DEPARTMENT OF
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# BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

RECORD 1976/16



## AUGER DRILLING OF BEACH RIDGE COMPLEXES
## WESTERN CAPE YORK PENINSULAR, 1973

by

J. Smart

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## SUMMARY

Auger drilling and levelling of beach ridge complexes in western Cape York Peninsula in 1973 together with $C^{14}$ dating show that an older group of late Pleistocene age and a younger group of Holocene age are present. The Pleistocene ridges probably originated as barrier-island complexes, as did the first set of Holocene ridges. The rest of the Holocene ridges formed as cheniers. An age of about 120 000 years seems probable for the Pleistocene ridges, and the Holocene ridges range from over 6 000 years B.P. to the present day.

# AUGER DRILLING OF BEACH-RIDGE COMPLEXES, WESTERN CAPE YORK PENINSULA, 1973

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## INTRODUCTION

Extensive beach ridges border the southern and eastern margins of the Gulf of Carpentaria; they extend from the Roper River in Arnhem Land to Cape York, are patchily developed between the Roper River and Gove, and are also present on the Wellesley, Pellew and Wessel Islands and Groote Eylandt. The beach ridges have been examined by many workers and have been mapped by field parties of the Bureau of Mineral Resources (BMR) and the Geological Survey of Queensland (GSQ) between 1969 and 1973 (discussed below). However, investigations prior to 1973 have lacked systematic drilling and levelling data. The present Record reports the results of drilling and levelling of beach ridges on the west coast of Cape York Peninsula from August to October 1973. The purpose of the study was to elucidate the stratigraphy of the beach ridge complexes and to provide information on the late Pleistocene-Holocene geological history of the area, particularly in terms of sea level changes. The results of $C^{14}$ dating of shells from this and adjacent areas are also discussed and the history of beach ridge formation in the region briefly reviewed.

The survey area lies within the Aurukun Aboriginal Reserve. The mission authorities maintain a cattle station in the survey area at Peret, and outstations at Ti-Tree and Bamboo (Fig. 1). Access to the area is normally by air (airstrips at Peret, Ti-Tree and Bamboo); heavy supplies are carried to Bamboo by boat from Aurukun on the north side of Archer Bay. There is a track from Bamboo to Peret and on to Kenchering and Ti-Tree.

Overland access to the area is possible from Merluna, using tracks constructed by Aurukun Associates, but the section south of Tompaten Creek to Stone Crossing on the Archer River is virtually trackless. It is also possible to reach the area from Edward River Mission but there are no tracks north of Christmas Creek and local knowledge is essential.

BMR required access suitable for heavy vehicles to drill BMR Aurukun 1 shallow stratigraphic hole (Gibson et al., 1974) as well as the beach ridge investigation and so a track of about 126 km was bulldozed from Merapah Creek to the fence line on the Archer River, about 18 km from Peret. The track was marked by painted blazed trees and Department of Services and Property survey bench marks are located along it. Most of the track is on high ground but several swamps persist late into the dry season and access is not normally possible before August. The tidal flat areas on the Love River and south of Kenchering are hazardous before September and after the October king tides.

A further 50 km of track was bulldozed to provide access to the beach ridges and to provide three traverse lines across the ridge sequence.

Twenty-four auger holes were drilled in the beach ridges and adjacent swales using a Gemco 110 auger drill. Holes were logged in the field by J. Smart and D.L. Gibson. Samples were taken at 2-m intervals and an allowance made for lag time. Cuttings are stored at the BMR Core & Cuttings Laboratory, Fyshwick, A.C.T., and are available for examination. No wireline logs were run. A few of the holes have been reported on by Smart et al. (1974).

The drill hole sites were subsequently levelled by a survey party from the Department of Services and Property (leader, D. Hoops). The ends of the traverse lines were located by astrofix and the lines levelled to provide detailed profiles. The elevations were tied to the Australian Height Datum at Coen Airfield. Total distance levelled was 280 km, of which 39 km was detailed.

## PREVIOUS INVESTIGATIONS

Jackson (1902) first reported the existence of the ridges and noted that he based some of those on Sweers Island was above present sea level. He regarded them as aeolian. Twidale (1956) briefly described the beach ridges along the southern shore of the Gulf, between the Leichhardt and Gilbert Rivers. He divided the ridges into two groups; an older series of three ridges, whose formation was followed by a younger series of two ridges after an emergence of about 6 m. The ridges were all considered to be formed as offshore bars and he said that a present day analogue was currently forming. Twidale attributed the emergence to eustacy and said that the coastline displayed features characteristic of emergence. In 1966, Twidale presented a $C^{14}$ date of 3320 $\pm$ 125 years B.P. for shells from the youngest beach ridge at Karumba and suggested that its emergence may be related to a eustatic fall in sea level during the Holocene (Twidale, 1966).

Valentin (1959, 1961) carried out a reconnaissance of the west coast of Cape York Peninsula, between the Jardine and Norman Rivers. He noted (1959) that the oldest beach ridges near the Jardine River were 7.6 m higher than the oldest at Weipa and inferred a tilting of the coast. However, the oldest ridges at the Jardine River are probably Pleistocene (Powell & Smart, in press) and most of those at Weipa, Holocene (Smart, in press, a) and the difference in elevation is due to the ridges having been formed at different sea levels. In the area South of Archer Bay, Valentin (1961) noted the two ages of beach ridges. He regarded the older ridges as having formed partly from many parallel dunes blown together by wind action and partly as old individual dunes. He divided the present coast line into areas where either erosion or deposition is dominant and showed inferred directions of long shore drift but did not relate it to beach-ridge development.

Whitehouse (1963) discussed the beach ridges on the west side of Cape York Peninsula in a general review of sandhills in Queensland. He reported augering showing that the youngest ridges at Edward River Mission rested on marine muds and he postulated a sequence of beach ridges in three zones: firstly, young ridges with sharp profiles along the coast, secondly a series of older ridges having a more subdued relief with some incipient claypan development and finally an area, many kilometres wide, of sand with abundant claypans. The first two series are recognized in this paper as Holocene and Pleistocene beach ridge sequences respectively, but the area of sand with claypans is considered to be the result of weathering and deflation of fluvial sediments (Grimes & Doutch, in prep.).

Doutch et al. (1972) discussed the morphology and origin of the beach ridges in the area between latitudes 15° and 17°S. They presented a conjectural cross section of the ridge sequence and Needham & Doutch 1973 (a,b) presented a similar account in the explanatory notes covering the area which subsequent work (this Record) has shown to require revision.

Ingram (1973) described the beach ridges in the Burketown 1:250 000 Sheet area. In contrast to Twidale (1956) Ingram could see 'very little difference in height above mean sea level of the nearest and farthest ridges from the coast'. Gibson (*in* Doutch et al., 1973) briefly described the beach ridges on the west coast of Cape York Peninsula and recognized two ages of ridges. He reported a range of $C^{14}$ dates between 470 and 5630 years B.P. for the younger ridges. No details of localities were presented and the significance of the ages was not discussed.

Grimes (1974) described the beach ridges along the southwestern coast of the Gulf of Carpentaria in Queensland and briefly discussed the results of $C^{14}$ dating of ridges at Edward River Mission on Cape York Peninsula. He did not distinguish different ages of ridges on his maps, but his Figures 6 & 7 can be interpreted as showing two sets of ridges. Powell & Smart (in press), Smart (in press, a & b) and Grimes (in press) interpret two sets of beach ridges on the west coast of Cape York Peninsula, of Holocene and Pleistocene (?) age. Whitaker & Gibson (in press) show similar features on the Charlotte Plain on the east coast of the Peninsula, and Gibson (1975) reported on auger hole drilled through one of the younger ridges.

On the Gulf coast of the Northern Territory, the older and younger ridges can be identified as far as the Roper River area, north of which point there is only minor patchy development of younger ridges and no older ridges. This is probably due to a lack of sediment on that part of the coast. The published geological maps show all the beach ridge as Czs, in an undifferentiated category which includes calcareous and quartzose beach ridges and dunes (Dunn, 1963; Smith, 1963; Yates, 1963; Plumb & Paine, 1964; Dunnet, 1965; Plumb, 1965; Plumb & Roberts, 1965).

## GENERAL DESCRIPTION

The results of the 1973 drilling are summarized as beach-ridge sections in Figure 3 and detailed logs are presented as Appendix 1. $C^{14}$ dating results are shown in Appendix 2. The beach-ridge sections show that there is a group of ridges near the coast and more subdued ridges inland. These correspond to the younger (Qhm) and older (Qpm) ridges respectively mapped by Powell & Smart (in press), Smart (in press, a & b), Grimes (in press) and noted by Valentin (1961) and Whitehouse (1963). Photo-interpretation suggests that they also correspond to the younger and older ridges described by Twidale (1956) from the southern end of the Gulf of Carpentaria.

No concentrations of heavy minerals were noted from any of the beach ridges. The only significant concentrations of heavy minerals known in the area are on Holocene beaches in some of the estuaries (Miller, 1957).

The coastal plain on which the ridges lie has been called the Karumba Plain in the south by Twidale (1956) and the term has been extended by Doutch et al. (1970, 1972, 1973) and Grimes (1974) to cover the coastal plain between Archer Bay on Cape York Peninsula to the N.T. border. The name Mapoon Plain was used by Powell & Smart (in press) for the corresponding coastal plain from Albatross Bay northwards. The corresponding plain on the east of the Peninsula was called the Charlotte Plain by Whitaker & Gibson (in press). These coastal plains consist largely of muddy sand and silt (coastal alluvium, Qac), and locally extensive modern salt pans (Qhp). The Older beach ridges lie along the landward edge of the coastal plains, and the younger ridges are spread across it, between the sea and the older ridges. Doutch (in prep.) discusses some details of the Karumba and Mapoon Plains. The Charlotte Plain is apparently similar in origin and history.

## OLDER BEACH RIDGES

### Distribution

The older group of ridges has been mapped along the western coast of Cape York Peninsula as far south as latitude 15$^{\circ}$ and is shown on the 1:250 000 geological maps as Qpm (Powell & Smart, in press; Smart, in press, a & b; Grimes, in press). South of this, the older ridges have been recognized along the coast as far as the Northern Territory border (Needham & Doutch, 1973 a,b: Ingram, 1973; Grimes, 1974) and can be recognized beyond on air photographs as far as the Roper River area.

Morphology

The older group comprises low, rounded ridges, which are covered by tall trees and contain, in a few places, deflation features (clay pans and minor blow outs; (Fig. 2). Air-photo interpretation suggests the presence of four sets of ridges within the older sequence, all of which can be traced over most of the coast. In this Record they have been mapped out, within the Survey area, as $Qpm_1$, $Qpm_2$, $Qpm_3$ and $Qpm_4$ from the oldest to the youngest (Fig. 1).

The $Qpm_1$ ridges are poorly preserved as low, linear, sand ridges whose trends are generally discordant to the $Qpm_2$ and $Qpm_3$ ridges. No ridges of this group have been levelled but their crests appear similar in height to the $Qpm_2$ group.

The intermediate set, $Qpm_2$, is the best preserved set in the survey area and appears to be best preserved elsewhere on the coast. The crests of the $Qpm_2$ ridges are around 5 m above sea level but it is unlikely that this is their original height (discussed below). They are present over all the survey area south of the Love River.

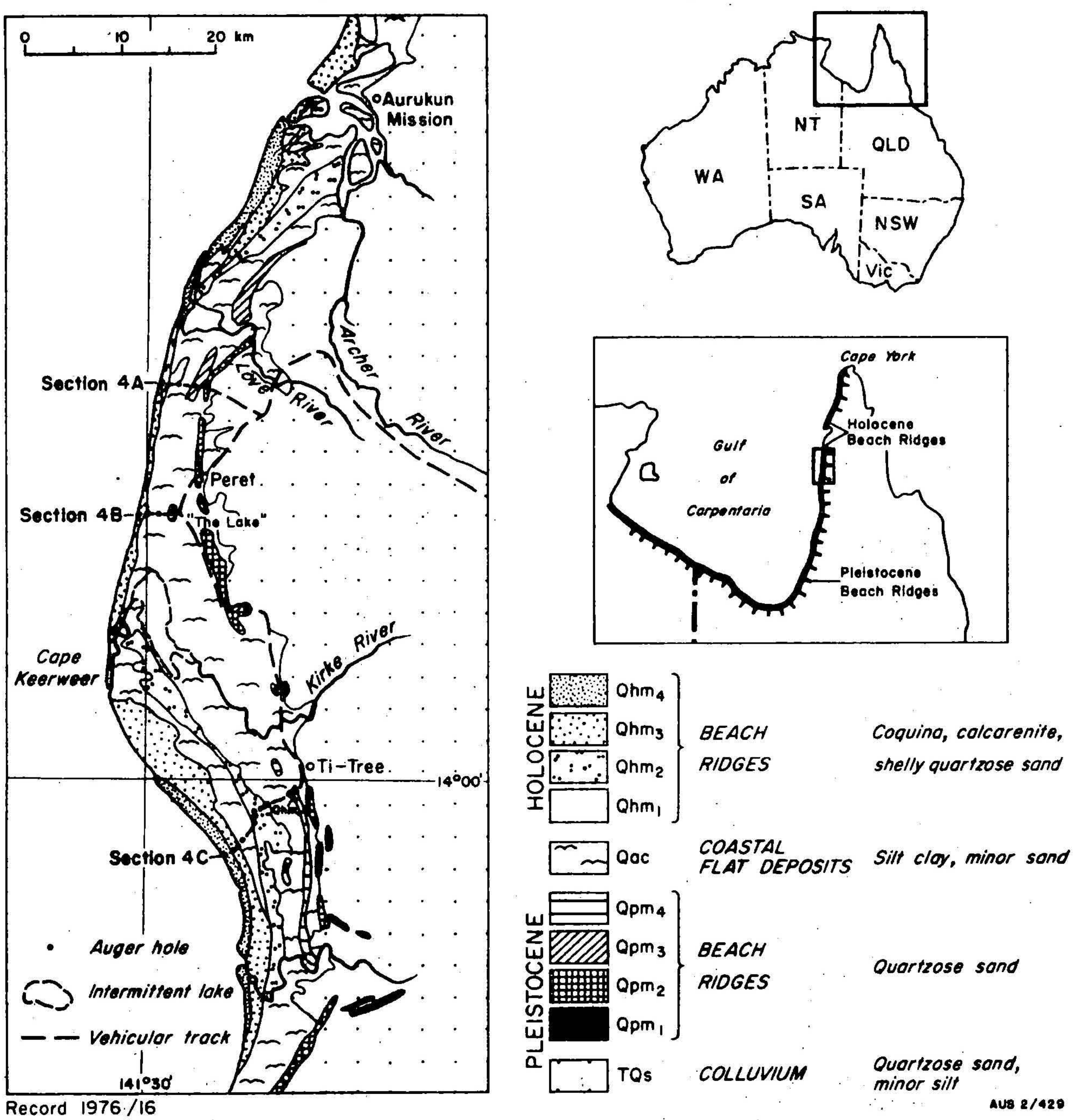
Within the survey area, the $Qpm_3$ ridges are recognized only west of Don Yard, where they lie slightly discordant to the $Qpm_2$ ridges. Claypans characterize the $Qpm_3$ ridges but there are only a few deflation features on the other Pleistocene ridges. The present elevation of the $Qpm_3$ ridge crests is about 2 m above sea level.

The youngest of the group, $Qpm_4$, has a less degraded appearance than the older ridges although its crest lies at about the same elevation, about 3.5 m above sea level. Vegetation cover is similar to that on the older ridges except that there are fewer large trees.

The $Qpm_4$ ridges are present only in the south of the survey area (Fig. 1), and have been mapped both as Qpm (Smart, in press, b) and Qhm (Grimes, in press) in the recent 1:250 000 geological maps, as their affinities are less certain than those of the other ridges. However, the drilling and levelling data (see below) suggests their formation at a higher sea level than present and so they are probably part of the older group.

A possible explanation for the restriction of deflation features to the $Qpm_3$ ridges is that deflation occurred immediately after the formation

## Fig. 1 Distribution of beach ridges

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of the $Qpm_3$ ridges and before deposition of the $Qpm_4$ ridges. If the previous climate had been more humid and the $Qpm_1$ and $Qpm_2$ ridges had developed a thick vegetation cover, they would have been little affected by the deflation episode. However, the only arid period so far established in the Late Pleistocene is from 30 000 to 11 000 years B.P. (Doutch, in prep.).

Lithology and relationships

The older beach ridges consist of slightly clayey quartzose sand, with local traces of shell material at depth. The sand is generally yellow or brown, locally red-brown, and is sub-horizontally bedded. A soil profile about 0.5-1.0 m thick is present on top of the ridges but no old soil layers or humic material have been encountered in drilling.

The oldest ridges, ($Qpm_1$) have not been drilled but photo-interpretation suggests they rest on the sequence of Pliocene-Pleistocene alluvial fan deposits in the survey area. Sections across the other ridges are shown in Figures 3a and 3c. The $Qpm_2$ ridges rest on the Pliocene-Pleistocene fan deposits (TQa), their bases being up to 1.5 m above present sea level. $Qpm_4$ ridges also rest on fan deposits (Fig. 3c); their bases are about 1.5 m above present sea level on the landward side. They contain minor shell fragments, which are virtually absent from the older ridges. The seaward portion of these ridges rests on muddy silt and sand (Qac) (Fig. 3a) and their base is below present sea level.

Age

Negligible carbonate material has been recovered from the Qpm beach ridges and $C^{14}$ dates have not been obtained. However, the probable age of the ridges (see below) is well beyond the limits of the $C^{14}$ method. Consideration of late Pleistocene history in the region and comparison with other coastal features in Australia has led Doutch (in prep.) to suggest an age of about 120 000 years B.P. for the group. An age of 120 000 years B.P. corresponds to a sea-level high of 4-6 m in southeast Australia (B.G. Thom, pers. comm.). The maximum age is probably younger than 170 000 years B.P., as Jongsma (1974) found a eustatic low of -200 m before 170 000 years B.P. and considerations of regional geology (Doutch, in prep.) suggest the ridges postdate this sea-level low.

## YOUNGER BEACH RIDGES

### Distribution

The younger ridges are present along most of the coast in the survey area. They can be traced on airphotos northwards as far as the mouth of the Jardine River and are also present on the Torres Strait Islands and in New Guinea. Southwards they are present around the coast to the Roper River area and some patchy development further north. They have been mapped as Qhm by Willmott & Powell (in press), Powell & Smart (in press), Smart (in press, a & b) and Grimes (in press). In other 1:250 000 scale geological maps of the region, they are mapped as Qm in the Queensland sector and included in Czs in the Northern Territory.

### Morphology

The younger ridges show fairly sharp relief, have a cover of small trees, shrubs or grass, and lack deflation features. Airphoto interpretation shows the presence of four sets of ridges, the younger three of which can be traced over most of the west coast of Cape York. The oldest is poorly preserved and can be recognized in only a few places. Within the survey area, the ridges have been mapped out as $Qhm_1$ , $Qhm_2$, $Qhm_3$ and $Qhm_4$, from oldest to youngest (Fig. 1).

The $Qhm_1$ ridges are low and broad, and have crests, about 2 m above sea level, but they may have been higher originally, the loss in height being due to leaching. The $Qhm_2$ ridges are extensive and are present along most of the survey area as well as farther north and south. They are 3-4 m above sea level in the Cape Keerweer area, but 5-6 m farther north, west of Don Yard. The latter are the highest ridges in the survey area. The $Qhm_2$ ridges have sharper relief than the $Qhm_1$ ridges, but the relief is not quite so sharp as that of the younger ridges. In several areas fresh-water lagoons have developed in the swales (e.g. Bull Yard Swamp).

The $Qhm_3$ ridges are extensive and show a marked discordance with the $Qhm_2$ ridges just north of Cape Keerveer (Fig. 1). They are asymetric, about 5 m high on the seaward side, and about 2 m on the landward side. Their morphology is slightly sharper than that of the $Qhm_1$ ridges. Southwest of Don Yard, the $Qhm_3$ series appears to merge with and slightly overlap the $Qhm_2$ series.


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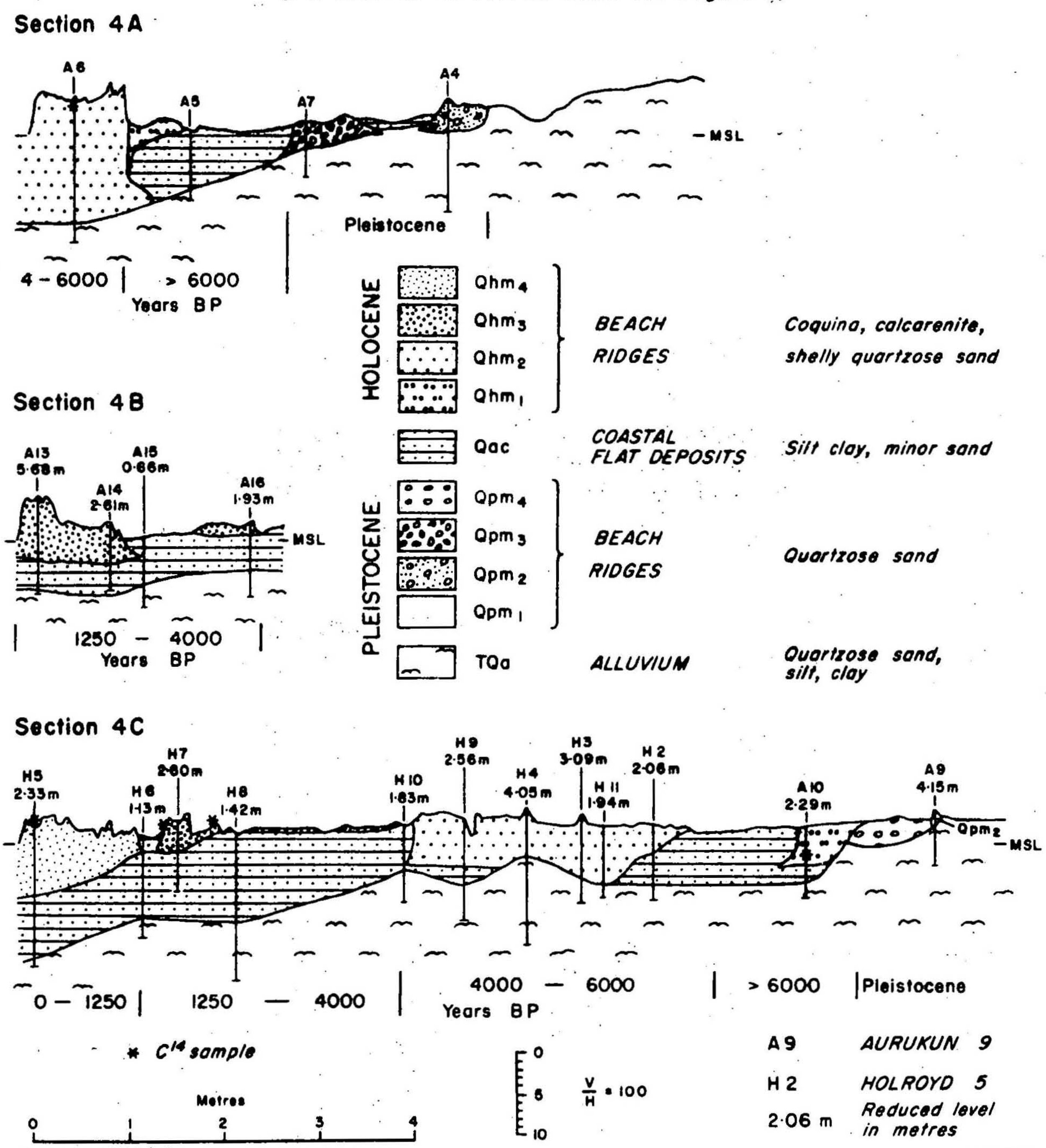
Fig. 2 **HOLROYD Run 2 Photo 46**
**Aerial photograph of beach ridges**
**Kendal River area**

Fig. 3 Beach ridge sections, based on auger drilling data; Levelling by Department of Services and Property (For location of section lines see Figure 1)

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The vegetation on the younger (Qhm) group of ridges is more dense than that on the Pleistocene ridges; the $Qhm_1$ and $Qhm_2$ ridges have small trees or large shrubs and the younger ridges have a cover of shrubs only. The ridges nearest to the coast are generally grassed and have few shrubs. On all the Qhm ridges, the trees and shrubs tend to be best developed on the ridge crests, and the intervening swales have a grass cover. Other workers have noted that crests are initially vegetated preferentially to swales, and Bird (1960) suggests that this is due to the lower salinity of the crests (due to more rapid removal of salt). Russell (1948) noted that the crests of cheniers in Louisiana had better developed soils than the flanks.

The $Qhm_4$ ridges are present only in the north and south of the survey area. The ridges are about 5 m above sea level and well defined with sharp ridge crests. They appear to be still forming.

<u>Lithology and relationships</u>

The younger (Qhm) ridges consist of slighly clayey, quartzose sand, with some shell sand and whole shells. Shell material is abundant in the $Qhm_4$ and $Qhm_3$ ridges ($>$ 50% in $Qhm_3$) but less so in the older ridges of this group, which generally have no carbonate in the upper part (discussed below). On the ridge tops, a soil profile up to 0.5 m thick is present (Fig. 4); its thickness increases with the age of the ridges. The bedding within the ridges is sub horizontal.

The $Qhm_2$ ridges rest on Tqa (Figs. 3a, 3c), and their bases are up to 10 m below present sea level. The partly contiguous $Qhm_1$ ridges appear to rest on muddy silt and sand (Qac). The $Qhm_4$ and $Qhm_3$ ridges rest on muddy silt and sand (Qac) as noted by Whitehouse (1963). The base of the $Qhm_4$ ridges are 4-5 m below sea level but those of the $Qhm_4$ ridges range from 3 m below to 1 m above sea level.

<u>Age</u>

Results of $C^{14}$ dating are presented in Appendix 1, and are summarized below. The $Qhm_1$ ridges have not been dated directly, but by comparison with the $Qhm_2$ ridges, a minimum age of about 6500 years B.P. seems likely. E.G. Rhodes (pers. comm.) has obtained an age of 6440 years B.P. for the most inland ridge north of Edward River. The $Qhm_2$ ridges have given ages between 4130 and 5330 years B.P. in the survey area and slightly older farther south (5630 years B.P.) so that a time span of 4000-6000 years B.P. seems probable. The time represented by the erosion between $Qhm_2$ and $Qhm_3$ sequences north of Cape Keerweer is uncertain. Ages for the $Qhm_3$ ridges go back to 2500 years B.P. in the survey area, but this specimen appears to be in the middle of the sequence (Au 111). A specimen from the landward side of the sequence at Edward River Mission (Ho 246) gave an age of 3935 years B.P. The youngest ages are about 1250 years B.P., giving a time span of 1250 to about 4000 years B.P., which suggests probable continuity of deposition without a break. The absence of $Qhm_2$ ridges between Cape Keerweer and Don Yard may have been due to erosion contemporaneous with beach-ridge formation to the south, or to non-deposition.

The youngest ridges, $Qhm_4$, have given ages between 1110 and 820 years B.P., which fits well with the ages of the $Qhm_3$ ridges. However, the problem of reworked shells should be noted (Appendix 2).

## ORIGIN OF BEACH RIDGES

### Beach-ridge nomenclature

Beach ridges are a common feature worldwide. Johnson (1919) considered them to have been built upon offshore bars and called them by that name. Later workers preferred the term barrier for depositional features above high tide, restricting the term bar to features submerged at some point of the tidal cycle (Shephard, 1952). The beach ridge is, strictly speaking, a berm built on top of a barrier (Bird, 1960). The term chenier has been applied to beach ridges in various areas (e.g. Cook & Polach, 1973; Needham & Doutch, 1973a, b) particularly for a sequence of prominent ridges separated by muddy swales, but there is some confusion regarding the exact meaning of the term. The original description of the chenier plains of Louisiana was by Howe et al. (1935) who wrote, 'Rising slightly above the surrounding marshes, several long, narrow, sandy ridges run roughly parallel to the coast of southwestern Louisiana and form the most conspicuous topographic features of the region. Sharply localized, well drained and fertile, they support naturally luxuriant vegetation cover ... the ridges have been called cheniers by their Creole inhabitants'. Price (1955) used the term chenier plain for this type of coastal feature and described cheniers as 'shallow-based, perched, sandy ridges resting

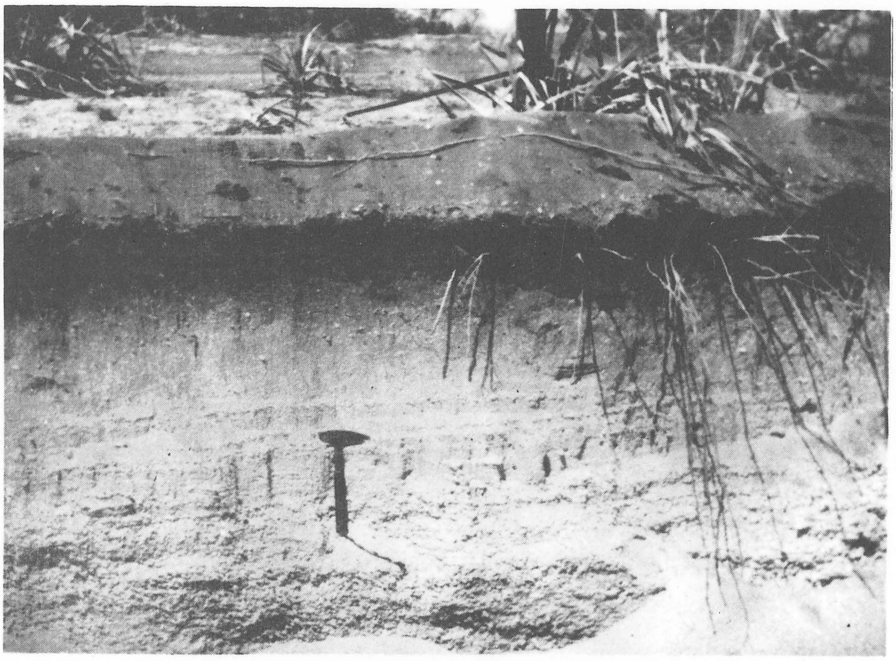

Fig. 4

Section through $Qhm_3$ beach ridge west of The Lake. Note dark soil horizon with leached shells, cementation in the lower part and subhorizontal bedding.

on clay'. Subsequent work, including extensive drilling (Byrne et al., 1959; Gould & McFarlane, 1959; Bernard et al., 1959; Coleman, 1966), has revealed the stratigraphy of the beach ridge sequence in detail. The typical chenier does not rest on swamp mud as assumed by some (Russell & Howe, 1935; Tanner, 1961) but on a firm base of marine sand and silty clay. Todd (1968) distinguishes cheniers from barrier islands and he noted that the near-shore gradient of the seabed was twice as steep where barrier islands had developed as where cheniers had developed; otherwise conditions were similar. Leblanc (1972) summarised the geometry and stratigraphy of the two types of beach-ridge formation. Essentially, the chenier is a sand body resting on coastal sediments associated with the progradation of the coastline, while the barrier island is a thick sand body which rests on 'basement', with its seaward margin underlain by marine sandy mud.

Todd (1968) suggests that three conditions are necessary for the formation of cheniers.

(1) Stability or fall of sea level;
(2) a variable supply of sediment from rivers;
(3) effective longshore currents.

If the supply of sediment is fairly constant, the classical chenier plain will not develop, and in its place a continuous sequence of sand ridges overlying muddy sediments will form. These ridges are similar in genesis to cheniers but the term chenier is not appropriate for them.

## Older Ridges

The Pleistocene ridges in the survey area are all of the barrier-island type (see above), resting on a basement of older fan deposits and having their seaward margins underlain by marine sandy mud (e.g. Fig. 3c).

## Younger Ridges

The $Qhm_1$ ridges appear to rest on sandy mud and may represent a chenier-type ridge sequence which failed to develop fully because it was superseded by the development of a barrier island, the $Qhm_2$ ridges. The latter fit the barrier island model of Leblanc (1972) very well, being thick sand bodies, formed mainly below sea level, resting on 'basement' and having their seaward margin resting on sandy mud.

The $Qhm_3$ and $Qhm_4$ ridges are chenier-type t, relatively thin sand bodies, resting on sandy mud. They do not form a classical chenier plain, as ridge development has been almost continuous throughout the Holocene, probably due to a fairly constant supply of sediment (cf. Todd, 1968).

Leaching

The removal of carbonate from beach ridges by leaching is a common process and has been reported from many places (e.g. Salisbury, 1925; Russell, 1948; Bird, 1965). Salisbury (1925) showed that the carbonate content of sand dunes dropped from over 6% to zero in less than 300 years in a cool wet climate. Bird (1965) reports a steady reduction of soil pH with age and a consequent change of plant species on beach ridges in Victoria. A costean into a Holocene ridge ($Qhm_3$) west of The Lake (Fig. 4) showed a sequence:

| | |
|---|---|
| 0-0.60 m | dark brown sandy shelly soil; shell content increases downward. Shells leached friable |
| 0.60-0.90 | shelly sand |
| 0.90-1.20 | thinly interbedded shell and shell sand, about 10 mm each |
| 1.20-1.70 | hard cemented shells and sand |
| 1.70-2.00 | cemented shelly sand; damp |

The costean was dug in late September, 5-6 months after the wet season, so the cementing seems to occur at the dry-season water table. Hand augering of $Qhm_2$ ridges near the Kirk River in 1972, found no carbonate above the water table, which was about 2 m above sea level (Abney Level measurement). Unfortunately, it was impossible to continue augering below the water table. Other hand auger holes in $Qhm_3$ ridges penetrated a cemented interval at about the dry season water table. It therefore appears that the cementation is due to the precipitation at the water table of carbonate leached from the upper part of the profile. If the process continued, the final profile would be a leached zone devoid of carbonate, over a hard pan of carbonate-cemented sand and shells ( a 'ground-water podzol' of Stephens, 1962).

The bed of the Gulf of Carpentaria adjacent to the Holocene beach ridges is underlain by a shelly sandy mud (mapped as Qcm by Smart, in press) (a,b) and the sand and shells of the Holocene ridges were derived by the winnowing of this by wave action. Similarly, the Pleistocene ridges had an analogous offshore provenance in the calcereous sandy clay (Qpc) which has subsequently been indurated during the late Pleistocene (Smart, op. cit.). However, the Pleistocene ridges are now essentially devoid of carbonate although their original composition was presumably similar to that of the Holocene ridges. It is therefore inferred that they have undergone leaching since their formation. Pleistocene ridges in South Australia contain abundant carbonate (P.J. Cook, pers. comm.), but the present rainfall in that area is less than half that of the survey area, and average temperatures are lower.

The Holocene ridges show a decline in carbonate content landwards, and an increasing depth of leaching. Drilling in 1973 showed a relatively low carbonate content in $Qhm_1$ and $Qhm_2$ ridges but no indurated horizons were detected. The groundwater podolization process has not proceeded to finality in the survey area; the reason is uncertain.

## CORRELATIONS

A sequence of Late Pleistocene and Holocene beach ridges is known elsewhere in Australia and is present along much of the southeast coast of the continent (e.g. Sprigg, 1959; Bird, 1965; Langford-Smith & Thom, 1969). The Pleistocene ridges of 100 000 to 120 000 years B.P. based on uranium-series dating, are associated with a sea level 4-6 m above the present (Thom, pers. comm.), and Doutch (in prep.) correlates the Qpm series of the Gulf of Carpentaria with these. Cook & Polach (1973) compared ages of individual ridges at Broad Sound on the east coast of Queensland with ages of Holocene beach ridges from other parts of the world and could find no direct correlation.

### Sea-Levels

The Pleistocene beach ridges formed at a sea level slightly higher than present. The exact height above present sea level is uncertain. Thom (pers. comm.) suggests a high of 4-6 m for 120 000 years B.P. in S.E. Australia and other authors suggest highs of the same order elsewhere (e.g. Chappell, 1974), but evidence of strand lines around the Jardine River and the Charlotte Plain indicates a higher strand, perhaps as much as 15 m (Doutch, in prep.). The ridges appear to have formed during regression from this sea-level high.

The Holocene ridges show no indication of a lea level different from the present at time of formation, but the configuration of the older ones ($Qhm_1$, $Qhm_2$) does not preclude a slightly higher sea level in the early Holocene, as postulated by others in northern Queensland (Hopley, 1968, 1971; Doutch, in prep.). However most workers do not accept a worldwide Holocene sea-level high (e.g. Thom et al., 1969, 1972).

## Geological History

The history of the ridge sequences is summarized as follows:

1. Late Pleistocene sea-level high (14-15 m), 120 000 years B.P.; followed by regression.
2. $Qpm_1$ ridges formed locally.
3. $Qpm_2$ ridges formed over most of the coast.
4. $Qpm_3$ ridges formed locally, followed by deflation under arid climate.
5. $Qpm_4$ ridges formed, southern part of survey area only.
6. Sea level low. Gulf was basin of inland drainage 35 000-24 000 and 20 000-11 000 years B.P. (Smart, in prep.).
7. Holocene transgression (11 000-7 000 years B.P.); then coastline prograded by deposition of Qac.
8. $Qhm_1$ ridges deposited locally.
9. $Qhm_2$ ridges deposited along most of coast as a barrier island complex.
10. Progradation continued, with deposition of Qac and $Qhm_3$ and $Qhm_4$ ridges as cheniers. Deposition along most of coast, but most active south of Cape Keerweer, distribution controlled by sediment supply.

The flooding of the Gulf between 11 000 and 7 000 years B.P. correlates with a great increase in rainfall (Smart, in prep.). Rainfall at this time was greater than at any time in the previous 100 000 years (Kershaw, 1975), and it is reasonable to suppose that this increase in rainfall was accompanied by an increase in sediment supply. The much greater development of the Holocene Ridges as opposed to the Pleistocene ridges may be due to the greater sediment supply during the relatively wet Holocene.

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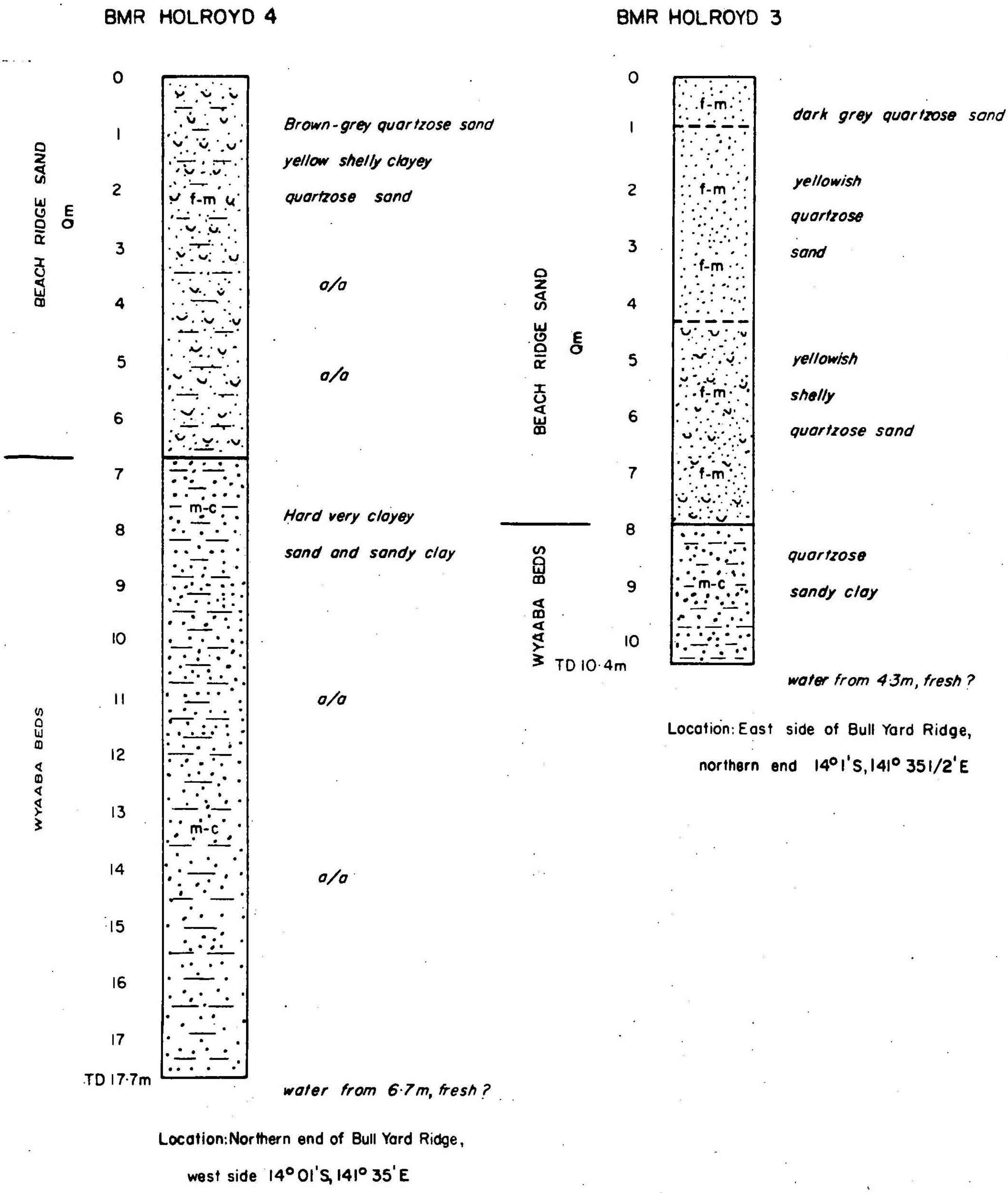
Appendix 1

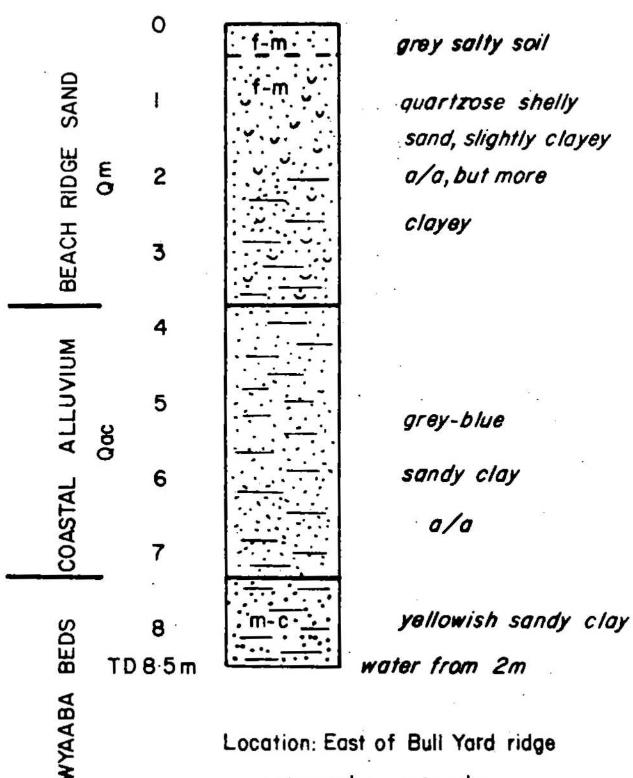
Drill logs of auger holes




To accompany Record 1976/16

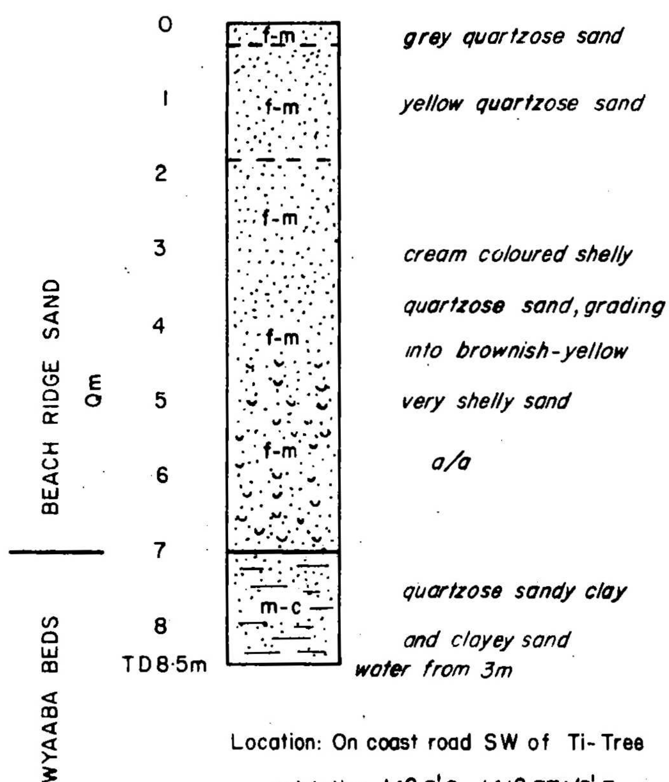
Q/A/552

BMR HOLROYD 2



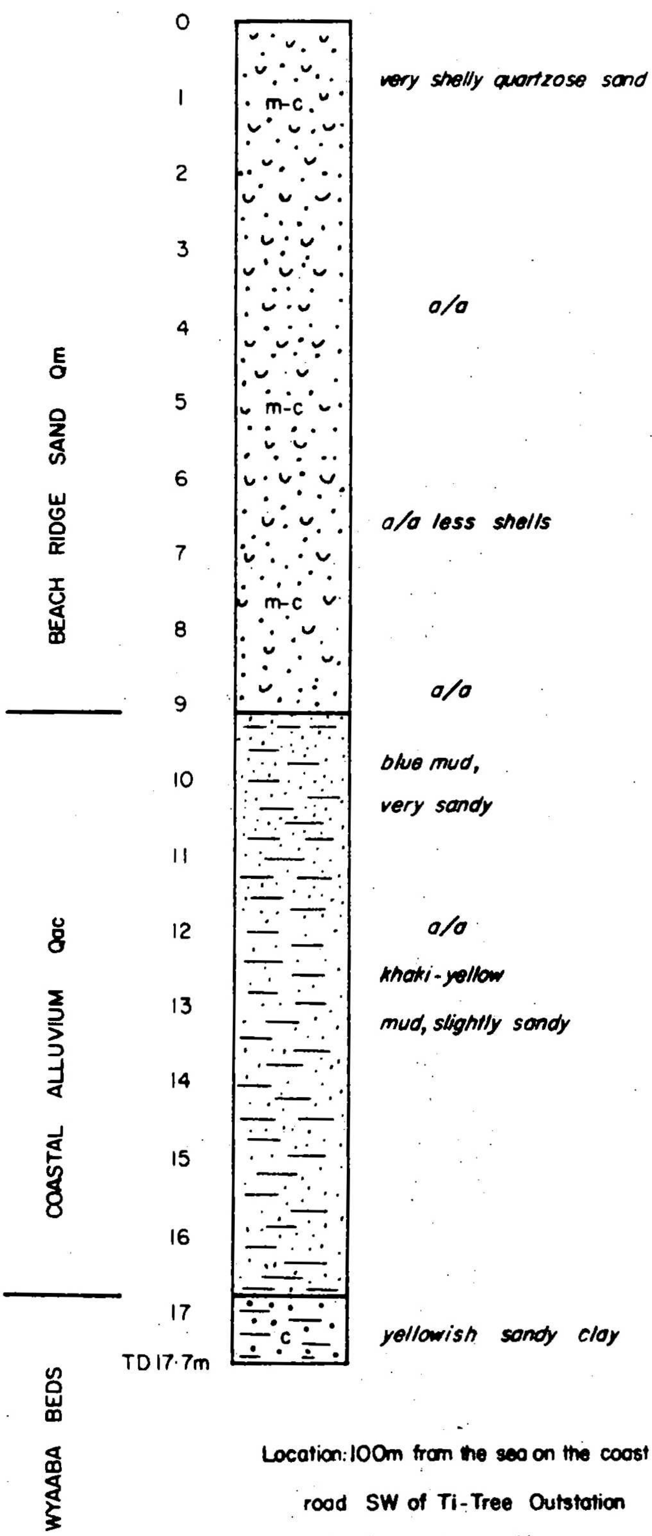

Location: East of Bull Yard ridge
14° 01/2'S 141° 36'E

BMR HOLROYD 11



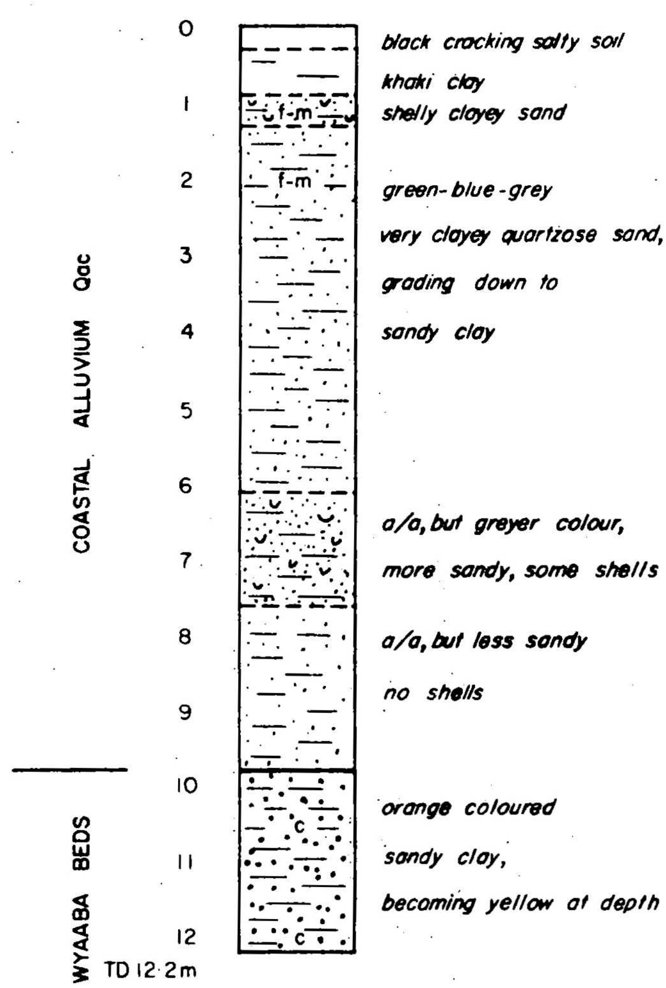

Location: On coast road SW of Ti-Tree
outstation 14° 0'S 141° 37 1/2' E

BMR HOLROYD 5




Location: 100m from the sea on the coast road SW of Ti-Tree Outstation 14° 04'S 141° 36 1/2'E

BMR HOLROYD 6

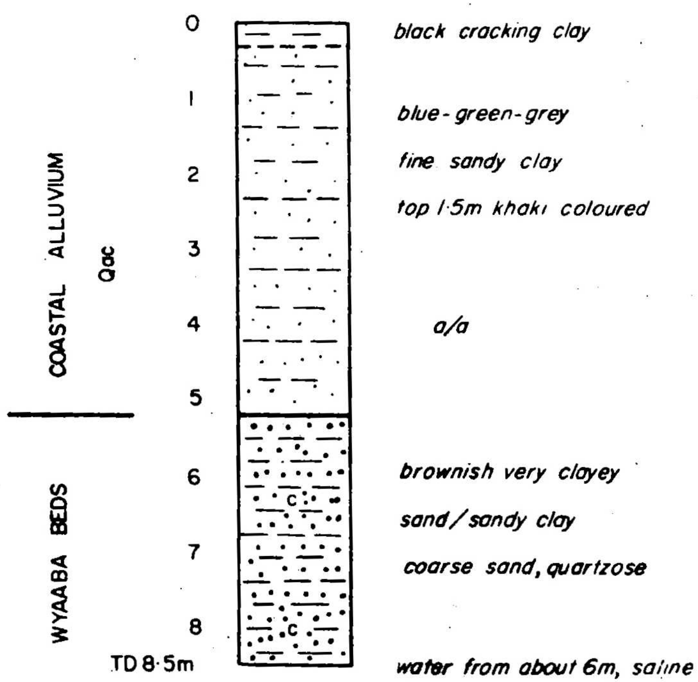



Location: In swale between ridges, E of BMR HOLROYD 5 14° 31/2'S 141° 35' E

To accompany Record 1976/16

Q/A/554

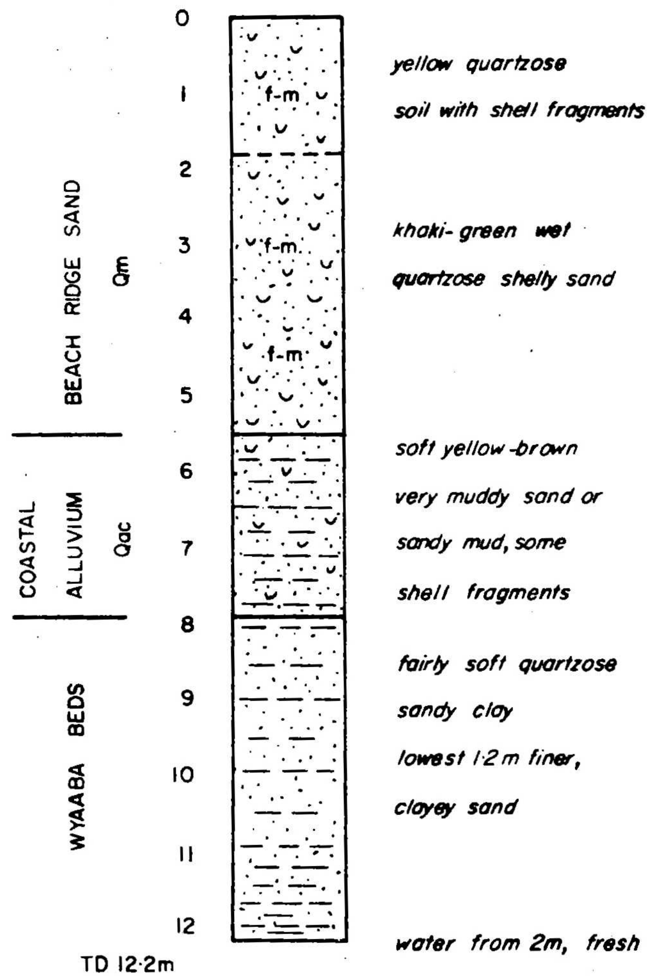
BMR HOLROYD 10




Location: On salt flats 300m west of

Holroyd 9 14°2'S 141° 36'E

BMR HOLROYD 9



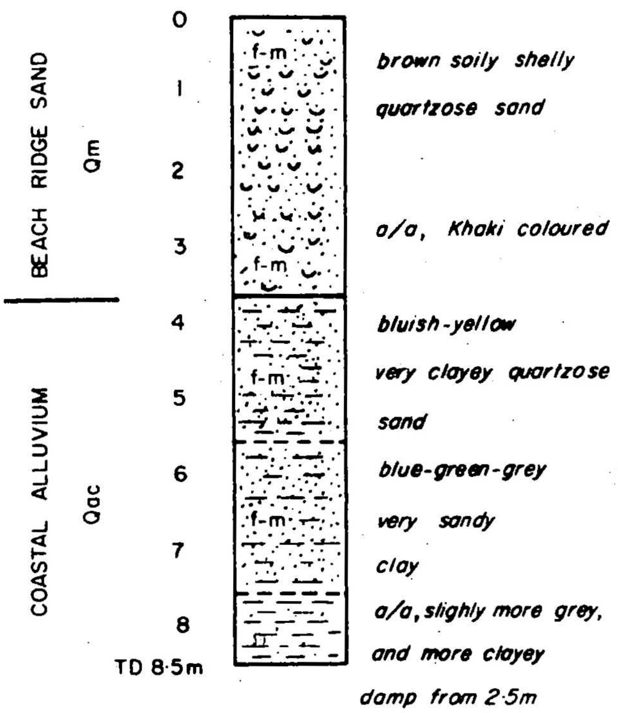

Location: West side of Bull Yard Lagoon

on sand ridge 14°02'S 141° 36'E

To accompany Record 1976/16

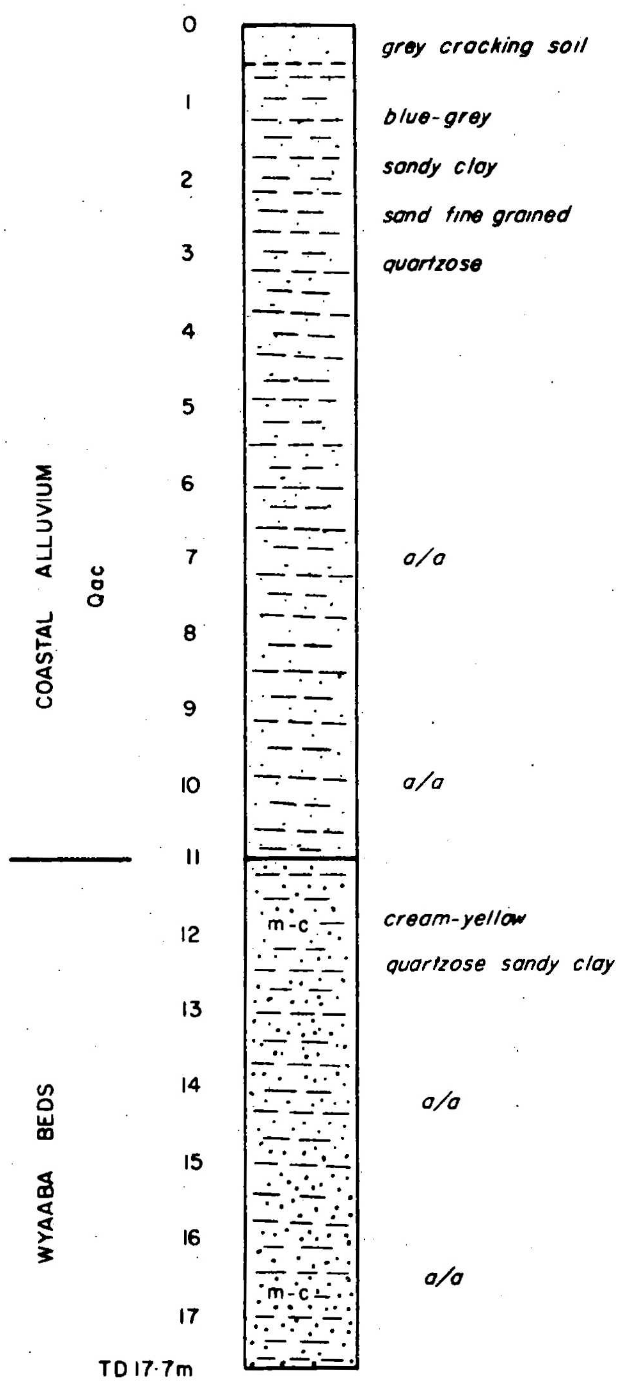
Q/A/556

## BMR HOLROYD 7



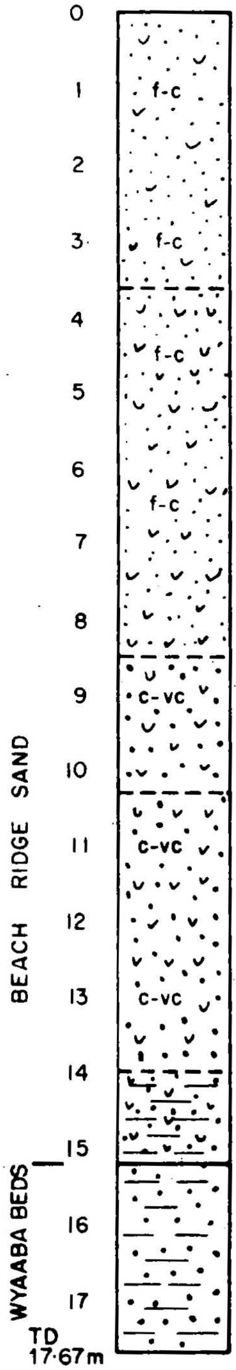

Location: In low valley within Beach Ridge Complex SW of Ti-Tree Outstation. 14° 41/2' S 143° 35' E

## BMR HOLROYD 8




Location: Middle of salt arm, SW of Ti-Tree Outstation. 14° 03' S 141° 35 1/2' E

## BMR AURUKUN 6




*brown fine to coarse quartzose sand. Minor ferruginous fragments minor shell fragments coarse size*

*a/a*

*a/a, shell fragment coarse to very coarse and abundant. Sand damp*

*a/a*

*a/a but coarser grain size yellow-brown colour. A few whole shell up to 1·5 cm*

*a/a, grey-brown colour*

*a/a*

*a/a, more clayey*

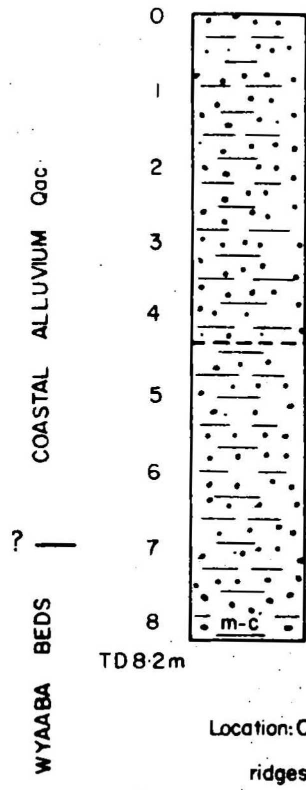
*grey-brown sandy clay*

*a/a, yellow-brown*

*water from 15·2m, saline*

Location: Beach ridges west of Don Yard, about 0·5km from the sea 13°40'S 141°30 1/2'E

## BMR AURUKUN 5




*heavy stiff clay, grey brown, becoming olive green below 0·6 m some medium-coarse quartzose sand, and some calcareous fragments*

*a/a*

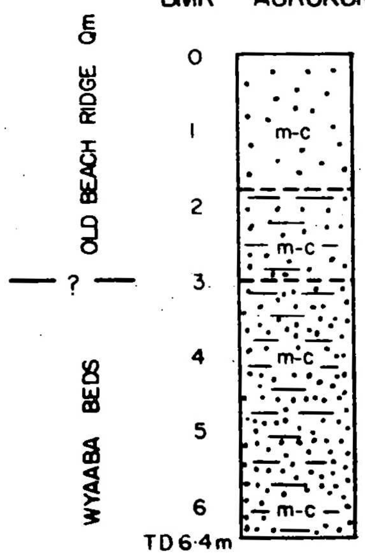
*salt water at 4·3m, colour paler cuttings are pale grey clay slurry with quartzose sand*

*grey-white clayey sand on bit*

*water from 4·3 m, saline*

Location: On rough gilgai flat east of coastal sand ridges, Don Yard fence line 13°40'S 141°32' E

## BMR AURUKUN 7




*poorly sorted quartzose sand, grey at top, becoming yellow-brown with depth*

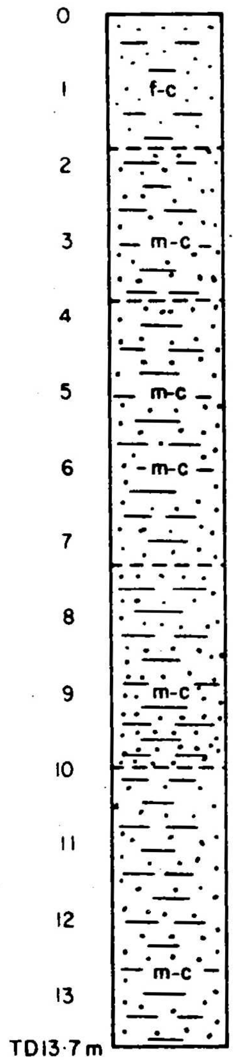
*a/a, but clayey*

*red, quartzose very clayey sand*

*water at 4·3 m*

Location: On low sand ridge 1·5 km west of Don Yard 13°40'S 141°32 1/2'E

## BMR AURUKUN 4




*poorly sorted slightly clayey quartzose sand. Grey-brown at top, becoming yellow and brown at depth*

*red-brown clayey quartzose sand, some red/yellow mottling*

*red-brown sandy clay, sand quartzose medium-coarse grained abundant pisolites and nodules up to 10mm*

*a/a, less lateritic material*

*brown sandy clay a/a, quartzose granules and pebbles up to 12 cm*

*more sandy, some pisolites present*

*white clay quartzose sand*

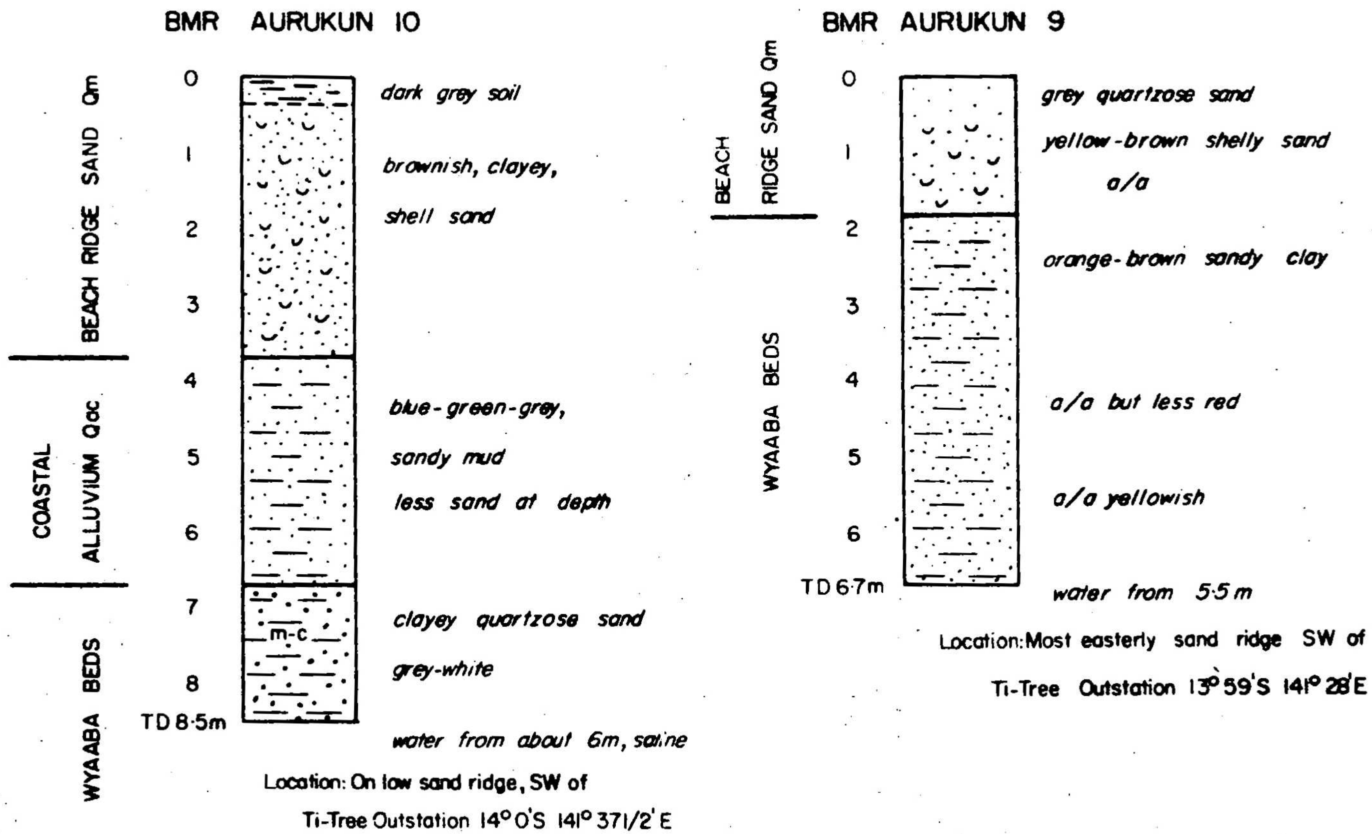
*a/a*

*water from 10m*

Location: On old beach ridge at Don Yard 13°40'S 141°33'E

To accompany Record 1976/16

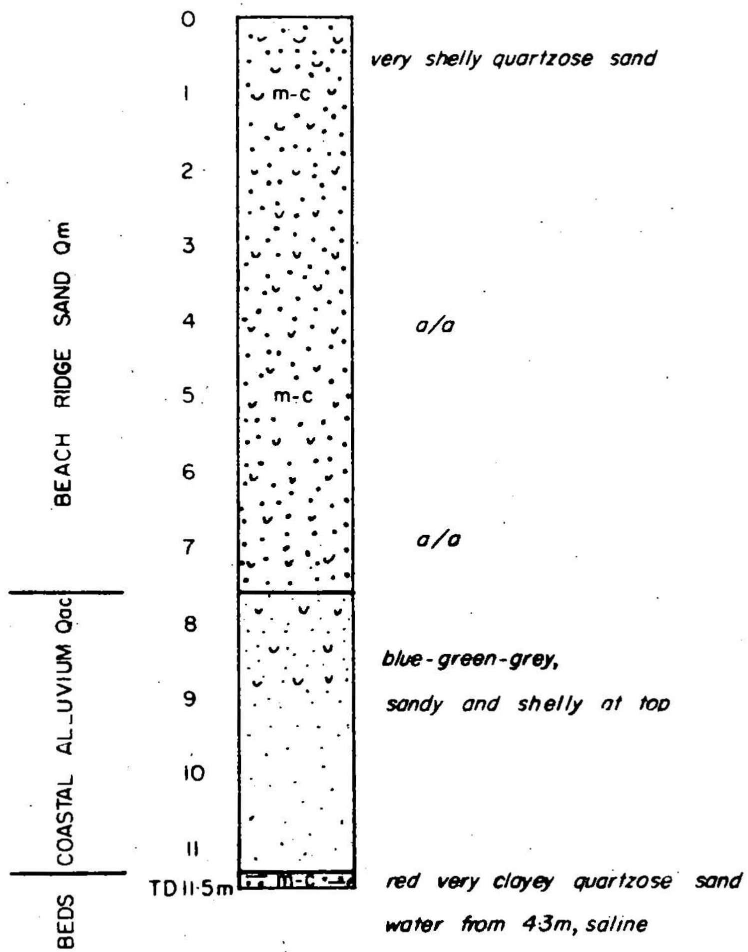
Q/A/558




To accompany Record 1976/16

Q/A/559

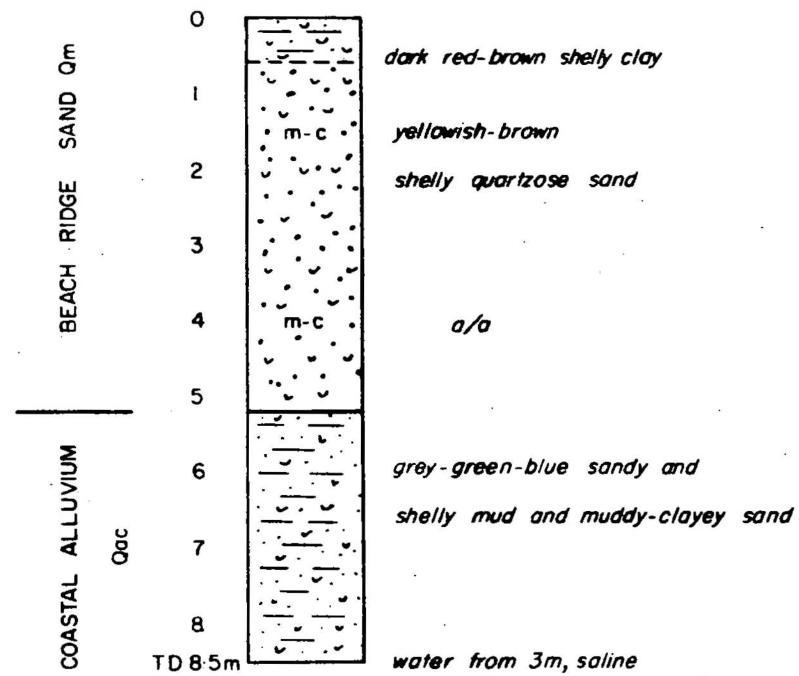
## BMR AURUKUN 13




Location: 200m from sea on fence line west of

The Lake 13°45'S 141°30'E

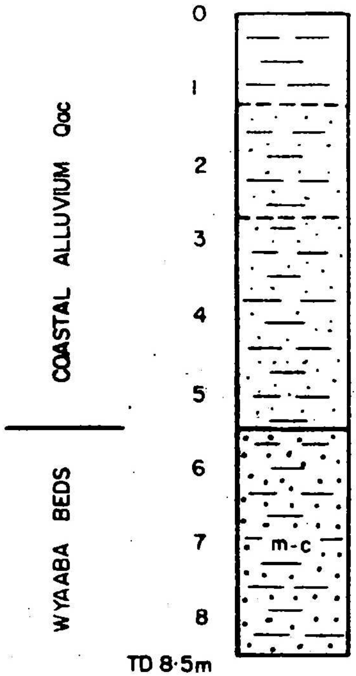
## BMR AURUKUN 14




Location: On fence line west of

The Lake 13°45'S 141°30'E

## BMR AURUKUN 15




*grey-khaki mud*

*blue grey mud,*
*slighly sandy*

*grey-green*
*muddy sandy, soft*

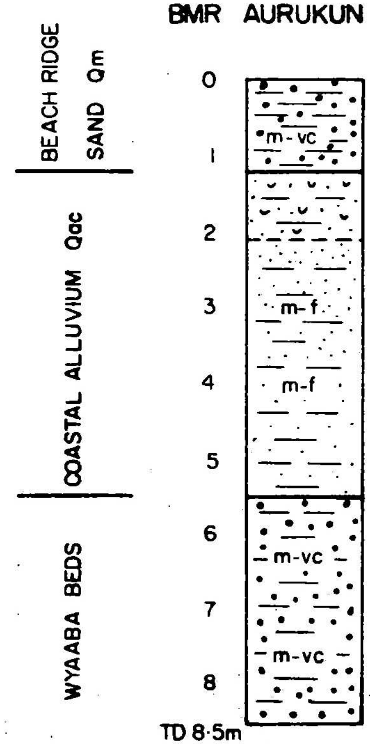
*hard, very clayey,*
*quartzose sand,*
*yellow colour,*
*pinkish towards the bottom*
*bottom 1·0m is, orange-brown*
*water from 5·5m, saline*

Location: On fence line west of

The Lake 13°45'S 141°32'E

To accompany Record 1976/16

## BMR AURUKUN 16




*quartzose very clayey sand,*
*medium-fine gained at top, then coarser*

*soft light khaki brown shelly,*
*sandy mud*

*grey soft sandy mud,*
*less sandy downwards*

*harder drilling at 5·5m*
*brownish clayey*
*quartzose sand,*
*becoming fawn*
*and white downwards*
*water from 52m*

Location: On fence line west of The Lake, on low

sand ridge 13° 45' S 141° 32'E

Q/A/561

## APPENDIX 2

## C14 DATING

Dating of samples was carried out by the Universities of Sydney and New South Wales and dates are attributed appropriately in Table 1. Samples submitted so far have been from the Holocene ridges only, but small amounts of material are on hand from the older ridges for further dating. All samples from the $Qhm_1$ and $Qhm_2$ ridges showed signs of leaching and some were partly cemented. The $Qhm_3$ samples appeared fresher. No checks were made on any samples for aragonite-calcite transformations. However, the ages obtained are all internally consistent and young seawards. They substantially agree with other dating of Holocene beach ridges (e.g. Cook & Polach, 1973).

Shells were cleaned by washing and brushing to remove dirt and cemented material and then the outer 10-15 percent was removed by acid. Ages were calculated using the N.B.S. Oxalic Acid reference standard.

Shells made of calcite such as Ostrea sp. were generally absent and the choice was generally limited to a Turritella-like gastropod and two pelecypods, one probably Anadara sp. Dating was carried out on all three shell types but no obvious pattern emerged (Table 1). Differences in ages between gastropods and pelecypods from the same locality are up to 900 years; the pelecypods generally, but not always, giving a greater age. Shells from present-day beaches have given ages up to 1350 years B.P. (HO 243) and were probably reworked from the adjacent $Qhm_3$ ridges. These shells could conceivably be incorporated in a younger set of ridges. Similar reworking and incorporation of older material could have operated in the past.

TABLE 1 (Appendix 2) C14 DATES

## AURUKUN 1:250 000 Sheet area

| Sample No. | Field No. | Lab. No. | Location | Age | Remarks |
|---|---|---|---|---|---|
| 72797020 | Au 20? | SU 185 | 13°53'S; 141°23'E | 4130 ± 80 | |
| 72797025 | Au 25 | SU 202 | 13°23'S; 141°38'E | 1110 ± 85 | |
| 72797026 | Au 26 | SU 203 | 13°23'S; 141°38'E | 910 ± 70 | |
| 72797011 A | Au 11 | SU 201A | 13°25'S; 141°41'E | 5330 ± 85 | bivalves |
| B | | SU 201B | | 4430 ± 85 | gastropods |

## HOLROYD 1:250 000 Sheet area

| Sample No. | Field No. | Lab. No. | Location | Age | Remarks |
|---|---|---|---|---|---|
| 72796243 | Ho 243 | SU 197A | 14°54'S; 141°37'E | 1350 ± 75 | bivalves ) present |
| | | B | | 470 ± 80 | gastropods) beach |
| 72796244 | Ho 244 | SU 198A | 14°54'S; 141°37'E | 750 ± 70 | bivalves |
| | | B | | 980 ± 75 | gastropods |
| 72796245 | Ho 245 | SU 199 | 14°54'S; 141°37'E | 995 ± 75 | |
| 72796246 | Ho 246 | SU 200 | 14°54'S; 141°37'E | 3935 ± 85 | |
| 73797110 A | Au 110 | NSW 120 | 14°04'S; 141°35'E | 1780 ± 70 | |
| 73797111 A | Au 111 | NSW 121 | 14°03'S; 141°36'E | 2600 ± 80 | |
| (Holroyd) | | SU 427 | | 2580 ± 115 | |
| 73797110 A | Au 110 | SU 429 | 14°04'S; 141°35'E | 1760 ± 95 | bivalves |
| (Holroyd)B | | SU 430 | | 1700 ± 100 | gastropods |
| C | | SU 431 | | 1790 ± 100 | bivalves |
| D | | SU 432 | | 2510 ± 140 | |
| 73797111 B | Au 111 | SU 428 | 14°03'S; 141°36'E | 2150 ± 100 | |

## GALBRAITH 1:250 000 Sheet area

| Sample No. | Field No. | Lab. No. | Location | Age | Remarks |
|---|---|---|---|---|---|
| 70795047 | Ga 47 | SU 183 | 16°42'S; 141°15'E | 5630 ± 120 | |
| 70795050 | Ga 50 | 184 | 16°42'S; 141°12'E | 820 ± 70 | |

NSW - University of New South Wales

SU - University of Sydney