CHAPTER 4

THE TOWNSVILLE COASTAL PLAIN

The Townsville coastal plain, bordering Halifax and Cleveland Bays, consists of three distinct parts. In the south, fringing the Muntalunga Range and extending between the mouth of the Ross River and Cape Cleveland, is a narrow chenier plain. West of Townsville the coastal plain widens into a large embayment in which the coastal plain rises to 400 feet. The main escarpment here is 15 miles from the sea. The embayment comprises the combined drainage basins of the Black, Bohle and Ross Rivers. Beyond the headwaters of the Ross a coastal "corridor" (Sussmilch, 1938) extends behind Mount Elliot through to the Haughton River. The watershed between the two catchments is poorly defined and less than 200 feet high. North of the Black River as far as the Herbert delta, the coastal plain narrows to a width of less than three miles in places. A steep escarpment leading up to the Tertiary erosion surface overlooks the coastal plain and materials produced by retreat of the scarp have contributed to the deposits of the plain. The escarpment in the north rises to over 3,000 feet in the Paluma Ranges, but falls to less than 2,000 feet in the Harvey Range further south. The isolated Mount Elliot massif forms the eastern boundary of the region.

Numerous outcrops interrupt the level surface of this coastal plain. Both these outcrops and the main escarpment are comprised largely of rhyolitic and andesitic flows of late Palaeozoic age into which a series of granitic rocks has been intruded (Wyatt, 1968). It is the granites which
generally form the larger outcrops such as Mount Elliot, Magnetic Island and the bulk of the Mount Stuart Range. The Frederick's Peak plateau is an isolated part of the Tertiary erosion surface, the spectacular pinnacle of Frederick's Peak itself being part of a dacitic ring dyke. The majority of the smaller hills are craggy outcrops of volcanic rocks with small exposures of conglomerate, sandstone and sedimentary rocks.

Previous investigations into the geomorphology of the area have been made, though on either a purely descriptive basis or on a general scale only. Physiographic descriptions of the area occur in the early reports of the Great Barrier Reef Committee. Hedley (1925) describes the Townsville plain explaining the higher parts and stranded beach ridges in terms of tectonic uplift. This report is valuable however, as a description of the lower Ross area prior to building development. A more complete and accurate description is provided by Jardine (1928). A shorter description of the area is found in Sussmilch's (1938) analysis of the geomorphology of eastern Queensland. Most recently the coastal plain deposits have been broken down into 'land systems' which correspond on a general level with the actual distribution described in this chapter. Christian et al (1953) ascribe the upper pediment and fan deposits to the Millaroo land system, the finer textured alluvials to the Rocky Ponds system, the clay plain away from the major streams to the Northcote system and the coastal environments to the Bowling Green and Littoral systems. A geomorphological reconnaissance of the coast area covered by this chapter was made by Driscoll and Hopley (1968). A number of revisions are made to the conclusions of this paper. The Bureau of Mineral Resources mapping of the area, though clarifying the solid geology adds little
to the knowledge of the coastal plain alluvials (Wyatt, 1968). Russell (1967), and Russell and McIntire (1965, 1966) have referred briefly to beach rock occurrences in the region and to the beaches of the Rollingstone area. Macnae (1966, 1967) describes the mangroves of the Townsville area. Thus, although a certain amount of literature is available for the Townsville region it generally lacks detail and no attempt has previously been made to define a chronology for the coastal plain deposits. A survey of the soils of the Townsville plain currently being carried out by the C.S.I.R.O. has greatly aided the compilation of this chapter (see below).

**The Muntalunga Chenier Plain**

The Muntalunga chenier plain is a small region comprising widely spaced cheniers of surprisingly varied lithologies and heights and resting on salt marsh or clay plain deposits. Although this type of morphology is restricted in the area covered in this research programme (analogous areas are found in Bowling Green Bay and near the mouth of the Bohle River), comparison with areas along a wider sector of the North Queensland coast suggests that this is typical of areas of low to moderate wave energy but capable of receiving high storm waves at widely spaced intervals (probably during cyclones) and where a direct source of supply of coastal sands from either off-shore or from an adjacent river mouth, is not available.

The major features of the geomorphology of the region are shown on figure 4.1. The proximity of the area to the extensive beach ridge series south of Cape Cleveland and the obvious contrast in beach materials promoted the same detailed examination of the Muntalunga cheniers. The
Fig. 4.1 Geomorphology of the Townsville area. Numbers refer to sampled chanlers.
results are seen in Appendix C and in graphic form in figure 4.2. Discussion of the results and comparison with the Cleveland ridges in terms of beach materials will be made in Chapter 6. The location of the five cheniers analysed is shown in figure 4.1.

The major ridge of the series is the one winging the Muntalunga Range (Ridge 2), a chenier with a thick aeolian cap rising to between 25 and 30 feet to the west of the range and to 15 to 20 feet to the east. In front of it is an expanse of tidal flat, periodically inundated by the highest tides but bare of all vegetation. Macnae (1966) has indicated that such areas are wetted by fewer than 117 tides per year. Behind the main dune ridge the cheniers rest upon a clay plain just beyond the reach of high tides (at about 3 feet above M.H.W.S.). Augering has indicated heavy black muds underlying this clay plain which are similar in all respects to those of the salt pans. The area is colonised by Sporobolus virginicus and by halophytes (Arthrocnemum leioestachyum, A. halocnemoides, Salicornia australis) which become more common towards the edge of the salt pans. Unvegetated salt pans also extend behind this higher area, the junction between the two levels often occurring as a low salting cliff.

Mangroves are extensive, occurring along the outer edge of the coast, between the cheniers near Ross River and along all the minor creeks draining the area. Avicennia spp. make up the outer edge of the littoral zone, with a Rhizophora spp. zone behind. Discontinuous Ceriops spp. thickets occur on the landwards side. Between the cheniers the lower wetter areas are colonised by forests of Rhizophora and Bruguiera, the higher areas by Ceriops. The creeks are fringed by either Rhizophora or Avicennia.
Landwards of these Holocene coastal deposits is a slightly higher area, its seaward margin marked by a low salting cliff, but gently sloping up towards the solid outcrops of the Muntalunga Range and Mount Stuart. Whilst the higher areas fringing the Ross River are undoubtedly Holocene river levee deposits, the remainder of this high coastal plain has solodic soils identical to those north of Townsville which will be given a late Pleistocene age (see below). The inner-most of the chenier ridges of the Muntalunga sequence rests upon this surface. The Ross River's levee and floodplain deposits are not extensive. Changes in river course discussed below indicate that the Ross has not long occupied its present position.

The cheniers are the most interesting of the features of this area. The detailed analysis tabulated in Appendix C was made of the cheniers to the west of the Muntalunga outcrop where the sequence is most complete.

a) Chenier 1

The outer-most ridge rises sharply from the surrounding salt pan to a height of 10 feet. Complete analysis was made of only the upper six samples as the lower part of the ridge, below 5 feet was composed almost completely of coarse shell grit. The overlying sands, the mean characteristics of which are indicated in Table 4.1, show an increase in carbonate content with depth and shell fragments make up the coarser fraction throughout. Mean size of these sands is comparatively coarse, within the range 1.2335 Ø to 1.5585 Ø. Sorting is only moderate throughout and the negative skewness of all but the surface sample suggests that an aeolian cap is lacking, though only the sample from 3 feet suggests a beach origin with any certainty. Kurtosis values are generally lower than those
<table>
<thead>
<tr>
<th>Ridge No</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean Size</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sorting (o)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Skewness</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kurtosis</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Carbonates</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Fig. 4.2 Characteristics of Muntalunga chenier deposits.
Table 4.1

Mean size, sorting, skewness, kurtosis and carbonate average values for each ridge

<table>
<thead>
<tr>
<th>Ridge No.</th>
<th>Mean size (φ)</th>
<th>Sorting (σ)</th>
<th>Skewness</th>
<th>Kurtosis</th>
<th>Carbonates %</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1.3973</td>
<td>0.8213</td>
<td>-0.1475</td>
<td>3.6361</td>
<td>42.0</td>
</tr>
<tr>
<td>2</td>
<td>2.0552</td>
<td>0.4829</td>
<td>-0.0756</td>
<td>4.7004</td>
<td>2.0</td>
</tr>
<tr>
<td>3</td>
<td>1.2872</td>
<td>0.8196</td>
<td>0.4831</td>
<td>3.7093</td>
<td>3.9</td>
</tr>
<tr>
<td>4</td>
<td>1.3771</td>
<td>0.8776</td>
<td>0.0527</td>
<td>2.7295</td>
<td>3.8</td>
</tr>
<tr>
<td>5</td>
<td>1.5080</td>
<td>0.8740</td>
<td>0.3500</td>
<td>3.7539</td>
<td>3.0</td>
</tr>
</tbody>
</table>
recorded for the Cleveland ridges.

The upper sands consist of angular quartz and feldspar grains. These become coarser at depth and form the non-calcareous fraction in the lower shell grits. This material is considered to be of local origin and is similar to the coarse granite sands being shed by both the Cape Cleveland and Muntalunga outcrops.

b) Chenier 2

This is the high dune ridge and has completely contrasting characteristics to the outer ridge. The aeolian origin of the sands is indicated by a smaller mean size (2.0552 φ), by better sorting and by a positive or only small negative skew. Kurtosis values are again moderate. Very low carbonate contents are recorded, giving a mean CaCO₃ value of 2.0%. A thick aeolian capping is undoubtedly found on this ridge. Only the upper 18 inches are humus stained, which is indicative of the young age of the ridge.

c) Chenier 3

The third chenier is just within the lee of the Muntalunga Range and rises to only 10 feet. Beach rock was struck at between 6 and 7 feet, at a height of about 3 feet above M.H.W.S. This may indicate a higher sea level at the time of formation of the beach rock. Unfortunately no large samples suitable for dating could be brought to the surface. The chenier is undoubtedly older than those to the seaward with humus staining down to 3.5 feet.

The sands are positively skewed throughout this chenier though the small fragments of beach rock from 6 feet contained coarser shell grit suggestive of a beach origin at this depth. The mean size of material is higher than that of the dune ridge and sorting is again only moderate.
Comparatively low Kurtosis values are recorded. Carbonate values are again low, but still twice those of the dune ridge. The conclusion reached is that Chenier 3 has a core of beach sands overlain by a 6-foot capping of aeolian sands. The nature of the dune sands is again suggestive of a local origin, probably material washed from the slopes of the Muntalunga Range.

d) Chenier 4

This feature is very similar to Chenier 3, though about 2 feet higher along the line of transect. All properties are similar to those of the ridge to seawards. Although beach rock was not found in this ridge, carbonate values increase with depth. However, the material is apparently aeolian throughout the depth examined.

e) Chenier 5

The most landward of the cheniers again displays a remarkable change in appearance. Resting upon coastal deposits which are interpreted as Pleistocene the ridge, not surprisingly, displays a profile of red oxidised sands throughout. It is also much wider than the ridges to seaward. However, its other characteristics are very similar to those of the two cheniers to seawards and it is evident that, although Pleistocene in age, and rising to 20 feet, the ridge has evolved in much the same way as the Holocene cheniers. The positive skewness throughout is suggestive of a dune origin for the sands. The gritty appearance of the coarser fraction suggests that this material too originated as slope wash from the Muntalunga Range.
The Bohle - Ross Plain

A large part of this area lies within the boundaries of the city of Townsville and reclamation and urban development have obliterated much of the original morphology, especially along the lower Ross River. Hedley (1925), for example, describes beach ridges on Ross Island between the Ross River and Ross Creek, but no sign of these features remains today as the whole area has been infilled and reclaimed. Extension of the harbour area has obliterated ridges at the mouth of the Ross River, though these are visible on the 1961 aerial photographs. Essentially this is a low lying deltaic area, much of it salt marsh less than 5 feet above M.H.W.S., across which the Bohle and Ross Rivers have migrated. Higher areas are provided by beach ridge sequences, Ross River levees and by the older Pleistocene deposits. The general morphology of the area has been controlled by the solid outcrops of Castle Hill, Mount Louisa and the Many Peaks Range.

The close proximity of the upper Ross and upper Bohle Rivers, which for a distance of 10 miles flow in parallel courses only a mile apart, is at first sight puzzling. However, detailed mapping of the levee deposits of both streams (fig. 4.1) indicates how this anomalous situation has come about. The oldest surface deposits indicating the former course of the Ross-Bohle system are found south of Mount Louisa where channel deposits trend east to west and are joined by a number of similar channels trending north from the present Ross River. They lead into a deltaic fan area extending from Mount Louisa northwards to Castle Hill. The beach ridge south-east of Mount St. John appears to have been deposited during an early stage of the delta's construction. However, this ridge is regarded as a
continuation of the shoreline found on the west bank of the Bohle estuary and which is definitely late Pleistocene in age (see below). The soils of the delta and channel deposits are much more highly developed than those of any clearly Holocene features of a similar type. The soils are solodics and, by comparison with the deposits of the coastal plain to the north, may be allocated a late Pleistocene age. The late Pleistocene Ross-Bohle Rivers thus appear to have flowed into a bay which now forms the Town Common.

In comparison to the solodic soils of the Pleistocene channels, the Holocene deposits display soils of a much earlier stage of formation, mainly red earths and red podsols. The oldest of the Holocene river courses is that which branches from the present Ross near its confluence with Five Head Creek to join the Bohle. As there are no indications of a Holocene diversion around the southern side of Mount Louisa it is assumed that this system flowed over the col between Mount Louisa and Mount Bohle. As bedrock outcrops in the stream at this point it is highly unlikely that this course could have been maintained at a low sea level stage and it seems likely that the joint Bohle-Ross flowed here during the latter part of the Holocene transgression. Evidence of a low sea level stage has been obliterated but it is assumed that the Ross and Bohle were quite separate systems during this stage.

North of the Mount Louisa-Mount Bohle col, the joint rivers were joined by Saunders Creek and appear to have incised themselves into the earlier Pleistocene deposits, breaking through the Pleistocene beach ridges and continuing northwards. As much of the Town Common is at a height which would put it below sea level during the postulated maximum of the Holocene transgression, the lack of a Holocene delta
in this region and the incision of the rivers into the Pleistocene deposits is suggestive of an age for this joint Bohle-Ross system prior to the maximum of the transgression. There is also no direct evidence of shoreline development associated with this stage. However, the large beach ridge series west of the present Bohle's mouth appears to indicate a sediment supply much greater than that of the Bohle River alone. The ridges themselves are young but appear to be fed from a large sub-aqueous sand accumulation north of the Bohle estuary and the Range of Many Peaks. It is suggested that this accumulation is the deltaic area of the joint Bohle and Ross Rivers.

Evidence from the upper catchment of the Ross River suggests that at the time when the Ross joined the Bohle, some of the major headwaters of the Ross, including Landsdowne Creek, joined the Major Creek drainage catchment which, in turn, joins the Haughton River. The watershed between the two systems is poorly defined today and the soil pattern of the C.S.I.R.O. pastoral research station at Landsdowne certainly indicates the truncation of Ross River headwaters (G.G. Murtha, pers. comm.). The eventual acquisition of new headwaters, combined with the Holocene transgression, may well have been the factors influencing the Ross River's abandonment of its course across to the Bohle and around the north-western corner of Mount Stuart. Subsequent courses have been as follows.

1. The Ross flowed north of a small isolated outcrop, meandered through what are now the western suburbs of Townsville and around the southern and eastern edge of the older Pleistocene delta, across to Castle Hill and out to sea in Rowes Bay. Most of the beach ridges trending north to the Range of Many Peaks were constructed at this time, the Town Common
forming a lagoon or marsh between the Ross and Bohle systems.

2. Meander migrations finally caused the Ross River to abandon the Rowes Bay mouth and to enter the sea at Ross Creek.

3. The latest change has been a migration south to the present Ross estuary.

The latter part of this sequence was accompanied by incision of the river into its levee deposits, probably as a result of downward movement of the sea level over the last 3,000 years demonstrated by evidence from adjacent areas. However, the Ross during floods can still utilise all its former courses. Hedley (1925) records that the Ross can still revert to a course which flows out to sea at Rowes Bay. Sedimentation and marine regression have combined to produce the salt marsh of the Town Common and to connect the Range of Many Peaks to the mainland by more than the Rowes Bay beach ridge sequence.

Remnants of a Pleistocene beach ridge sequence are found on the western side of the Bohle and also just east of Mount St. John. These will be discussed with the deposits of the coastal plain to the north.

The evidence suggests that the Range of Many Peaks was an island during mid-Holocene times. The area is shown in figure 4.3. Even the southern side of the range has undercut slopes and small undercut stacks. The northern side of the range has a series of moderately developed shore platforms at varying heights (see Chapter 7) together with some shallow caves partially concealed beneath the sand ridges which rest against the solid outcrop. On the western end of the former island (or pair of islands) is a stable vegetated boulder spit rising to nearly 15 feet. The boulders
Many Peaks area. Range 0 mile line of eroded SPI; sand and Cape Pallarenda BayHalifax Bohle estuary

Fig. 4.3 Range of Many Peaks area.
are roughly graded along the spit, having a diameter of up to 2 feet at the anchor point to less than 1 foot at the tip of the spit. The southern end is buried beneath coarse sand deposits, but drilling has confirmed the present of boulders 2 to 3 feet beneath the sand along the entire length of the feature. The close resemblance of the boulder spit to similar features on the off-shore islands which have been shown to be mid-Holocene in age may indicate a mid-Holocene age for the Many Peaks spit.

Large beach ridges are found around the Range of Many Peaks. South of Cape Pallarenda is a dune 20 feet high which is a continuation of the Rowes Bay ridges. Behind this, however, is a higher dune 25 feet high. Although humus staining in this inner dune extends to 3 feet, the sands are not weathered in any way and appear quite fresh at depth. The ridge is considered Holocene, possibly mid-Holocene in age.

A contrasting series of ridges is found on the northern side of the range behind Shelly Beach. The inner ridges are simple dunes, infilling a small embayment. The outer-most ridge, however, is more complex. It grew in the form of a spit with many curved laterals from an anchor point at the eastern end of the Many Peaks Range. The western end is still extending but the spit has been broken by erosion in the anchor point section and the mangrove depression behind is now exposed on the present beach. East of the break, a sand mound is the only sign of the former spit. Just west of the point where mangrove muds and roots are exposed on the beach, is a complete section through the ridge and in this area a small patch of beach rock is exposed in a position which would put it in the centre of the former ridge. This material is friable and only lightly
cemented but the strike of the deposit follows the line of the spit, not that of the present beach. The height of this outer ridge is 10.5 feet.

The second ridge rises to a maximum of 19.8 feet, but has a general height of between 11 and 12 feet. It has been fretted along its northern edge by the mangrove creek between it and the outer spit and this has revealed some good sections through the ridge. Shell grits form the lower 5.25 feet and these are overlain by dune sands which still appear to be accumulating. An aboriginal midden site, complete with charcoal, heat-shattered rocks and punctured shells was found in one section 2 feet below the surface. Radio-carbon dating of the charcoal gave a result of 840 years ± 80 B.P. (GaK-1109). Thus 2 feet of dune sand has accumulated since this date. As the location of such camp sites is normally close to the beach it is suspected that the outer spit may have been constructed since this date. The second ridge is older. Its alignment is continued in the west by a band of firmly cemented inter-tidal beach rock, though the ridge itself has been truncated by the present beach. It is not surprising to find beach rock at the base of this ridge considering the shelly nature of the basal material. Shell from the beach rock gave a radio-carbon age of 2,460 years ± 80 B.P. (GaK-1508).

The inner-most ridge is an extremely broad one having a maximum width of nearly 200 yards. It has several crests, the outer one, the highest, reaching 27.5 feet, though the general level is not much more than 15 feet. This is an older ridge resembling the inner dune at Cape Pallarenda. Beach rock was encountered in two auger holes at 3 feet and 7 feet. Unfortunately exact heights of this cemented deposit could not be taken, but it is estimated to occur at approximately 12 feet above M.H.W.S. This is
strongly suggestive of a mid-Holocene age.

The Bohle River enters the sea less than half a mile west of the Range of Many Peaks. A complex history is indicated for this area. A wide series of beach ridges is found on the western side of the Bohle north of the Mount Low Range. These are comprised of dominantly quartzose sand throughout. A 10-foot section exposed in the west bank of the Bohle at the rear of the sequence indicates 8 feet of dune bedded quartz sands overlying coarse grits. The whole sequence rests upon a heavy clay base rising to M.H.W.S. which suggests that the feature is better described as a chenier than a beach ridge. In contrast to the western ridge sequence a small series of ridges is found on the east bank widely separated by mangroves and salt flat. These all rest upon a similar clay base of constant height but their materials are quite different from those on the opposite bank. From the seawards side inland the sections exposed in the ridges are as follows:

<table>
<thead>
<tr>
<th>Depth</th>
<th>Description</th>
<th>Mean size (6)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ridge 1</td>
<td>0 - 4.4 feet</td>
<td>Shell grit</td>
</tr>
<tr>
<td></td>
<td>4.4 down</td>
<td>Heavy clay</td>
</tr>
</tbody>
</table>

This ridge is found behind mangroves and curves as a spit to a small granitic outcrop near the Bohle's mouth.

<p>| Ridge 2 | 0 - 0.25 feet | Humic stained calcareous sand | 0.7625 |
|         | 0.25 - 1.0   | Sand and shell slightly stained | 1.2046 |
|         | 1.0 - 2.0    | Fine shell grit               | 0.4908 |
|         | 2.0 - 2.5    | Coarser shell grit            | 0.2243 |
|         | 2.5 - 5.0    | Coarse shell grit             | -0.6190 |
|         | 5.0 down     | Heavy clay                   | -     |</p>
<table>
<thead>
<tr>
<th>Depth</th>
<th>Description</th>
<th>Mean size (φ)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ridge 3</td>
<td>0 - 0.4 feet Humic stained sand with shell</td>
<td>0.6258</td>
</tr>
<tr>
<td></td>
<td>0.4 - 0.75 Sand and shell grit</td>
<td>0.7393</td>
</tr>
<tr>
<td></td>
<td>0.75 - 1.8 Fine shell grit</td>
<td>1.0176</td>
</tr>
<tr>
<td></td>
<td>1.8 - 6.3 Shell grit lightly cemented at base</td>
<td>-0.2290</td>
</tr>
<tr>
<td></td>
<td>6.3 down Heavy clay</td>
<td>-</td>
</tr>
<tr>
<td>Ridge 4</td>
<td>0 - 1.2 feet Humic stained sand and shell</td>
<td>0.8821</td>
</tr>
<tr>
<td></td>
<td>1.2 - 4.25 Shell grit</td>
<td>0.8408</td>
</tr>
<tr>
<td></td>
<td>4.25 down Heavy clay</td>
<td>-</td>
</tr>
<tr>
<td>Ridge 5</td>
<td>0 - 6 feet Brown quartz sand</td>
<td>2.5270</td>
</tr>
</tbody>
</table>

This is a higher ridge rising to nearly 10 feet. No base to the sand was reached at 6 feet.

Behind Ridge 5 is another area of low sand ridges of similar material. The contrast between these ridges and those to seaward is remarkable. However, ridge 5 and associated remnants appear to be an extension of the similar though higher ridges to the west on the opposite bank. Their lower altitude appears to be the result of their position in the lee of the Range of Many Peaks. Meander traces indicated on the aerial photographs suggest that the Bohle formerly flowed further east close up against the boulder spit on the end of the Many Peaks Range. Examination of the area indicates that shell grit material originates around the rocky shores of the Range moving westward to the Bohle's mouth. The depth of the Bohle estuary, however, does not allow coarse shell grit to pass across it. Thus, when the Bohle flowed further east, the ridges to which it was contributing material received only the quartzose sands of the Bohle itself. Since the river has migrated west and
breached the beach ridge or chenier barrier, the coarser shell grit has been transported further west to form the shell grit cheniers of the eastern bank (see fig. 4.3). The migration of the river mouth also led to the construction of a new set of beach ridge-cheniers to the west with a slightly different orientation to the older ones which they truncate.

Three radio-carbon dates from the outer shell grit cheniers give an indication of both the rate of chenier construction (where the material is almost completely biogenic) and also of the date when the Bohle took up its present position. Charcoal within a narrow pumice layer in the outer ridge gave a date of 1780 years ± 90 B.P. (GaK-1108); shell from the second ridge dated at 1320 years ± 70 B.P. (GaK-5110); and shell from the third ridge at 2350 years ± 90 B.P. (GaK-1511). The first date is probably too old, the ridge accumulating driftwood of much greater age. It is obvious that growth of cheniers in this situation is extremely slow and each one is possibly dependent upon a catastrophic event such as the passage of a tropical cyclone. The Bohle probably took up its position about 2,400 years ago. The indications are that sea level at this time was not much different from that at present and has varied little in the intervening period.

The Coastal Plain North of Townsville

This region includes the large embayment around the headwaters of the Black River and the narrower coastal plain to the north. It is an area of extremely complex deposits which, in general, form massive coalescing alluvial fans and distributary systems radiating out from the base of the coastal escarpment and from the isolated coastal
Holocene River deposits
Mid-Holocene Terraces
Fans
Younger clays
Older clays
River deposits
Coarser outwash
Beach ridges

Late Pleistocene

Fig. 4.4 Coastal plain deposits.
hills. However, the pattern of simple grading of deposits from coarse to fine towards the coast is complicated by the presence of fans and alluvial deposits of varying ages. Also, the accumulation of deposits during fluctuations of sea level has resulted in alternate phases of incision and aggradation, at least in the zone within a few miles of the present coast. Fluctuations in the climatic pattern between sub-humid and humid with corresponding fluctuations in geomorphic processes further adds to the complexity of the deposits.

This section of the chapter attempts to unravel the changes mentioned. Interpretation has been greatly helped by a soil survey of the same area by the C.S.I.R.O. (Mr. G.G. Murtha, Soils Division, Townsville) and it is largely with the co-operation of C.S.I.R.O. that the map of deposits (fig. 4.4) has been drawn. Thus the interpretation is based not only on geomorphological data but also on a description of soil and weathering profiles. Figure 4.4 indicates fourteen separate types of deposits apart from the solid outcrops. These fall naturally into two divisions, an older, apparently Pleistocene series and a younger, Holocene series, though age differentiations can be made within these two broad categories.

Pleistocene Deposits

1. **Solid Outcrops and Pediments**

All solid outcrops are ringed by a pediment slope of varying width and inclination, with one exception, the Range of Many Peaks, where any former pediments have been trimmed back by the sea or are found beneath the surrounding coastal deposits. Only one other outcrop occurs
on the coast, Mount Douglas, and though pediment destruction by marine processes is taking place here, the exposures are probably the most significant in the whole area. Elsewhere the pediments extend up to one and a half miles from the sharply defined pediment angle and have a slope of up to 15°. Bedrock protrudes through the pediment deposits in many places, and the veneer, away from the major fans, is relatively thin, of the order of 5 to 10 feet. These deposits have great variety and appear to be a composite cover of several periods. In places they may be seen to consist of boulders and sandy loams with only slight signs of leaching and are of apparently Holocene age. They overlie, with an abrupt transition, heavy clays which grade into sands, gravels and boulders of probably Pleistocene age.

The occurrence of clays within the pediment deposits is indicative of a break in the process of pedimentation. Indeed, it is doubtful whether the pediments are extending themselves at present, for the majority of streams, though flowing only seasonally, are incised into the deposits and into the pediment itself. However, there are indications that pediment deposits in the form of fans have accumulated during the Holocene (see below). There appears to have been no continuity in the development of pediments and deposits between the earliest examples of Pleistocene age, and the later Holocene features. Thus Pleistocene river deposits indicating channel flow, as opposed to the laminar flow required for pedimentation, also cross the pediments. The best example of this is found in the headwater of the Alice River below Frederick's Peak where a linear deposit of weathered fluvial sediments crosses the pediment between the main escarpment and Mount Margaret. Complete stabilization and cementation of the older pediment and fan deposits has also occurred and they have in general not
become mobile again during the more recent period of similar accumulation.

Sections in the pediment deposits are rare and the exposures at Mount Douglas on the coast are thus of great interest. Mount Douglas is a narrow ridge of volcanic rocks about 1,200 yards in length and 250 yards wide which rises to 157 feet (fig. 4.5). It is the only rock outcrop in the mainland littoral between the granite tor at the mouth of the Bohle River and Tam O'Shanter Point near Tully some 120 miles to the north. As a guide to the nature of pediment deposits and the weathering processes which have operated in this part of North Queensland, the sections exposed along the shore are invaluable. The Mount Douglas site gains further significance as it lies on the climatic boundary between the Aw climates to the south and wetter Af and Am climates to the north. Although no records are available for the Mount Douglas area, it is estimated that the average annual rainfall here is in the range of 50 to 55 inches.

The geology of the area is complex. Mount Douglas is the last of a line of similar hills trending east-south-eastwards across the coastal plains from the main escarpment (fig. 4.4). It is composed of late Palaeozoic volcanic rocks which on the landward side are mainly tuffs, but which along the coast are fluidal and spherulitic rhyolites. The crest of the ridge to the west is determined by an intrusion of massive porphyritic rhyolite about 20 feet wide and smaller intrusions of similar material outcrop intermittently along the coast. Sand beach ridges trend northwards and southwards from the headland. Behind these and extending right to the base of the ridge is a coastal plain about 15 feet above M.H.W.S.
Fig. 4.5 Mount Douglas. Section lines are indicated.
Appreciation of the sections on Mount Douglas cannot be made without a consideration of the current processes of rock disintegration. A contrast in general weathering processes is observed in the area within and outside the rainforest which clothes the coastal escarpment behind Mount Douglas. Slope deposits in the rainforest appear to be quite stable even on 20° slopes. Occasional cuttings along the roads in the ranges display up to 30 feet of deeply weathered material predominantly red kaolinitic clays, overlying a partially decomposed granite in situ. The boundary between the two levels is sharp. The lighter vegetation cover of the lower rainfall areas appears to be the main influence on the greater instability of slope deposits here. During the dry winter season there is comparatively rapid mechanical breakdown of the rocks, of a granular type on granites and by fracture along joint and flow lines on volcanics. The torrential downpours of the wet season allow for a rapid downslope movement of these materials.

Mount Douglas is typical of these less humid coastal hills. Its open woodland vegetation consisting, of a tree storey dominated by Eucalyptus tessellaris, E. polycarpa and E. drepanophylla and a medium height herbaceous layer (mainly Heteropogon contortus), leaves much bare ground especially towards the end of the dry season. The angular regolith which clothes most of the ridge is susceptible to rapid soil creep and debris slides during the wet season.

Under normal sub-aerial weathering, the tuffs and rhyolites generally break down into angular rubble. However, the porphyritic rhyolites along the crest are more resistant and produce tor-like forms surrounded by large boulders. Both tors and boulders are subject to spherulitic weathering, individual spherules being about half an inch in
diameter giving the rock surface the appearance of a conglomerate. Within the spray zone the rhyolites are subjected to wetting and drying and/or exsudation. Here, the porphyritic rhyolites decompose quickly and become kalinised. Rapid decomposition is also experienced by the spherulitic rhyolites but the fluidal rhyolites take on a polished, highly resistant surface, and it is these rocks which form the small promontories around the headland.

Rock outcrops along the crest of the ridge, in the form of tors at the western end and as a dome partially buried by angular rubble in the centre of the ridge. The whole of the landward slopes are covered with active slopewash rubble. Two small excavations near the base indicate at least 4 feet of this material.

The seaward side of Mount Douglas is of greater significance. For the most part the littoral zone consists of convex cliffs slightly steepened at their bases and with a few poorly developed shore platforms which have been described previously (Driscoll and Hopley, 1968). However, at the western end and in a small cove to the east (fig. 4.5) are the remains of a former weathering profile, consisting of lateritized slopewash material which is now being subjected to cavernous weathering.

The western exposures are by far the best, and here the full profile of approximately 8 feet can be seen. The material is a stabilised slope deposit consisting of angular debris with individual boulders up to 3 feet in diameter. This closely resembles the active slopewash deposits, especially close to the summit of the ridge, where the calibbre of the material is larger. Following stabilisation the deposits suffered a period of deep weathering and lateritisation. Sesqui-oxides are
concentrated in the upper one and a half feet of the profile in sufficient quantity to produce a cap-rock effect. However, the iron concentration is by no means as high as that observed in the laterite of the uplifted late Tertiary surfaces behind the coastal escarpment. Below this upper horizon is a mottled zone about three and a half feet deep, followed by a kaolinised pallid zone of about 3 feet. In all three horizons the original boulders of the slopewash deposits are clearly seen, but individual boulders are completely rotted. The full profile is not seen over the complete exposure and in places it is only the kaolinised material which remains. Where this occurs, this lower part of the profile is silicified.

The morphology of the outcrop can be seen in the sections of figure 4.6. The indurated material emerges from beneath active slope deposits about 20 feet above mean high water mark and with a slope of about 18°. In only one place can the horizon be traced higher (on the headland near profile G-H) and here it rapidly thins as the slope increases. The main outcrop is cliffed with cavernous weathering extending the work of marine agencies so that the sharp break of slope is retreating in a parallel fashion from the shoreline. In front of the cliffed exposure is a shore platform actively being extended though the remains of another platform some 4 feet higher may be present and may be the line from which the erosional scarp is retreating. If the slope and depth of the lateritic material were constant from the main outcrop, one would expect the maximum width of the shore platform to be only 25 feet, with a progression upwards through the profile so that the lateritic material would be outer-most on the platform. However, a decrease in slope is suspected for the platform has a width of up to 90 feet, with the entire extent being cut into the mottled and pallid
Unweathered boulders

Pitted silicified platform

Deeply weathered rock in situ

Unweathered rock dome

Present slopewash

Angular slopewash material

Beach sand

Silicified

Unweathered rock dome

Sand

See detail

Detail of cliff base only

Lateritised material

Beach sand

Detail of cliff base only

Lateritised material

Beach sand

Probable weathering front

Thin veneer of angular fragments

Fig. 4.6 Mount Douglas sections.
zones. In places the ancient weathering front, in the form of much weathered rock in situ, outcrops on the surface. This can also be seen in places along the main exposure. Both the rotted rock and the lateritic-silicified material within the inter-tidal zone are deeply pitted. At about mean high water mark, remnants of the silicified zone are found as pedestal rocks.

The smaller outcrop to the east is very similar, though the low cliff with its cavernous weathering is found behind a beach berm which completely masks any extensions of the deposits as platforms. However, 100 yards to the west is a small platform cut across deeply weathered rock in situ (Section I-J). Unweathered rock forms the cliff behind, but the relationships here suggest that whilst marine erosion is responsible for the lower and steeper portion of the cliffs of Mount Douglas, the bare upper convex slopes of some of the lower headlands are exhumed weathering fronts.

The ancient weathering profile clearly extends below present sea level suggesting a late Pleistocene aged during the latest low level stand of the sea. The material subjected to deep weathering, and the deep weathering episode belong to contrasting climatic conditions. The angular nature of the material and its position at what appears to be a pediment angle suggest the origin of the material as an unstable piedmont fan extending over a pediment with a slope of about 3°. The nearest location on the coast where similar landforms are active today is in the granite area behind Bowen 120 miles to the south, though even here there is evidence that the pediments and deposits at least originated in the late Pleistocene as they slope beneath Holocene alluvial deposits. On and around Mount Douglas similar slopewash materials are active today, though of a smaller calibre and without obvious signs of pedimentation.
The original climate for the assembling of the weathered deposits is suggested to be one slightly drier than today with a rainfall possibly in the order 30 to 35 inches and probably extremely seasonal.

The stabilisation of the deposits and subsequent severe weathering suggests a trend of the climate in a more humid direction. This could be attained by a southward movement of the tropical disturbances which bring the heavy, extended rains to the coast north of Ingham. Similar deposits are reported in the Herbert River Delta near Ingham (De Keyser, Fardon and Cuttler, 1965) and these are commonly mottled and cemented.

The latest trend has been towards dessication allowing the induration of lateritized material and initiating slopewash activity. The ancient pediment junction and its deposits are being covered by small angular material. The rising Holocene sea level has initiated the parallel retreat of the lateritic horizon. The steeper slopes of Mount Douglas probably never allowed a deeply weathered mantle to form over the whole ridge. However, parallel retreat is as much responsible for the removal of the cover from the lower slopes (including the present headlands) as marine erosion.

The original Holocene shorelines were seawards of these exposures. East of the main exposure are three lines of boulders marking the trends of three former shorelines (lag gravels of Driscoll and Hopley, 1968, see below). The beach ridges behind the present beach are all extremely young and it is evident that the shoreline has been in a position to expose the lateritic material in this area for only a short period of time. Similarly, lines of boulders across the mouth of the small cove in which the other exposure is found also suggest a protective barrier here.
2. **Pleistocene Outwash Fans**

   Around the base of Frederick's Peak, the piedmont deposits tend to take on the morphology of true outwash fans. A Holocene fan series is found here (see below) but beneath and beyond this is an older outwash deposit interpreted as Pleistocene. Closer to the scarp foot it tends to rise above the younger fan, possibly indicating an originally steeper slope to the Pleistocene deposits. The materials are composed of bleached sands overlying waterworn gravels. The main feature distinguishing the Pleistocene deposits from the later fans is the presence of ironstone nodules and iron impregnated gravel throughout the section. The lower gravel may be cemented in places.

3. **Pleistocene River Deposits**

   Sandy deposits overlying coarse sands and water-worn gravels at depths of 5 to 6 feet, occur as linear extensions over various parts of the coastal plain. The majority of present coastal streams have steep levee banks rising above the surrounding plains and the morphology of the Pleistocene deposits suggests a similar formation as they form low rises, though they may only be detected as such by detailed survey. The deposits are strongly leached, though there may be a concentration of ferro-manganese nodules at a depth of 3 to 4 feet.

   The most extensive area of these deposits is in the north across the narrower part of the coastal plain. The closely spaced pattern reflects that of the present streams, but the current drainage lines are unrelated to the Pleistocene deposits. The drainage lines are particularly close around Bluewater Creek where they form a large fan-type distributary system, probably indicating the sphere of migration of the proto-Bluewater during late...
Pleistocene times. Further south the channel deposits are limited to the upper parts of the Black River embayment. They tend to form fan-like aprons of closely spaced channels just beyond the pediments but on morphological grounds appear younger than the Pleistocene outwash fans and tend to be more restricted to true channels. A particularly prominent drainage line trending west to east in the headwaters of the Alice River appears to anticipate the Little Bohle River.

4. **Pleistocene Sandy Outwash Plains**

Surrounding the clearly delineated river deposits are areas of weathered sandy alluvials which appear to be the old floodplains of the Pleistocene river system. Aerial photographs indicate signs of channelled flow within these areas but in general they appear to be lower than the highest parts of the channel deposits. They may have formed the lower parts of the levee system.

These deposits are generally strongly leached coarse sands on the surface becoming mottled and clayey at depth. Coarser fine gravels may be encountered at depth and especially within the Black River embayment. At between 4 and 5 feet siliceous or ferruginous nodule pans are encountered. Concentrations of silica or ferro-manganese nodules at depth appears to be diagnostic of the Pleistocene deposits (see below).

5. **Older Pleistocene Clay Plains**

By far the largest area of the coastal plains is taken up by clay deposits forming solodic soils with a very even surface, sloping imperceptibly down to the sea. The deposits are of a duplex nature consisting of silt size or even sand size material in the upper one or two feet but invariably overlying heavy clays. They generally occur on
the interfluve areas and indicate low energy environment depositional conditions. Some of the deposits may have originated under marine or littoral conditions and may be older than the last interglacial.

Like many of the other deposits of Pleistocene age, the clay plains contain ferro-manganese nodules, sometimes throughout the soil profile, more commonly in the lower layers. Concentration of these sesqui-oxides in the profile is the result of seasonal fluctuations in the water table, impregnation following the lines of least resistance where water can circulate (Maignien, 1966). Current research being carried out by C.S.I.R.O. in Townsville has indicated that even in the wettest years in the area at present, such fluctuations are limited to the upper 3 feet of the heavier deposits. Accumulation of sesqui-oxide nodules is thus limited to the upper few feet, a much more restricted area than that found in the Pleistocene clays. It is considered that wetter conditions, though still with a strong seasonal rhythm, were required to form the bulk of ferro-manganese accumulation.

Nodules of calcium carbonate up to half an inch in diameter are also found in the profiles, from about 12 inches down. It is difficult to envisage conditions which would promote the precipitation of both sesqui-oxide and carbonate nodules together, and with the leaching factor of CaCO$_3$ being up to 75 times more rapid than that of iron (Miller, 1961) the carbonate nodules are considered to belong to a drier phase occurring between the period of ferro-manganese accumulation and the present. A radio-carbon date on one carbonate nodule suggests that there was a period of carbonate accumulation approximately 15,000 years ago (see below, Pleistocene Shorelines).
6. **Younger Pleistocene Clay Plains**

   The older Pleistocene clay plains are limited to the seawards end of the coastal plain system, generally below 100 feet. Above this level the clay plains become more restricted, inter-digitating between the coarser fluvial and fan deposits. These higher clay areas appear to be younger than those of the coastal zone. In particular, ferromanganese nodules, though occurring, are by no means as common. The relationship of these plains with the younger drainage lines indicates that they definitely pre-date the Holocene drainage pattern. The interpretation which is offered is that the lower clay plains were deposited during the last interglacial with a high sea level. During the subsequent glacial period, the lowered sea level produced incision by the coastal streams, thus isolating the clay interfluves from further deposition. In the headwaters of the coastal streams, however, there was isolation from the eustatic changes in sea level for a longer period and deposition continued well into the low sea level phase. Such isolation of a headwater sector from eustatic changes in sea level, with consequences for soil development have been described by Walker (1962a, b1, and Butler (1967) in the Nowra district of New South Wales.

   In the Black embayment especially, the younger clays overlie fine quartz gravels and weathered granite fragments more consistent with the higher fans. Changing climatic conditions may be indicated by the changing patterns of sedimentation (see Chapter 8).

7. **Pleistocene Shorelines**

   Pleistocene shorelines in the form of weathered beach ridges are rare in the area and the upper limit of the late Pleistocene transgression appears to have been seawards of
much of the present coast. This is also suggested by the Pleistocene drainage pattern. Two low sandy rises occur north of Mount Douglas attached to an outcrop of bedrock. North of Leichhardt Creek is another similar ridge. Extension of the drainage pattern seawards during the regressive stage has cut a number of gaps through this ridge.

The best documented of the Pleistocene shorelines is found near the lower Bohle River. A small outcrop of granite occurs inland from the present shoreline and trending south from this are the remnants of at least three wide sandy ridges. One of the ridges continues south to cross the Bohle 3 miles upstream. It apparently continued in a south-easterly direction to join Mount St. John. East of this small outcrop are interrupted remnants of the same ridge, probably trending towards Castle Hill. The Bohle and Ross Rivers have jointly obliterated much of this shoreline. However, a fine section is seen through the ridge and adjacent Pleistocene clay sediments in the west bank of the Bohle. The ridge is composed of coarse sands throughout, bleached white or grey in the upper 2 feet but becoming yellow or brown at depth. The most surprising feature is the presence of a firmly cemented calcareous and jointed sandstone in the core of the ridge. This is exposed as a ledge for 30 yards along the Bohle's banks. Its level surface, which rises to 8 feet above M.H.W.S., is similar to that of the beach rock plateaux of the off-shore islands, and there seems little doubt that the sandstone originated as beach rock. If so, then a late Pleistocene sea level of about 8 feet higher than present is indicated.

Above the cemented horizon in the forward part of the ridge are carbonate nodules about a half an inch in diameter. Examination of sections through these nodules showed no sign of "onion" skins indicating periodic or intermittent growth
The coastal plain around Bluewater Creek. The mid-Holocene deltaic fan of the Black River is seen to the east.
and a sample was submitted for radio-carbon assay. The result (GaK-2010) of 14,680 years ± 310 B.P. confirms the ridge as Pleistocene, and possibly indicates a period of carbonate nodule formation.

Holocene Deposits

1. Holocene Outwash Fans

The Holocene outwash fans are composed of leached white sands overlying coarse waterworn gravels. The deposits are uncemented and overlie or enclose the older Pleistocene fan deposits. They occur at the base of Frederick's Peak and have a remarkably similar distribution to their older counterparts. They are not active today and are being incised by the small streams flowing from the Frederick's Peak scarp.

2. Holocene Terraces

In the upper Black River and upper Bluewater Creek catchments are terraces up to 25 feet above the present streams. The materials consist of coarse sands overlying waterworn gravels at depth. The upper parts of these terraces, especially in the upper Bluewater area appear to merge into outwash fans. They have not been differentiated in figure 4.4. The presence of these deposits in the upper areas of the catchments suggests that the terraces are related to climatic and not eustatic fluctuations.

3. Mid-Holocene River Deposits

A number of sandy rises similar to those described as Pleistocene river deposits, but not as weathered and much more pronounced, occur in the southern part of the coastal plain. These linear deposits are independent of the present drainage lines but it is obvious that part of the present drainage pattern is inherited from the older mid-Holocene
pattern. Thus the upper parts of the present Saunders Creek and the lower course of Stony Creek are joined by a low sinuous ridge of mid-Holocene fluvial deposits. Similar relationships can be found in the upper part of Saunders Creek and between the Bohle and Ross Rivers. The most continuous of the mid-Holocene courses is that of the Black River which flowed to the north and west of its present course, branching into an extensive distributary area in its lower section just behind the present beach ridges.

The deposits, which consist of red podsolised sands, are considered mid-Holocene because of the stage of development of their soils (but without ferro-manganese nodules). They are also perched on the clay plain above the present river courses which have been incised up to 20 feet into the plain probably as a result of the late Holocene regression. The soils and texture of the deposits resemble the low sandy rises which protrude through the clays of the Barrattas area in the Burdekin region. These were also regarded as mid-Holocene (see Chapter 3). The abandoned Black River course passes between Mount Saunders and another small outcrop of solid in much the same way as the Burdekin flows over the rock bar at The Rocks and the similar passages of the Bohle and Ross Rivers described above. As the example of the Black River occurs close to the shore and not far above sea level, it is considered that such a course would be possible only during a phase of rapid aggradation, probably close to the mid-Holocene maximum sea level.

4. Holocene River Deposits

Sands and gravels are found along all the present watercourses, as narrow floodplains or levees. On the lower parts of the coastal plain the streams have incised into
these deposits and the levees have been stranded on the upper banks. Where this has occurred the deposits may be mid-Holocene and have developed red earth soils. Bluewater and Leichhardt Creeks have small deltaic areas of recent origin, though both appear to have been trimmed back by the waves and are fronted by very fresh beach ridges. A number of minor stream diversions are indicated by the Holocene river deposits.

5. **Holocene Shorelines**

Beach ridges have built up along the entire coast, many of them showing distinct signs of developing as spits under the influence of a strong south to north littoral drift. The ridges are generally closely spaced and overlie a variety of deposits including little modified Pleistocene clay plain, mangrove muds, beach rock and unconsolidated gravels. Beach recession appears to be taking place along much of this coast and the present shoreline truncates the trend of the older ridges. This is especially so just north of Rollingstone Creek where excellent sections in the ridges are exposed in a low cliff. The outer ridges have a core of shingle and coral fragments with a dune capping of about 3 feet. The inner ridges rest upon a platform of mangrove muds with stumps in situ rising 1.8 feet above M.H.W.S., generally above the level of growth of close stands of large mangroves as indicated by the deposit. The rear-most ridges may thus have formed during the higher mid-Holocene sea level. The evidence from the Cleveland ridges of a fairly constant thickness to the dune cap may be applicable along part of this coast as the inner ridges are usually higher than the outer. Thus a series north of Rollingstone Creek has heights of 5.3, 8.3, 6.3, 12.8 and 16.3 feet above M.H.W.S. However, factors other than a higher sea level could be involved.
6. Mangroves and Salt marsh

Mangroves and salt marsh are not extensive along the coast. Mangroves are limited to the small creeks draining the beach ridge areas. Of the major streams, only the Bohle has extensive mangroves at its mouth. Salt marsh and salt pan are found behind the beach ridges in areas of formerly impounded tidal drainage. Some areas may have originated as small lagoons.

Detailed contouring of the whole of the coastal plain is not available, but a section line is contoured between the Bohle River and Rollingstone Creek which shows the relationships of the different deposits. This was surveyed along the line of the north coast railway prior to its construction in the early part of the century. The section and deposits found along it are shown in figure 4.7. The near constant level of the Pleistocene clay plain is interrupted only by minor gullies and by the extensive levee systems of present, mid-Holocene and Pleistocene streams. In particular the mid-Holocene deltaic system of the Black River rises some 20 feet above the general level. The degree of incision of the streams into their Holocene deposits is striking. Towards the northern end of the section line, the ground surface rises as the coastal plain narrows and the main escarpment approaches the line of the railway.

Cemented Deposits of the Townsville Plain

Cementation of deposits other than the fan gravels of the piedmont zone occurs throughout the coast plain area, and in particular along the stream courses and on the coast. Cementation of river sediments occurs in the banks of many streams to within a foot or two of the surface. These deposits, variously described as "creek rock", "stream rock"
Fig. 4.7 Section across the lower part of the Townsville coastal plain.
or "water table rock" have been described by Russell and McIntire (1965) and Russell (1967) and attributed to accumulation of the cementing agent along the stream banks by fluctuations in water table level. These fluctuations are much greater adjacent to the streams than in the coast plain deposits generally and up to 15 feet of cemented deposits may occur alongside the streams, often forming a ledge with a more or less horizontal surface. The level of cementation along many streams, especially close to the coast, appears to be well above the level of present water table fluctuation. In some examples the cemented deposits are underlain by uncemented materials and are almost certainly fossil features related to a higher water table produced either by a wetter climate or by a higher sea level or by a combination of both. Drilling has indicated that the cemented horizon does not extend horizontally for any distance away from the stream banks, which seems to confirm Russell's hypothesis that complete lithification occurs only with exposure to the atmosphere. The cementing agent in most examples examined appeared to be silica, but iron and calcareous cements were observed and occasionally induration appears due to the illuviation of clay particles in a particular horizon.

Beach rock occurs along the coast but exposures are not widespread. However, augering in many of the beach ridges immediately behind the present beach and examination of sections exposed where small creeks have cut through the ridges or where coastal retreat has occurred, show that incipient beach rock, only lightly cemented is found in many ridges, especially where coarser materials form the basal deposits. Well cemented deposits consisting of large boulders and blocks of coral up to 2 feet across in the basal portion occur at Balgal and within the outer-most beach ridge to the
south where it is exposed at creek exits. This exposure has been described by Russell and McIntire, (1965, 1966) and Russell (1967) though the upper level of beach rock (which occurs almost exactly at M.H.W.S.) above the lower beach was over-estimated by these authors. Coarse shingle extends out into the lower beach flat with detached or displaced patches of beach rock and conglomerate, and apparently indicates the former extent of cemented deposits. Other areas of coarse gravels occur along the coast on the lower beach (the lag gravels of Driscoll and Hopley, 1968). They appear stable with crusts of oysters and other marine organisms. There is no evidence that these were cemented but they do seem to indicate the position or positions of the former coastline. The example at Mount Douglas has already been described. North of Rollingstone Creek where the present coast truncates the beach ridges, the line of these ridges is continued on the lower beach by similar trending exposures of these coarse gravels, which also form the basal portion of the ridges.

The coastal streams are not supplying material of this calibre to the beach at present. The shingle and boulders appear to have been incorporated in the Holocene beaches through erosion of the coastal plain and dislodgement of late Pleistocene and mid-Holocene perched fluvial gravels. However, the presence of blocks of coral in the conglomerates of a larger size than is generally encountered on the beach today, may indicate stormier conditions, or alternatively more rapid erosion of off-shore reefs exposed to erosion by a falling sea level. Shell from the Balgal conglomerate gave a radio-carbon date of 2,180 years ± 80 B.P. (GaK-1509).
Summary Evolution of the Townsville Coastal Plain

1. A late Pleistocene high sea level is indicated in the area with a maximum height of 8 feet above present. The climate of this period may have been wetter than present as widespread clay plains were found at this time. Alternatively the clay plains may have been inherited from an earlier phase.

2. Towards the end of the high sea level phase the climate became drier allowing the construction of coarse alluvial fans and the formation of pediments. This drier climate continued when sea level fell below that of present.

3. At the low sea level phase a more humid climate, probably wetter on a seasonal basis, set in, causing deep weathering of the earlier deposits, especially the coarser ones which allowed a deeper penetration of water and the formation of ferruginous pans. Ferro-manganese nodules formed in the deposits of the clay plains, which now extended into the headwater reaches of the Black River, over the earlier coarse deposits.

4. Towards the end of the Pleistocene, probably by 15,000 years ago, the climate became considerably drier, a position which possibly continued into the Holocene period. The climate was probably drier than that of present. New alluvial fans of coarse material developed, and streams courses were clogged with coarser deposits.

5. At the mid-Holocene stage, sea level in the area may have been higher than that of present and with rapid aggradation, the streams had many changes in course.
6. A slight change towards a wetter climate has accompanied the regression from the mid-Holocene level. Stabilization of the fans with subsequent incision into these and the pediments and their deposits has occurred. The streams generally carry finer calibre material, sands overlying the older gravels. Streams have became incised, as a result of the falling sea level close to the coast, and as a result of a lowering of the coarse fraction of the transported load in the headwater reaches. In the sheltered environments of the south, chenier development has continued through this period. In the north, the latest event on the coast has been one of shoreline retreat.
References


