LATE QUATERNARY SEDIMENTATION IN MORETON BAY

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(with 4 Text-figures)

ABSTRACT. The record of Quaternary events in Moreton Bay has been investigated through studies of both submarine and onshore sediments. Samples of the sea floor sediments have been collected and further information has been provided by geophysical and coring programmes. Three submarine sedimentary zones are recognised and five principal lithofacies types have been related to these zones. Holocene and Pleistocene sediments have been distinguished in submarine cores and criteria for their recognition are listed. The onshore Quaternary record on Mud and St Helena Islands consists of beach ridges and platforms, beachrock deposits and a relict coral reef. Evidence for a sea level slightly higher than that of the present is provided by an exposed fossil coral facies on Mud Island.

INTRODUCTION

Moreton Bay is a wedge-shaped embayment enclosed on one side by the mainland and on the other by offshore dune islands. The water body is approximately 80 km long, 35 km wide in the north, tapering to less than 5 km in the south and in places is more than 40 m deep (Text-fig. 1). Towards the mainland, the bay is bordered by extensive estuarine flats representing Pleistocene and Holocene progradation. Coastal headlands and most of the bay islands are formed of Tertiary basalts and freshwater shales, Mesozoic sandstones, and Palaeozoic metamorphics with laterite profiles developed at the surface.

Moreton Bay is situated close to the southernmost limit of reef-building corals and is of special interest as an area of coral growth in a relatively muddy environment (Wells 1955; Slack-Smith 1960). The most prolific present-day coral growth occurs around Peel Island, with smaller patches at St Helena and Green Islands. It is probable that an interglacial reef-building phase was represented in this area, especially in view of the recent discoveries of Pleistocene corals in New South Wales (Marshall and Thom 1976). Studies of foraminiferal assemblages west of St Helena and Green Islands have revealed two distinct faunal assemblages – one modern and one relict (Palmieri 1976).

The sedimentary history of Moreton Bay is closely connected with the development of the offshore sand islands. Equivalents of the Pleistocene "Inner Barrier" accretion ridges of New South Wales have been recognised on Bribie Island and on the inner part of the coastal plain in the Deception Bay area. On Bribie Island, two Pleistocene beach ridge accretion systems similar to those of the Gold Coast occur. They indicate two periods of sea

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level several metres higher than the present level. The more exposed offshore islands – Moreton and North Stradbroke Islands – include deposits of sand piled up by several periods of high blowout activity. These different stages of dune development have characteristic soil profiles (Thompson and Ward 1975).

SEDIMENTARY FACIES OF MORETON BAY

Maxwell (1970) published a generalised map of three main sedimentary facies in Moreton Bay: Mud Facies, Muddy Sand Facies, and Clean Sand Facies. The Geological Survey of Queensland has since collected samples on a more closely spaced grid resulting in the distinction of additional facies (Hekel *et al.* in prep.). Further intensive sampling by Stephenson *et al.* (1977) in Bramble Bay has indicated significant variations in sediment type occurring over short periods of time. Lithofacies patterns shown in Text-fig. 1 are based on the Geological Survey's sampling and also take into consideration the Bramble Bay results. Five principal lithofacies have been distinguished: Sand – more than 90% sand; Muddy Sand – 50-90% sand; Sandy Mud – 50-90% mud; Mud – more than 90% mud; Gravelly Mud – mud with more than 5% gravel.

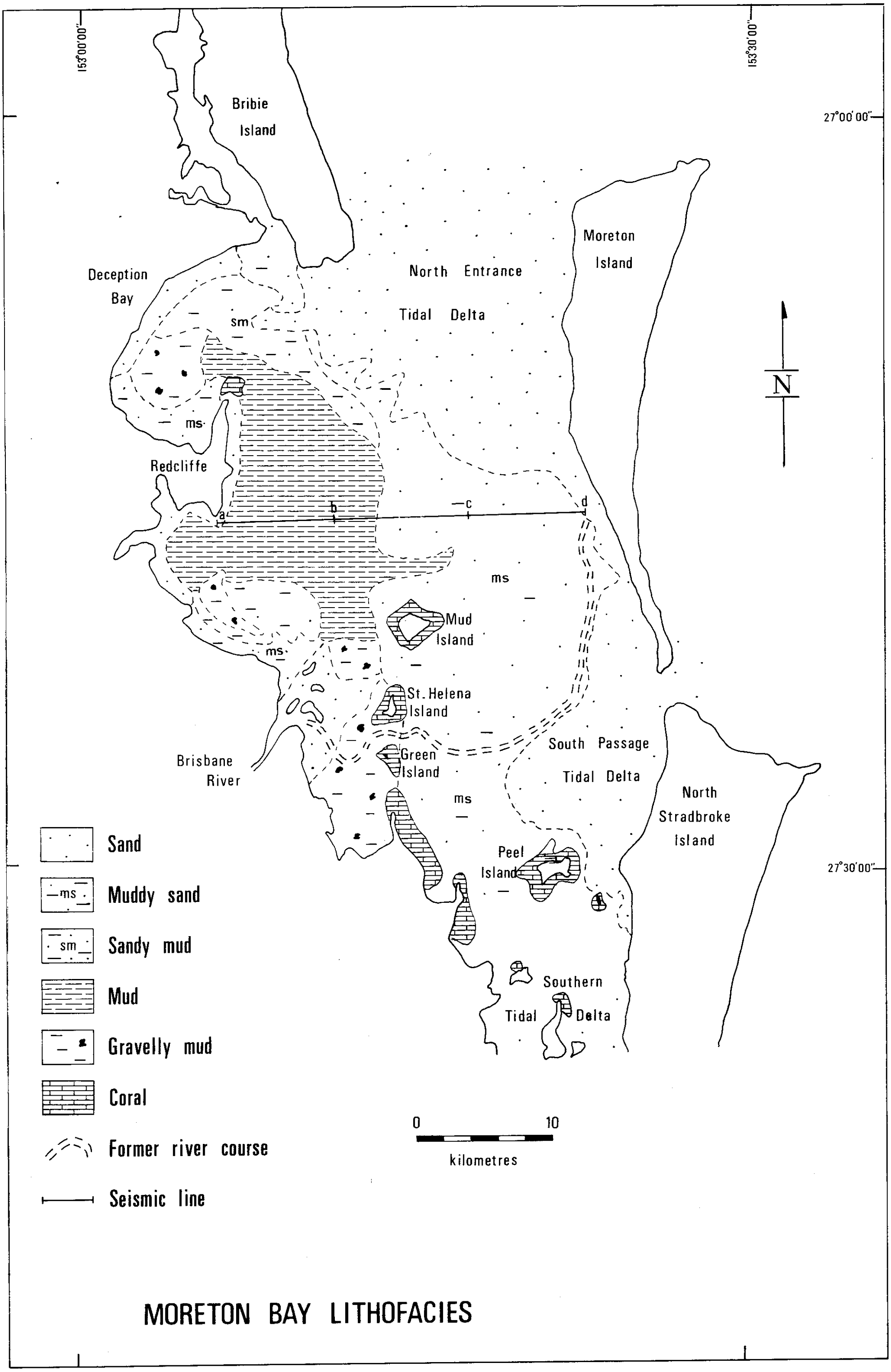
Additional investigations involving seismic profiling and core studies have delineated areas of high and low Holocene sedimentation rates (Hekel *et al.* 1976), and four sedimentation zones have been identified:

1. Nearshore zones of active sediment accumulation: This is the tidal flat environment and seaward progradation of sands and muddy sands occurs in this zone. Where conditions are favourable (e.g. around Peel Island), horizontally prograding coral reefs occur.

2. Quiescent basin sedimentation: Depressions in a pre-Holocene topography have been filled by marine mud. Sea floor slopes within this zone are of the order 0.08 degrees to the east and the area covered corresponds with that of the mud facies (Text-fig. 1). The total sediment accumulation over the pre-Holocene surface rarely exceeds 10 m. The Brisbane, Pine, and Caboolture Rivers have been the principal active suppliers of fine-grained sediments in this zone.

3. Zone of minimal deposition: In this zone, tidal movement has kept muds in suspension and Pleistocene sediments are either exposed or covered by a thin layer of muddy sand. The muddy sand facies corresponds over wide areas with this zone (Text-fig. 1). Occasionally, the sand component of these sediments contains a significant proportion of foraminiferids.

4. Tidal delta depositional zone: Much of the littoral drifting sand of the ocean beaches of Moreton and Stradbroke Islands is trapped by the tidal deltas which have developed at the entrances to Moreton Bay. Three major tidal deltas, in different stages of development, are found at the southern, central eastern, and northern bay entrances. The sand facies coincides with



Text-fig. 1 Moreton Bay lithofacies.

tidal delta areas on the eastern side of the bay (Text-fig. 1).

The southern tidal delta between North Stradbroke Island and the mainland is no longer active. No data on the details of its geological history are yet available but its main activity was presumably in the Pleistocene. At present the delta consists of sand islands with mangrove mud fringes, separated by numerous small channels. During the acme of its development the delta sands filled the depressions between the southern Moreton Bay islands, and its northern front approached close to Peel Island.

The central eastern tidal delta, here referred to as the South Passage tidal delta (Text-fig. 1), has developed as a predominantly intertidal sand body of over 100 km^2. In the northern part, the first mangrove stabilized islands have appeared on the sand banks. In historic times two main channels have operated alternately in intervals of decades in extending the delta further into Moreton Bay. The northern tidal delta, referred to as the North Entrance tidal delta (Text-fig. 1), is an incipient feature which is only locally filled to intertidal level.

PLEISTOCENE SEDIMENTS IN MORETON BAY

Several types of Pleistocene sediments have been identified. Sub-marine relict sediments are readily recognised if they are of continental origin; however, where Pleistocene sediments are marine, they are difficult to differentiate from Holocene deposits. Diagnostic characteristics of Pleistocene continental and marine sediments are as follows:

Continental sediments

These may be recognised by three features: consolidation (lithification), colour, and carbonate content. There is a marked contrast in the degree of consolidation between the soft marine muds and the compact Pleistocene continental clays. The latter are extremely cohesive and hence difficult to sample. Colours such as light blue, grey, red, and light ochre brown of the continental clays contrast with the consistently dark olive grey of the marine muds. Continental sediments, including those of the supratidal flats, are generally carbonate-free in the mud fraction, in contrast to Holocene marine muds which consistently contain biogenic carbonate.

Clays of weathering profiles, which contain ferruginous concretions, and thin bedded alluvial muds are typical of continental sediments. In seismic profiles, continental clays were inferred from strong reflectors representing irregular erosional surfaces, and coring has generally confirmed this interpretation.

Marine sediments

The Pleistocene marine sediments of the bay were exposed to sub-aerial weathering during the periods of lowered sea level. During this time, limonitic concretions developed in zones close to the surface of weathering. These concretions, up to granule size, have the appearance of pisoliths of a lateritic profile. Smaller concretions and fossils were recognised in grain mounts using reflected light.

The significance of authigenic limonite grains for recognising Pleistocene marine sediments in submarine cores has been substantiated by deep coring carried out by the New South Wales Department of Mines (P. Roy pers. comm.). Indirect evidence for relict marine muds is provided by the seismic records where erosional surfaces overlie mud lithologies. The presence of relict foraminiferal assemblages in sediments is a further indication of Pleistocene marine sediments.

ISLANDS WITHIN NORTHERN MORETON BAY

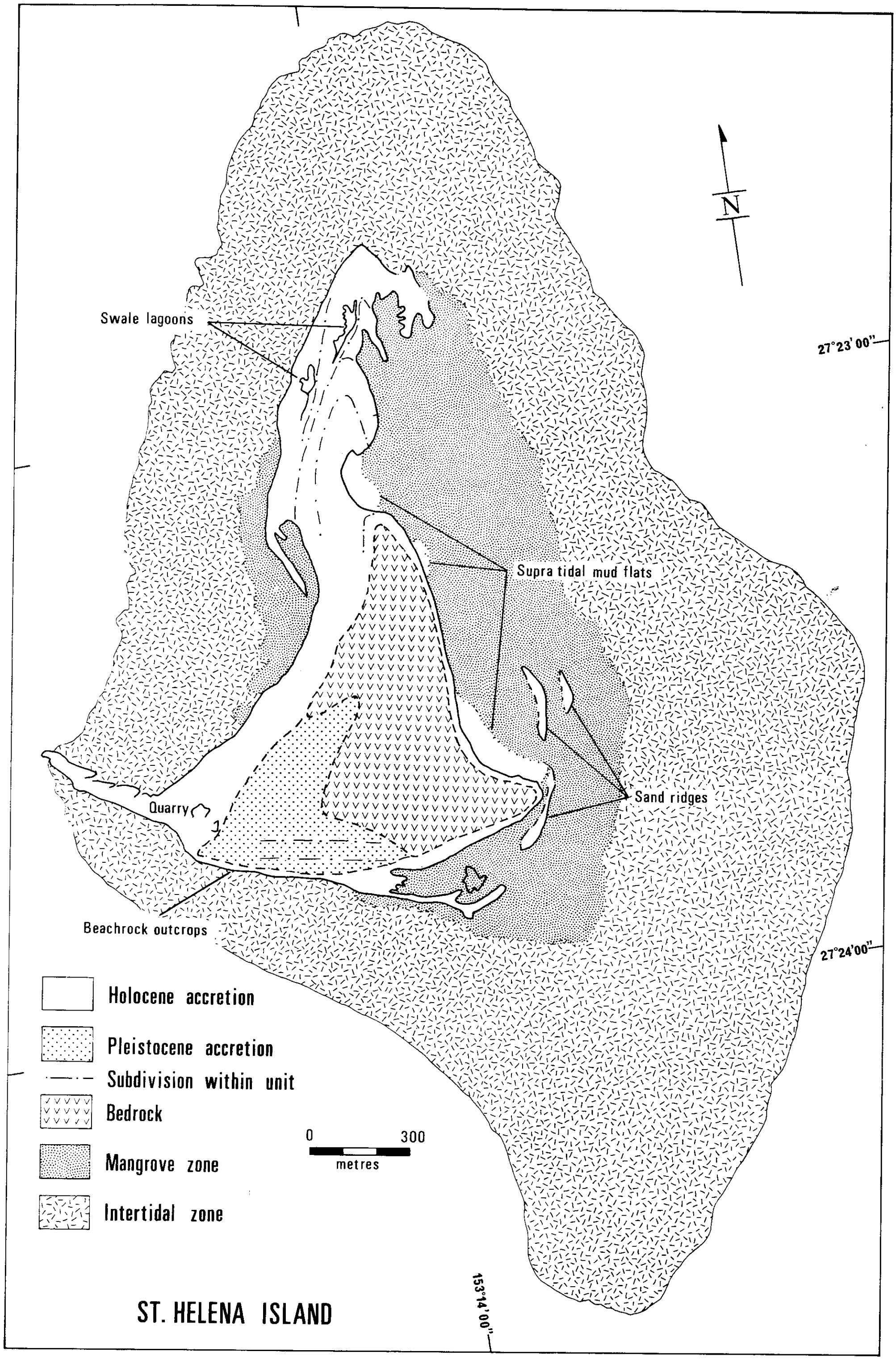
The principal islands within Moreton Bay are Mud, St Helena and Green Islands, which form a north-south chain along a Tertiary basalt high, and Peel Island, which has a Mesozoic sandstone core. The Quaternary record is best preserved on St Helena Island, which is also the most readily accessible island. Radiocarbon age determinations have been made on samples from St Helena and Peel Islands (Lovell 1975; Rubin and Alexander 1958), and uranium series dates are available from Mud Island (Marshall pers. comm.).

St Helena Island

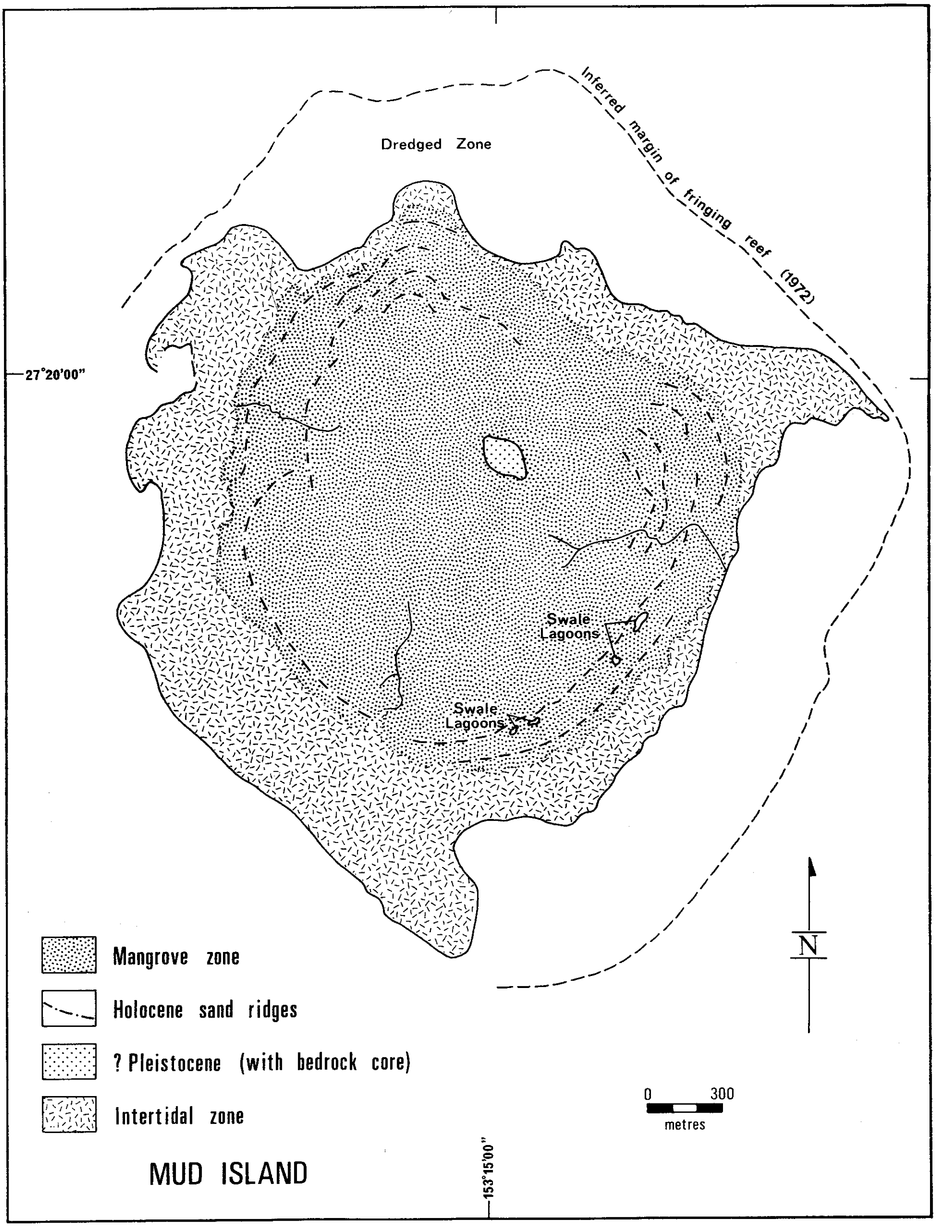
St Helena Island (Text-figs 1, 2) has a core of Tertiary basalt with a maximum elevation of 21 m. Several stages of accretion about this core have been identified. In the southwestern part of the island, a platform area with an elevation of approximately 5 m overlaps the bedrock core. Two distinct east-west trending sand ridges cross this area, and scattered shells on the surface are thought to be midden deposits. A drop in height to a second level defines the outer boundary of the platform. The sand ridges have a degraded appearance and the platform feature is considered to be of Pleistocene age.

On the western side of St Helena Island, a second, lower platform occurs, across which several accretionary divisions may be recognised. Lagoons are present in two successive swales near the northern tip of the island. The accretion ridges on the lower platform on the island show contrastingly sharp ridge crests when compared with the Pleistocene platform and are considered to be of Holocene age. Traces of two ridges occur in the mangrove zone on the eastern side of the island. These are further remnants of Holocene accretion stages. The presence of several accretionary stages on St Helena Island could suggest a comparison with the sequence of Holocene cheniers at Broad Sound, Queensland, which provides dated evidence for several accretion systems within the past 5 000 years (Cook and Polach 1973).

A carbonate beachrock occurs on the southwest margin of St Helena Island, and from this a C14 date of 2540 ± 85 y B.P. for a mollusc shell was obtained (Lovell 1975). This date suggests Holocene overlapping of beachrock onto the southwest margin of the Pleistocene platform. Whether beachrock



Text-fig. 2   St Helena Island.



Text-fig. 3 Mud Island.

can be regarded as a sea level indicator as precise as Lovell suggests, is open to question.

A noticeable feature of St Helena Island is the width of the intertidal zone within which the coral platform has built up. The zone is widest in the southeast reflecting more favorable growth conditions in this area. Portions of this zone may have developed during the low sea level suggested by terraces at approximately 4 m below present Low Water Datum in adjacent areas of Moreton Bay (Smith 1973).

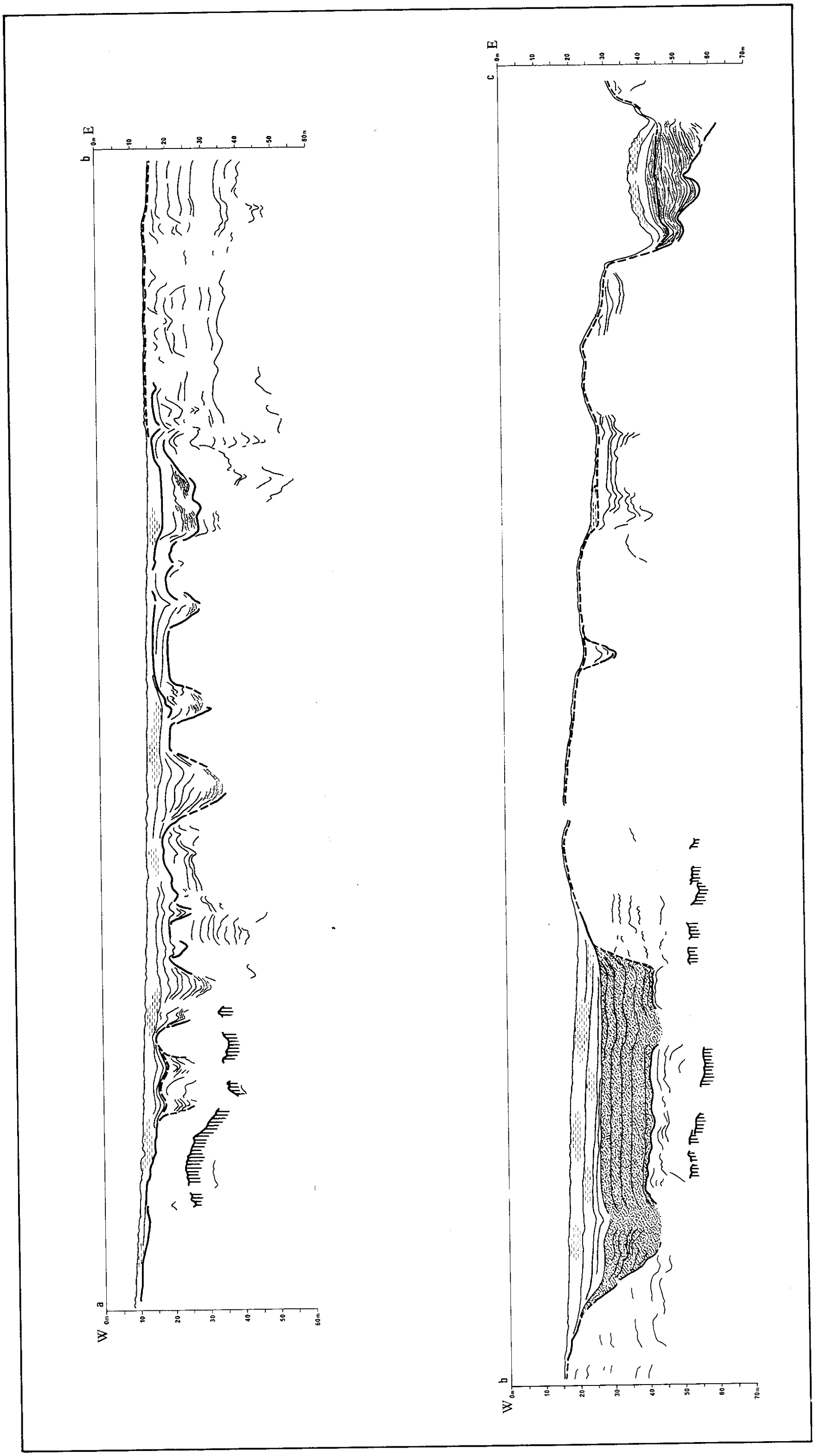
Mud Island

Mud Island (Text-figs 1, 3) lies approximately 3 km to the north of St Helena Island. At the centre of the island a small vegetated sand mass has built up around a basement core. Accretion around the core has taken place with nearly equal vigour in all directions so that the island is almost circular. A fossil fringing coral reef occupies the subtidal and intertidal zones and at present is being dredged for cement manufacture. The supratidal zone is quite extensive and is vegetated by mangroves and halophytic plants. Within the vegetated supratidal zone, a number of sand ridges concentric with the island centre may be distinguished on aerial photographs. Dredging operations have approached the margin of the mangrove zone on the northern side of the island, and have exposed a number of coral types which are atypical with respect to those presently growing within Moreton Bay (Lovell pers. comm.). The facies with *Acropora* abundant, both in growth position and overturned, has been exposed by dredging and is similar to coral now growing on fore-reef slopes in southern areas of the Great Barrier Reef. The scarcity of *Acropora* and the dominance of *Favia* in Moreton Bay under present day conditions are interpreted as indicative of a change in environmental conditions. In particular an increase in the turbidity of the water is suggested.

The fossil corals have been sampled and uranium series dates obtained. Two *Acropora* samples were dated at 4 600 and 6 000 years and a *Favia* at 4 100 years B.P. (Marshall pers. comm.). Evidence from the site of the sample dated at 4 600 years B.P. suggests that sea level may have stood as much as 1 m above present mean sea level at that time. Since the dated corals were located approximately 750 m behind the present outer margin of the fossil reef, a rapid lateral reef progradation rate of 12 to 16 cm per year is inferred. This is slightly in excess of measurements by Shinn (1976) who determined growth rates of 10 cm per year with *Acropora cervicornis* in storm-devastated reefs off the coast of Florida.

RESULTS OF GEOPHYSICAL PROFILING

A number of seismic profiles have been made across Moreton Bay using a high resolution boomer system. A line drawing of a complete east-west traverse from Redcliffe to Moreton Island (Text-fig. 1) is shown in Text-fig. 4 and illustrates the principal features of the subsurface in Moreton Bay.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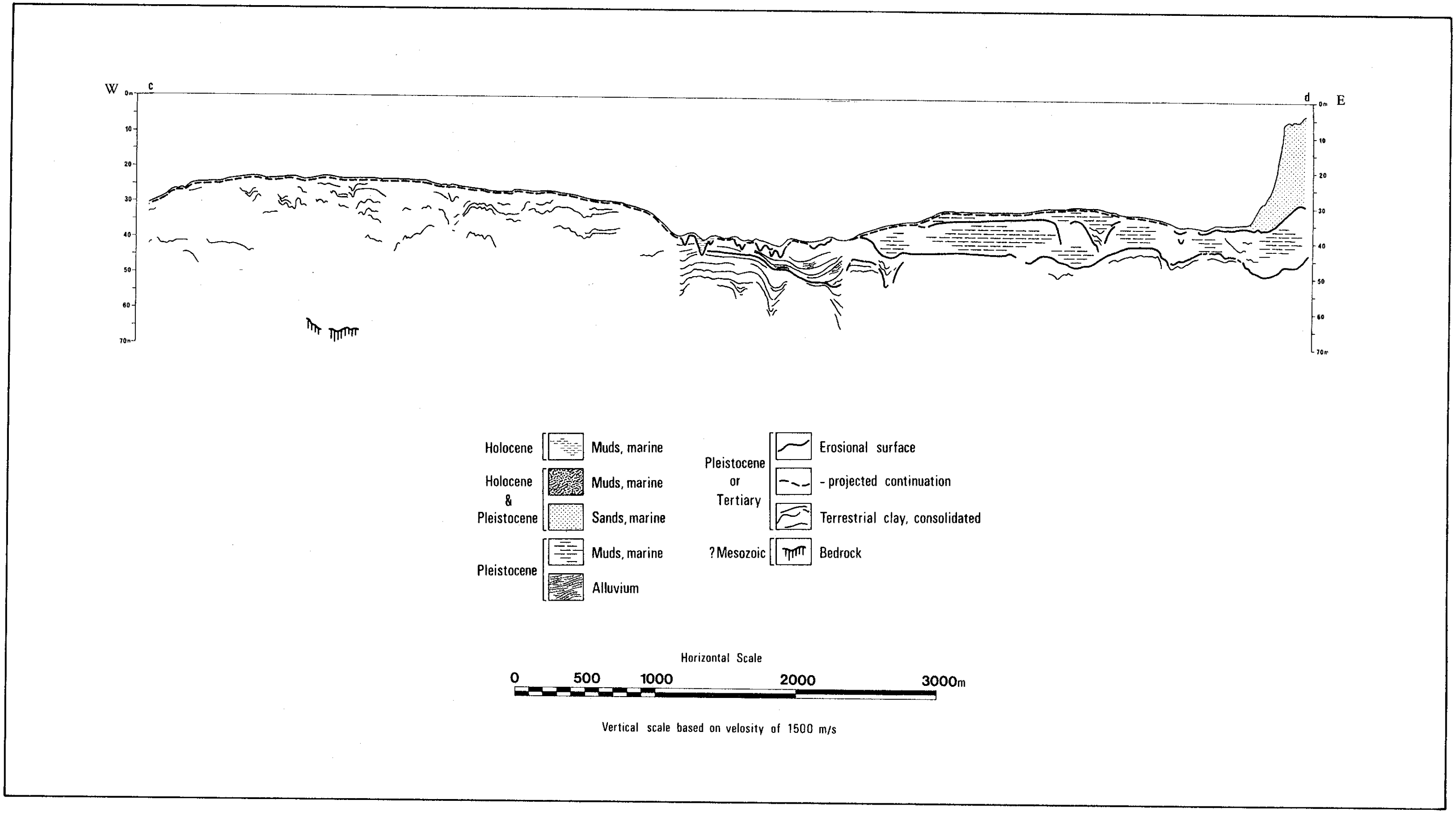

Text-fig. 4 East-west seismic section showing principal reflectors. See Text-fig. 1 for location.

The eastern side of the Redcliffe Peninsula is dominated by cliffs of compact lateritic clay containing ferruginous nodules. The clay extends eastwards into Moreton Bay and forms an undulating continental surface beneath the sea floor. The lower parts of channel features on this surface are assumed to contain alluvial deposits. In the central area of Moreton Bay, the erosional surface rises and a veneer of muddy sand forms a covering without subduing its relief. Several erosional surfaces enclosing interpreted Pleistocene interglacial marine muds have been identified on the geophysical records. At the eastern end of the record, the Pleistocene/Holocene sand accumulation of the Moreton Island coast lies directly over an erosional surface at a depth of approximately 20 m. Deep reflectors on the seismic records have been interpreted as Mesozoic bedrock (Text-fig. 4).

The seismic records have revealed a number of completely and partly sediment filled river channels between Mud and St Helena Islands, and St Helena and Green Islands, extending across Moreton Bay to Moreton Island. These are relict river channels which formed during times of lowered sea level. Evidence for the sea having remained at –4 m, –7 m and – 20 m with respect to present Low Water Datum within Moreton Bay is provided by terraces found at these levels.

SEQUENCE OF EVENTS IN MORETON BAY

During the Pleistocene glacial ages, the sea level was lowered resulting in a more easterly location of the coast line. Bathymetric evidence indicates that the coast line would have been to the east of Moreton Island and fossil shorelines have been postulated at depths of as much as –184 m (Jones 1973). At such times, the land surface which now forms the sea floor in Moreton Bay was completely exposed and soil profiles developed on this surface. The Brisbane River formed channels whose traces still remain (Text-fig. 1). At least one channel has been partially covered by the sand accretion which forms Moreton Island. During the Pleistocene several major transgressions occurred some of which brought the level of the sea to several metres higher than its present level. The inner platform at St Helena Island may be a relic of one of these events. One of the high sea levels may be correlated with the last interglacial period approximately 120 000 years B.P. (Marshall and Thom 1976). Another (relatively) high Pleistocene still-stand of sea level is reflected by drowned accretion ridge features and intertidal flats, about 7 m below Low Water Datum. Humic sandrock layers which formed as a cementation zone parallel to the original landform can be identified within the North Entrance tidal delta.

The dates from both St Helena and Mud Islands indicate periods of Holocene sea level possibly up to 1 m higher than at present. The Holocene trangression was complete by approximately 6 000 years B.P. and the level appears to have been maintained within ± 1 m of present sea level since that time (Thom and Chappell 1975). The outer platform of accretion ridges, the onlapping beach-rock on St Helena Island, and the coral margin on Mud

Island have all formed since the end of the Holocene transgression. Little is known at present of the relationships between the submarine geological features of Moreton Bay and the record of Quaternary events preserved in the dune systems of Moreton and North Stradbroke Islands.

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