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A SEQUENCE OF LATE QUATERNARY DEPOSITS AT PIPE CLAY LAGOON, SOUTHEASTERN TASMANIA

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(with three tables, five text-figures and two plates)

ABSTRACT

A record is presented of late Quaternary deposits from two sections on the Lumeah Point Peninsula, Pipe Clay Lagoon. The results permit interpretation of some of the main geomorphic events and environmental changes that have occurred during the late Last Glacial and Holocene stages.

Interglacial marine deposits of sand, clayey-sand and gravels are unconformably overlain by freshwater organic sediments dated to about 25,000-20,000 BP. Pollen analysis indicates a change in vegetation from *Eucalyptus* forest to *Eucalyptus*-savannah during this time. After 22,000 BP aeolian sands began to accumulate at Site A and probably continued during the maximum of the Last Glacial stage. Once stabilised, the aeolian and adjacent marine sands were strongly podzolised during the Holocene. Aboriginal middens and thin coversands resulting from forest clearance for agriculture by European settlers occur in and on the A_1 horizon of the podzol.

INTRODUCTION

The South Arm is formed by a series of low hills composed of Permian sandstones and mudstones which are locally intruded by masses of Jurassic dolerite. The low hills of the eastern part of the peninsula are separated from those of the western part by a small graben, the southern portion of which is flooded by the sea to a depth of 1-3 m in Pipe Clay Lagoon, southwest of Cremorne (fig. 1.) The graben is floored with sands, clays and ironstones of Tertiary age (Green 1961).

The low hills have been linked by terraces of marine and aeolian sediments of Late Quaternary age to form the present peninsula. Davies (1959) recognised the presence of a 4-5 m marine terrace in southeastern Tasmania which he named the *Llanherne Level* and assigned to the Last Interglacial stage. This level is widely represented in South Arm and is associated with other higher terraces of marine deposits at levels up to at least 21-22 m which are considered to be of Last Interglacial age.

The surfaces of these marine terraces are not everywhere flat or gently sloping but are locally interrupted by both shallow (< 5 m) and deep (> 5 m) deflation hollows. Some of these hollows are occupied by lagoons and a few, such as Rushy Lagoon, are flanked on their leeward sides by lunettes.

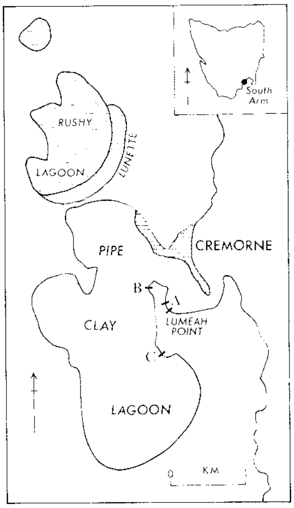

FIG. 1 - Location of Pipe Clay Lagoon and the Lumeah Point Peninsula

Late Quaternary Deposits at Pipe Clay Lagoon

The lagoons and lunettes of South Arm are generally considered to be of Last Glacial age. They are formed in and from marine deposits of Last Interglacial age.

In late 1972 an important section was found at Site A (figures 1 and 2) on the low peninsula of Lumeah Point (Lat. 42°55' S., Long. 147°34' E.) which extends northwards into Pipe Clay Lagoon and has an undulating surface between 3-4 m above OHWM. The section revealed a sequence of Late Quaternary marine, freshwater and aeolian sediments which when considered with other deposits exposed by marine erosion on the western side of Lumeah Point (Section B-C, fig. 3) help to date the development of the deflation hollows and to elucidate some of the environmental changes experienced in South Arm during the Last Glacial stage. It is the purpose of this paper to record and interpret the sequence of Late Quaternary deposits exposed on the Lumeah Point peninsula and to discuss some of the implications of the inferred environmental changes.

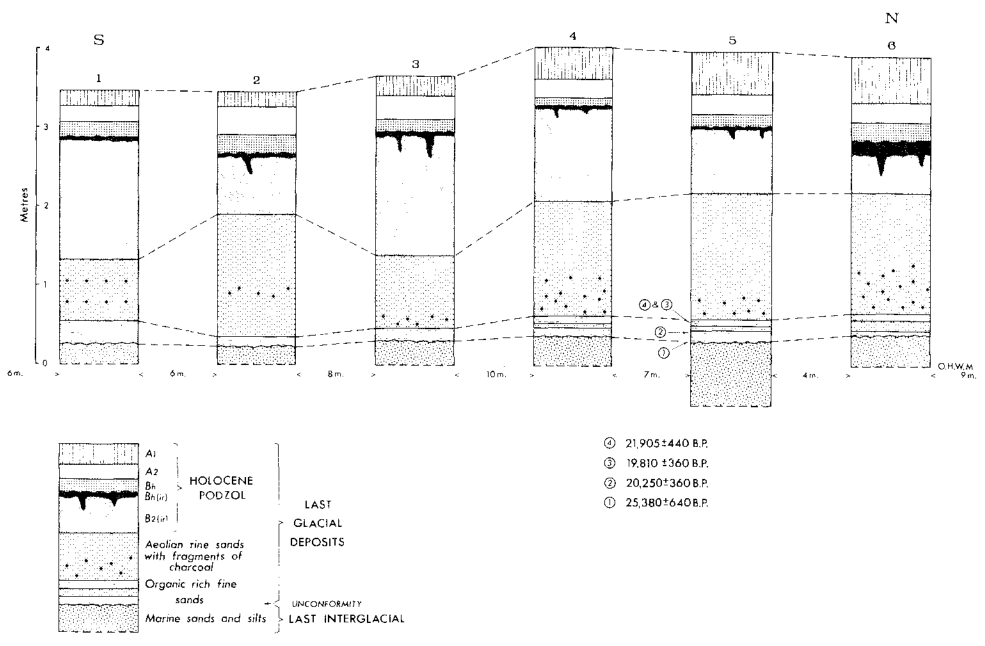

FIG. 2 - Stratigraphy of deposits at Site A

STRATIGRAPHY OF SITE A

The sequence of deposits exposed at Site A is summarised in figure 2 which owing to slumping of the cliffline has been drawn as six profiles. The profiles are numbered from south to north with the intervening distances given in metres and the continuity of units shown by dashed lines. The sequence consists of four sedimentary units, a strongly developed soil profile, and at least one unconformity (plate 1.)

The basal unit consists of beds of greenish-grey (Standard Soil Color Charts (1967); moist condition.) sandy-clay with dark olive mottles, fragments of rotted dolerite up to 5 mm diameter, and beds of grey and greyish-olive well rounded medium

PLATE 1 - Site A showing freshwater deposits, aeolian sands and deep podzol profile

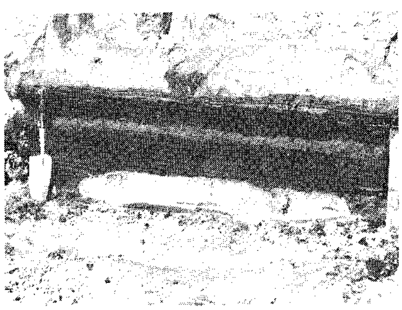

PLATE 2 - Site A showing freshwater organic deposits and aeolian sands overlying interglacial marine sands. Note laminated structure of the upper organic sands.

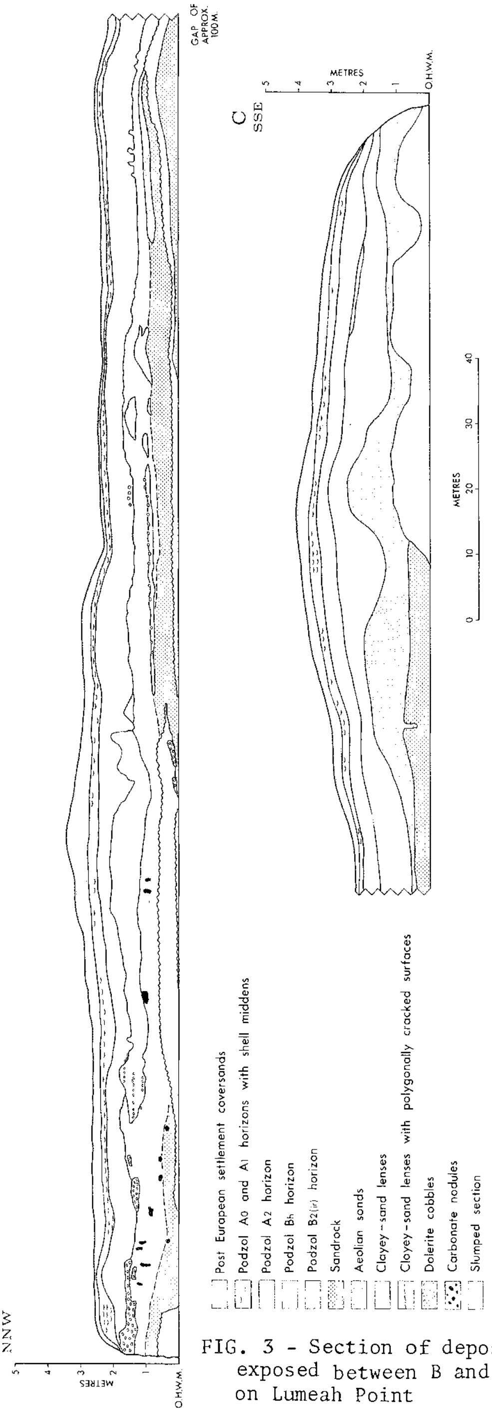

FIG. 3 - Section of deposits exposed between B and C on Lumeah Point

grade beach sands. These deposits are of marine origin and extend from a depth of more than 0.62 m below OHWM as determined by augering in profile 5 to 0.46 m in profile 6. They are mainly composed of granules, coarse and medium sand (table 1.). The beds of sandy-clay with dark olive mottles have resulted from the mixing of the marine sands with rotted dolerite clay and weathered rock fragments that existed prior to the marine transgression across this site.

A marine platform cut in dolerite probably occurs at shallow depth. This suggestion is based on water borings made immediately behind the site which reached weathered dolerite clay at between 3-4 m depth. It is also supported by the presence of a fossil platform cut in dolerite which passes beneath the marine sands at the northern end of Lumeah Point. The marine deposits at Site A have no free carbonates and a negligible organic carbon content of 0.47 per cent by weight; a value probably attributable to slight organic enrichment from the overlying beds and possibly a trace of moisture expelled during dry combustion. (Organic carbon determined by weight loss on dry combustion for 16 hours at 500° C.).

The marine deposits are strongly gleyed and pass upwards into black highly humified organic enriched (14.4% organic carbon) clayey-sand deposits that vary from 60-140 mm in thickness (plate 2). Samples were taken from this horizon in profile 5 at 310-360 mm and at 390-440 mm for ^{14}C dating. Samples were also taken at 330-340 mm, 370-380 mm and 420-430 mm for pollen analysis (fig. 4).

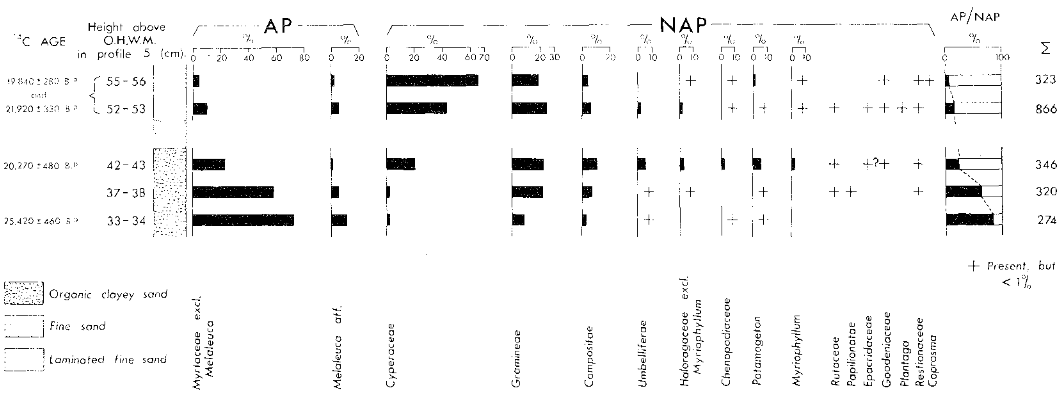

FIG. 4 - Pollen spectra from the organic deposits at Site A

This stratum is succeeded in profiles 4 to 6 by a thin bed of greyish yellow-brown, unconsolidated, aeolian fine sand, with small specks of charcoal, which varies from 40-120 mm in thickness. This bed lenses out southwards and disappears between profiles 4 and 3.

In profiles 4 to 6 the aeolian sand is overlain by black organic horizons that are separated by laminae of aeolian fine sand which together have an organic carbon content of 9.2 per cent. The alternate lamination of the organic horizons and aeolian sand indicates periodic production and accumulation of organic materials in the shallow pond or marshy depression while sand was being blown across the area. A sample was taken in profile 5 at 0.52-0.56 m above OHWM for ^{14}C dating and samples were taken at 0.52-0.53 m and 0.55-0.56 m for pollen analysis (fig. 4).

TABLE 1

CHARACTERISTICS OF SEDIMENTS AT SITE A, PIPE CLAY LAGOON

Sample	Stratum	Location of sample in profile 4 above OHWM	Colour[1]	Granules % > - 1ϕ	Coarse Sand % < 1ϕ > 1ϕ	Med. sand % < 1ϕ > 2ϕ	Fine Sand % < 2ϕ > 4ϕ	Silt & Clay % < 4ϕ	pH	Organic Carbon % weight
1	A_1 horizon	3.85 m	Brownish-grey 7.5YR 5/1	0.0	0.0(Tr.)[2]	2.6	94.5	2.3	3.5-5.5	11.9
2	A_2 horizon	3.5 m	Brownish-grey to greyish-brown 5YR 6/1-2	0.0	0.0	4.8	93.8	1.4	3.5-4.0	0.9
3	B_h horizon	3.33 m	Dull reddish brown 5YR 5/4	0.0	0.0	3.0	96.5	0.5	4.0	1.0
4	$B_{h(ir)}$ horizon	3.26 m	Reddish-black 2.5YR 2/1	0.0	0.0	2.5	96.0	1.2	4.0	3.7
5	$B_{2(ir)}$ horizon	2.98 m	Yellowish-brown 10YR 5/6	0.0	0.0	3.2	96.4	0.4	7.0	1.7
6	$B_{2(ir)}$ horizon	2.18 m	Bright yellowish-brown 10YR 6/6	0.0	0.0	4.4	95.2	0.4	6.5	0.6
7	Aeolian sands	1.10 m	Light grey to light yellow/orange 2.5YR 8/2-3 to 10YR 8/4	0.0	0.0	1.4	98.0	0.6	7.0	0.3
8	Organic sands	0.58 m	Black to dull yellow 10YR 2/1 to 2.5YR 6/3	0.0	0.0(Tr.)	0.8	95.5	3.5	7.0	9.2
9	Organic clayey-sand	0.43 m	Black 10YR 1.7/1	0.0	1.2	20.6	40.5	36.2	6.5	14.4
10	Marine Sands	0.20 m	Greyish-olive 5YR 6/2	0.3	3.1	41.8	46.9	7.8	6.5-7.0	0.4

[1] Standard Soil Color Chart; moist condition

[2] (Tr.) Trace < 0.1 %

This unit of laminated organic materials and aeolian sands is succeeded by 2 m to 2.5 m of cross-bedded aeolian fine sands. Above the winter watertable, which occurs at 0.9 m, these sands vary in colour from pale yellow through yellowish-brown to brown with increasing degrees of iron oxidation. Below the watertable the aeolian fine sand is dull brown in colour. The aeolian sand is well sorted with approximately 95 per cent or more of samples from all horizons (table 1, samples 1-8) consisting of fine sand. The deposit contains numerous small fragments of charcoal of 1-3 mm size which are mainly dispersed throughout the lower unoxidised part of the deposit, but in profiles 1 and 2 the charcoal fragments occur within the cross-bedded structures and indicate that they were blown into the depression with the sand. The average strike of the cross-beds and their southeasterly dip indicates that the winds which filled the hollow with sand blew predominantly from the northwest which is also the present prevalent wind direction. The fine sand of the infill was derived from the fine marine sands that form most of the Lumeah Point peninsula west and northwest of Site A and comprise the main sedimentary unit represented in Section B-C (fig. 3).

At Site A the upper 0.5 to 1.7 m of aeolian sand has been altered to a podzol soil profile with strongly developed A_1, A_2, B_h, $B_{h(ir)}$ and $B_{2(ir)}$ horizons.

The $B_{2(ir)}$ horizon varies from bright yellowish-brown in colour near its base to brown near its boundary with the $B_{h(ir)}$ horizon. It is moderately cemented in its upper part where in places weak sub-angular peds of 10-40 mm size have been developed. On exposure this horizon rapidly develops a striking honeycomb weathering structure which extends for approximately 0.5 m depth. Below this the $B_{2(ir)}$ horizon is generally weakly cemented, except on several horizons of local iron concentration, and merges with the parent aeolian sand.

The overlying $B_{h(ir)}$ horizon varies from 20-150 mm in thickness with frequent root-like extensions that penetrate the underlying $B_{2(ir)}$ horizon for 100-300 mm depth. This horizon is reddish-black in colour and is strongly cemented with iron and humic materials which latter give this horizon an organic carbon content of 3.7 per cent (table 1.). There is a marked reduction in pH from neutral and near neutral reaction in the $B_{2(ir)}$ horizon and underlying deposits to the strongly acidic values of the $B_{h(ir)}$ and overlying horizons. The surface of the $B_{h(ir)}$ horizon is strongly impacted and is sharply separated from an overlying dull reddish-brown coloured B_h horizon that consists of 100-250 mm of incoherent aeolian fine sands. This horizon is coloured by small amounts of organic carbon and oxidised iron.

The B_h horizon merges with the A_2 horizon which consists predominantly of grey coloured, structureless, aeolian fine sand that is held together only by penetrant fibrous roots. This 250-350 mm A_2 horizon is succeeded by a 200-550 mm thick A_1 horizon composed of brownish-grey, incoherent, aeolian fine sand that is bound loosely by a thick mat of fibrous roots. This horizon contains abundant charcoal and layers of oyster shells that mark former aboriginal midden sites. Locally the A_1 horizon is capped by a very thin (< 50mm) deposit of light yellow-brown aeolian sand which has formed since European settlement of the area.

STRATIGRAPHY OF SECTION B-C

A drawing of the deposits exposed on the western side of the Lumeah Point peninsula was made for the purpose of relating the stratigraphy at Site A to the wider local extent of the 3-4 m marine terrace (fig. 3).

The bulk of the deposits north-northwest of the gap in the section consist of shallow water marine fine sands with extensive lenses of clayey-sand and occasional lenses of weathered dolerite cobbles and ironstone fragments. The deposits resemble those that are currently being formed in the intertidal zone of Pipe Clay Lagoon and the presence of several horizons of polygonal shrinkage cracks on the surfaces of the lenses of clayey-sand indicate that this formation was also deposited under protected intertidal conditions. The lenses of dolerite cobbles are former accumulations of beach cobbles which confirm that the sedimentary sequence was built up in shallow water during a marine transgression.

Since their deposition these marine sediments have been weakly cemented by iron and humic materials under the influence of soil forming processes that have resulted in podzolisation and under the influence of seasonally fluctuating groundwater tables. This has resulted in the upper parts of the deposits being weakly cemented with illuvial iron and humic materials into distinct $B_{h(ir)}$ and $B_{2(ir)}$ horizons, and the lower parts of the deposit being cemented with iron and humus at and below the water-table and in zones of water perched above the lenses of clayey-sand to form a sandrock. Nodules of carbonate have been developed locally within these marine sands and are from 50-300 mm in diameter.

The uppermost metre of this part of Section B-C is composed chiefly of fine marine sands with granules of ironstone. Locally these fine sands have been redistributed by wind action and the polished ironstone granules have been concentrated into lag-horizons. Locally the surface of the undistributed marine sands exhibits wind-scour flutings.

Both the marine sands and the locally redistributed aeolian sands have been strongly podzolised and exhibit distinct A_1, A_2, $B_{h(ir)}$ and $B_{2(ir)}$ horizons which cut across the marine and aeolian lithological units. The A_1 horizon contains numerous oyster shells and charcoal associated with former aboriginal midden sites. It is overlain by 0.2-0.7 m of yellow-brown aeolian sand which has accumulated since European settlement of the area.

South-southeast of the break in Section B-C the deposits consist entirely of aeolian fine sand which formed a dune (fig. 3). The sand varies from light grey to yellowish-brown and is cemented near its base by iron and humic materials to form a sandrock. The surface of the dune exhibits clearly the A_1, A_2, $B_{2(ir)}$ horizons of a podzol soil and a $B_{h(ir)}$ horizon is locally developed. The greater thickness of the deposits here than in the northeastern part of the section serves to separate clearly the podzol soil profile above from the groundwater podzolised sandrock horizon below. The A_1 horizon of the dune contains shell midden horizons with associated charcoal and is overlain by up to 0.5 m of unconsolidated yellow-brown aeolian sands.

DISCUSSION

The preceding record of the deposits exposed on Lumeah Point shows that a complex series of marine, freshwater and aeolian deposits form the peninsula. When these are considered in association with other information known from South Arm and adjacent areas of southeastern Tasmania it is possible to reconstruct a partial sequence of geomorphic events and environmental changes that have occurred in this locality since the later part of the Last Interglacial.

The burial of the marine platform cut in dolerite on Lumeah Point beneath the sequence of sands which forms most of the peninsula, and the composition and structure of these intertidal deposits, proves that the sea transgressed the graben of Pipe Clay Lagoon and formed the marine terrace that extends to 3-4 m above present OHWM. The deeply weathered nature of the dolerite beach cobbles at the north-northwestern end of Section B-C suggests that the platform and marine deposits were formed during the Last Interglacial stage. Although the field evidence shows that most of the marine sediment was deposited in a protected intertidal environment there are no distinct shoreline features at this site from which to determine the upper limit of transgression.

These deposits may represent intertidal deposits that accumulated before the maximum transgression level was attained and survived as bay floor sediments when the water became deeper. These shallow water marine deposits are separated by an unconformity from the overlying freshwater and aeolian deposits which accumulated in a depression in the land surface which was 2-3 m deep and more than 60 m wide.

The samples taken for dating from the lower freshwater organic sands and from the upper laminated organic sands in profile 5 gave the following radiocarbon ages:

0.52-0.56 m	19,810 ± 360 BP	(SUA - 153, and
	21,905 ± 440 BP	(SUA - 153/2)
0.39-0.44 m	20,250 ± 360 BP	(SUA - 152)
0.35-0.36 m	25,380 ± 640 BP	(SUA - 151)

When the samples were submitted for ^{14}C dating it was indicated that infinite dates might be obtained and that sample SUA - 153 should be processed first to ascertain if the organic sands were likely to provide finite dates. When the result of 19,810 ± 360 BP (SUA - 153) was found to be considerably younger than expected an assay was carried out on another portion of the same sample after boiling in alkali and washing. This yielded a radiocarbon age of 21,905 ± 440 BP (SUA - 153/2). If the probability limits are examined and the assays are tested using the relationship of the arithmetic difference between the assays and the square root of the sum of the squares of each deviation (Polach and Golson 1966) then it is highly probable that SUA 153/2 differs significantly from SUA - 153. As it is possible that traces of modern humic acid may have decreased the age of SUA - 153 the older date is considered the better.

While the date 20,250 ± 360 BP (SUA - 152) lies between SUA - 153 and SUA - 151 to give a consistent time series it is apparently younger than SUA - 153/2. Using the same tests it is fairly probable that SUA - 152 differs significantly from SUA - 153 and probable that it differs significantly from SUA - 153/2. The oldest assay of 25,380 ± 640 BP (SUA - 151) differs significantly from all the other dates.

Mr R. Gillespie of the Sydney University Radiocarbon Laboratory has informed me that sample SUA - 152 required dilution during processing which could be a possible cause of slight error though he considers that the slight variations in the dates are more likely to be due to the incomplete removal of slightly younger humic materials. Even allowing for these possibilities the assays appear to be consistent enough to permit the general conclusion that the shallow lake or marsh in which the organic sands accumulated existed between about 20,000 to 25,000 BP.

The samples taken from profile 5 for pollen analysis were processed by the technique of Mehringer (1967). The pollen was identified by comparison with modern reference material in the collection of the Botany Department, University of Tasmania. The taxonomic nomenclature follows Curtis (1956, 1963, 1967). The pollen sum used to construct the relative diagram (fig. 4) comprised all pollen counted on two slides from each sampled horizon being approximately 300 grains except between 0.52-0.53 m in which pollen was more abundant. Though the lithostratigraphy shows a distinct break between the lower three and upper two spectra the trends of the pollen curves and the sequence of radiocarbon assays indicate that sedimentation was continuous at this site and that the included aeolian sand horizons were probably deposited rapidly.

The most striking feature of the short pollen diagram is the marked decline of arboreal pollen from just over 83 to 6.2 per cent at an apparently constant relative rate and a corresponding relative increase in Cyperaceae from 2.2 to nearly 66 per cent. The increase in Cyperaceae is probably strictly local and with the low percentages of *Potamogeton* and *Myriophyllum* can be associated with the infilling of the shallow lake to form a marsh. While part of the relative decline in the tree pollen can be directly attributed to the increase of Cyperaceae a comparison of the ratios of Gramineae and total non-arboreal pollen (excluding Cyperaceae and aquatics) to total arboreal pollen (table 2) reveals a real relative increase of grasses, herbs and shrubs, and a decrease of tree pollen with time. The trends of the curves (fig. 4) and the trends of the ratios (table 2) indicate that the vegetation of *Eucalyptus* (Myrtaceae in fig. 4) forest gradually altered to a *Eucalyptus*-savannah with herbs and occasional shrubs, in which small lakes and marshy hollows surrounded by sedges occurred.

TABLE 2

Height above OHWM in profile 5 (m)	Gramineae/AP (Myrtaceae)	Total NAP-Cyperaceae & Aquatics / AP (Myrtaceae)
0.55-0.56	3.00	3.95
0.52-0.53	1.56	2.39
0.42-0.43	0.92	1.85
0.37-0.38	0.35	0.50
0.33-0.34	0.10	0.15

It is difficult to suggest the reasons for the alteration of the vegetation from *Eucalyptus* forest to *Eucalyptus*-savannah during the period 25,000 to 20,000 BP as no deposits of comparable age are known from eastern Tasmania. Because of this it is not yet possible to ascertain whether this change was of local importance only or was a change of regional significance. The dating of the deposit is of interest as it places the vegetational change within the time of advance of the small ice cap and piedmont glacier extensions of the Tasmanian West Coast Ranges to their maximum limits which were attained after 23,640 ± 1030 BP (GaK-5597) (Colhoun 1975). The coincidence of timing suggests that the vegetation change may be a response to colder and drier climatic conditions in southeastern Tasmania as the ice sheets developed in central and western Tasmania. Evidence from further sites in eastern Tasmania is needed to test this hypothesis.

The aeolian sands which filled the hollow at Site A indicate that the land surface became unstable after about 22,000 BP. The sand dune at the southern end of Section B-C was probably also formed at this time which seems to have coincided with the phase of maximum intensity of the Last Glacial Stage between approximately 20,000 and 15,000 BP. Field evidence in eastern Tasmania indicates that many dunes and aeolian sandsheets were formed at this time (Nicolls 1958), and a ^{14}C date of 15,740 ± 700 BP (SUA - 376) has been obtained on charcoal from a sand dune 25 km north-northwest of Cremorne at Malcolms Hut Road near Richmond. The presence of finely divided charcoal fragments within the aeolian sands at Pipe Clay Lagoon indicates the occurence of fires during this time. To what extent fire may have been influential as a reinforcing agent that operated in the same direction as the colder and drier climatic effects, or directly as a causal factor in producing ground surface instability and vegetation changes is not yet possible to determine.

Once the hollow was infilled and the sands were stabilised, a deep podzol soil profile (> 1m depth) was developed. The podzol exhibits deep A_1 and A_2 horizons with complete removal of free iron oxides (determined by the Sodium Dithionite-Citrate-Bicarbonate method of Jackson (1956) and colloidal jumus (fig. 5). The free iron has been eluviated as an iron-humus complex and has been concentrated in distinct B_h and $B_{h(ir)}$ horizons in which a maximum of 1.2 per cent free iron occurs. This value decreases rapidly to 0.3 per cent in the surface of the $B_{2(ir)}$ horizon, and declines to undeterminably low (< 0.1%) quantities throughout much of the horizon except for local concentration on specific beds with values of up to 0.3 per cent. The local concentration is due to groundwater effects and not directly to pedogenic illuviation.

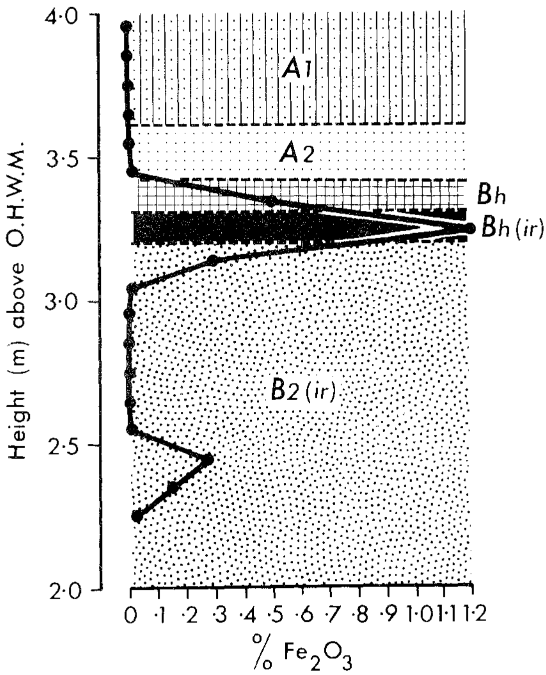

FIG. 5 - Free iron concentration in profile 4 at Site A

The marked absence of free iron in the parent sand and its concentration in the B horizons suggests that the humus-iron complex was largely derived from the vegetation cover associated with the development and maintenance of the deep podzol.

This deep podzol profile is not unique. It occurs as the regionally developed soil of sandy areas in southeastern Tasmania except for sandy marine and coastal dune deposits of Middle to Late Holocene age from which it is markedly absent. These deposits have much shallower podzol profiles (< 0.5 m depth) that have been developed during the last 5,000 to 6,000 years. The development of a deep podzol profile on the dune at Malcolms Hut Road shows that the deep podzols were formed after 15,740 BP, and are likely to have been formed by the continuous operation of processes of podzolisation on sandy substrates since about 12,000 BP. Although a full discussion cannot be included here, field evidence indicates that the widespread podzolisation of sandy regions in southeastern Tasmania during the late Glacial and Holocene periods occurred in association with a predominant *Eucalyptus* forest cover under a sub-humid climatic regime.

At sites A and B-C at Pipe Clay Lagoon thick aboriginal shell middens with charcoal and stone artifacts occur as part of the A_1 horizon and also overlie the deep podzol soil. Although not dated, the middens are probably of Middle to Late Holocene age. The thick accumulations of *Ostrea* sp. and *Mytilus* sp. shells have been partially leached of carbonate and many have powdery surfaces. The passage of carbonate through the profile is indicated by the occurrence of near neutral pH values in the B_2(ir) horizon at Site A (table 1) and of numerous soft carbonate nodules in the marine sands of Section B-C. The association of the precipitated carbonate with the middens is clearly demonstrated as the most numerous and largest nodules underlie the thickest middens. Except where influenced by midden shells or recent fertilisation

TABLE 3 Chronology of Geomorphic Events and Environmental Changes at Pipe Clay Lagoon

Stage	Approx. age BP	Geomorphic Events	Surface Stability	Climate	Soils	Probable Vegetation
Holocene	(AD 1804 - present)	Local European induced instability of sands. Coversands to 1 m depth.	Culturally induced local instability	Cool temperate sub-humid	Podzols ↑ Carbonate enrich-ment ↑	*Eucalyptus* wood-land due to burning ↑
	6,000	Aboriginal disturbance of terrestrial sands, marine and coastal dune sands. Numerous middens formed	Stable		Podzols	*Eucalyptus* forest
	10,000					
Last Glacial	12,000 16,000	Aeolian deposits in-filling hollow at Site A and forming dune near C and at Malcolms Hut Road near Richmond	Unstable	Cold-dry (?)		
	20,000 22,000 25,000	Organic deposits in shallow pond and marsh at Site A	Unstable ↑ becoming ↑ Stable	Cool temperate sub-humid		*Eucalyptus*-savannah becoming *Eucalyptus* forest
	100,000					
Last Interglacial		Marine sands, clays and beach gravels of Site A and B-C				

the pH values of the podzol A horizons are 3.5 to 4.0. The simplest interpretation is that after continuous podzolisation of the siliceous sands during the Early to Middle Holocene carbonate was introduced to the site as the middens accumulated. Subsequent leaching and precipitation of carbonate in association with seasonally fluctuating groundwater levels in the sands has increased the pH and carbonate values of some horizons in the deep podzol and some areas of the marine sands, but otherwise has not significantly altered their podzolised characteristics.

The light yellow-brown, aeolian fine sands that overlie the A_1 horizon of the podzol soil in Section B-C have resulted from the disturbance of incoherent sandy soils by European settlers. Similar thin coversands related to European forest clearance and farming developments occur widely in the settled sandy regions of eastern Tasmania and postdate AD 1804.

CONCLUSIONS

The Late Quaternary deposits exposed on the Lumeah Point peninsula provide certain limited evidence which permits an interpretation of some of the environmental processes that have operated on the landscape and changes that have occurred since the end of the Last Interglacial Stage. The conclusions from this site with some additional observations from the local region are summarised in table 3 which provides an outline chronology of the major geomorphic events and environmental changes that have occurred.

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