitisation or pebble bands characteristic of the Dunwich Sandstone are in evidence, the origin of these floaters is in doubt.

In Section IV. B.1. of this report it is suggested that during an interglacial stage of the Pleistocene glacial Epoch, when the sea-level was approximately 100 feet above present sea-level, a sandbank a little below the surface of the sea passed through the locality where these sandstone floaters occur. Possibly, the old sandbank or what remains of it, has become cemented, and has given rise to the sandstone floaters. (The field logs of Zinc Corporation's bores (Tables 1 to 4) show that the overlying dune sands have, in places, become firmly cemented or indurated through considerable thicknesses).

The field logs of Table 4 show that a sandstone, apparently harder than the indurated dune sand, occurs beneath the dunes within an area southwards from Blue Lake for $\frac{3}{4}$ of a mile and westwards from the Eighteen Mile Swamp for $\frac{1}{4}$ of a mile. Bores C1, C2, D3 and E2 which were put down by comparatively heavy power-boring equipment, bottomed on "sandstone" or "hard sandstone" at 30 to 40 feet above present sea-level. Bores B5 and D1 bottomed on "sandstone" at levels, respectively, of 160 and 130 feet. However, these latter were put down with post-hole diggers, which would not have been able to penetrate indurated dune sand.

As no specimens are available it has not been found possible to offer, with any confidence, suggestions regarding the origin and age of the sandstone found at the bottoms of the deep bores. The fact that the sandstone occurs at the same level as the floaters of sandstone north of Blue Lake may be of some significance.

TABLE I.

FIELD LOGS OF ZINC CORPORATION BORES WHICH BOTTOMED IN SANDSTONE.

The localities of these bores are shown in Plate 3.

BORE	LOCALITY	DEPTH	LEVEL REFERRED TO MSL.	HEAVY MIN. VOL. %	REMARKS
B.5	700' west of Swamp at latitude of northern extremity of Blue Lake.	0 - 5	180 - 175	3.1	
		5 - 10	175 - 170	2.7	
		10-15	170 - 165	2.1	Sandstone at depth of 20'
		15-20	165 - 160	1.8	
C.1	150 yards west of swamp, ¼ mile south of Blue Lake	0-10	100 - 90	2.7	White
		10-20	90 - 80	0.7	
		20-30	80 - 70	0.6	Yellow
		30-40	70 - 60	0.7	
		40-50	60 - 50	1.0	Indurated
		50-60	50 - 40	0.8	Hard indurated. Bands of hard sandstone.
		60-70	40 - 30	1.0	Hard sandstone at 70' depth. (level 30')
C.2	¼ mile west of Eighteen Mile Swamp; ¼ mile south of Blue Lake. See Tables 1 & 2.	0-30	270 - 240	3.8	Yellow
		30-110	240 - 160	3.1	Brown
		110-120	160- 150	0.5	Light Yellow
		120-140	150 - 130	0.9	Hard indurated bore sand.
		140-150	130 - 120	1.5	Brown and White
		150-190	120 - 80	0.6	Hard bands
		190-220	80 - 50	0.55	Very hard
		220-230	50 - 40	0.5	Sandstone (at 230' ?).
D.1	450' west of Swamp; ½ mile south of Blue Lake	0- 8	145 - 137	0.2	Sandstone bands
		8- 15	137 - 130	0.3	Clay and stone at 8' depth. Hard sandstone at 15' depth.
D.3	Approx. ¼ mile west of Swamp; ½ mile south of Blue Lake.	0 -20	200 - 180	3.3	
		20 -30	180 - 170	1.6	22'-30' Indurated sand
		30 -60	170 - 140	1.7	
		60 -90	140 - 110	0.4	
		90-170	110 - 30	Tr. to 0.1	At 170' depth, hard sandstone.
E.2	¼ mile west of Swamp; ¾ mile south of Blue Lake	0 -20	100 - 90	1.3	20-25' depth, hard, black organically stained sand. Below 25', change to reddish colour, with very hard seam sandstone. Very hard at depth of 59'.
		20 -60	90 - 80	1.2	
			80 - 70	0.4	
			70 - 60	0.3	
			60 - 40	0.2	

3. Point Lookout Rhyolite.

Fluidal rhyolite rising to 200 feet above sea level forms the headlands from Rocky Point to Point Lookout, and extends at least two miles south of Point Lookout. Exposures occur on the tops and sides of the dunes. The exact boundary is obscured by the dunes which rise to 400 feet within a mile and a half south of Point Lookout.

No relation of the rhyolite to any sedimentaries was noticed but the age has been assumed to be Mesozoic (Ball 1930). The fluidal character of the rhyolite is particularly marked on the more elevated portions, the lower parts (near sea level) being rather massive and blocky. Small quartz phenocrysts occur throughout, and spherulitic crystalisation is in evidence in the lower, blocky portion. There is a haphazard variation in colour from pink to green. In some of the gorges which follow the joint pattern of the headland at Point Lookout there is a suggestion that there are two distinct flows of rhyolite but the apparent contact surface could not be examined because of heavy seas.

The field logs of several of the bores put down by Zinc Corporation in the area between the ocean beach and the foot of the Pleistocene dunes suggests that the Recent dune and swamp area may be underlain by rhyolite for a distance of approximately 3 miles south from Point Lookout. Thus in Table 2, it is seen that Bores 12, ZD9, 78, 86 and ZH7 bottomed in "clay", "hard clay" or a mixture of clay and sand, usually at a depth of about 6 feet below the present day High Water Level.

In bore 75, which is shown on Zinc Corporations sections to be approximately 40 feet above Mean Sea Level, "hard rock" was encountered at a depth of 25 feet, i.e., approximately 12 feet above High Water Level. The heavy mineral content of the samples from bore 75 did not exceed 0.1 per cent, yet in bores 78 and 86, 250 feet and 500 feet further south, where the clay is 1 to 7 feet below High Water Level, 5 foot samples contained respectively, 21 per cent and 58 per cent by volume of heavy minerals. If the "clay" represents weathered rhyolite, it follows that, during the sub-Recent recession of the sea, the rhyolite outcropped several feet above High Water Level at the locality of bore 75. It would be expected that deposits of heavy minerals would be retained south of this locality.

The "sandstone and clay" of bore AA16 is almost certainly indurated dune sand or dune rock, in which the cementing material is partly kaolinic and partly limonitic. This type of dune rock outcrops in the scarp adjacent to the Eighteen Mile Swamp. It is discussed in section D.2c. below.

FIELD LOGS OF ZINC CORPORATION BORES WHICH BOTTOMED IN CLAY

The localities of these bores are shown in Plate 3.

BORE	LOCALITY	DEPTH	LEVEL REFERRED TO MSL.	HEAVY MIN. VOL. %	REMARKS
12.	Approx. 1 mile south of Pt. Lookout, 600' West of beach	0 - 5 5 -10 10 -15 15- 17 17 -20 20 -25	Level not known, Probably does not exceed 20'.	Trace 1.7 16.3 32.7 28.0 6.0	W.L.17'. Mixture of white clay and sand at 23'.
ZD9.	Approx. 2 miles south of Pt. Lookout near E. edge of swamp, 900' west of beach.	0 - 5 5 -10 10 -15 15 -20 20 -25	15 - 10 10 - 5 5 - 0 0 to -5 -5 to -10	1.9 2.05 13.9 3.5 Trace	W.L. 7' Clay at 17'6", 12' above H.W.L.
75.	2½ miles south of Pt. Lookout. Near Eastern edge of Swamp	0 - 5 5 - 25	Level not known. May be 40'.	0.1 Trace	Indurated sand at 7'. Hard rock, 25' (Heavy concs. of mineral 500' S.of 75. Perhaps 75 was rock, above sea-level during sub-Recent retreat). (Some min. in 78, 300' S. of 75)
78.	250' south of 75.	0 - 5 5 -10 10 -15 15- 20 20 -25 25 -30	Level probably about 25'	2.2 3.5 3.3 21.0 5.2 1.1	W.L. 15'. Hard clay at 30'.
86.	250' south of 78.	0 - 5 5 -10 10 -15 15 -20 20 -25	Level probably about 25'.	2.1 0.9 3.9 58.4 7.7	W.L. 15'. Yellow clay 23 - 25'
ZH7.	Approx. 3 miles south of Pt. Lookout at E. edge of swamp 800' W. of beach	0 - 5 5 -10 10 -15	5 - 0 0 to -5 -5 to -10	0.8 4.6 Trace	2' above H.W.L. W.L. 1'. Clay sand 7' - 15'.
AA16	27 chains west of Eighteen Mile Swamp, at latitude of middle of Blue Lake	0 -20	220 - 200'	Trace	Sandstone and clay at 20'.
AA10.	Some 300' south-east from bore AA16.	0 - 5 5 -10 10 -20	150 - 145 145 - 140 140 - 130	0.7 0.4 0.2	Hard stone at 18'.

D. Pleistocene.

I. Introduction. It is considered that the low dune areas, such as those of the Eastern Area, which separate the present coastal swamps from the ocean beaches, are Recent in age, and have formed since the sub-Recent fall in sea-level. The higher dunes which cover the greater portion of the island, viz. those of the Central, North-Western, Western and Southern Areas, are clearly older and are thought to have formed during the latter half of the Pleistocene period. Deposits of materials other than dune sand which are found within the Pleistocene dunes and which have formed, presumably during the period of dune building, must also be Pleistocene in age. In this section, the occurrence and distribution of the Pleistocene deposits is discussed. Some references are made to Section IV where the processes of formation and the ages of the deposits are considered.

2. Dunes. Plans showing the boundaries of the dune areas, and the outlines and trends of the Pleistocene dunes, are given in Plate 4 accompanying this report.

(a) The Relative Ages of the Dunes. An inspection of aerial photographs of the island shows that the building of the Pleistocene dunes proceeded certainly in two, and probably in three major stages. It was stated in Section II.B. above that the "high dunes of the Central Area terminate along an irregular or serrated line which runs from about 3 miles north-east of Dunwich to Rocky Point on the north coast. Lower dunes continue in a north-westerly direction....and make up the main part of the North-Western Area". Evidence of the probable major stage of dune building mentioned above is found here. Aerial photographs suggest that the high dunes of the Central Area have advanced over and buried the south-eastern portions of North-Western Area dunes. The same impression is gained when one examines the contours of this area on the Military Map "Queensland Zone 8 No. 183 Brisbane". Evidence of the two certain major stages of building of the Pleistocene dunes is found near the eastern edge of the high dunes. Aerial photographs show quite clearly that younger dunes have climbed up the eastern fringe of the Central Area dunes, for distances up to about one and a half miles inland from the Eighteen Mile Swamp. It can be seen that these younger dunes overlie older northwesterly-trending dunes from a short distance south of Point Lookout southwards to the southern apex of the Central Area. For a distance of two miles further southwards, i.e., in the northern part of the Southern Area, the younger dunes have transgressed about half-way across a sandy region, somewhat elevated, but much lower than even the inter-crest portions of the adjacent Central Area. This somewhat elevated sandy region displays no pattern of dunes other than the young transgressive north-westerly dunes. Further southwards, ridges of these younger dunes separated by broad low-lying sandy and swampy areas have moved without obstruction completely across the island, reaching in places, to the edge of the narrow northerly trending Western Area.

The statements in the two preceding paragraphs lead to the following inferences :- The oldest of the north-westerly trending dunes are those of the North-Western Area. The youngest are those which fringe the eastern part of the Central Area, and cross the Southern Area. The high dunes of the Central Area are intermediate in age. The dunes of the Western Area must be somewhat older than the dunes in the Southern Area, i.e., than the youngest of the Pleistocene dunes. It has not been found feasible on the basis of air-photo interpretation to relate the age of the Western dune Area to the ages of the older dunes of the North-Western and Central Areas. Section IV F.A.(ii) of this report suggests that the Western Area dunes formed just a little earlier than those of the Southern Area.

(b) Heavy Mineral Concentrations in Dune Sand. The heavy mineral content of the Pleistocene dune areas of the island has been partly determined by Zinc Corporation Ltd. Widely spaced scout bores have been put down in the Central Area, the southern part of the North-Western Area, and the northern, north-western and southern parts of the Southern Area. Further boring has been completed to a maximum depth of 230 feet, in an area which contains appreciable concentrations of heavy minerals, viz. an area adjacent to the western edge of the Eighteen Mile Swamp, one to one and a half miles wide, and lying between latitudes respectively 3 miles and 13 miles south of Point Lookout. It can be seen that the southern limit of the mineral-bearing area coincides with the southern limit of the Central Area. The samples which have been obtained indicate that the upper portions of the dunes in this area contain an average of more than 2 per cent. by volume of heavy mineral concentrate. Immediately below the richer upper portions of the dunes, the percentage of heavy minerals decreases sharply.

Data obtained from the logs of some of the bores are given in Table 3 below. The localities of these bores are shown on Plate 4 Fig.

Table 3.

BORE	LOCALITY	DEPTH	LEVEL REFERRED TO M.S.L.	HEAVY MIN. VOL. %.	REMARKS
C.3	½ mile south of Blue Lake ½ mile West of Swamp	0 - 40 40 - 60 60 - 70 70 -120 120 -160 160 -180 180 -200	260 - 220' 220 - 200' 200 - 190' 190 - 140' 140 - 100' 100 - 80' 80 - 60'	3.3 - 0.7 1.5 - 0.5 0.6 0.3 - 0.1 0.7 - 0.1 0.4 Less than 0.1	Decomposed wood in thin seams of white sand at a depth of 47 feet i.e.,(level of 213 feet). Indurated sand at depth 92' (Level 168').
C.2	¼ mile west of Swamp.	0 - 100 100 - 150 150 - 230	270 - 170 170 - 120 120 - 40	3.5 - 1.1 1.0 - 0.5 0.55	Light yellow sand at depth 100 - 120' (level 170-190' Bands of hard indurated sand from 120 to 230' (levels 170 - 40').
D.5	¼ mile south of C.3 and 1 mile west of Eighteen Mile Swamp	0 - 70 70 - 90 90 - 100 100 - 200	180 - 110 110 - 90 90 - 80 80 to -20	1.5 - 0.2 0.75 1.3 Trace to 0.3	Hard indurated sand at 130' depth (level of 50') Coarse yellow sand at depth of 190 - 200' (level -10 to -20').

Zinc Corporation's sampling has proved that the heavy mineral-bearing area coincides with that portion of the Central Area, within the same latitudes, which is covered by the youngest of the Pleistocene dunes (Plate 4). This implies that the sand from which the youngest dunes were formed, in this area, contained a relatively high concentration of heavy minerals. The youngest dunes appear along practically the whole of the eastern side of the island (paragraph a, above), but only those which occur between latitudes 3 miles south and 13 miles south of Point Lookout have a comparatively high content of heavy minerals. The absence of appreciable concentrations of heavy minerals outside this area, particularly in the northernmost 3 miles of the youngest dunes, may appear anomalous, but Section IV of this report shows that the processes which resulted in the emplacement of the three series of Pleistocene dunes would also have brought about the present distribution of the mineral-bearing sands.

Reference to Tables 1, 3 and 4 shows that the heavy mineral content of the older Pleistocene dunes, though small, is quite appreciable. Some concentration had taken place in the sands from which the older dunes were built.

(c) Indurated Dune Sands. It has been noted that practically the whole of the surface of the island is covered by loose sand, but that the surface is stable because it is vegetated. At some distance below the surface, at least in the eastern portion of the Central Area, the sand is varyingly consolidated or indurated, so that the term "dune rock" is more applicable than "dune sand". Dune rock has been intersected by all of the deeper bores put down by Zinc Corporation, and is exposed in places along the scarp at the western edge of the Eighteen Mile Swamp. The logs of bores C.2 and D.5 quoted in Table 3 above show that (at these two localities) the heavy-mineral content of the sand decreases sharply at a depth of approximately 100 feet and that 20 or 30 feet deeper the sand is hard and indurated, or contains hard, indurated bands. It was suggested in the preceding paragraph that comparatively high concentrations of heavy minerals arerestricted to the latest of the Pleistocene dunes, and that the underlying sands with their much smaller heavy-mineral content represent older dunes. The logs of bores C.2 and D.5 suggest that the latest Pleistocene dunes consist of loose sand but that the older dunes are, for the most part, consolidated. The same suggestion is conveyed by the log of bore C.3 in Table 3, where the depths to the base of the youngest Pleistocene dunes and to the indurated sand, respectively, are about 70 feet and 90 feet. The logs of bores D.4 and E.2 quoted in Table 4 below are in accordance with this suggestion.

The older dune rock is exposed in places along the scarp at the western edge of the Eighteen Mile Swamp. The exposures are at a considerable height above the base of the scarp, because a fringe or apron of detrital sand and sand rock covers the lower part of the scarp. The cementing material in the indurated dune sand may consist of limonite, or of a kaolinic clay with or without some free silica. Further references to this indurated dune sand are made in Section 5 below.

At several localities west of the latest Pleistocene dunes, viz., a short distance north and south of Blue Lake, but about a mile west of the Eighteen Mile Swamp, and also on the ridge running north-west from Mt. Vane, patches of loose limonitised sand occur, with "cakes" and rodules of sand cemented by limonite. It is probable that, in these localities, the indurated dune sand or dune rock occurs at a shallow depth. In some deep, north-westerly trending valleys, such as the valley nearly ½ mile north-east from Blue Lake, the sides of the older dunes are exposed below the covering of the latest Pleistocene sands. Here, limonitic fragments, and fragments of siliceous concretions which appear to be associated with the kaolinic sand, are found on some of the valley slopes.

3. Deposits of Chocolate-Coloured or Black Organically-Bonded Sand.

(a) General. Deposits of organically-bonded sand outcrop at two distinct levels, viz., from 30 to 60 feet and from 90 to 110 feet above sea level, at various localities along or at a short distance inland from the western coast of the island, and from the scarp which marks the eastern edge of the Pleistocene dunes. The general appearance of the organically cemented sand in all of the outcrops is similar. The colour of the deposits varies from chocolate to black. The grains are mainly of quartz, of small size, sub-angular to well rounded in shape. The spaces between the grains are filled with moderately soft, black or brown, finely divided carbon and carbonaceous matter. This interstitial material, apparently of organic derivation, is the principal bonding medium, although in some instances a small amount of limonite is present.

The mass of organically-bonded sand is hardly coherent enough to be termed a "rock", but for convenience it will be referred to below as "organically-bonded sand-rock". The organically cemented sand in these deposits is similar to deposits accumulating in the present-day swamps on the island. The organically-bonded sand rock at the surface of the outcrop is frequnetly riddled with what appear to be worm holes, about 5 millimeters in diameter. These seem to be best developed in the most carbonaceous sand-rock. At the locality in Canaipa passage, hundreds of beetles (?) were seen in the holes.

The deposits outcropping along the scarp adjacent to the Eighteen Mile Swamp usually contain abundant, hollow shells of limonite ranging from less than a foot to two or three feet in diameter. The thickness of the limonite shell varies from a fraction of an inch up to about one inch and each shell is filled with organically-bonded sand. Isolated, rounded shells are observed, but usually, numbers of shells occur adjacent to one another. Commonly, adjacent shells share the one limonite wall, so that, in effect, the organically-bonded sand-rock is traversed by a "boxwork" of limonite. Where thebase of the organically-bonded sand is exposed, one or two approximately horizontal seams of limonite may occur in the consolidated dune sand or dune rock beneath.

It is not known whether the limonite shells are due to deposition near the surface of the outcrop, or whether they persist for some distance into the deposit of organically-bonded sand. The ferric oxide in the limonite shells was probably derived from ferruginous minerals, principally ilmenite, in the sands, taken into solution in the ferrous state in the reducing environment provided by the organic matter, and later oxidized and deposited.

The presence of the organically-bonded sand rock is readily observed where some erosion is proceeding, e.g., along the steep scarp adjacent to the Eighteen Mile Swamp, at localities along the west coast where tidal currents are eroding the coast, and in the gullies of some of the creeks, on both the western and eastern sides of the island. Where erosion is not proceeding, the surfaces of the outcrops become oxidised, completely lose their carbon, and become a mass of grey or evenwhite sand. Where the deposit is traversed by a boxwork of limonite shells, oxidation does not proceed uniformly. Portions of the deposit completely enclosed in a limonite shell and hence protected from oxidation may retain all or nearly all of the carbon; other adjacent portions may be completely oxidized, and greyish or creamy white in colour. A completely oxidized outcrop of organically bonded sand may be recognised by its structureless appearance, viz., the lack of any stratification, by its friability, and, in the case of the deposits along the Western scarp, by the frequent occurrence of limonite shells. Old dune rock outcropping along the Western scarp usually remains appreciably indurated, and usually shows some remnants of its original stratification. The dune rock may contain flattish veins of limonite, but not the limonite shells or "boxwork".

In addition to the deposits which occur at levels of 30 to 60 and of 90 to 110 feet, a deposit of organically-bonded loosely coherent sand-rock occurs along the eastern scarp at levels ranging from 150 to 250 feet.

(b) Deposits at 90 to 110 feet above sea level. Outcropping between levels of 90 feet and 110 feet above sea level along the eastern side of the older dunes are deposits of a loosely compacted, greyish-black, sandy rock. The outcrops were found over an area extending approximately for seven miles south of Blue Lake and for one mile north of the Lake (see Plate 3). Only occasionally is any indication of bedding seen. The bedding then appears to be horizontal, although in one instance, an apparent dip of 3 degrees in a south westerly direction was observed.

(c) Deposits 30' to 60' above sea level. An organically-cemented sand with its upper limit between 30 and 60 feet above sea level exists in several widely separated localities on the island. The best development is on the west coast, in Canaipa Passage, about thirteen and a half miles south of Dunwich. Other localities are :- on the western side of the island three miles south of Dunwich; in Flying Fox Gully which is about three miles north of Dunwich; and in Ferny Gully which is two miles east of Amity Point.

The locality in Canaipa Passage appears on the seafront as cliffs rising vertically for about twenty to thirty feet. Deep water runs right up to the base of these cliffs. The bottom three feet is a chocolate-coloured, fairly well cemented sandstone. Limonite is the principal cementing material in this lower three feet and possibly, since this portion of the cliff is below high water level, results from the action of sea water on the minerals, and organic material in the rock. The next six inches is much darker and is quite distinct in this regard from the rock above and below. Above the 6-inch dark band is about eight feet of yellowish-brown, current-bedded sand rock which has an apparently horizontal attitude. This is capped with greyish-black organically cemented sand which rises back from the cliff edge to about forty feet.

A specimen of the six inch darker band mentioned above yielded two per cent by weight of heavy mineral concentrate having the following percentage composition as determined by grain count analysis :-

Zircon	...	39.0%
Rutile	...	34.4%
Ilmenite	...	26.3%
Other Minerals..		0.3%

The heavy mineral grains are smaller than those occurring in any of the dunes which have been sampled. No euhedral crystals of zircon are present. Both the zircon and rutile are markedly iron-stained.

It can be seen that, at this locality, the organically-bonded sand-rock overlies a current bedded sand rock in which the cementing medium is mainly limonitic, with little organic matter. A concentration of heavy minerals occurs.

Three outcrops of organically-bonded sand-rock at an elevation of 30 to 60 feet were also noticed on the eastern side of the island, the first about a half mile north of Blue Lake, the second at about the latitude of Blue Lake, in the valley of the creek which flows from Blue Lake to the Eighteen Mile $S_w$amp, and the third about a mile south of Blue Lake. In each of these cases, the deposit occurs in a relatively low-lying area or valley between the higher north-westerly trending dunes. In no instance was a deposit of organically-bonded sand at an elevation 30 to 60 feet observed on the eastern scarp below a deposit at 90 to 110 feet. However, as noted in paragraph a. of this Section, the lower part of the scarp is covered by talus and hence even if a deposit at 30 to 60 feet does occur beneath the higher level deposits, it would probably not be seen. In Section IV. of this report, it is suggested that the 90 to 110 feet deposits are the older, and that the 30 to 60 feet deposits, though occurring in valleys adjacent to the high level deposits, do not continue below the older dunes (See Section IV. F.). It is thought that the 90 to 110 feet deposits do continue into or beneath the older dunes. (See Section IV. B.).

TABLE 4.

FIELD LOGS OF BORES WHICH MAY HAVE INTERSECTED THE HIGH LEVEL FOSSIL SWAMP DEPOSITS.

The localities of these bores are shown in Plates 3 and 4.

BORE	LOCALITY	DEPTH	LEVEL, REFERRED TO M.S.L.	HEAVY MIN. VOL. %	REMARKS
D.4	½ mile west of Eighteen Mile Swamp and ½ mile south of Blue Lake	0 - 10	200 - 190	1.5	
		10 - 20	190 - 180	1.0	
		20 - 30	180 - 170	0.6	Indurated sand.
		30 - 40	170 - 160	1.3	Water at depth of 85'.
		40 - 50	160 - 150	0.5	(level 115')
		50 - 60	150 - 140	0.1	
		60 -120	140 - 80	Trace	
C.2	¼ mile west of Eighteen Mile Swamp, and ¼ mile south of Blue Lake.	0 - 10	270 - 260	3.5	
		10 - 20	260 - 250	4.7	Yellow
		20 - 30	250 - 240	3.0	
		30 - 40	240 - 230	2.3	
		40 - 50	230 - 220	3.3	
		50 - 60	220 - 210	3.5	
		60 - 70	210 - 200	4.5	Brown
		70 - 80	200 - 190	2.8	
		80 - 90	190 - 180	4.1	
		90 -100	180 - 170	3.1	
		100 -110	170 - 160	1.1	
		110 -120	160 - 150	0.5	Light Yellow
		120 -130	150 - 140	0.7	Hard indurated
		130 -140	140 - 130	1.1	brown sand.
		140 -150	130 - 120	1.5	Brown and White
		150 -160	120 - 110	0.6	Hard bands.
		160 -170	110 - 100	0.6	Hard bands.
		170 -190	100 - 80	0.5	
		190 -210	80 - 60	0.6	Very hard.
		210 -220	60 - 50	0.5	
		220 -230	50 - 40	0.5	Sandstone.
E.3	½ mile west of Swamp; ¾ mile south of Blue Lake	0 - 40'	170 - 130	Trace	17' - 19' (levels 151-153') organically stained sand. 19'-47' (levels 120-150') bands of hard yellow sand, 59'-85' (levels 85-110'), dark sand, thin seams sandstone.
		40 - 50'	130 - 120	0.3	
		50 - 60'	120 - 110	0.2	
		60 -100'	110 - 70	Trace	
E.2	¼ mile west of Swamp; ¾ mile south of Blue Lake	0 - 10	100 - 90	1.3	20 - 25' (level 75-80'), very light, black, organically stained sand, too hard for hand boring. Below 25', (level 75'), sand changing to reddish colour with very hard seam sandstone. Very hard at 59' (level 40').
		10 - 20	90 - 80	1.2	
		20 - 30	80 - 70	0.4	
		30 - 40	70 - 60	0.3	
		40 - 60	60 - 40	0.2	

A careful study of the field logs of Zinc Corporation's bores may provide some evidence of the occurrence of these organically cemented sands beneath the dunes some distance west of Eighteen Mile Swamp. Thus the log of Bore C.2, given in Table 2 below, notes "hard bands" from 80 to 120 feet above sea level. The strata here were apparently distinguished by the bore-runner from those above and below, and could be the organically cemented sands of b. above. In Bore D.4, water was recorded at the unusually high level of 115 feet above sea-level. The water could be resting on a layer of sand rendered impervious by organic material. In Bore E.2 "very light, black, organically stained sand" occurs from approximately 75 feet to 80 feet above sea-level. In Bore E.3 from 85 to 110 feet, "dark sand, with thin seams of sandstone" is recorded. It is recognised that the evidence in each of these cases is little better than negative, i.e., the logs of some of the bores indicate the presence of a distinctive formation corresponding in level with the higher level organically bonded sand. The significance of the "organically stained sand" in Bore E.3 at levels of 151 to 153 feet, is considered in para. 4 below. The "indurated sand" appearing in Tables 1 and 2 at levels up to 170 feet is discussed in para. 5 below.

(d) Organically-bonded, loosely coherent sand-rock occurring between 150 to 250 feet above sea level. Dark grey sand loosely cemented with organic material is exposed on the eastern flanks of the old dunes bordering the Eighteen Mile Swamp. The outcrops occur chiefly within the 150-250 feet contour interval. The variation in levels at which this dark grey sand occurs, the smaller amount of organic material present in comparison with the deposits described in the preceding paragraphs (paras. a. to c.), and the gradual merging into the overlying and underlying dune sand suggests that the dark grey sand was not deposited in situ from swamps. It was thought that this organically-bonded sand may represent an old vegetated surface, viz., the old vegetated surface of Section IV= which, it is supposed existed at the time when the sea-level stood at 50 feet above its present level. However, the amount of carbon present in the sand seems to be much larger than the amount which could have been provided by humus in a sandy soil. An alternative explanation is that these are wind blown deposits derived from extensive swamps on the eastern side of the island. In Section IV, it is pointed out that swamps, similar to the present day Eighteen Mile Swamp, but more extensive, must have existed along the eastern side of the island during the recession of the sea from the 50-foot level. The organically stained sand intersected in Bore E.2 (Table 2) at levels of 151 to 153 feet may represent the organically-bonded sand of this section.

E. Economic Geology.

1. General. North Stradbroke Island has, since the year 1946, assumed considerable importance as a source of zircon, rutile, monazite and ilmenite. These minerals occur at or just below the surface of the ocean beach, beneath the Recent eastern dunes, and in the latest of the Pleistocene dune deposits discussed in Section II. D.2 above. The Recent eastern beach and dune area has been scout-bored by the Queensland Mines Department, and tested by closer boring by A.W. Beasley in association with Zinc Corporation Ltd. The latter Company has also completed preliminary boring and sampling of the Pleistocene dune areas.

2. The Ocean Beach. Concentration of heavy minerals occur in the upper portions of the beach from about 4 miles south of Point Lookout almost to the southern end of the beach. The main deposits are about twelve to thirteen miles south of Point Lookout. The average percentage composition of these concentrates determined by grain counting, is (Connah, 1948) :-

Zircon	Rutile	Ilmenite	Garnet	Monazite
30.6	36.9	31.2	1.0	0.2

The deposits are similar in form to those which occur on the mainland beaches, but are inferior in thickness, grade, and tonnage of concentrate.

3. The Recent Eastern Dunes. Deposits of heavy minerals occur beneath low northerly-trending dunes from about one mile to 3½ miles south of Point Lookout (Donaldson & Stuart, 1948). The deposits, narrow and lenticular and elongated parallel to the dunes, are similar in form to those which appear on the ocean beach. They represent beach deposits, buried by the dunes which formed during the latest recession of the sea. In its quantities of heavy mineral this dune area compares favourably with any similar area on the mainland. The percentage composition of the concentrates (Donaldson & Stuart, 1948) is :-

Zircon	Rutile	Ilmenite	Garnet	Other Minerals
26.2	25.7	46.0	0.3	1.8

4. The Pleistocene Dune Deposits. The occurrence of these deposits has been discussed in Section III D.2b.above. It can be seen that, although the percentage of heavy minerals in the dunes is low, the volume of the mineral-bearing sands is very large. The quantities of heavy mineral concentrate are many times in excess of the known reserves on the mainland. The percentage composition of the concentrates (Donaldson & Stuart, 1948) is Zircon 28.2, Rutile 26.8, ilmenite 24.9, garnet 0.2, and other minerals 1.9.

PART 2. IV. THE HISTORY OF THE DEVELOPMENT OF THE ISLAND.

A. The Data upon which the Interpretation of the History has been based.

1. Physiography. The general outlines of the history are based on the following observations and inferences :-

(a) The island consists mainly of exceptionally large sand dunes which could only have been formed during one or more major recessions of the coastline, when an adequate supply of sand would be available.

(b) The topography of the Central and North-Western Areas and the distribution of heavy minerals within the dunes (Section III D.2.) suggests that the dunes were built up in certainly two, probably three, distinct periods.

(c) The occurrence in several widely separated localities of fossil swamp deposits at elevations of 90 to 110 feet and 30 to 60 feet point to two periods of stationary sea level, at elevations respectively about 100 feet and 50 feet above the present sea level. The swamp deposits occur beneath the youngest of the Pleistocene dunes described in Section III. D.2a. of this report, and hence the deposits, and the supposed periods of high sea level, must at least be older than these dunes. The higher and the lower-level swamp deposits have not been observed together in the one locality, and hence the lower-level deposits are not necessarily the older ones. The relationships between the physiographic units of the island suggest that the higher-level deposits are the older. The lower-level deposits appear to be either marginal in occurrence or, as in the deposits near Blue Lake, to have formed in swampy tracts which developed in valleys between the high-dune ridges.

(d) The Eastern dune and swamp area may be assumed to have formed at the same time as the similar dune and swamp areas on the mainland coast, i.e. during and after the sub-Recent fall in sea level.

2. Stratigraphy. The periods of high sea-level and the recessions of the coast-line postulated above apply with remarkable aptness to geological history from mid-Pleistocene to Recent times. Brief references to probable correlations are made throughout the following discussion of the history of the island, and in Section IV. H. the suggested correlations are given in greater detail.

The eustatic changes in sea level during this period (Browne, 1945) are summarised in Table 5.

TABLE 5.

EUSTATIC CHANGES IN SEA LEVEL WHICH HAVE TAKEN PLACE SINCE THE MIDDLE OF THE PLEISTOCENE PERIOD.

TIME	MAXIMUM OR MINIMUM SEA-LEVEL, REFERRED TO PRESENT-DAY SEA LEVEL.
Mid-Pleistocene	Maximum, approximately 150 feet
Early part of Upper Pleistocene.	Minimum, possibly - 250 feet.
Middle of Upper Pleistocene	Maximum, approximately 50 feet
After mid-Upper Pleistocene	Minimum, approximately 250 feet
End of Pleistocene	Maximum, 15 to 20 feet
Mid-Recent	Attainment of present sea-level.

B. The Period when the Sea Level was 100 Feet above Present Sea Level.

1. Geography. (Fig. 1). Just prior to the period when the dunes commenced to build, North Stradbroke Island was probably represented by an island of solid rock between the Dunwich and Point Lookout areas, surrounded by a sea which stood at a level approximately 100 feet above the present sea level. The solid rock at the Point Lookout area appeared above the surface of the sea, while the Dunwich area was submerged. The two areas were separated by a depression in the surface of the bedrock, i.e., if the sea level had fallen about 40 feet, the Dunwich area would have emerged, but would still have been separated by a channel from the Point Lookout area. A sandbank extended for many miles southward from the Point Lookout area, and was at only a shallow depth below the surface of the sea for a distance of at least 13 miles from Point Lookout (i.e. to the southern boundary of the Central Area). A sandbank also extended southwards from the Dunwich area, but at a greater depth below the surface of the sea.

2. Stratigraphy. At the middle of the Pleistocene period (during the Mindel-Riss interglacial stage) the sea rose to approximately 150 feet above its present level. The 100-ft level suggested above is thought to have been a transient level of the sea during the recession from this mid-Pleistocene level of 150 feet. The sandbank south of the Point Lookout area began to emerge at this stage of the recession. Hence the sandy portion of North Stradbroke Island began to form when the sea had fallen to a level of approximately 100 feet during the upper-mid-Pleistocene recession.

3. The Origin of the Sandbanks. The sandbanks existed during the period of high sea level which accompanied the Mindel-Riss interglacial stage. Prior to this period of high sea level, during the Mindel glaciation, the sea level had fallen to possibly 250 feet below its present-day level. (See Table 6, Section IV.H.) It may be supposed that, during this major recession, great dunes were formed south of the Dunwich-Point Lookout Area. The sandbanks were the remnants of these dunes, eroded and submerged during the subsequent period of high sea level.

During the reconnaissance survey of the island, it was thought that some evidence of an old beach line, or an old elevated sea bed might be found along the scarp at the western edge of the Eighteen Mile Swamp. Layers of semi-consolidated fine sand, 2 to about 12" thick, occur along the scarp a short distance north and south of the creek which runs from Blue Lake to the Swamp. These layers appear horizontal in the face of the scarp, but no reliable exposure in an east-west direction was observed. One such exposure along the scarp about half a mile south of the creek appeared to have a very slight dip (a degree or two) in a westerly direction. It was concluded that this bedded sand could just as well have been deposited by wind as by water. Fairly hard thinly banded sandstone floaters, of which the grains were larger than dune grains, were found along the scarp a little north of the creek from Blue Lake. These floaters, and "sandstone" on which several of the Zinc Corporation bores bottomed, from $\frac{1}{4}$ to $\frac{3}{4}$ mile west of the Eighteen Mile Swamp and up to $\frac{3}{4}$ mile south of Blue Lake could possibly represent the old sandbank (see Section III. C.2 above).

4. Heavy Mineral Concentrations. In part D. of this Section, it is suggested that, when the sea advances against a coast built up from sand dunes, heavy minerals are concentrated along the beach, and during the advance, concentrations of heavy minerals may be left on the sea-bed. Such concentrations are likely to be formed, or rather, retained, when a headland such as Point Lookout occurs along the coast. Hence, during the period when that portion of Stradbroke Island south of the Point Lookout area existed as a sandbank below sea level, some heavy-mineral concentrates may have existed on or a little below the sea-bed east of the sandbank.

C. The Recession of the sea from the 100-Foot Level.

1. High Level Swamp Deposits (Figs. 2 and 3). After the sea began to recede from the 100 ft. level, the highest portion of the sandbank south of the Point Lookout area became exposed. As the sea-level continued to fall, the sandbank continued to emerge in a southerly direction, and to increase in width. Northerly-trending dune ridges built up along the eastern shore line. Extensive swamps developed inland from the dunes, just as the Eighteen Mile Swamp developed after the relatively small mid-Recent fall in sea level. Sand which was constantly blowing over the dunes into the swamps accumulated in poorly-bedded, fine-grained deposits, discoloured and cemented by humic substances in solution or in suspension in the swamp water. These organic materials sealed the pore-spaces in the sand underlying and surrounding the swamps. As a result, the swamps were maintained above sea level for considerable periods, and thicknesses of up to 30 feet of fine sand and organic material accumulated within them. Temporary cessation or minor reversals of the downward movement of the sea level may have assisted in the building up of the swampy deposits.

At an early stage of the recession of the sea from the 100-ft. level, the eastern portion of the sandbank, in the locality of the eastern margin of the present-day Central Area, was exposed at 90 to 100 feet above sea level for a distance of at least 15 miles from Point Lookout. The organically-bonded sand of III.D.3b. which occurs along this margin at an elevation of 90 to 110 feet above sea level is thought to represent the swamp deposits described in the preceding paragraph.

2. Dunes.

(a) The Building of Dunes along the Eastern Coast. It was stated in the preceding paragraph that, as the sea level continued to fall, a series of dune ridges built up along and behind the eastern shore line. These ridges formed in the same way as the parallel, low dune ridges which occur adjacent to the mainland coast-line at the present-day, such as those at Broadbeach, Cudgen Beach, and Seven Mile Beach.

The latter apparently represent the recession of the coastline subsequent to the latest (Mid-Recent) fall in sea level. On North Stradbroke Island low dunes parallel to the present coastline occur in the Eastern Area, most noticeably near its northern end, and are mentioned in Sections II D. of this report.

It may be expected that the very much greater fall in the level of the sea from its maximum Pleistocene level resulted in the formation of larger coastal dunes than those found along the present-day coast. The dunes formed during the early stages of the recession of the sea from the 100-ft. level contributed only a comparatively small porportion of the sand which was eventually deposited on the island, because the only supply of sand available for building them was that provided by the emergence of the sandbank. Along the mainland coast receded as far easterly as Stradbroke Island the processof dune building on the old exposed sandbanks proceeded on a greatly enhanced scale. Long lines of high parallel dunes developed along and behind the eastern shore line, and the swamp deposits were completely buried. It is stated in Section III.D.3 that organically bonded sands at 90 to 110 ft. above sea level occur up to 7 or 8 miles south from Point Lookout, viz. to the southern extremity of the Central Area. The series of dunes parallel to the eastern coastline must have extended some miles further south from this point, and must also have been associated with swamp deposits formed during the recession of the sea from the 100-ft. level. Such early dunes and swamp deposits which formed south of the present-day Central Area, i.e., along the northern and eastern parts of the Southern Area, are not seen now, because, as stated in Section D. below, that part of the island south of the Central Area was eroded and submerged during a subsequent rise in the level of the sea.

In the early stages of dune building along the emerged sandbank south of Point Lookout, the sand transported northerly by surf action banked up just south of the rocky portion of the island, where it was blown by the wind into sandhills or sand-masses larger than the northerly trending dunes. Additional supplies of sand reaching the northern end of the beach piled up against the sandhills already there. As this process continued, the sand-mass tended to grow in a southerly direction, and easterly, and its crest tended to shift towards the south. By the end of the period of dune building, the greatest quantities of sand had been deposited probably more than 3 miles south, and to the east, of Point Lookout. The eastern margin of the dunes along the coast was parallel to the present eastern beach.

(b) North-Westerly Migration of Dunes. It is probable that, during the entire period of dune formation, considerable volumes of sand migrated across the island in the direction of the prevailing wind as north-westerly trending dunes. The comparatively low north-westerly trending dunes of the North-Western area may have developed during the early stages of the recession of the sea from the 100-ft. level. This process of dune building must, however, have been retarded by the active development of shielding coastal dunes, and by the eastward recession of the coastline. When the shore-line had receded some distance east of Point Lookout (it can be expected that, during the recession, the headland extended further eastwards), much of the sand which was migrating northerly along the beaches moved beyond the island. The quantities of sand then blowing up from the beach were smaller than the quantities which were removed from the coastal dunes by wind action. As a result, blow-outs and northwesterly trending dunes advanced rapidly through and across the older dune masses, and the eastern dune front, receded inland. A large portion of the great volume of sand behind the original dune front advanced as exceptionally high dunes across the dunes which had preceded them, i.e., the dunes which had been forming prior to the time when the main coastline receded east of Stradbroke Island.

The final position of the high-dune front formed by the north-westerly migration of sand appears on military maps along a line which runs in a north-easterly direction from the southern end of Kounpee Swamp past the northern end of Blue Lake. The high dunes extend from this front in a north-westerly direction to the "irregular or serrated line" of Section II.B. which forms the boundary between the Central and the North-Western Areas. The extremities of the earlier, lower dunes, the dunes of the North-Western Area, extend one to three miles further in a north-westerly direction.

(c) The High-Dune Portion and the Southerly Triangular Portion of the Central Area. When the high-dune front had receded inland, the Central Area consisted of two portions, viz., the northerly high-dune portion described in the preceding paragraph, and a southerly triangular portion. The huge volume of sand which raised the average level of the High-Dune Portion to more than 200 ft. above the average levels of the surrounding areas, was derived almost entirely from the Southerly Triangular Portion. The latter then existed as a series of parallel north-westerly trending ridges and valleys. Towards their north-eastern extremities, viz. towards the foot of the High-Dune Area, these ridges of the Southerly Triangular Portion may have had an elevation of about 300 ft. Towards the south-east their general elevation decreased. The eastern boundary of the Southerly Triangular Portion was probably marked by wind-eroded remnants of these dune ridges occurring along a line a little east of Point Lookout.

Along the line of the present-day eastern boundary of the dunes (adjacent to the western edge of the Eighteen Mile Swamp), the sand ridges of the southern portion of the Central Area probably had an average elevation (referred to present sea-level) of less than 200 feet, and the bottom of the valleys were probably below present sea level. Such a deep valley seems to have existed at the latitude of the present-day Blue Lake; and it was bounded on the north and on the south by long north-westerly trending valleys which passed respectively a little to the north and a little to the south of Blue Lake. The swamp deposits which had accumulated at 90 to 110 feet were still preserved below the surfaces of the sand ridges, but had been removed from the localities of the valleys.

3. The Dunwich Area.

As noted in paragraph 1. above, the Dunwich area and the sandbank trending southwards from it must have remained below sea level for some time after the sandbank south of the Point Lookout Area had emerged. When the sandbank south of Dunwich did emerge, dune building associated with the development of fringing swamps probably did ensue, but on a much smaller scale than the dune building further east. Probably the shallow bay separating the Dunwich sandbank from the Point Lookout sandbank was rapidly silted near its northern end, giving rise to a swampy area which rapidly extended southwards. The position of such a swampy area would be approximately the position of the present-day Western Chain of Lagoons and Swamps. (However, it is not considered that the present Western Chain of Lagoons and Swamps represents a swampy area which formed at the period of the recession of the sea from the 100 ft. level. See Section IV. F. 1.a.). Some of the north-westerly migrating dunes from the eastern part of the island probably transgressed the narrow bay at intervals, cutting off portions of it. Wind-blown sand accumulated in the swampy areas, forming poorly bedded deposits rich in organic matter. Where bars were formed across the bay, by silting or by the transgression of north-westerly migrating dunes, it is probable that somewhat low and irregularly distributed dune masses were formed.

4. Heavy Mineral Concentrations. In Section III D.2.b. it is noted that the heavy mineral content of the older dunes, i.e., the dunes of the Central and North-Western Areas, is low but yet is high enough to indicate that some concentration had taken place. Possibly the heavy mineral in the dunes may, as suggested in B.3 above, have existed prior to the recession as concentrates on or just below the sea bed.

D. The Advance of the Sea to 50 Feet Above Present Sea Level.

The fall in the level of the sea from the maximum level attained in mid-Pleistocene time continued to approximately 250 feet below present sea level. It is clear that the mainland coast must then have receded beyond the present eastern limit of Stradbroke Island.

1. The Eastern Shore-Line. When the sea began to rise, after the major recession from the 100-foot level, the coast advanced westwards probably against a straight line of sandy cliffs fringed by narrow beaches. Little sand was available for dune building. The northerly drift of sand along the coast (which, though east of Stradbroke Island, was actually the mainland coast) continued, though in smaller quantities than during the recession. The advancing strand line encountered the north-eastern end of the high-dune portion of the Central Area (Section IV. C.3.c.) at some distance east of Point Lookout. The high dunes were rapidly broken down, the sand moving up by current and surf action past the north-eastern end of the island. Some delay in the removal of the sand from these high dunes may have resulted in a slight easterly flexure of the coast-line at the point where it met the high-dune front. It may be expected that rapid erosion ceased when the coastline had advanced to the edge of the Point Lookout Area. The north-easterly trending high-dune front then reached the coast at a point about 3 miles south of Point Lookout. During the remainder of the period of rising sea level, the high-dune front formed the northern part of the coastline, resulting in a sharp curvature of the beach at about 3 or 4 miles south of the Point Lookout Area. The portion of the island which remained above sea level south of the high-dune front was the Triangular Portion of the Central Area, which, as noted in IV.C.3.C, was traversed by deep, wind-eroded, north-easterly trending valleys. During the advance of the sea to the 50-ft. level, these valleys must have been occupied by inlets of the sea. Bars or sand-spits and low dunes probably formed across their mouths when the sea level had become stationary.

2. Concentration of Heavy Minerals. As cliff faces collapsed, exposing masses of sand to surf action, deposits of heavy minerals formed along the ocean beach. This process may be observed on South Stradbroke Island at present. The southern and eastern coasts of the island are bounded by sandy cliffs, which are being eroded by the sea. Considerable concentrations of heavy minerals appear along the upper portions of the beaches during stormy weather, when the erosion is at a maximum. The deposits of heavy minerals which were concentrated along the shores of North Stradbroke Island during the advance of the coast-line were dissipated in the following ways :-

a. Portions moved northwards beyond the island in the constant migration of sand along the coast.

b. Some of the heavy mineral sand was probably blown up from the beach into the minor dunes which must have occurred just behind the shore-line. Such dunes would occur in the wind-eroded valleys of the Southerly Triangular Portion of the Central Area (described in Section IV.C.3.c.) and may have been associated with sandspits or bars formed across the mouths of the valleys (or, as they had now become, inlets of the sea).

c. Portions were moved westward by the advancing sea.

d. Portions were covered by the advancing sea.

It was pointed out in the preceding paragraph that a sharp north-easterly flexure developed at about 3 miles south of Point Lookout when the westerly advancing strand line passed west of the meridian of Point Lookout. Large deposits of heavy minerals were retained within this flexure and for many miles southward along the beach.

3. Marine Transgression of the Southern and Western Areas.

(a) The Western Area. During the rise of the sea to 50 feet above its present level, the portions of the island south of the present-day Central Area (i.e. south of the scarp (Section II.B)) which runs from a mile or two north of Lake Kounpee to a point approximately 5½ miles south of Blue Lake) were eroded and covered by the sea. The scarp which bounds the Central Area on the south-east was formed by marine erosion during this period. The low-lying tract between the Western and the Eastern areas became a comparatively deep inlet and probably assisted in the erosion of the Western Area. It is probable that during the period of maximum sea level (50 feet above the present level) a channel was cut through the northern extremity of the submerged western dunes. The submerged western area probably existed as a sandbank approximately 20 feet below the high sea-level (30 feet above present sea-level) at about the latitude of Lake Kounpee and 35 to 40 feet below the high sea level (10 to 15 feet above present sea level) near Canaipa.

The Western Area was eroded largely by tidal currents sweeping northerly past its southern corner. The re-sorted dune sand was laid down as current-bedded deposits typical of shallow-water deposition. Local concentrations of heavy minerals appeared. As the erosion of the western edge of the western dune area or old sandbank area proceeded northwards and eastwards, the swampy deposits of the adjacent low-lying area to the east (Section C.3 above) were exposed, eroded and re-deposited, in many places on top of the re-sorted dune or sandbank sand. As dune and swamp deposits were being eroded simultaneously, it is probable that much of the sediment being deposited was composed partly of dune sand and partly of sand mixed with black finely divided carbonaceous material.

The six-inch dark band near Canaipa containing two per cent. by weight of heavy minerals (Section III.D.3c, Page 13) is probably a local concentration formed during the re-sorting of dune sands. The organically cemented, fine-grained, current-bedded sandstone overlying the 6-inch band was derived from swamp deposits of the adjacent low-lying area probably with the addition of sand from eroded dunes.

(b) The Southern Area. A wave-cut, submerged platform occurred between the sandy scarp or cliff-line which marked the south-eastern boundary of the Central Area, and the edge of the channel which occurred a little further west. The platform continued southwards just below sea-level from the southern tip of the Central Area to a short distance south of Ibis Lagoon, a distance of about 2 miles. Southwards from this point, its surface sloped downwards to greater depths.

4. Stratigraphy.

The 50-ft. sea level discussed in the preceding paragraphs is thought to have been the sea level which prevailed during mid-upper-Pleistocene time. (See Table 5 above and Section IV.H.).

E. Summary of the Development of the Island up to this Period (i.e., Sea-Level 50 feet above Present Sea-Level).

The events described above accompanied a fall in the sea-level from 100 feet above present sea-level to a considerable depth below present sea-level, and a subsequent rise to about 50 feet above the present level of the sea. The mainland coast-line receded from some distance west of the present mainland coast to some distance east of Stradbroke Island, and subsequently advanced again to a position west of the present mainland coast-line.

1. The Western and Southern Areas. During this second period of high sea level (50 feet above present sea level) all of the island south of the Central Area was completely submerged. The Western Area was represented by a sandbank, the upper portions of which were built up largely of current-bedded, fine-grained sand, derived partly from the re-sorted swamp deposits of the Western Trough. The portions derived from the re-sorted dunes contained low-grade local concentrations of heavy minerals while the portions derived from the re-sorted swamp deposits were brownish, dark-grey or chocolate-coloured because of admixed organic matter.

The Southern Area, completely submerged, existed as a wave-cut platform fringing the scarp or cliff-line which marked the south-western edge of the Central Area, and extending in a southerly direction for 2 miles from the southern end of the Central Area. Beyond this point, the platform merged into a sandbank which continued for some miles at an increasing depth below sea level.

2. The Central Dune Area was the only part of the island south of Dunwich and Point Lookout which remained above sea level. It consisted of a northern High-Dune Portion and a Southerly Triangular Portion. The Northern Portion of the Central Area is clearly marked out at the present day, and contains the highest dunes on the island. The north-westerly trending ridges of the Southerly Triangular Portion of the Central Area, though of much lower elevation, stood at a considerable height above the sea from about a mile and a half north of the present-day Blue Lake (the northern apex of the triangle) to a point about 5½ miles south of Blue Lake (i.e., to the most southerly point of the trianble). Between these northerly trending ridges were bays or inlets which had formed by wind erosion during the preceding major recession of the sea. The entrances to these bays may have been barred by sandspits, surmounted by minor dunes. The high-level swamp deposits which had formed during the early stages of the recession of the sea from the 100-ft. level had been removed from the localities of the bays or inlets. These deposits still occurred in the north-westerly trending ridges, beneath a sandy cover of varying thickness, and outcropped from the cliffs facing the ocean.

Deposits of heavy minerals occurred along the beach from the flexure at the foot of the high-dune portion of the Central Area, about 3 miles south of Point Lookout, to the southern end of the east coast, about 5½ miles south of Blue Lake. The actual surface of the Southern Triangular Portion as it appeared at the time of the 50-ft. high sea-level (at least up to a mile and a half eastward from the present-day Eighteen Mile Swamp) is not seen today because (Section F.1.C(ii) below) it has been covered by the latest of the Pleistocene dunes. The position of the surface is indicated in bores by the sudden decrease in the heavy mineral content of the sands when the bores pass through the base of the latest Pleistocene dunes. The occurrence of fossil wood near the base of the latest Pleistocene dunes (Table 3, bore C.3) indicates that, during the period of the 50-ft. sea-level, the eastern margin of the island was vegetated and stable. The kaolinic material which is found inter-bedded with dune sand could possibly have been deposited by the wind during the period of low sea-level, when portions of the sea-bed to the east were stripped of their covering of sand, and underlying kaolinized bedrock, possibly rhyolite, exposed to the wind. (It was noted in Section III.C.3 and Table 2 above that bores in the Recent dune and swamp area east of the Eighteen Mile swamp bottomed in clay from 1 mile to more than 3 miles south of Point Lookout, and at one locality east of Blue Lake).

F. The Development of the Island from the Period of the 50-Ft. Sea-Level to the Period of the Early-Recent High Sea-Level.

The formation of the deposits of organically cemented sandstone at 40 to 60 ft. above present sea level and the final stages in the development of the Pleistocene dune areas took place during a second cycle of retreat and advance of the shore line. The third or final period of high sea level, attained at the end of this second cycle, was the sea level which prevailed prior to the late-Recent fall of 10 to 15 feet.

1. The Recession of the Sea from the 50 Ft. Level. (Figs. 4 & 5)

The sequence of dune-building and development of associated swamps which took place during the previous recession of the sea from the 100-ft. level was repeated during the recession from the 50-ft. level, with some differences in the distribution of the dunes. The principal deposits of heavy mineral bearing sands were emplaced. On the eastern side of the island, successive lines of dune ridges were formed, parallel to the coast, and these were separated by swampy tracts. At a fairly advanced stage of the recession, the northerly-trending dunes were broken up by wind erosion, and their sand was formed into north-westerly migrating dunes. Similar dune and swamp development ensued along the exposed sandbank on the western side of the island, but on a much smaller scale. The greatest quantities of sand were here built into dune masses, rather than into a dune system, towards the northern end of the emerging channel (the channel which separated the western sandbank from the eastern portion of the island. This channel was rapidly silted. At intervals its northern part was cut off by sand bars, and by north-westerly trending dunes which had migrated from the eastern side of the island. The swampy areas thus formed are represented at the present-day by the Western Chain of Lagoons and Swamps.

(a) The Western Area. Considerable quantities of sand were made available on either side of the channel because of the emergence of the western sand-bank and the submerged platform of the Southern Areas. It is suggested in Section IV.D.3 above that, during the period of the 50-ft. sea-level, the channel cut through the northern part of the submerged western sandbank. If so, the northern part of the channel must have been quickly sedimented, since the newly exposed sand-tracts on the western and the eastern sides of it converged towards a locality about a mile north of Lake Kounpee.

It is probable that the channel was wide enough to permit a surf action along the east coast of the emerged western sandbank, and hence the movement of sand towards the north. The south-east winds must have swept up through the "funnel" provided by the narrowing channel, and shifted large quantities of sand along each side of the channel towards its northern end. As a result of these agencies - surf, wind, and the convergence of eastern and western shorelines of the channel - sand was transported rapidly enough to build up dune masses at the northern or north-western end of the channel. At the same time, lesser dunes associated with swamps developed along the emerged sandbank parallel to the eastern coast. Such swampy deposits occur about 3 miles south of Dunwich at an elevation of 30 to 60 feet, (III.D.3c), and near Canaipa, at an elevation of 15 to 40 feet (III.D.3c. and IV. D.3a).

The dune masses of the Western Area developed steadily, attaining a height of 200 to 250 feet, to about the latitude of the southern end of Kounpee Swamp. Apparently at this point, sedimentation from the Western and the Southern areas formed an easterly trending bar across the Western Trough, resulting in the banking up of sand south of the bar to a height of 400 feet. The building of the Western Areacontinued steadily as before to about Ibis Lagoon. Sedimentation and the formation of bars across the trough may have taken place south of Blakesly Lagoon and of Black Snake Lagoon.

It is probable that, south of Ibis Lagoon, the dune pattern is the combined result of building of western dune masses as described above, and the movement of north-westerly trending dunes from the eastern side of the island. These north-westerly trending dunes were formed and began to move across the island at a fairly advanced stage of the recession, as had previously occurred during the recession of the sea from the 100 ft. level (IV.C.2b). The Western Dunes north of Ibis Lagoon must have formed before the north-westerly migrating dunes in that area had reached the western channel. In the following paragraph, it is pointed out that these youngest Pleistocene dunes transgressed the island during an advanced stage of the recession of the sea from the 50-ft. level. It follows then that the Western Dunes north of this Lagoon were emplaced during an earlier stage of this recession.

(b) The Southern Area. In the initial stages of the recession, sand tended to build up on the emerged platform near the southern edge of the Central Area, forming the "somewhat elevated sandy region" of Section III.D.2a. At the same time, coastal swamps and foreshore dunes developed. As the sea level continued to fall, the process of swamp and dune formation continued along the eastern coast contemporaneously with sedimentation of the eastern part of the Western Trough, to about the latitude of the Canaipa Jetty. When the mainland coast had receded as far easterly as Stradbroke Island, the process of dune building was accelerated (See C.2 this section) The high-dune area south of Native Companion Lagoon may have commenced to form at this stage. The low-lying tract from Native Companion Lagoon to Horseshoe Swamp may represent a low-lying southern portion of the island which existed just prior to the recession of the mainland coast to Stradbroke Island.

The most prominent feature in the topography of the Southern Area is the series of north-westerly trending dunes discussed in Section III.D.2. The history of these dunes is in general a recapitulation of the history of the north-westerly trending dunes which developed in the Central Area during the recession from the 100-ft. sea level. Their major development commenced when the coastline had receded east of Point Lookout.

(c) The Central Area.

During the recession of the sea from the 50-ft. level, the main events along the eastern margin of the Central Area were the building of northerly trending dunes together with the development of coastal swamps, and the subsequent development of north-westerly migrating dunes containing appreciable concentrations of heavy minerals and large quantities of organic matter derived from the old coastal swamps.

(i) Coastal Swamps. As in the case of the recession from the 100-ft. level, extensive coastal swamps developed largely as a result of the building of coastal dunes. These, like the present-day Eighteen Mile Swamp, appeared along the eastern margin of the Central Area, and in addition they occupied the deep inlets or bays which occurred between the north-westerly trending dune ridges (Section IV.D.1 above). As had happened previously during the recession of the sea from the 100-ft. level, the coastal swamps, after receiving thicknesses of up to 30 ft. of wind-blown sand, were buried as the process of dune-building advanced. At the present day, remnants of the swamp deposits which filled the bays or inlets occur as the 30 to 60 ft. level organically-bonded sands. The extensive swamp deposits which formed along the eastern margin of the area were destroyed and removed, mainly by wind erosion during the advanced stages of the recession from the 50-ft. level. Remnants of the black carbonaceous sand from these swamps are found in the dunes near the eastern margin of the Central Area at elevations of 150 to 250 ft. (Section III.D.3 and next paragraph).

(ii) Dunes. The topography of the east coast and the submerged banks further south at the period when the sea began to retreat from the 50-ft. level differed greatly from the topography of the submerged sandbanks which existed prior to the recession from the 100-ft. sea-level. The distribution of the sand made available during the later recession was correspondingly different. In the period of recession from the 100-ft. level, coastal dunes developed along the entire length of the exposed sandbank, but the greatest quantities of sand were deposited at a locality south of the Point Lookout area. The locality moved during the progress of the recession from immediately south of the Point Lookout rhyolites to some miles further south and eastwards (Section IV.C.3.a). During the early stages of the recession from the 50-ft. level, coastal dunes were formed along the shore-line east of the Central Area, as mentioned in the preceding paragraph, but the northward movement of masses of sand from further south tended to be arrested, firstly at the southern end of the Central Area, and later at the edge of the platform about two miles further south. As a result, dune building east of the Central Area, though considerable, was not on as large a scale as during the recession of the sea from the 100-ft. level.

When the coastline had receded beyond Point Lookout, heavy deposition of sand onto the island ceased, and the sand which had already been deposited migrated in a north-westerly direction, climbing up over the older dunes and partly filling in the old valleys for a distance of one to one and a half miles west of the present-day Eighteen Mile Swamp. These, the latest of the Pleistocene dunes, can be plainly distinguished in aerial photographs, (Section III.D.2), from immediately south of the Point Lookout area to the southern tip of the Central Area. In fact, these dunes continue to the southern end of the island, and have been discussed in parts a. and b. of this Section (the Western and the Southern Areas). The formation of Blue Lake appears to be a direct result of the emplacement of these latest dunes, i.e., the drainage from the area west of the lake was dammed by the dunes. Seepage of ground water downwards through the bed of the lake is prevented because of the fact that the lake occupies the locality of one of the inlets or bays referred to in paragraph (i) above, which had been converted into a swamp during the recession of the sea from the 50-ft. level. Hence the sand underlying the lake has been impregnated with carbonaceous material and made impervious. This organically-bonded sand outcrops in the gully of the creek flowing from Blue Lake (Section III.D.3.c) and is exposed, in an oxidised condition, in a hole sunk by Zinc Corporation in the valley approximately $\frac{1}{4}$ mile east of the south-eastern tip of the lake.

Air photos give a faint suggestion that the latest of the Pleistocene dunes built up in two stages. The dunes of the first stage, if they do exist, extend a little further in a north-westerly direction than the well-marked dunes of the second stage. If this is correct, the sequence of dune building during the recession from the 50-ft. level closely parallels the sequence of building during the recession from the 100-ft. level. During that period, as pointed out in Section III.D.2., an early stage of building produced dunes, the extremities of which are seen in the North-Western Area, and a later stage of building produced the high dunes of the Central Area.

It will be noticed that the distribution of heavy minerals in the dunes, as quoted in Tables 1, 3 and 4 of this report, suggests that the latest dunes may have been built up in two periods.

It was noted in Section III.D.3.d. that sand containing much black carbon occurs on the dunes adjacent to the Eighteen Mile Swamp at elevations of 150 to 250 feet. In that Section, and also in the paragraph preceding this one (paragraph (i)) it is suggested that this carbonaceous sand is simply dune sand formed from the coastal swamps during a late stage of the recession of the sea from the 50-ft. level.

(iii) Concentrations of Heavy Minerals. It was pointed out earlier in this report (D.2 and E.2 of this Section) that during the period of the 50-ft. sea-level deposits of heavy minerals occurred along the beach from about 3 miles south of Point Lookout to the southern end of the Central Area, and also on or just below the sea-bed further east.

The heavy minerals contained in these deposits were carried along by the wind with the common sand, and contributed to the building of the latest Pleistocene dunes. (It is noted in Section III.D.2.b. that these dunes, from 3 miles south of Point Lookout to the southern end of the Central Area, contain an average of more than two per cent. by volume of heavy minerals).

It has been noted in the preceding paragraph (paragraph (ii)) that the distribution of heavy minerals within the latest dunes may point to two stages in the building of these dunes.

2. The Final Advance of the Shore Line.

During the second (and final) advance of the shore-line, active dune building ceased, as it had previously during the first advance of the shore-line. As before, the coastline consisted of sandcliffs, fringed by a long, narrow beach on which concentrations of heavy minerals developed.

During the previous advance of the shore line to 50-ft. above present sea level, the heavy mineral concentrates were retained on the beach, south of the high-dune front which extended in a north-easterly direction, passing through a point about a mile north of Blue Lake, and reaching the meridian of Point Lookout at about three miles south of Point Lookout. Marine erosion during the advance to the 50-ft. level, and marine and wind erosion during the subsequent retreat of the sea, caused the northern portion of the high dune front to recede westerly. Hence, during the final advance of the sea, the beach, carrying concentrations of heavy minerals, continued northward almost to the solid rock south of Point Lookout.

The upper limit of the sea-level at the end of this final advance, at the end of Pleistocene or the beginning of Recent times, was 10 to 15 feet above present sea-level.

G. The Development of the Island since the Final (Mid-Recent) Fall in Sea-Level.

The most prominent features resulting from the mid-Recent fall in the sea-level are the swamps which have developed around the coastline, and the eastern active dune area.

At the present time, a pronounced off-shore bar runs for a considerable distance parallel to the ocean beach. It is probable that the present beach and recent dunes makr the position of an off-shore bar prior to the med-Recent fall of ten to fifteen feet in the level of the sea. Quantities of sand made available as a result of the emergence, were moved up by the action of the surf on to the exposed bar and northwards along the bar. The sand was built up by wind action into a line of dunes parallel to the coast. The fall in sea-level was insufficient to cause the mainland coast to recede as far easterly as Stradbroke Island, hence the only important supply of sand available for building the recent dunes has been the mass of sand raised above sea-level. Most of this has already been shifted beyond the reach of the surf, with the result that, at present, fresh dunes are not forming rapidly enough to protect the earlier dunes from wind erosion. "Blowouts" and north-westerly trending dunes are developing rapidly.

Deposits of Heavy Minerals. The deposits of heavy minerals which had formed south of the solid rock of the Point Lookout area, together with quantities of dune sand, remained in situ and were covered in part by the Recent swamp, and in part by the Recent dunes (Section III.E.3). The deposits on the Ocean Beach have been derived in part, probably, from concentrations which existed on or a little below the seabed (l.c.(iii)) this Section), and in part by the concentrating action of the surf on common beach sand containing very small quantities of heavy minerals. (See Fisher, 1948).

H. A Possible Correlation between the Stages in the Development of Stradbroke Island and the Pleistocene Fluctuations in Sea Level.

It has been suggested in preceding sections of this report that the cycles of falling and rising sea level which have been completed since the middle of the Pleistocene period provided the conditions under which the sandy portions of Stradbroke Island developed. Table 6 below summarises sections of the Australian Pleistocene chronology (Browne, 1945) and shows possible correlation with Nth. Stradbroke Is.

TABLE 6. NORTH STRADBROKE ISLAND. SUGGESTED PLEISTOCENE CORRELATION.

Period	Epoch	European Sub-division	Australia		North Stradbroke Island	
			Eustatic Movements	General		
RECENT	Later Recent (c.4000 yr.)			Younger living dunes	Active dunes of Eastern Area.	
	Mid-Recent Interval		Emergence of 15-20'	Raised beaches, &c.	North-trending dunes, swamps and heavy mineral deposits of Eastern Area.	
	Earlier Recent (c.5000 yr.)			Deposits in coastal swamps, e.g. Mowbray Swamp Tas. Some older dunes & dune ridges, mostly cemented & vegetated		
PLEISTOCENE	Late Pleistocene (about 230,000 years)	Wurm Recession	Final sub mergence of about 270'	Getting warm. Glaciers melt in Tasmania & Kosciusko	Concentration of heavy minerals south of Point Lookout rhyolites	
		Wurm Glacial	Fi Emergence	Yolande-Margaret Glaciations(Tas) 2nd Kosciusko (N.S.W.)	Formation of latest Pleistocene dunes, containing in places, heavy mineral deposits. Formation of Western Area dunes. Fossil swamp deposits at 40-60'	
		Riss-Wurm Interglacial	Submergence 45' terrace formed	Some older dunes & dune ridges largely cemented & vegetated.	Sea transgresses Southern & Western Areas.	Deposition of heavy mineral on beach & sea-bed from 3 to 13 miles south of Pt. Lookout.
		Riss Glacial	Emergence possibly 250' below present sea level	Malanna (Tas.) & 1st Kosciusko glaciation.	High dune & southerly triangular portion of Central Area, North Western Area Dunes.	Dunes have a low but appreciable heavy mineral content.
					Fossil swamp deposits at 90 - 110'.	
	Middle Pleistocene (about 185,000 years)	Mindel-Riss Interglacial	Deep submergence producing 100' terrace in Tas., W.A. & N.S.W.		The rocky areas appear above sea level. Submerged sandbanks extend southwards. Concentrations of heavy minerals on sea bed south of rocky islands	
	Early Pleistocene (about 175,000 years)	Mindel Glacial	Emergence to possibly 250' below present sea-level		During the two periods of emergence, sand was deposited south of the rocky portions of the island.	
		Gunz-Mindel Interglacial	Submergence			
		Gunz-Glacial	Emergence			
	Pre-Glacial				?	

The first period of high sea level, suggested in this report, to have been approximately 100 ft. above the present sea-level, was the level at which the submerged sandbanks first emerged. The organically-cemented sandstone occurring on Stradbroke Island at an elevation of 90 to 110 ft. may have formed shortly after the commencement of the Riss glaciation. The fall in sea-level, which accompanied this glaciation, may have witnessed the main period of deposition of sand on the island, the development of the older dunes of the Central and North-Western areas, and the bodily migration of sand to form the high-dune portion of the Central Area.

The sea-level during the succeeding (Riss-Wurm) interglacial period was approximately 50 ft. above the present sea-level. Old shore-lines at an elevation of 40 to 50 feet on the north coast of Tasmania (Lewis, 1935) have been correlated (Edwards, 1940) with this interglacial stage. It seems reasonable to correlate also with this interglacial period of high sea-level the transgression of the Southern and Western areas of Stradbroke Island. The formation of the deposits of organically-cemented sandstone at elevations of 30 to 60 feet, the emplacement of the latest of the Pleistocene dunes, and the building up of the high dunes of the southern area, must have taken place during the fall in sea-level which accompanied the final (Wurm) glaciation. The final rise in sea-level to 10 or 15 feet above present sea-level was completed at about the end of the Pleistocene Period, and the subsequent fall to the present sea-level occurred in mid-Recent times.

The Queensland Pleistocene climate provided two well-marked pluvial periods (Whitehouse, 1940). These may have been synchronous with the interglacial stages of high sea-level. If so, suitable conditions existed for the development of considerable thicknesses of swamp deposits, and for the vegetation of the island during the period of the 50 ft. sea-level.

Conversely, the inter-pluvial periods may have culminated in comparative aridity during the recessions of the sea, providing favourable conditions for the transport of sand by wind action.

The Possibility of More Detailed Interpretations and the Prediction of Heavy Mineral Concentrations.

The history of the development of Stradbroke Island as given in this report needs to be substantiated, and the suggested correlation supported in the following ways :- (a) additional field observation of the occurrence of the fossil swamp deposits; (b) examination of the fossil swamp and dune deposits for microfossils; (c) boring to determine the boundaries of the extensions of the solid rock areas of Dunwich and Point Lookout.

It may then be possible to interpret minor events which have been neglected. Thus, during each glacial epoch the intensity of the refrigeration passed through more than one maximum while approaching its climax, (Browne, 1945), and presumably, while receding from the climax. The minor oscillations of the sea-level probably reproduced, on a small scale, the sequences of dune-building, vegetation and fixing of dunes, and concentration of heavy minerals that were enacted during the major fluctuations of the sea-level. Occurrences at more than one horizon of the deposits of organically-cemented sandstone, indurated sandstone, fossil wood, and bands enriched in heavy minerals could possibly be correlated with minor oscillations of the sea-level. Similarly, in the Southern Area, the occurrence in a southerly direction of a succession of low-lying, swampy tracts, with high dunes immediately to the south of them, may point to alternating periods of active dune-building and of cessation of dune-building.

Again, if the general outline of the development of the island can be accepted, it should be possible to define the stages in the development of each locality, and predict the possibility of the existence of heavy mineral concentrations. Thus, along the eastern edge of the Western Dune Area, deposits may have formed :- (a) near the northern end where the area approaches the south-easterly trending boundary of the Central Area. Concentrations of heavy minerals could not have been retained here if, during the transgressions at the time of the 50 ft. sea level, a channel was cut through the submerged dune area; (b) at various localities further south where the northern movement of sand may have been arrested by the encroachment of dunes from the Southern Area.

The formation of economic deposits of heavy minerals may be dependent upon concentrations during an advance of the sea, and the presence of an obstruction to the northerly movement of the minerals along the beach. This process is discussed above in Section IV.D.2. It is possible that, during a major recession of the sea, the volumes of sand moving northwards along the coast may be too great to allow effective concentration of heavy minerals.

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