2. GEOLOGY AND GEOMORPHOLOGY OF LITTLE CAYMAN

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Introduction

Little Cayman forms one of the emergent islands along the northern rim of the Cayman Trench, between the Sierra Maestra of Cuba and the Gulf of Honduras. The Trench itself is 1700 km long and more than 100 km wide (Uchupi 1975). It includes the Oriente, Bartlett and Misteriosa Deeps, all reaching more than 6000 m depth. The nearest land areas to the Cayman Islands (other than Cuba), such as Jamaica and the Swan Islands, lie on the southern side of the Trench.

Early workers such as Taber (1922) considered the Trench to be the site of massive lateral movement. Such views have had to be modified in the light of plate tectonic theory, though some workers still envisage lateral movement along it of up to 1000 km. It is known that granodiorites outcrop in the walls of the Trench at depths of 600-3400 m, and geophysical data suggest a possible tensional origin. Spreading rates have been inferred of 0.4 cm/year since the Eocene, accounting for 200 km of left-lateral displacement between the Cayman Ridge and the Nicaraguan Plateau (Perfit and Heezen 1978); other workers suggest greater rates of spreading (Macdonald and Holcombe 1978). The Cayman Islands themselves probably have a granodiorite foundation, capped by basalt, and overlain by mid-Tertiary and later carbonates. Perfit and Heezen (1978) suggest a general subsidence rate of 6 cm/1000 years during the carbonate accumulation, but the exposure of marine limestones in each of the Cayman Islands indicates local uplift. Unpublished work on the late Quaternary shorelines of all three Cayman Islands (Woodroffe and Stoddart, *in litt.*) indicates that Grand Cayman, Cayman Brac and Little Cayman have each moved independently with respect to sea-level over the last 100,000 years.

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Rock units and landforms

Matley (1926) defined two main lithologic units in the Cayman Islands: the Bluff Limestone of mid-Tertiary age and the Ironshore Formation of Pleistocene age. Matley visited Little Cayman and produced a small-scale geological sketch map, indicating that the eastern half of the island consisted of Bluff Limestone, with a narrow peripheral belt of Ironshore, and the western half consisted entirely of Ironshore. As he described it, the Bluff Limestone formed a "highly honeycombed limestone corroded into jagged needles of rock and covered with irregular holes, sink-holes and fissures", and consisted of "hard white recrystallised limestone", probably of Miocene age (Matley 1926, 363-365). It was inferred that the Bluff Limestone reached a maximum height of 45 ft (14 m) at Weary Hill. The Ironshore Formation in the west consisted of a lower reef facies overlain by bedded limestone reaching 10-12 ft (3-3.7 m) above sea level. The boundary between the Bluff Limestone and the Ironshore Formation on Matley's map was tentative.

No further geological observations were made on Little Cayman until those of Mather (1971). He too distinguished the Bluff Limestone and the Ironshore Formation. He described the Bluff Limestone reaching a general maximum height of 20 ft (6 m), with a peripheral ridge reaching 40 ft (12 m) in places. The distribution of Bluff Limestone as mapped by Brunt *et al.* (1973, 212) resembled that shown by Matley. The Ironshore Formation was studied in greatest detail by Brunt *et al.* on Grand Cayman, where it was differentiated into reef, back-reef, lagoonal, shoal, and beach-ridge facies. In their treatment of Little Cayman, reef and back-reef facies were not specifically mentioned, but it was noted that lagoonal facies were of limited extent. They also identified "at a number of localities on ... Little Cayman ridges of calcarenite attaining elevations of over 7 m above sea level", and commented that "these rocks generally overlie sediments of lagoonal facies" (Brunt *et al.* 1973, 214). On Grand Cayman similar ridges consist of cross-bedded colites and are interpreted as submarine sand ridges formed in a lagoonal environment. Some of these ridges are shown diagrammatically in a geological sketch map of Little Cayman (Brunt *et al.* 1973, 212).

Neither Matley nor Brunt *et al.* apparently had much opportunity to traverse the island, or to relate the characteristics of rocks at outcrop to topographic features. More detailed study has been made possible by the publication of the Directorate of Overseas Surveys (D.O.S.) topographic map at 1:25,000, based on photogrammetry, with contours at 20 ft (6 m) intervals and some vegetation interpretation by the installation of a series of coastal benchmarks by D.O.S., most of which could be relocated in 1975; by the cutting of a network of trans-island traces by the Cadastral Survey of the Cayman Islands, mainly during 1974; and by the mobility made possible by the construction of a road round much of the coast in 1973. Aerial photographs are also available at a scale of 1:12,500, though these were flown in 1958 before the cadastral traces were cut.

The 1:25,000 topographic map clearly delineates a discontinuous series of narrow ridges (Figure 3; Plates 2-4) round the periphery of the island, immediately inshore of the coastal ponds and salt flats; they are defined by the 20 ft (6 m) contour, and isolated small sections reach 40 ft (12 m). Using this map and the aerial photographs an attempt was made so far as possible to define the relative extent of the formations described by Matley and Brunt *et al.* Where possible instrumental surveys were carried inland from the coast to establish elevations with respect to sea level. Figure 4 shows the main traverses made: it is clear that large areas of the interior were not visited directly, and the aerial photographs were used to extrapolate between traverses.

Two main features were mapped during the traverses. The Bluff Limestone was recognised (a) by its highly dissected surface topography, with pits, pinnacles, deep holes, and occasional collapse dolines leading into caves (Plates 5-8), and (b) by its appearance in hand specimen as a dense, white, extremely hard, largely structureless limestone. Veins and sheets of crystalline calcite occupying joints and bedding planes are common, as are irregular patches of tightly lithified and occasionally brecciated yellow and brown pipe-fill deposits. "Caymanite", finely bedded impure dolomitic limestone ranging in colour from white through red and brown to black, was never found on Little Cayman, though characteristic of Bluff Limestone, apparently as a fissure-fill, on both Grand Cayman and Cayman Brac. Otherwise the Bluff Limestone closely resembles that on the two larger islands, at least in hand specimen and topographic expression. On Little Cayman, Bluff Limestone outcrops on the coast only at the east end, where it forms ramp-like cliffs (Plate 9).

The second extensive unit on Little Cayman is interpreted as a Marl or Sand Ridge Facies of the Ironshore Formation. In hand specimen it is a fine-textured cream to buff limestone, massive, structureless, and usually lacking fossils. It forms a solid surface and in contrast to the Bluff Limestone often carries a soil and litter cover. In the western lowlands the surface is undulating, with a relief of 0.5-1 m, with red or yellow soils, often phosphatic, in the swales. In the central part of the island, south of Sparrowhawk Hill, the surface is more uniform and the soils darker, deeper and more continuous. This unit also forms the high peripheral ridges, reaching a height of 13 m above sea level, though some ridges, especially those in the northeast, are formed of Bluff Limestone. Ridges formed of Sand Ridge facies have undissected surfaces, and soil is present though thinner than in the lowlands. In hand specimen lithology appears similar irrespective of altitude.

The field relations of the two units are not easy to interpret. Little Cayman differs from Grand Cayman and Cayman Brac, where there is a high core of Bluff Limestone surrounded by an apron of Ironshore Formation. On Little Cayman the Sand Ridge facies of the Ironshore appears to penetrate into the centre of the island between ridges of dissected Bluff Limestone. The highest areas surveyed consist of Sand Ridge facies, but conversely there are large areas of dissected

Bluff Limestone which are not covered by the Sand Ridge or Marl Facies. The transition between the two units is often very abrupt, especially in interior depressions near present sea level. On field relations alone it is often impossible to be certain whether interior karst-eroded depressions consist of Bluff Limestone surrounded by Ironshore or of dissected Ironshore itself.

The Reef Facies of the Ironshore Formation outcrops to form coastal platforms at Salt Rocks and immediately south of the airstrip at the west end of the island. It is also found on the seaward side of Owen Island in South Hole Sound, but is absent from the rest of the south coast. There are low discontinuous exposures on the north coast at Bloody Bay, and at the east end at Calabash Spot (Figure 5; Plates 10-12). In addition to these coastal platforms, corals (mainly *Montastrea* species) are also almost always found in limestone below about 1.5 m above sea-level on the landward margins of salt ponds and salt flats (Plate 13), and this may represent the inner edge of the Reef Facies where it either abuts against Bluff Limestone or passes into back-reef facies. The upper surface of the Reef Facies proper stands at less than 2 m above sea level at all locations. It is highest at Salt Rocks, where it reaches 1.9 m; elsewhere it stands at less than 1.5 m and often less than 1 m above sea level. Where higher elevations are found these are on Sand Ridge Facies rather than Reef Facies.

The coral fauna is modern, and the same as that of Grand Cayman. Common components at Salt Rocks are:

Acropora palmata
Diploria labyrinthiformis
Diploria strigosa
Meandrina sp.
Montastrea annularis
Montastrea cavernosa
Porites porites

In the south, the dominant coral is *Montastrea annularis*, though *M. cavernosa* is also present. *Strombus gigas* is conspicuous and locally common.

The upper surface of the Reef Facies is horizontal, though deeply dissected in places by potholes (Plate 14); its inner part may be exfoliating and smooth. It is probably a depositional rather than erosional surface.

The contact between the Reef Facies and the Sand Ridge Facies is best seen at Salt Rocks (935745: Figure 6; Plates 15-16). Here the horizontal Reef Facies surface is overlain by bedded calcarenites 2 m thick at their outer edge. The upper surface of the calcarenite rises from 4 to 5 m above sea level in a distance of 25-35 m before passing beneath a Recent boulder beach; inland of the boulder beach the surface continues to rise and reaches a height of 13 m at 300 m from the sea (Figure 4A). The unit has three components: a basal coarse grit with rounded blocks of oolite and *Strombus* shells; a bedded calcarenite showing strong seaward dip; and an upper gently dipping calcarenite forming the ground surface. Similar bedded oolitic calcarenites overlie Reef Facies in a comparable location on Grand Cayman (at 589325).

By comparison with similar reefs on other Caribbean islands, the Reef Facies of the Ironshore Formation is probably of last interglacial age (ca 125,000 yr). The associated facies are probably of broadly comparable last interglacial age, though on both Grand Cayman and Little Cayman the Sand Ridge Facies presents problems of interpretation and chronology.

The peripheral Recent beach ridges (Figure 7; Plates 17-19) are variable in height, width and composition on Little Cayman. The cobble and rubble ridge at Pirate's Point (943738) is 100 m wide and reaches 4 m above sea level; it is one of the largest on the island. Sand ridges and mixed sand and cobble ridges are usually smaller. At the West Point light (933743) the ridge is 55 m wide and 3.7 m high; at Blossom Village (960738) the dimensions are 50 m and 2 m; at Paradise End (046777) 120 m and 2.9 m; and at Sparrowhawk Hill (004785) 50 m and 1.7 m. All these are asymmetric ridges, highest near the sea and declining to a salt pond or salt flat on the landward side. In some protected situations, as at Bloody Bay (973768), however, the ridge is low and featureless, forming a horizontal surface 150 m wide and 1.5 m high. All these ridges are probably built on a platform of Ironshore Formation at or slightly below sea-level, and in most cases this platform outcrops on the landward side as the rock floor of salt ponds and salt flats. The sand and cobble ridge at Salt Rocks is unusual in that it is perched on high-standing Ironshore about 80 m from the sea; it is about 35 m wide and 2.7 m thick. From Mary's Bay to Calabash Spot on the northeast coast, the modern beach ridge directly abuts the Bluff Limestone Cliff; there are no salt ponds or flats, and the height of the sand ridge is increased by dune deposits. The ridges are wholly formed of reef-derived carbonates, with the exception of locally abundant patches of drift pumice.

The cobble and rubble ridges are clearly localised formations attributable to major storms; it is noteworthy that they are all single features rather than sequences of ridges. There are also some large storm blocks, especially on the southern Ironshore platform hear the airstrip (Plate 21). Two large blocks here measured 1.2 x 1.5 x 1.5 m and 1.8 x 1.5 x 1.5 m.

The sand ridges consist of well-sorted carbonate sands in the coarse to medium sand categories (Figure 8). Beachrock is not common on the present beaches, but relict beachrock is quite extensively exposed a few metres from the beach foot along the south coast.

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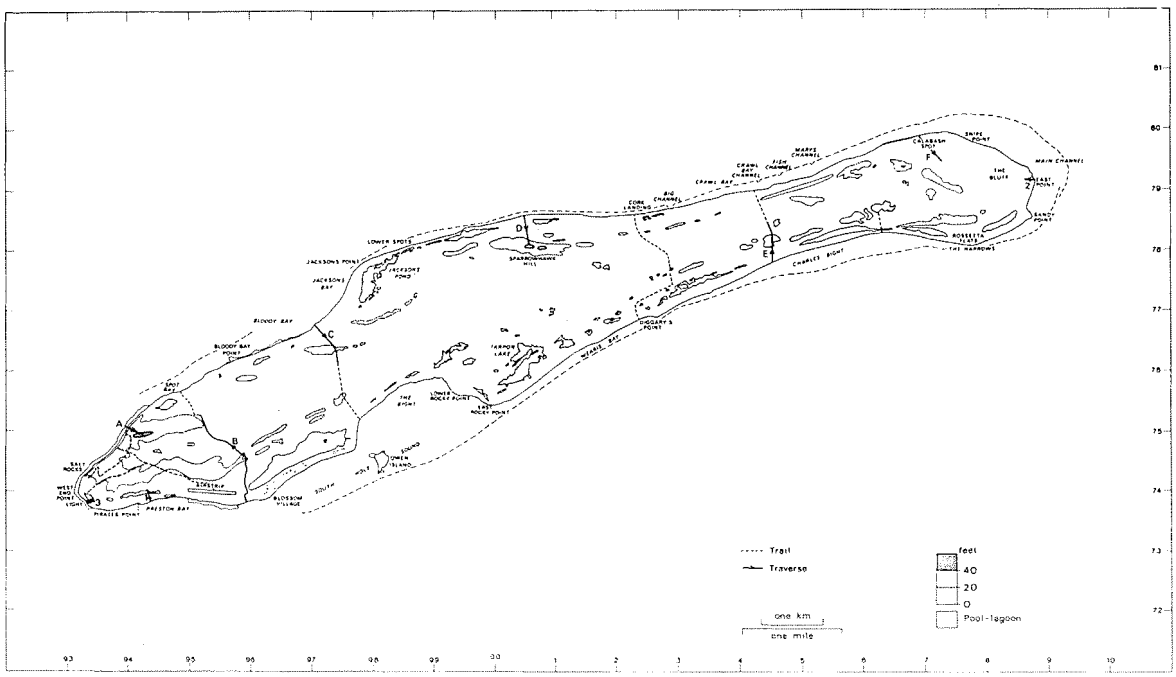

Figure 3. Topography of Little Cayman, based on the Directorate of Overseas Surveys 1:25,000 map (1965)

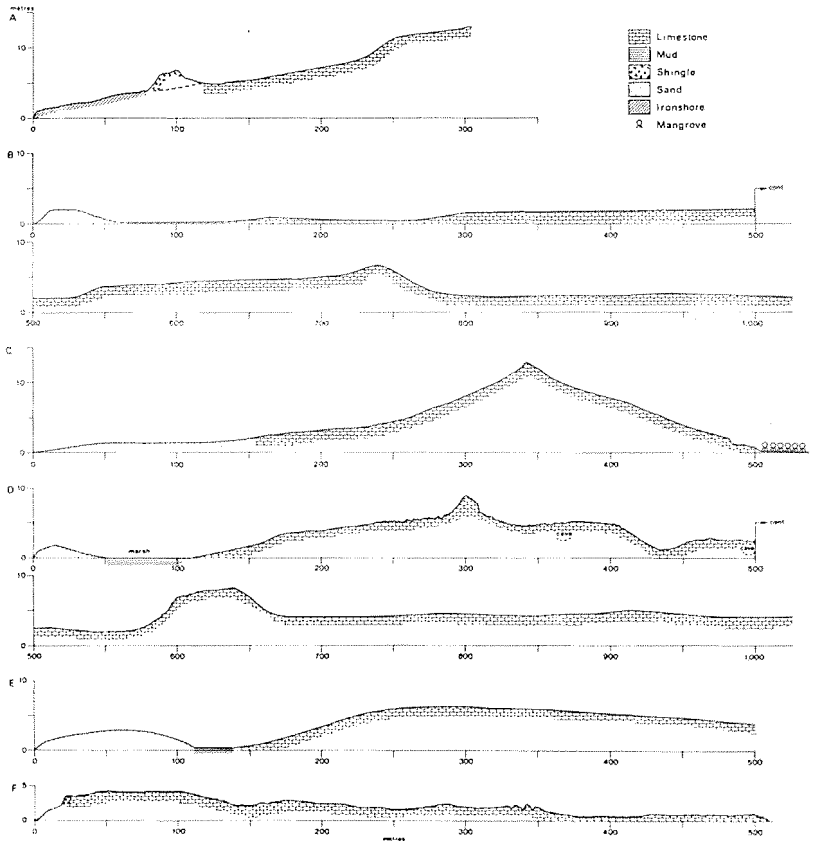

Figure 4. Topographic traverses A-F: for locations see Figure 3

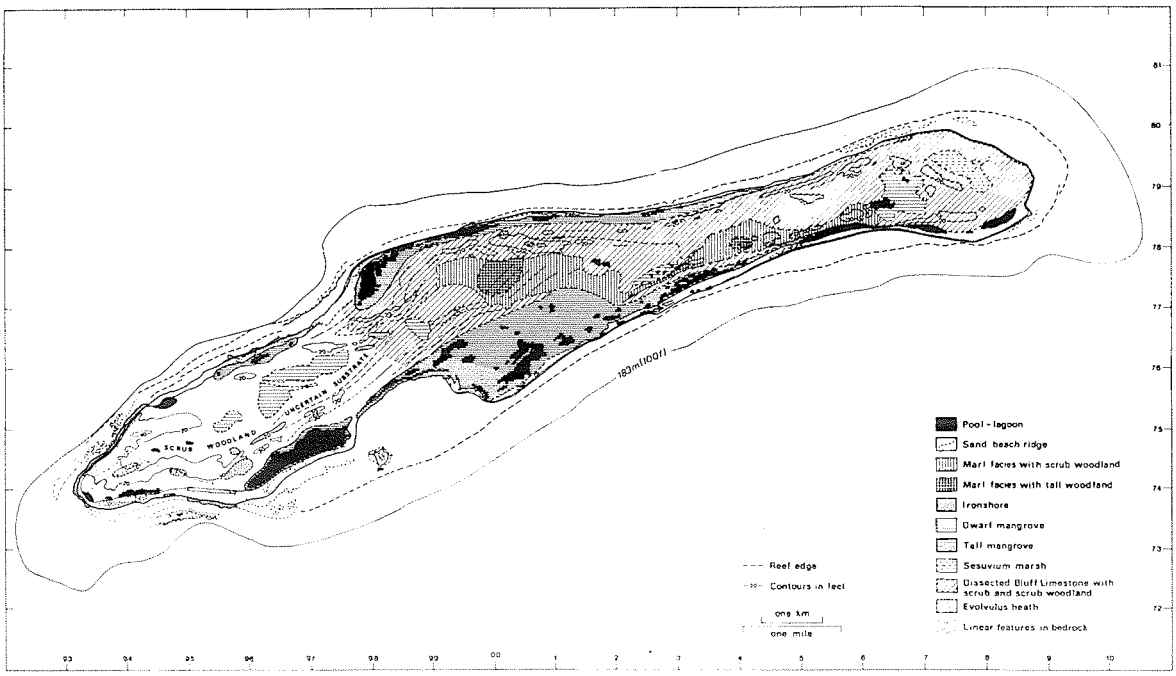

Figure 5. Geology and habitats of Little Cayman

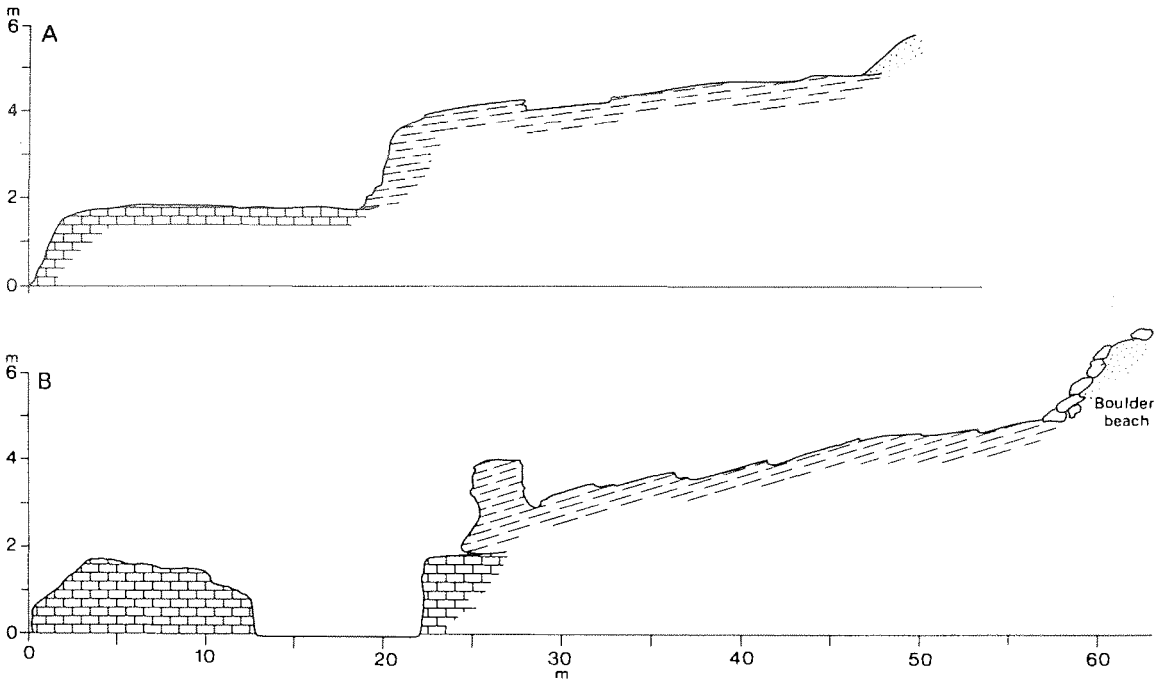

Figure 6. Topographic profiles at Salt Rocks

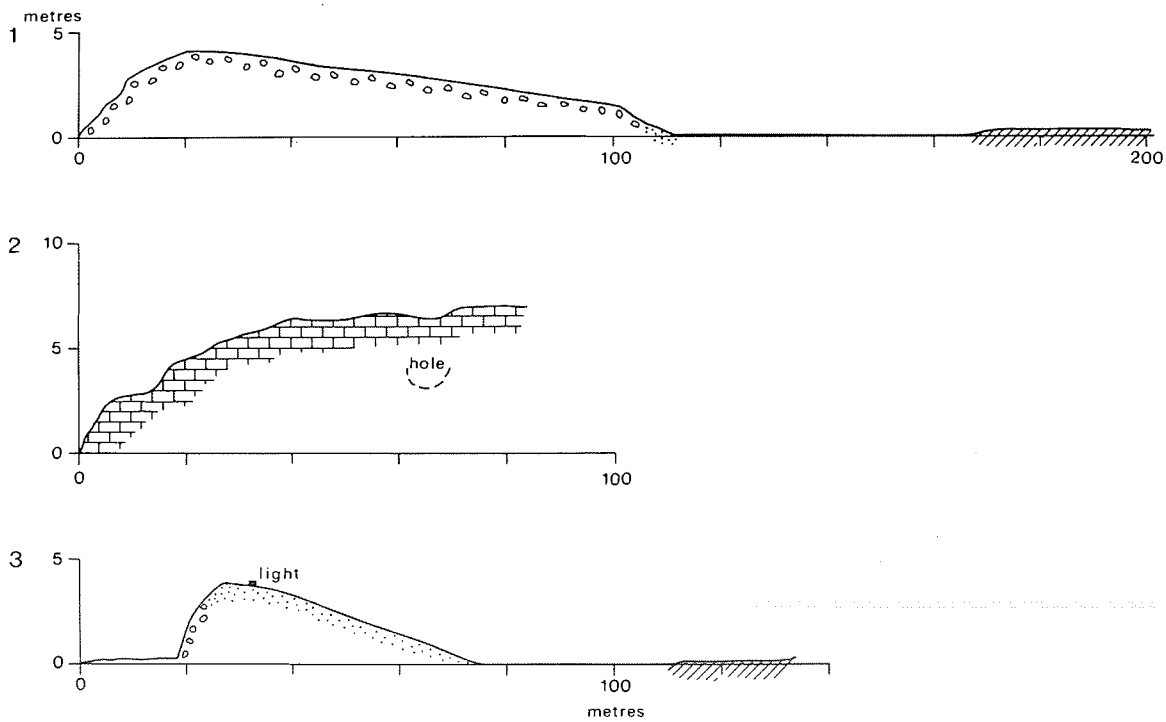

Figure 7. Beach ridge and cliffed coast profiles: for locations see Figure 3

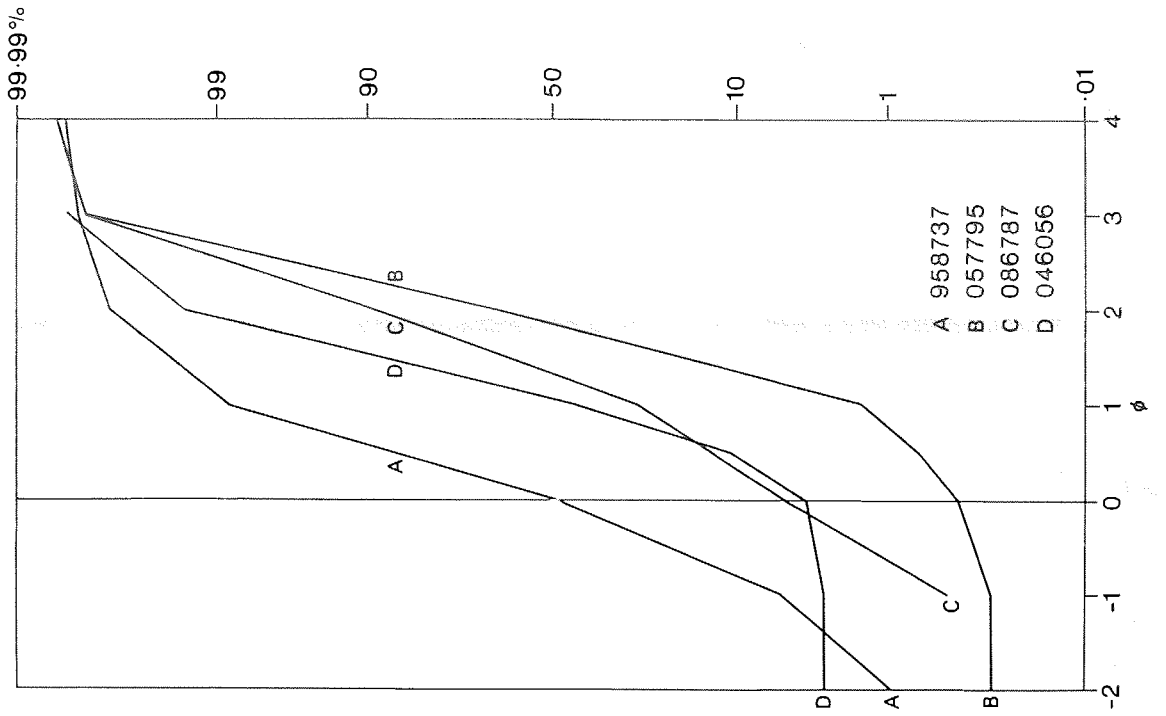

Figure 8. Size composition of beach sediments

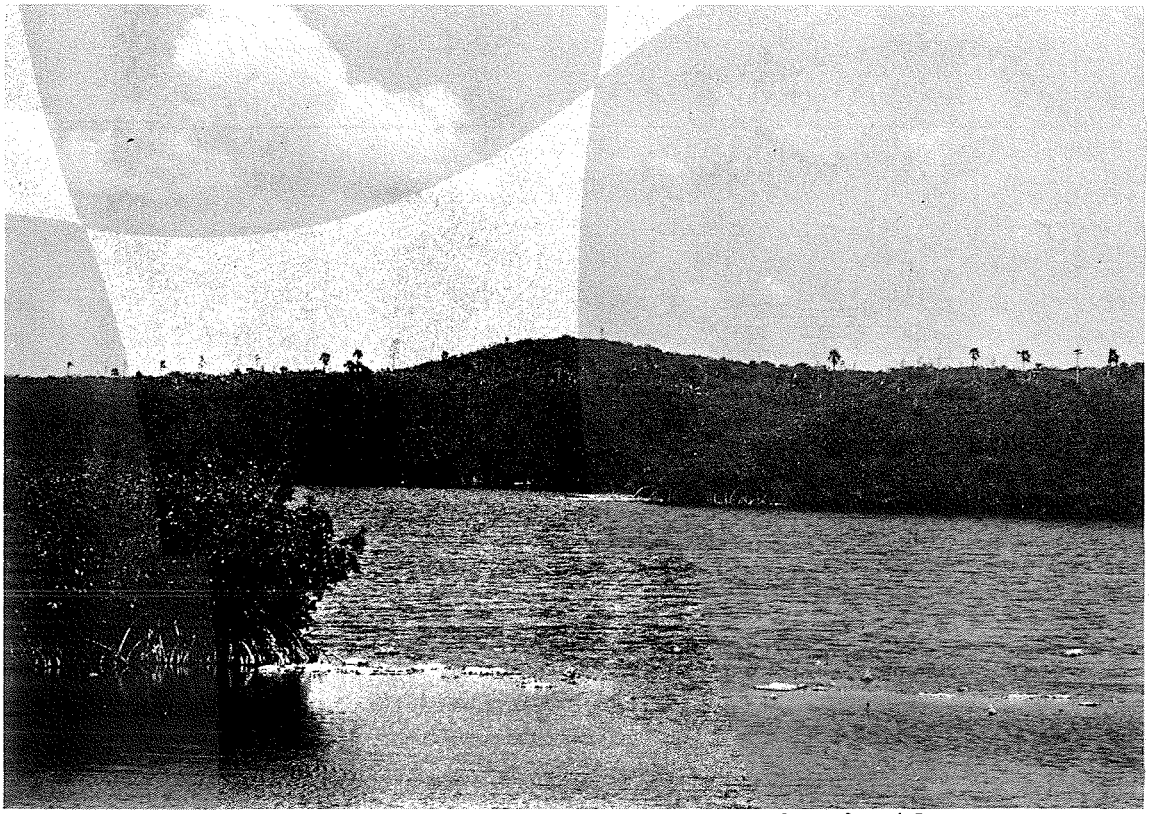

Plate 2. Sparrowhawk Hill from the north coast beach ridge

Plate 3. Limestone ridge inland of the coastal salt pond at Charles Bight

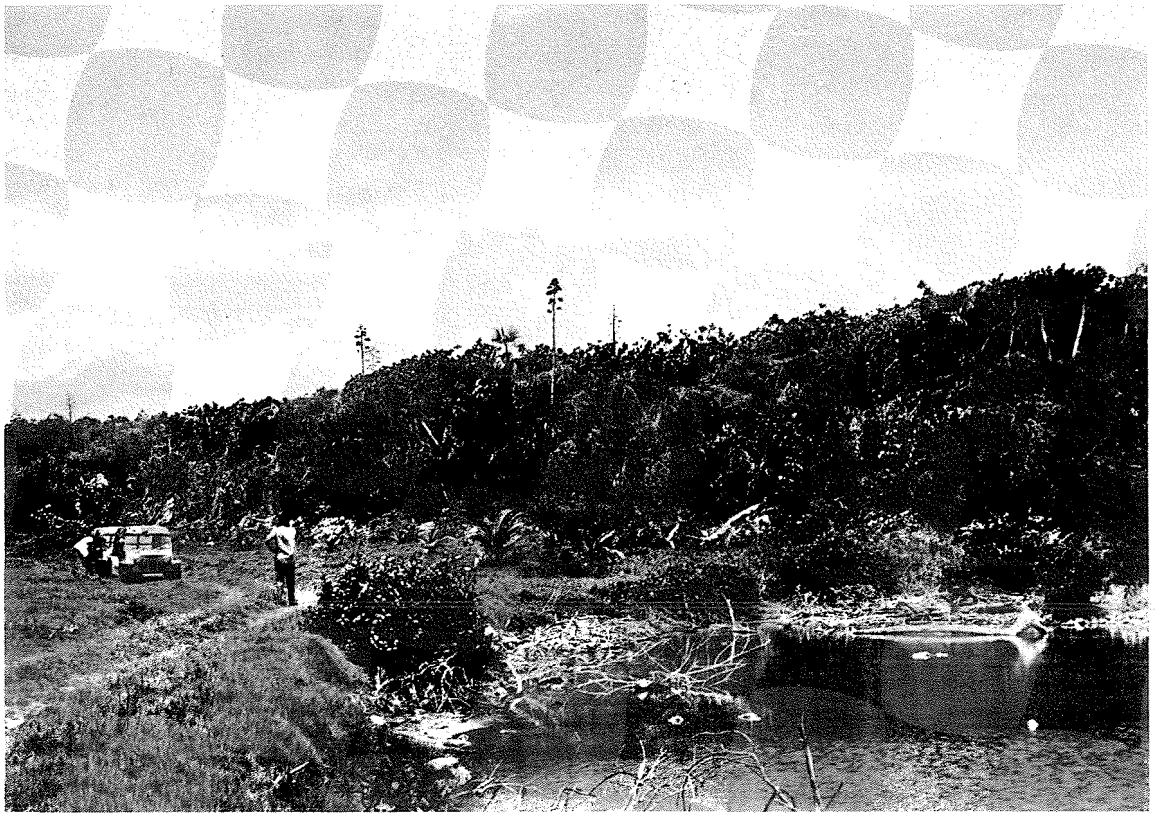

Plate 4. Limestone ridge and coastal sand flat and salt pond at Mary's Bay

Plate 5. Dissected surface on the Bluff Limestone (6032 1783); the sides of the frame are 50 cm long

Plate 6. Detail of surface dissection on Bluff Limestone

Plate 7. Large doline in Bluff Limestone (6028 1778)

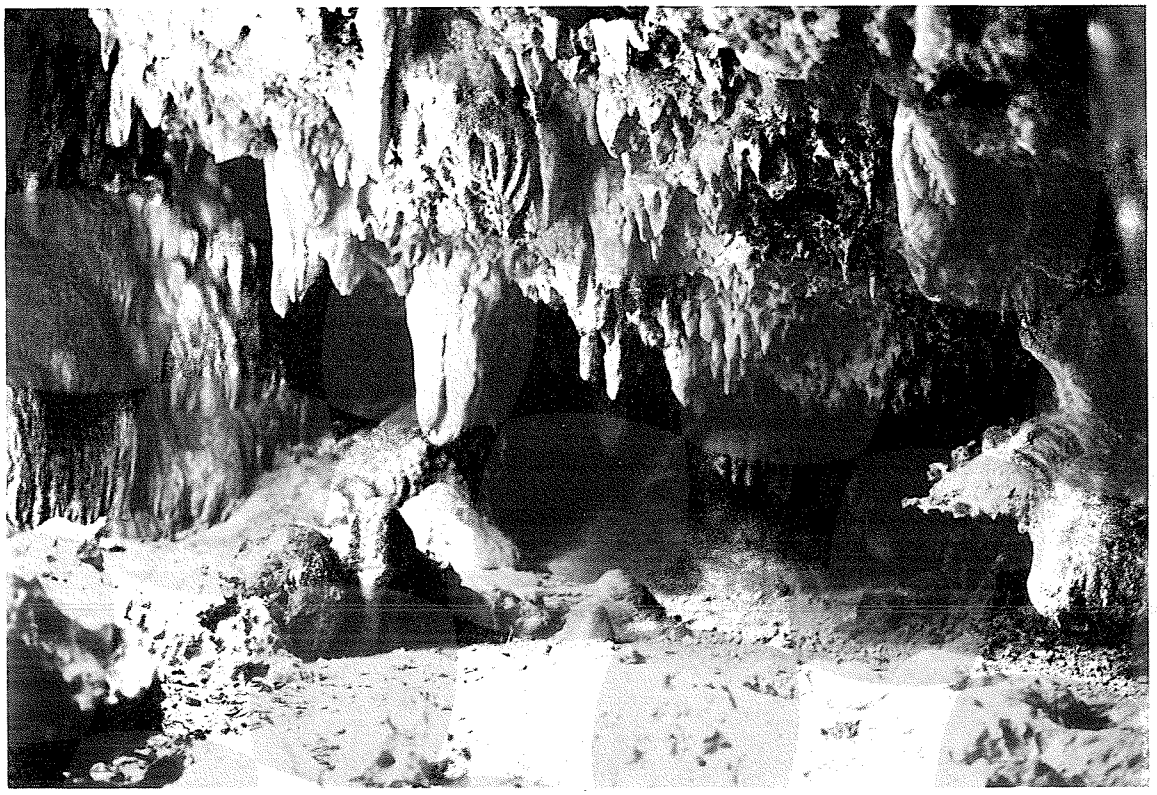

Plate 8. Cave speleothems revealed by roof collapse (6003 1781)

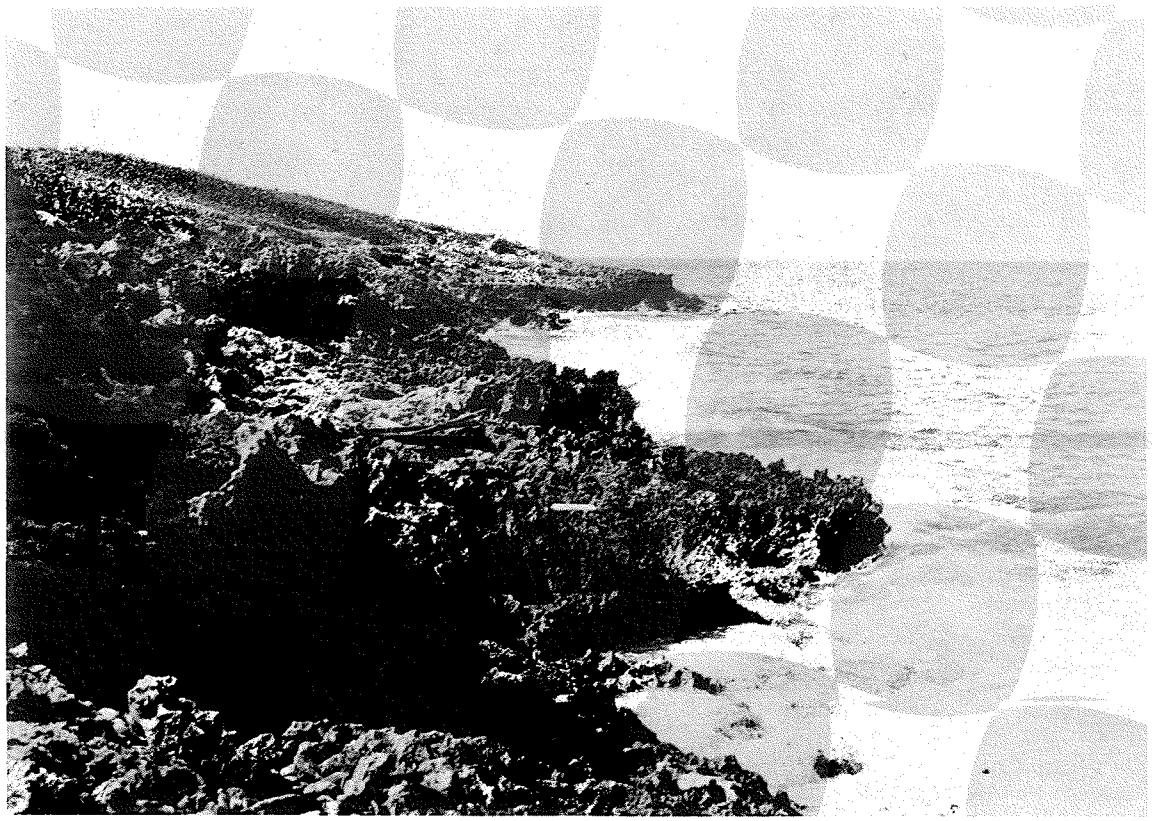

Plate 9. Bluff coast at East Point

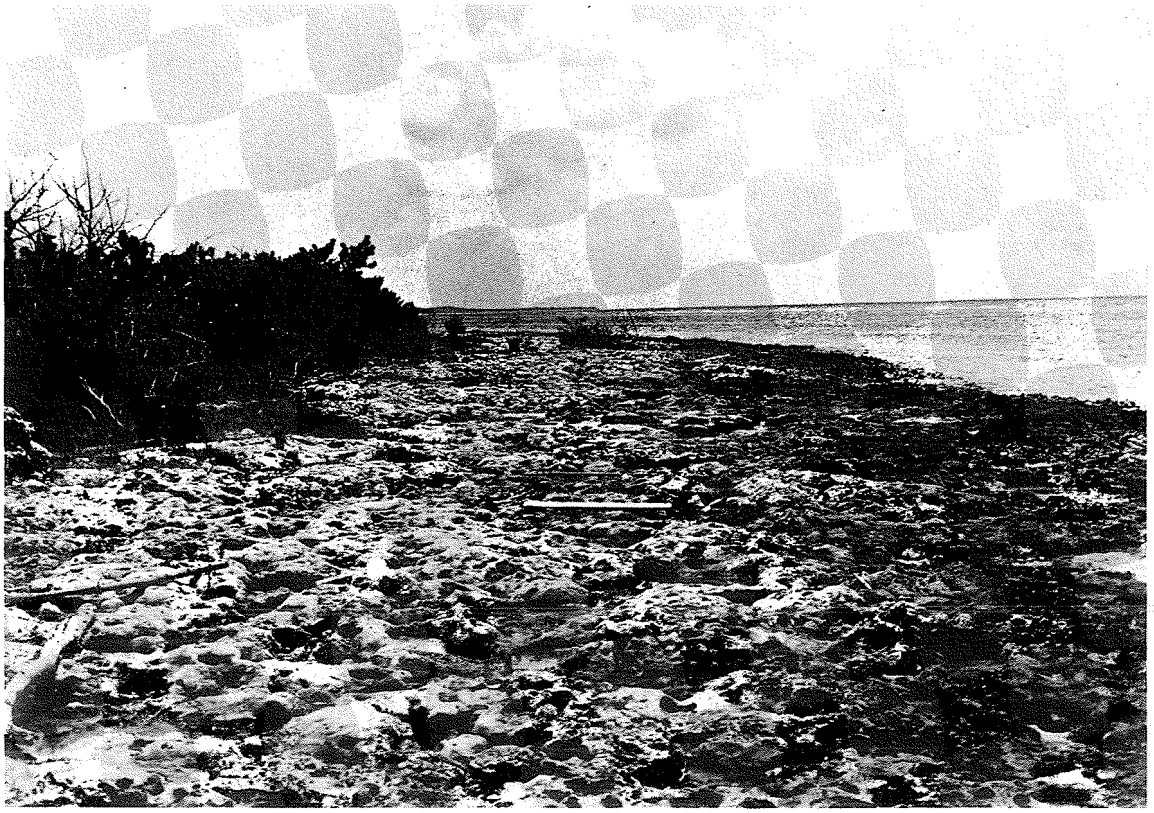

Plate 10. Ironshore platform west of Calabash Spot

Plate 11. *Diploria* colonies in coastal Ironshire at Salt Rocks

Plate 12. *Strombus* shells in coastal Ironshore at Salt Rocks

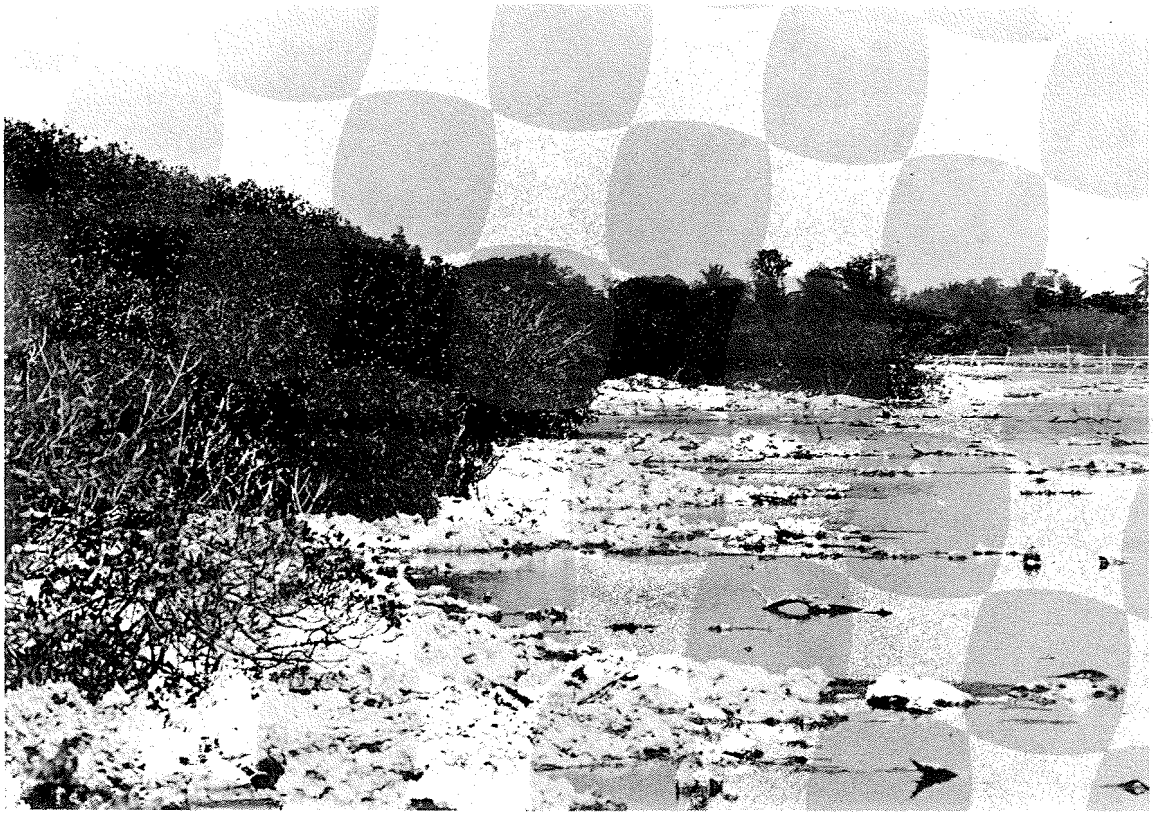

Plate 13. Ironshore deposits on the landward margins of the Blossom Village lagoon

Plate 14. Potholes in the Ironshore surface at Salt Rocks

Plate 15. Bedded calcarenites overlying reef facies in the Ironshore at Salt Rocks

Plate 16. Detail of the bedded calcarenites at Salt Rocks

Plate 17. Beach ridge east of Pirate's Point

Plate 18. Beach ridge at Calabash Point

Plate 19. Sand beach ridge with juvenile *Casuarina* in Wearis Bay

Plate 20. Storm wash-over cobbles north of East Rocky Point, Blossom Bay

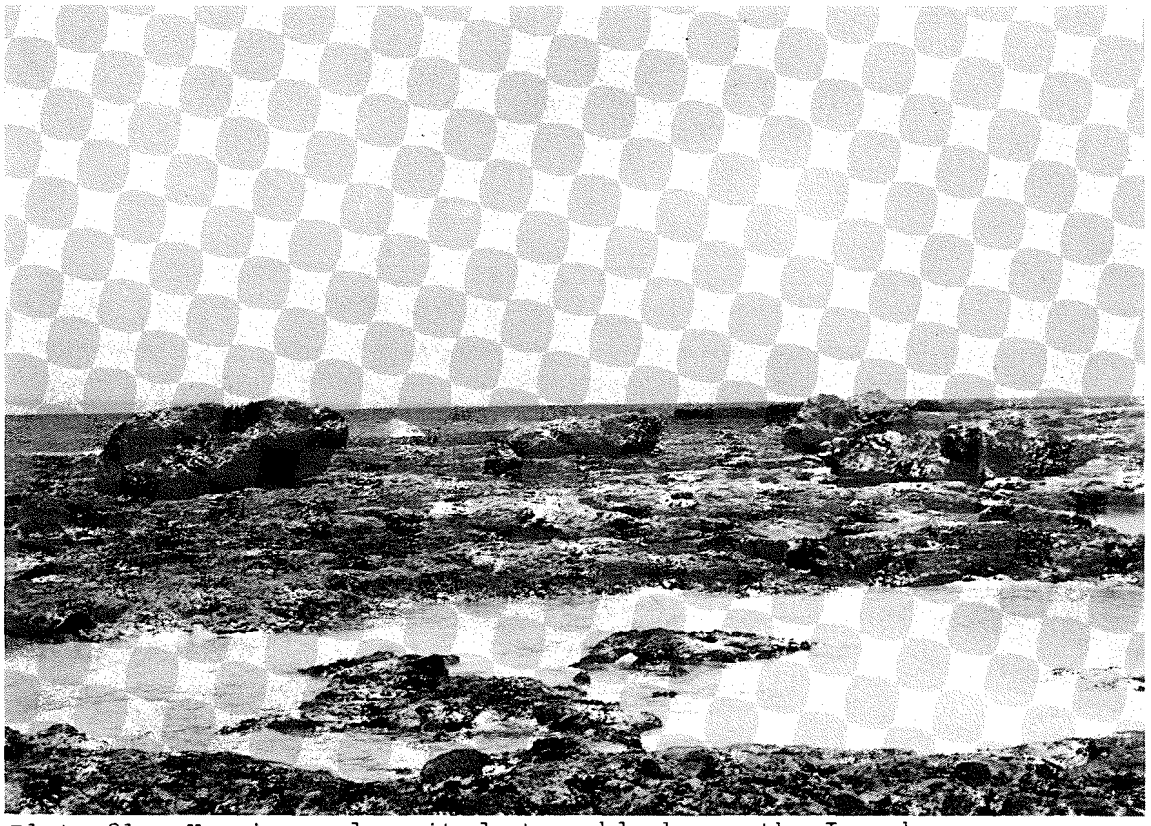

Plate 21. Hurricane-deposited storm blocks on the Ironshore platform south of the airstrip (5957 1737)