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FRASER ISLAND

QUEENSLAND

SHEET SG 56 – 3(PART) INTERNATIONAL INDEX

BY

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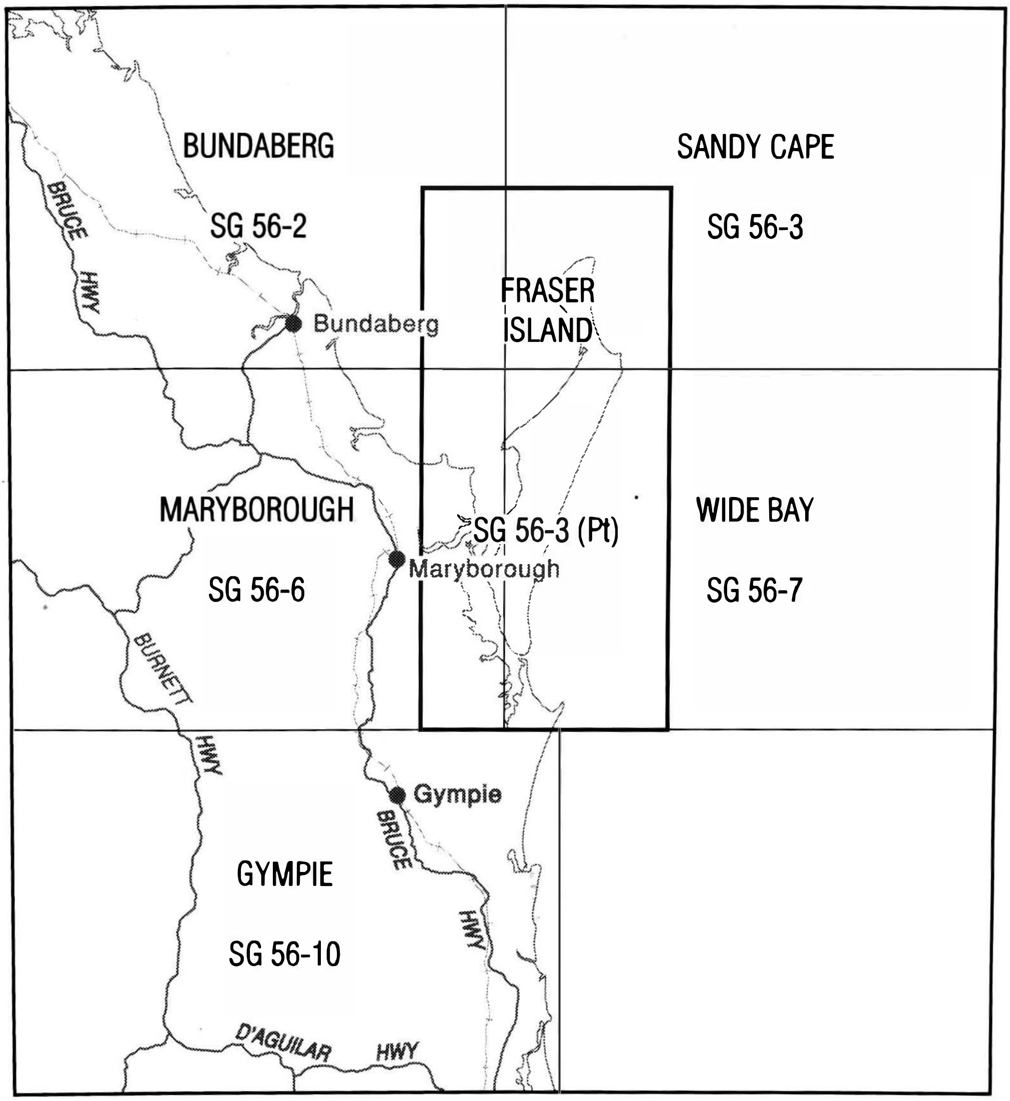


Frontispiece: Fraser Island 1:250 000 Geological Map locality

Introduction

The Fraser Island 1:250 000 Geological Map {SG 56-3 (Part)} is bounded by latitudes 24°30' and 26°S, and longitudes 152°45' and 153°30'E, and includes parts of the Sandy Cape (SG 56-3), Maryborough (SG 56-6) and Wide Bay (SG 56-7) 1:250 000 Sheet areas (Frontispiece). It covers Fraser Island and the adjoining part of the mainland, and overlaps with the eastern part of the Maryborough 1:250 000 geological map sheet (Ellis, 1968; Cranfield, in preparation).

The city of Maryborough lies just to the west of the sheet boundary. Townships within the sheet include the coastal resorts of Hervey Bay (the Pialba-Urangan complex), Happy Valley and Eurong on the east coast of Fraser Island, and Rainbow Beach on the mainland coast. Tin Can Bay is a fishing port and holiday village. Some smaller holiday settlements occur on the mainland coast of Great Sandy Strait (eg. Boonooroo). Sealed roads provide access to the Pialba area, Boonooroo, Tin Can Bay and Rainbow Beach, and there is a linking road through the State Forest between Boonooroo and Tin Can Bay. Access to Fraser Island is via vehicular barges from Inskip Point to the southern tip, and from Urangan to several points on the west coast. A network of sandy, four-wheel-drive tracks provides access in the southern two-thirds of the island, but tracks are sparse in the northern part, which is a National Park. Access is prohibited to the Tin Can Bay Military Area in the southern part of the sheet area.

The principal land uses in the area are forestry, grazing, agriculture, and tourism. Exotic pine plantations are located in the southwest of the sheet area, on the Triassic Duckinwilla Group. Until the proclamation of Fraser Island as a World Heritage area in 1991, timber-getting also occurred on Fraser Island, both in natural forests and in plantations of native species. Agriculture is restricted to the better soils developed on Mesozoic sediments and volcanics, Tertiary basalts and Quaternary alluvium in the Maryborough-Pialba area. Tourism is a major industry in the coastal areas and on Fraser Island.

Mining for heavy minerals in the coastal sands at Rainbow Beach and on the southern end of Fraser Island occurred between 1966 and 1976, at which time further mining was prevented by a Commonwealth Government decision made on the recommendation of an environmental inquiry (Hicks & Hookey, 1977).

The area has a warm, humid climate, with average daily temperatures ranging between 15°C and 27°C, and an annual rainfall of about 1100 mm with a summer maximum. The strongest winds are from the southeast.

Coverage of the sheet area by 1:100 000 scale topographic maps is complete, and 1:50 000 scale maps are available also for the southern part. Aerial photographic coverage includes high altitude, wide-angle Commonwealth photography flown in 1962 (Maryborough) and 1967 (Sandy Cape and Wide Bay), and lower altitude photography flown for the State in 1969-70 (Fraser Island), 1979 (Waddy Point and Happy Valley), 1983

(Pialba) and 1984 (Maryborough and Wide Bay). Earlier, low altitude photography also exists, and in some cases is of better quality. The Queensland Beach Protection Authority regularly flies low altitude colour photography along the coast. Landsat MS images of the area are available from Sunmap (ALS 89-77,78 and 90-77,78).

Previous Geological Investigations

A regional review and preliminary 1:250 000 scale geological map of the Maryborough Sheet area, which overlaps the western part of the Fraser Island Special sheet, was compiled by Ellis (1968). That review contains a bibliography of geological work up to that date. The Maryborough Sheet area has been remapped recently and a first-edition geological map and report are in preparation (Cranfield, in preparation). The stratigraphic nomenclature of the Mesozoic Maryborough Basin was revised during that project (Cranfield, 1989).

The only previously published detailed geological map of the remainder of the sheet area was that of Connah (1961). The Cainozoic evolution of the region has been summarised by Grimes and others (1984).

Soil and landform studies by the CSIRO and the present author provided a basis for the Cainozoic morphostratigraphy (eg. Ward, 1977; Ward & others, 1979; Thompson, 1983; Thompson & Bowman, 1984; Ward & Grimes, 1987).

A detailed drilling program formed part of a groundwater study on the coastal plain east of Maryborough (Laycock, 1969, 1975), and some isolated holes were drilled as part of a clay resource study in the same area (Siemon, 1980). Eight holes between 37 m and 158 m deep were drilled in two lines across the southern half of Fraser Island by the Queensland Water Resources Commission in 1980 as part of a groundwater study (B. Pearce, personal communication). A number of stratigraphic bores were drilled by the Geological Survey of Queensland as part of the mapping program; these include four deep stratigraphic bores in the Mesozoic and Tertiary rocks (Cranfield, 1982; Grimes, 1982) and 20 shallow holes in the coastal plains (Grimes, in preparation). Their locations are shown on the map.

There was extensive drilling on Fraser Island during exploration for heavy mineral sands, but in most of the available reports the information is restricted to heavy mineral contents and watertables, with little geological data. However, Squance (1968) described several drill lines on the western side of Fraser Island which intersected estuarine clay, sand and gravel beneath the 'dune' sands at depths between 10 m and 20 m below MSL. A few of the holes may have reached weathered Mesozoic basement. Whitehouse (1968) briefly mentions a hole at the mouth of Urang Creek, in which 30 m of recent sands overlie 'Burrum type' sandstone.

Seismic surveys on Fraser Island (Bruce & Thomas, 1964; Murphyores, 1967) suggest a Cainozoic sequence thickening from about 50 m at Moon Point to 250 m at Rooney point. GSQ Sandy Cape 1-3R at the northern tip of the island penetrated 592 m of Cainozoic sediments and volcanics (Grimes, 1982). Offshore seismic profiling by the Bureau of Mineral Resources provides depth to a reflector which might be at the base of the Cainozoic or at a Miocene unconformity (Marshall, 1977, 1978). A number of seismic lines in the northern end of Great Sandy Strait and the adjoining part of Hervey Bay were undertaken as part of honours thesis work (Draper, 1971; Stephens, 1971).

The Bureau of Mineral Resources conducted a number of marine surveys on the continental shelf (Marshall, 1977, 1980). The SONNE cruise in 1980 provided information on the shelf sediments east of Fraser Island (Stephens, 1982b; Kudrass, 1982). The Marine and Coastal Investigations Subprogram of the Queensland Department of Mines made a detailed study of the sediments and evolution of the mainland coastline of Hervey Bay (Stephens & others, 1988).

Mineral resources of the area have been tabulated by the Geological Survey of Queensland (1981); reserves of industrial rocks and minerals on the mainland were documented by Robertson (1981a, b). Mineral exploration to 1978 in the Maryborough Sheet area was summarised by McLeod (1979) and from 1978 to 1988 by Cranfield and Garrad (1991).

Acknowledgments

The author is indebted to Bill Ward of the CSIRO for introducing him to the use of soil stratigraphy in the coastal sand mass, and for numerous discussions about the geological history of the area.

Physiography

The main physiographic divisions of the sheet area are shown in Figure 1. This section describes the landforms and how they formed, but it should be read in conjunction with that on MORPHOSTRATIGRAPHY which discusses their evolution and relationships in time.

Booyal Surface (Cranfield, in preparation b): This is a gently undulating, deeply weathered Tertiary land surface which is preserved only in places; for example, behind the **Como Scarp**, south of the Rainbow Beach road, where it lies at elevations between 50 m and 80 m. Elsewhere it has been buried by the sediments which formed the Elliott Surface, or it has been destroyed by later erosion and the underlying weathering profile has been partly or wholly removed.

Elliott Surface: This surface forms a low lying, swampy plain between Maryborough and Boonooroo. It is highest to the west, at about 25 m, and slopes very gently towards the coast. It formed in the late Tertiary as a depositional surface on the 'younger' Elliott Formation. The surface escaped subsequent erosion because of its low relief. A nodular ferricrete and deep weathering profile occur beneath the pale surface soils, and contribute to the

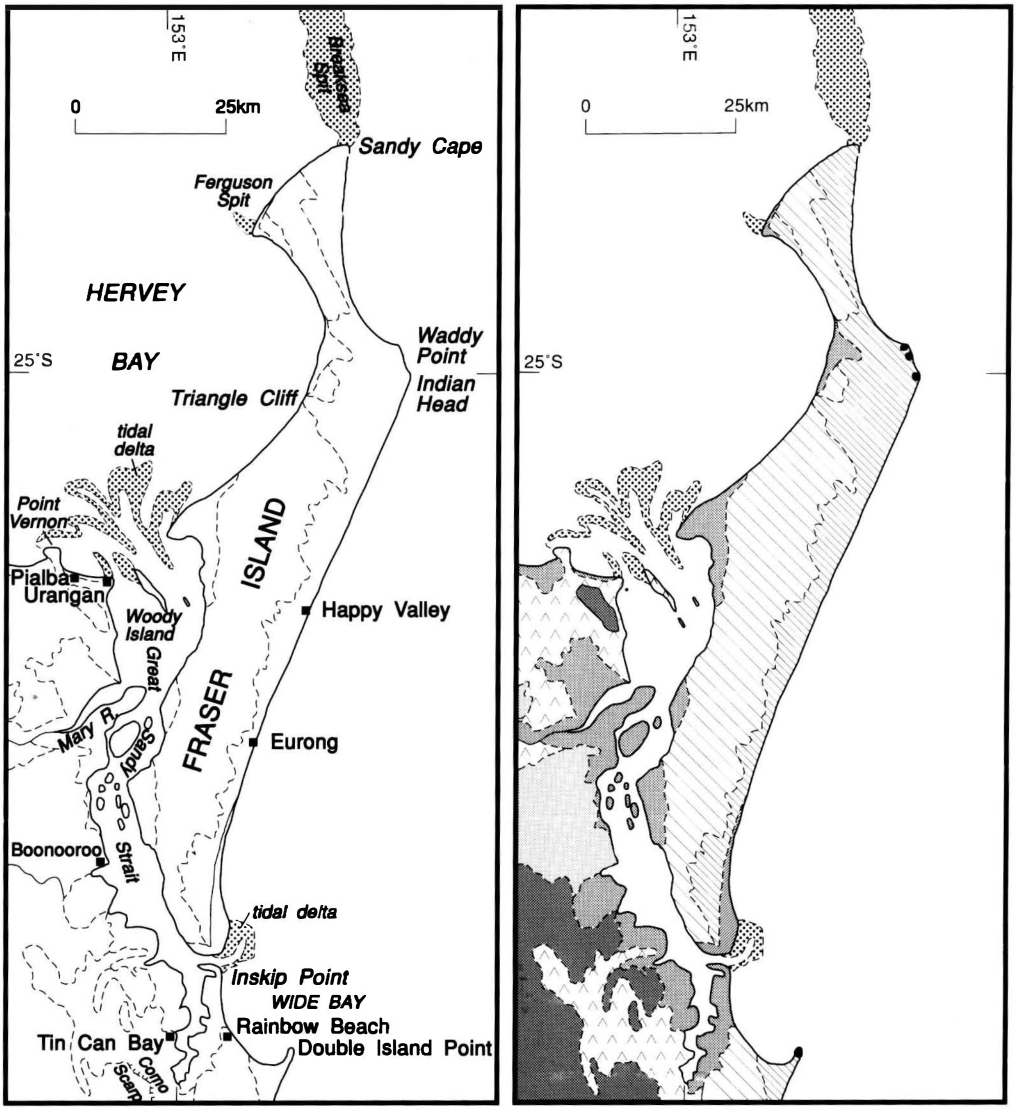
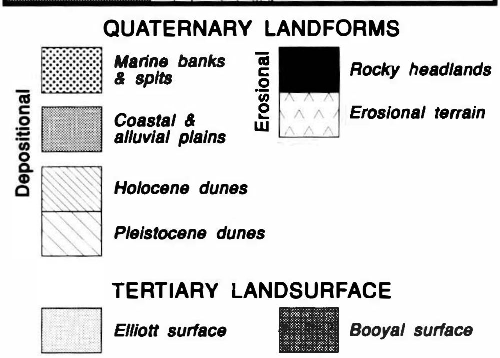


Figure 1: Cultural features and physiographic units of Fraser Island



waterlogged nature of the country. The sediments associated with the Elliott Surface appear to have buried the older Booyal Surface near Big Tuan Creek.

Erosional terrain: The erosional terrain was developed by late Cainozoic dissection of the Mesozoic and early Tertiary rocks and sediments. The structure of the Mesozoic rocks influenced the topography. The silicified bed at the top of the Maryborough Formation forms the Woody Islands at the northern end of Great Sandy Strait, and the linear ridges in the Pialba area. Further south, beds of hard quartz sandstone in the Duckinwilla Group form resistant rocky ridges. The **Como Scarp** is an erosional feature formed at the divide between the high gradient, aggressive coastal drainage and the less energetic, lower gradient streams which drain inland into Tinana Creek. It is not an old sea cliff, as suggested by some early workers.

Alluvial flats and terraces: These occur along the main streams in the area. The terraces are best developed adjacent to the Mary River. Their slopes are graded to older sea levels, which appear not to have been greatly different to the present. The highest, and oldest, terrace (**Qpa** on the map) may have formed during the last interglacial highstand of the sea. The river would have cut down into it during the lower sea levels of the last glacial period. The younger terraces have formed since the sea level rose at the end of this glacial period. The different heights and the break between them may reflect variations in sea level or in climate and river discharge. On Figure 1, the alluvial flats and terraces have been included in the coastal plains unit.

Coastal plains: Low-lying depositional plains are formed by Quaternary coastal sediments. The depositional landforms on the younger plains are still recognisable and can be mapped as morphostratigraphic units. However, on the older Pleistocene plains the landforms have degraded and are harder to recognise, so undifferentiated map units have been used in many areas (**Qpc, Qc** etc). The term **beachridge** is used here for the linear ridges that are built parallel to the shoreline on a prograding coast. They are formed from a vertically stacked sequence which grades up from marine through beach and into foredune deposits.

Great Sandy Strait: This is a low-lying area to the west of the high coastal dunes of Fraser Island. It would have been a coastal plain during the last glacial period, but was flooded by the postglacial rise in sea level. Tidal currents have kept the channels flushed, and prevented the strait from silting up. Tin Can Inlet is a drowned valley that was flooded by the rising sea. The present opening of Wide Bay Harbour, to the north of Inskip Point, formed between 4000 and 3000 years ago; prior to that the opening was via Pelican Bay, to the south of Inskip Point.

Marine banks and spits: These features formed as tidal deltas at each end of Great Sandy Strait as tidal shaped banks within the strait, and by a combination of longshore drift and tidal currents at Breaksea Spit and Ferguson Spit.

Dunefields: The bulk of Fraser Island, and the sand mass in the Cooloola area are massive dunefields. They have been built up as a series of overlapping parabolic sand dunes which reach elevations up to 244 m above sea level. The quartz sands extend below sea level to -40 m in the south, and -100 m at Sandy Cape. However, the difficulty in distinguishing dune sands from marine or coastal sands in this uniform lithology makes it uncertain how far below sea level the dune sands extend. Ward (1977) argues that most of the older dunes formed during the glacial periods, when sea levels were lower, so they may well extend a considerable distance below present sea level.

Most of the dunes have a parabolic form, with long trailing arms aligned parallel to the dominant southeast winds. This shape indicates that the dunes formed while moving across a vegetated surface, and the vegetation was stabilising the arms, and restricting the width of the bare sand area. In contrast, much of the **Qhd3** dune unit in the northern part of Fraser Island has a different landform of broad waving sand ridges, some of which lie transverse to the southeast winds. This is interpreted as indicating a broad sand 'sea' with little vegetation, and might reflect a drier climate, or stronger winds that were able to totally overwhelm the vegetation. The **Qhd3** sand unit probably formed during or immediately after the postglacial rise of the sea (Ward & Grimes, 1987).

Dune lakes: The dune lakes occur within the dunefields, but are not shown on Figure 1. They are of two types: groundwater lakes and perched lakes (James, 1980). Their origins are illustrated in Figure 2. In a uniform sand body the regional water table has a gently domed surface. Where a depression in a dunefield intersects this surface a groundwater lake will appear. On Fraser Island, Lake Yankee Jack at the southern end, and Lake Krambruk and its associates at the northern end, are examples of groundwater lakes. Perched lakes form where the water is held up above an impermeable or less permeable layer.

The reduction in permeability can be a result of several factors (James, 1980) — organic material can wash into a dune depression and seal the bottom; or organic materials, iron oxides and fine clay and silt-sized material derived from the weathering of labile grains can move down through the sand and accumulate either in the B horizons of the giant podsols, or as the black sandrock layers on the contemporary watertables. The seal need not be complete. James (1980) showed that a reduction in permeability to one tenth of the surrounding sand is sufficient to create a dynamic perching effect.

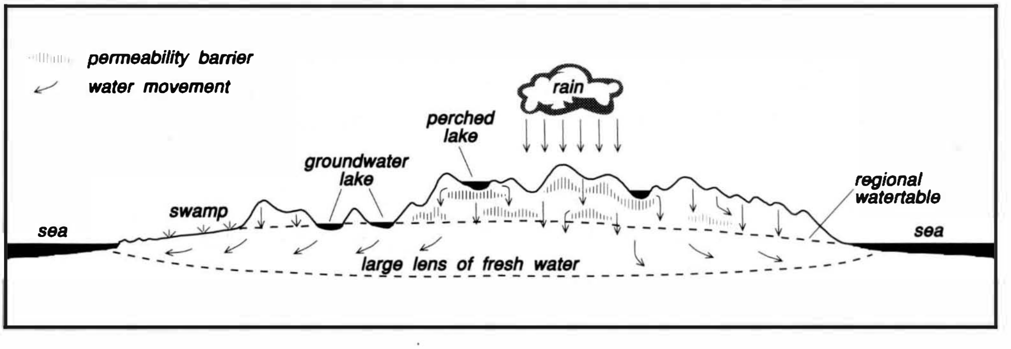


Figure 2: Origin of perched and groundwater lakes

Rocky headlands: Double Island Point and Waddy Point are formed on resistant volcanic rocks of Cretaceous and Tertiary age respectively. The headlands form the tie points which control the erosional and depositional balance which is responsible for the curves of the present coastline (Stephens, 1982a). The tidal delta of Wide Bay Inlet provides a third local tie point which is responsible for the bulge in the coast at Hook Point.

Lithostratigraphy

Pre-Mesozoic Basement

There is little information on the basement rocks beneath the Mesozoic Maryborough Basin. Petroleum exploration wells have not penetrated to the basement and the geophysical information is of limited use. To the west and south, Maryborough Basin sediments and volcanics unconformably overlie rocks of the Gympie Block (Cranfield, 1990) so it is reasonable to assume that the basin is underlain by folded and possibly metamorphosed Permian to Triassic rocks of the Gympie Block, and by late Triassic granitic bodies. A gravity low in the middle part of Fraser Island could indicate the presence of one such granitic body (Smith,1964).

Maryborough Basin

The Maryborough Basin is a northwesterly aligned structure with its deepest part lying just offshore beneath Hervey Bay, but its offshore extent and nature are poorly known. Grimes (1977a) summarises the offshore information derived from petroleum exploration. The structural inset and cross section shown on the geological map are interpretations based on this information. The geophysical evidence (Smith, 1965; Marshall, 1977,1980) suggests that, within the Fraser Island Sheet area, the Maryborough Basin is thickest between Urangan and Moon Point but thins to the northeast beneath Fraser Island, and that there is a basement ridge, the Bunker Ridge, extending northwest from Sandy Cape which could be regarded as the basin margin.

There appear to be several large faulted horsts and troughs beneath the island. The nature of the southeastern end of the basin is not known; it may extend to and be truncated by the continental slope some 80 km offshore. The descriptions which follow are derived mainly from the onshore exposures within and to the west of the sheet area (Table 1).

A review of the geology and stratigraphic nomenclature of the Maryborough Basin has been presented in Cranfield (1989, in preparation a), who recognised three depositional and structural entities:

(i) A basal sequence of fluvial channel, levee and flood plain deposits (Duckinwilla Group), which was folded, uplifted and eroded prior to the deposition of

Table 1 – Mesozoic Lithostratigraphic Units

Age	Unit	Lithology	Distribution	Thickness	Environment	Remarks
CRETACEOUS	**Burrum Coal Measures** Kb	Labile to sublabile sandstone, siltstone, mudstone,shale, coal, minor conglomerate and glauconitic sandstone	In synclines in the Urangan – Maryborough area	500 m	Fluvial, coal swamps	Poorly exposed
	Maryborough Formation Km	Mudstone, shale, siltstone, labile sandstone	In anticlines in the Pialba – Maryborough area. Narrow ridge SE of Maryborough	1800 m, 3000 m offshore	Marine	Silicified beds at top and bottom form marked strike ridges
JURASSIC	**Grahams Creek Formation** JKg	Intermediate flows and pyroclastics, minor sandstone, siltstone, and conglomerate	Poorly exposed belt between Maryborough and Double Island Point	1200 m, 380 m in subsurface	Volcanics and interbedded fluvial sediments	
TRIASSIC	**Duckinwilla Group** RJd	Quartzose and labile sandstone, shale, siltstone, minor conglomerate and coal	Southwest part of sheet area	> 1000 m	Fluvial	Strongly folded and faulted

(ii) A middle section of continental volcanics (Grahams Creek Formation), which is overlain disconformably by

(iii) An upper section of transgressive marginal-marine deposits (Maryborough Formation) and overlying regressive deltaic and paralic deposits (Burrum Coal Measures).

Duckinwilla Group (RJd): The Late Triassic to Middle Jurassic Duckinwilla Group is exposed in the southwest of the Fraser Island Sheet area and was also identified in the base of the GSQ Sandy Cape 1-3R bore, so it may extend at depth beneath most of the sheet area. It was defined in the Maryborough Sheet area by Cranfield (1989), and comprises the Myrtle Creek Sandstone and the overlying Tiaro Coal Measures. However, within the Fraser Island Sheet area those two components cannot be differentiated. This is partly because of the poor outcrop, deep weathering, and the strong folding and faulting, and partly because the quartz sandstones, characteristic of the former unit, and the more labile sandstones and finer grained sediments of the latter, appear to alternate in this area. Cranfield (1982,1989, in preparation a) interprets the Group as having formed in a fluvial to lacustrine environment.

Outcrop in the southwest of the sheet area shows the Group has been strongly folded along northwesterly axes, and faulting has repeated the strata. The total thickness is difficult to assess, but may exceed 1000 m.

Grahams Creek Formation (JKg): This dominantly volcanic sequence was defined by Ellis (1968). It forms a linear belt, largely obscured by Cainozoic deposits, extending northwest from Double Island Point. The geophysical evidence suggests that the formation could extend through much of the Maryborough Basin and might be even thicker beneath Hervey Bay, though in the offshore area the unit would probably be mainly composed of distal volcanogenic sediments.

The outcrop belt of the volcanics produces a strong signature on the aeromagnetic maps (Bureau of Mineral Resources, 1989). This signature disappears near the present coast at Double Island Point, which suggests the eastern limit of the volcanics. If so, the speculative eastward continuation of the Grahams Creek Formation shown on the structural insert to the map may not be correct. The belt of subcrop shown on the northeastern side of the Maryborough Basin on the structural insert is also fairly speculative, being based on a zone of relatively high first break seismic velocities (Smith, 1965). The formation appears to be unconformable over the folded Duckinwilla Group, and may also be faulted against it in places.

The volcanics are dominantly andesitic flows, tuffs, and agglomerates which are dark grey, green or purple in colour. Possible sources for the volcanics of this area are exposed some 20 km to the west of the sheet area at Mount Bauple and Mount Kanigan, but there might have been other volcanic centres further to the northwest. Cranfield (personal communication) suggests that true volcanics may be limited to the outcrop zone along the southwestern margin of the basin, and that in the basin centre the formation may be composed mainly of volcanogenic sediments. The sequence has a variable thickness, probably governed by distance from the source vents, and irregularities in the basal unconformity. In the GSQ Maryborough 10 stratigraphic bore, it is 380 m thick. The maximum exposed thickness is in the type area southwest of Maryborough where it reaches 1200 m. The thickness in the central part of the basin is unknown.

Ellis (1968) argued for an early Cretaceous (Neocomian) age for the unit, which has been supported by a K/Ar date (Green & Webb, 1974; Cranfield, in preparation a).

Maryborough Formation (Km): This unit crops out poorly in the Susan Anticline between Maryborough and Pialba, and in a low ridge southeast of Maryborough. Ridges of silicified mudstone at the top and bottom of the unit provide the best exposures. The formation is composed of shallow marine, bioturbated, fine-grained labile sandstone, siltstone and mudstone (Cranfield, in preparation a). It lies disconformably on the Grahams Creek Formation and Duckinwilla Group and was deposited during a late Neocomian to Aptian marine transgression. The unit is about 1800 m thick in the sheet area but could reach 3000 m offshore from Bundaberg (Smith, 1965; Ellis, 1968).

Burrum Coal Measures (Kb): Exposures occur in synclinoria in the Pialba-Maryborough area, and are best seen in the wave-cut platforms at Point Vernon and south of Urangan. The unit conformably overlies the Maryborough Formation and the boundary marks a change from marine to deltaic and paralic conditions (Ellis, 1968; Cranfield, in preparation a). It comprises interbedded fine to medium-grained labile sandstone, siltstone and shale in the lower part, which are overlain, to the west of the sheet area, by a finer grained coal-bearing sequence (Cranfield, in preparation a). Barnbaum (1976) reported palynomorphs that indicate a pre-middle Albian age. The lower part of the unit in the sheet area has a thickness of up to 500 m; to the northwest the unit as a whole could be over 3000 m thick (Ellis, 1968).

Cainozoic Lithostratigraphic Units

The Cainozoic stratigraphic units are mainly of Tertiary age (Table 2).

Tertiary basalt (Tb): Basalt flows and dykes of several ages occur in the area. The oldest flows (**Tb**) were recognised in drill holes in the Dundowran and Nikenbah areas (Laycock, 1969) where they appear to be interbedded with the 'older' Elliott Formation. Red soils in the Nikenbah area may be weathered basalt. Oligocene basalts form part of the **Tos** unit intersected in GSQ Sandy Cape 1-3R bore (see below) and similar basalts form dykes intruding the Waddy Point Volcanics. The Dundowran Basalt is of Miocene age, and is discussed below.

Takura beds (Tt): An unusual unit of cemented angular conglomerate occurs as thin linear bodies parallel to the silicified ridges of the Maryborough Formation (Ellis, 1968). It is a colluvial scree and slope wash deposit formed from fragments of the silicified siltstone. It appears to interfinger with the 'older' Elliott Formation.

Elliott Formation (Te): This name has been applied to a number of Tertiary deposits in the region, which may not all be of the same age (Grimes, 1988). The type area, assigned by Ridley (1957) on the Elliott River southeast of Bundaberg, is probably a mid to late Tertiary sequence and is referred to here as the 'younger' Elliott Formation. In the type area the formation has been deeply weathered and has a thin, discontinuous duricrust composed of nodular ferricrete.

In the Fraser Island Sheet area, the areas of 'Elliott Formation' and the adjoining Takura beds mapped in the Susan River area, south of Pialba (Ellis, 1968; Barnbaum, 1976) may be older, early or mid-Tertiary deposits, and are referred to here as 'older' Elliott Formation. These comprise poorly sorted fluvial and colluvial sandstones, conglomerates, siltstones and claystones, that have been deeply weathered and have siliceous or ferruginous duricrusts including nodular ferricretes. They may correlate with the Eocene Fairymead beds (Robertson, 1979). The position of the Elliott Formation box in the map reference is appropriate for these 'older' Elliott Formation deposits.

Laycock (1969, 1975) reported on a drilling program between Maryborough and Boonooroo, which delineated an old, easterly trending valley of the Mary River, now filled with up to 40 m of clay, sand and gravel which is mottled and ferricreted in its upper part, though poorly consolidated at greater depth. This valley fill is tentatively correlated with the 'younger' Elliott Formation of the type area and should be shown on the map reference as an additional box lying between the Oligocene and Miocene deep weathering events, or possibly in an even younger position, as the nodular ferricretes might be more recent than the main weathering events shown on the map reference.

Duricrusts and deep weathering profiles (Td and screen): The Mesozoic and Tertiary rocks have been affected by deep weathering several times during the Tertiary. The weathering profiles comprise mottled and bleached zones of kaolinised and ferruginised rock, and a siliceous or ferruginous duricrusted cap is preserved in some places.

On the map the dissected parts of the weathering profiles are shown as a screen pattern superimposed on the colour of the parent formation. Where a complete profile and its associated land surface and duricrust is preserved, it is shown in solid colour as the **Td** unit. All duricrusts are depicted on the map by the same screen symbol, as the different ages of weathering are difficult to differentiate except in local areas where morphostratigraphic relationships can be observed.

The older profiles are dissected and discontinuous, but appear to be associated with a gently undulating land surface (the Booyal Surface of Cranfield, in preparation b). On the 'younger' Elliott Formation, in the Boonooroo Plain, a deep weathered profile with a discontinuous nodular ferricrete is developed under a well preserved planar depositional surface. This surface with its nodular ferricrete is similar to the Elliott Surface found on the Elliott Formation in its type area, and there it seems to be younger

Table 2 – Tertiary Lithostratigraphic Units

Age	Unit	Lithology	Distribution	Thickness	Environment	Remarks
PLIOCENE	TQc	Poorly consolidated fine to very coarse sand, mud and gravel	Old coastal plain near Poona Point	> =14m	Alluvial, colluvial, possibly some coastal deposits	Not deeply weathered
	Tps	Quartz and calcarenaceous sand, calcreted at top	Offshore: 104 – 209 m in GSQ Sandy Cape 1-3R	105 m	Marine shelf	
MIOCENE	Tms	Shale and mudstone at base, quartz and calcarenaceous sand	Offshore: 209 – 434 m in GSQ Sandy Cape 1-3R	225 m	Marine shelf, above estuarine and fluvial	
	'younger' Elliott Formation Te	Soft silt, clay, sand and gravel. Nodular ferricrete at top	Between Maryborough and Boonooroo	40 m	Fluvial	Correlates with the type area of the Elliott Formation
	Dundowran Basalt Tmd	Olivine basalt	Small area west of Pialba	<45 m	Volcanic flows	
OLIGOCENE	Tos	Hypersthene and olivine basalts; shale, mudstone, glauconitic sublabile to quartzose sandstone, and conglomerate	Offshore: 434 – 592 m in GSQ Sandy Cape 1-3R	158 m	Volcanics, marine shelf, and fluvial	Strongly weathered at top

	Waddy Point Volcanics Tow	Dark trachyte, agglomerate	Small area on Fraser Island	Unknown	Volcanic flows and pyroclastics	Cut by basalt dykes
	Td	Duricrust: ferricrete, silcrete and indurated palaeosoils over a deep weathered profile	Widespread on mainland. On Mesozoic and earlier Tertiary units	Crusts 1–3 m; profile up to 20 m	Weathering	May be several superimposed weathering events
EOCENE	**'older' Elliott Formation** Te	Poorly sorted quartzose to sublabile sandstone, conglomerate, sandy claystone, claystone	Widespread, but discontinuous on mainland. May extend offshore beneath Fraser Island	20 m?	Fluvial, locally colluvial	Older dissected deposits
	Takura Beds Tt	Silicified lithic conglomerate and breccia	Narrow belts adjacent to ridges of silicified Maryborough Formation	< 10 m	Colluvial slope deposits	Laterally equivalent to the 'older' Elliott Formation
	Tb	Weathered basalt	Subsurface and small areas of red soil near Nikenbah and Dundowran	> 20 m	Volcanic	Identified by drilling; only red soil at surface

than the dissected Booyal surface and weathering profiles developed on the older rocks (Grimes, 1988).

The oldest datable weathering profile in the area underlies the late Oligocene marine deposits at -590 m in GSQ Sandy Cape 1-3R. A second weathering period is recorded in that hole by the weathered top of the late Oligocene volcanics, and predates the early Miocene transgression, though this may be a continuation of the earlier weathering which was interrupted locally by the volcanism and marine incursion. The two dated flows in the Dundowran Basalt (see below) appear to either bracket a younger, mid-Miocene deep weathering period, or indicate a continuation of the earlier weathering up to the mid-Miocene. This may also have been responsible for the formation of the nodular ferricrete and associated weathering profile on the 'younger' Elliott Formation, although it is possible that the nodular ferricretes have continued to form on the flat waterlogged Elliott Surface right up to the present.

The overall picture would seem to be that a climate suitable for weathering existed through most of the Tertiary at least, and deep weathering profiles would have formed on any land surface which remained stable for a significant time (that is, it was not subject to erosion or deposition). The Booyal and Elliott Surfaces are the most extensive of these old land surfaces — but these two surfaces are identified by their morphology and morphostratigraphic relationships, and so cannot be accurately correlated with the better dated weathered zones in the boreholes, nor with the small, dated exposure of weathered Dundowran Basalt (see below).

Waddy Point Volcanics (Tow): Volcanic rocks form the headlands at Waddy Point, Middle Rocks and Indian Head on Fraser Island. These are dark grey and green trachyte flows with a few lenses and beds of agglomerate (Grimes, 1977b). The trachytes have been cut by basalt dykes which have a similar composition to the flows in GSQ Sandy Cape 1-3R (Figure 3). The trachytic volcanics have been dated as Oligocene. They are the northernmost and oldest of a line of similar volcanics which include the Glass House Mountains and which become progressively younger to the south (Wellman & McDougall, 1974). This may be a result of the northerly drift of the Australian continental plate over a mantle 'hot spot' (Wellman & McDougall, 1974; Roy & Thom, 1987).

The thickness of the volcanic pile is unknown, but it could extend for a considerable distance below present sea level, as the basalts encountered in GSQ Sandy Cape 1-3R are at depths between 434 m and 586 m. The outcrops at the tops of the headlands have been strongly weathered but the volcanic texture is still apparent.

Tertiary shelf deposits (Tos, Tms, Tps): At the northern tip of Fraser Island, GSQ Sandy Cape 1-3R penetrated 488 m of Tertiary shelf sediments and volcanics underneath 104 m of Quaternary quartz sands (Grimes, 1982; Palmieri, 1984). The Tertiary sequence can be divided into three parts:

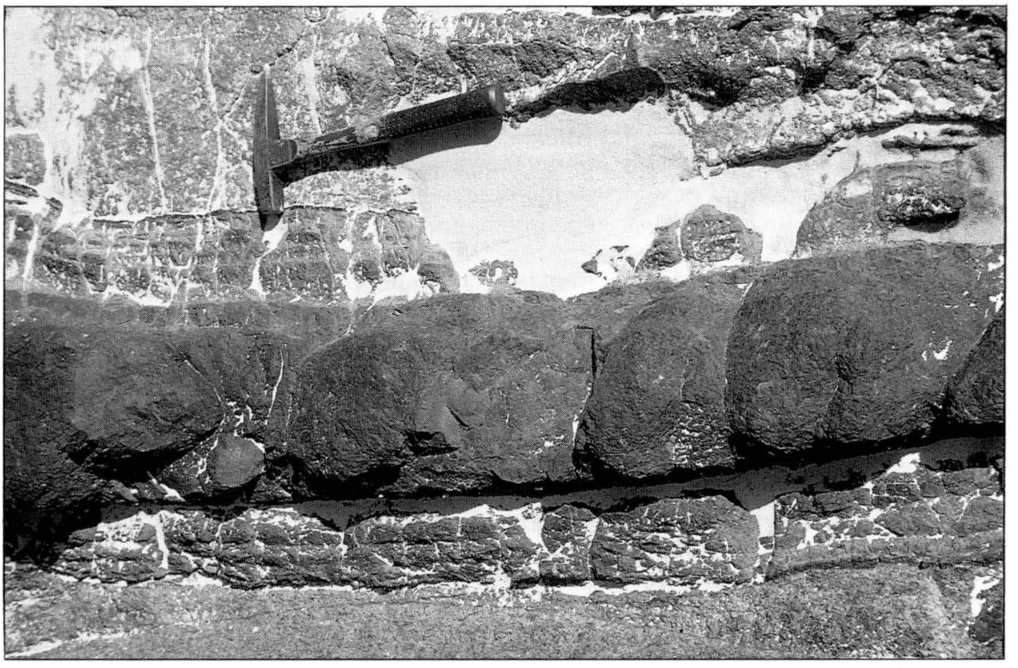


Figure 3: Basalt dyke with chilled margins, intruding the Waddy Point Volcanics

434-592 m: **Tos** Oligocene volcanics and fluvial, deltaic and marine sediments

209-434 m: **Tms** Miocene shelf sediments

104-209 m: **Tps** Pliocene shelf sediments

The basal unit (**Tos**) has a thin (4.4 m) fluvial sandstone sequence at the bottom which is overlain by thin (1 m) late Oligocene shallow marine sandstones and conglomerates (586 m to 592 m depth). Above these, between 434 m and 586 m, is a dominantly continental volcanic sequence, but with some thin (1.6 m) marine glauconitic sandstones near the base and a poorly recovered sequence of glauconitic sands and deltaic clays further up between 535 m and 556 m. The volcanics are hypersthene and plagioclase-phyric olivine basalts, and have red soil layers developed on the flow units. The top 29 m have been strongly weathered. These basalts have a similar composition to the dykes which intrude the Waddy Point Volcanics.

The **Tms** unit has at the base a 13 m thick, early Miocene sequence in which sandstones, carbonaceous shales and claystones show alternating deltaic and marine conditions within an overall transgressive sequence. The bulk of the unit lies above this and is a shallow marine shelf sequence with alternating quartz-rich and carbonate-rich sands. The sands are mostly poorly consolidated but there are some hard, cemented bands near the top. The fossil evidence indicates a period of non-deposition at the end of the Miocene, prior to deposition of the overlying **Tps** unit. On the present shelf, quartz sands occur in the near shore area and carbonate sands on the outer shelf. The alternation of quartz and carbonate sands in this unit could indicate migrations of the shoreline across the shelf, so that the drill site was in the nearshore zone at times of lower sea levels, and in the outer zone when the sea was higher.

The **Tps** unit is similar to the **Tms** unit, but has Pliocene fossils. At the top there is a well developed calcreted zone, which suggests subaerial exposure prior to deposition of the pure quartz sand of the Quaternary sequence, which is discussed in the section on MORPHOSTRATIGRAPHY.

Dundowran Basalt (Tmd): Olivine basalt is exposed on a small ridge behind Dundowran, as described by Barnbaum (1976). An older weathered flow which overlies deep weathered 'older' Elliott Formation has a minimum K-Ar age of 18.4 Ma; a younger, relatively fresh flow was dated at 12.0 Ma. These dates provide information on the termination of the deep weathering environment as well as the age of the flows.

Late Tertiary coastal deposits (TQc): In boreholes in the Poona–Tinnanbah area, up to 17.4 m of soft sediments overlie strongly weathered Mesozoic rocks (Grimes, in preparation). This **TQc** unit comprises white to dark coloured, poorly consolidated clayey and silty quartzose sand and sandstone, and minor sandy clay. The basal boundary with the underlying weathered Mesozoic units is difficult to pick. The darker colours appear to be in part due to an organic matrix, and could indicate the formation of a Quaternary sandrock or humicrete beneath the swampy coastal plain. Fluvial cross-beds occur in the sea cliffs at Tinnanbah.

The age of these deposits is uncertain; they may be younger than the 'younger' Elliott Formation because they lack both a deep weathering profile and the nodular ferricrete which typifies the Elliott Surface. However, the deposits appear older than the unconsolidated Pleistocene coastal deposits (**Qpa**) and have therefore been mapped separately.

Morphostratigraphy

Morphostratigraphic Principles

Geological mapping generally is based on the use of litho-stratigraphic units which are recognised on the basis of their lithologies (sandstone, shale, etc.), and have boundaries placed at changes in lithology or at stratigraphic breaks such as unconformities or disconformities. Morphostratigraphic units are recognised from the morphology of their depositional surfaces and are named after the dominant landform (beachridge, dune, alluvial flat, etc.). Morphostratigraphic boundaries are placed where the landform changes, or where a discontinuity that has stratigraphic significance is recognised.

Fraser Island is composed almost entirely of loose to poorly consolidated, well sorted, medium to fine-grained quartz sand, and would be defined as a single lithostratigraphic unit. However, the distinctive depositional landforms of the island allow this uniform lithology to be divided, at the surface, into several morphological types, and age relationships within and between these can be deduced from their morphostratigraphic relationships, their soils and vegetation, and the degree of degradation of the original landforms with time (Ward, 1977; Thompson, 1983; Thompson & Bowman, 1984). Unfortunately, it is difficult to extrapolate morphostratigraphic units below the surface, and at depth it is difficult even to distinguish dune sand from marine sand.

Morphostratigraphic relationships are shown where younger dunes have ridden over and buried older landforms, or where older coastal units have been eroded by a transgressing coastline, and then a younger sequence of coastal deposits have been built out as the sea retreated. These types of relationships are illustrated by the schematic block diagram and inset maps on the geological map.

A sequence of distinctive soils is associated with the different ages of quartzose dune sands and beachridges. The soils are mainly podsols and groundwater podsols. The age factor is best shown by the depth to the subsurface B horizon (Figure 4), which increases with time, and in some cases by the morphology of this horizon. Figure 5 illustrates the progressive deepening of the soils with age. Comparisons between the dune soils and those of the beachridges are only valid for the Holocene because in the older beachridges, the depth of soil development is generally restricted by shallow watertables. The soils on the Pleistocene beachridges (and undifferentiated sandy coastal plains) are groundwater podsols characterised by black or dark brown humicrete zones up to 15 m thick. These are known locally as 'sandrock', and can be seen cropping out as barriers on the beaches of Fraser Island (Figure 6), and at Rainbow Beach.

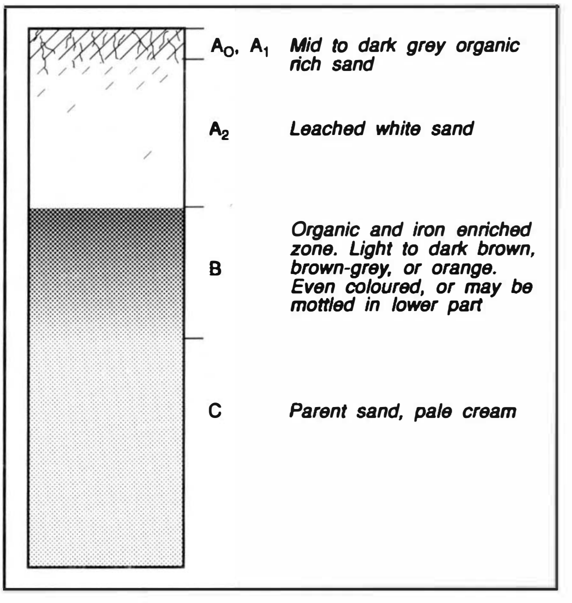


Figure 4: A typical podsol

By contrast, the Pleistocene dunes have giant podsol soils which have thick, richly coloured B horizons known locally as the 'Teewah' or 'Coloured' sands (Figure 7). Unfortunately, soils cannot be used reliably to correlate between the quartz sand units of the island and the shelly sublabile mainland beachridges west of Urangan, because the different parent materials form slightly different styles of soil in the two areas.

Changes in soil type and depth are accompanied by changes in the associated vegetation (Figure 5). The youngest dunes and beachridges are

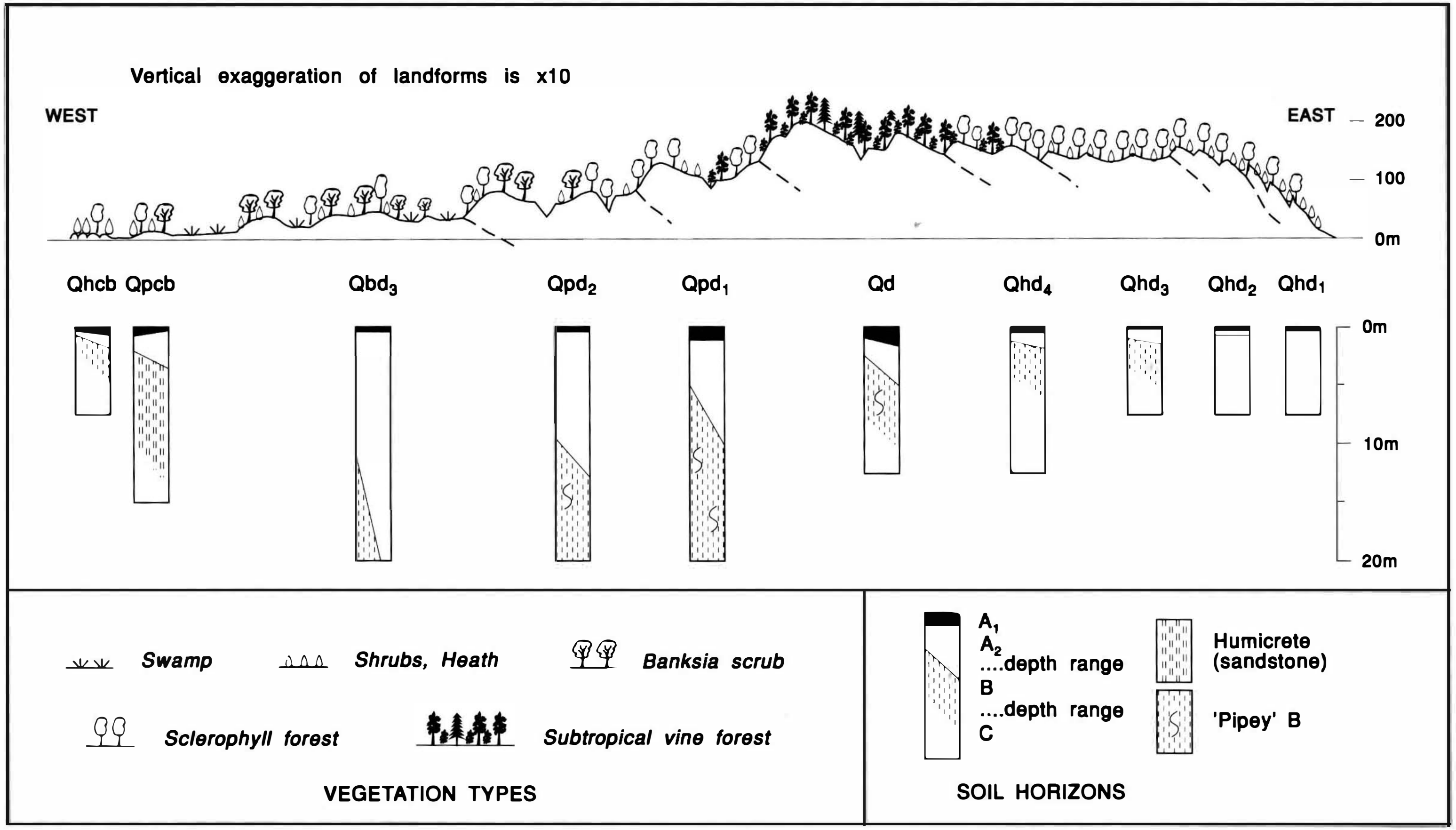


Figure 5: Diagrammatic transect across Fraser Island, showing landforms, soils and typical vegetation on the different morphostratigraphic units

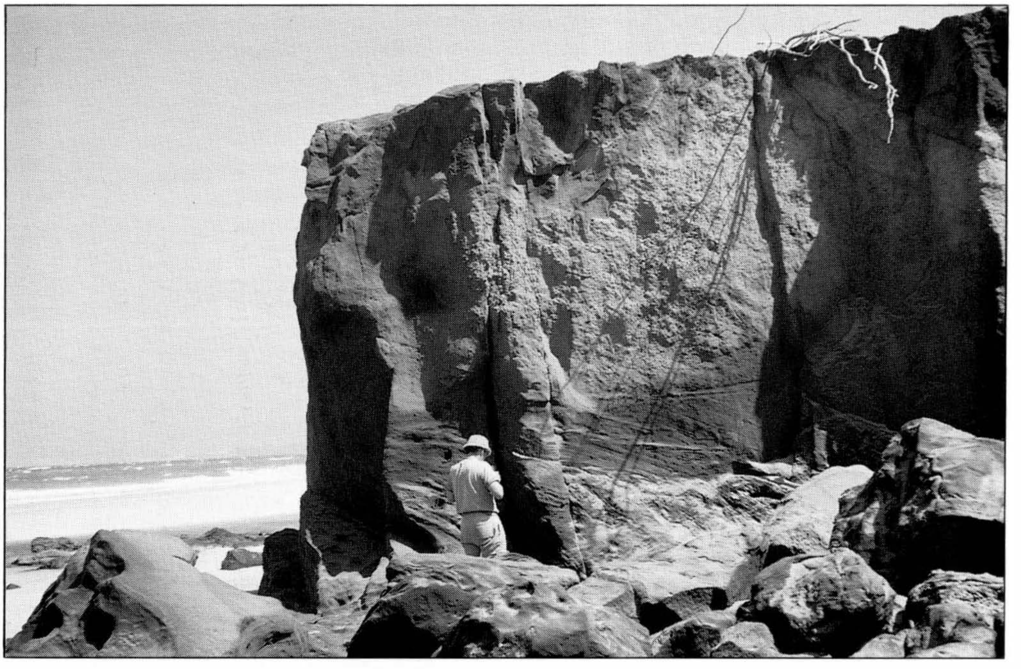


Figure 6: Sandrock exposed at Ngakala Rocks

bare, or have only thin vegetation. On progressively older dunes, we find low coastal scrub, sclerophyll forest and eventually the dense subtropical vine forest which is best developed on the **Qd** unit but also occurs on parts of the **Qhd4** and **Qpd1** units. The older Pleistocene dunes have soils which are so deeply leached that only depauperate open forest and scrub can grow on them.

The topography of the dunes and beachridges becomes progressively degraded with time, a result of progressive soil creep, slope wash, and gullying (Figure 5). The youngest units have the sharpest forms — narrow, well defined beachridges or sharp-crested dunes. The older dunes have more rounded crests, and become breached by stream valleys with time. In the oldest dune unit (**Qpd3**), the dune morphology has been almost completely obliterated. The older Pleistocene beachridges have degraded to broad bands of sand which were probably originally several separate narrow ridges.

On the geological map, the morphostratigraphic units are shown by letter symbols which indicate the broad age and morphological type, and by numeric subscripts which indicate their relative age in detail. Ward (1977) recognised nine episodes of dune formation with nine intervening episodes of strandplain development. Table 4 summarises the landforms and soil types of these dune and beachridge units, and relates Ward's informal nomenclature to the symbols used on the geological map. Other morphostratigraphic units shown on the geological map are alluvial plains, swamp deposits, lakes and lake beachridges, undifferentiated coastal plains,

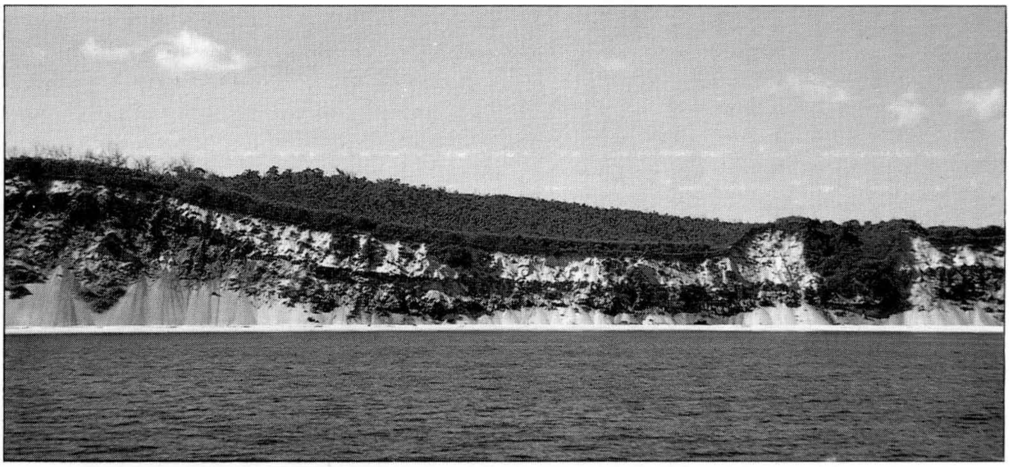


Figure 7: Deep podsol exposed in coastal cliff

tidal flats, estuarine deposits and marine sand banks (Table 3). Some of these other units have distinctive lithologies as well as morphologies.

Although the relative sequence of dunes and beachridges can be fairly easily deduced, the absolute ages are not so well controlled. Ward's (1977) time scale seemed too long, and recent radiocarbon dating and detailed studies of the morphostratigraphy suggest the revised ages, as shown on the reference to the geological map. Triangle Cliff was an important site in this study, and has been described in detail by Ward and Grimes (1987).

A distinctive soil and morphological break occurs in the beachridge sequence between the **Qhcb** units which have sharp ridges with podsols, and the **Qpcb** ridges which have broad degraded forms as well as groundwater podsols with a humicrete horizon. This change in character is taken as marking the break between the Holocene beachridges (formed in the last 7000 years) and the Pleistocene coastal deposits formed by the high seas of the last interglacial, between 100 000 and 125 000 years ago. A similar morphological break occurs in New South Wales between what are known as the 'inner' and 'outer' barriers. There the 'outer' barrier has given Holocene radiocarbon dates and the 'inner' barrier has provided Pleistocene uranium/thorium dates from coral fragments (Marshall & Thom, 1976). The age interpretation used here differs from Ward's (1977, 1985) age estimates, which place the sharp-crested **Qhcb5** unit in the last interglacial, and the degraded **Qpcb** units in earlier interglacials (220 000 years and older).

Morphostratigraphic Units

The morphostratigraphic units are all of Quaternary age (Table 3).

Alluvial plains: Three levels of alluvial terrace are associated with the Mary River, and smaller alluvial belts occur along streams on the mainland and the west coast of Fraser Island. The Mary River terraces comprise an older, partly dissected Pleistocene terrace (**Qpa**) and two lower terraces (**Qha1** and **Qha2**) which appear to be Holocene. Borehole data (Laycock, 1969) indicate thicknesses of up to 30 m of alluvium, composed of silt and clay, with sand and gravel beds. In the other areas the alluvium is thinner, and the lithology varies according to the catchment geology. The areas of **Qa** shown west of Boonooroo are thin low lying areas that are difficult to distinguish from the residual soils overlying the ferruginised 'younger' Elliott Formation. On Fraser Island, the alluvial flats are of pure sand with some peat beds. Here two Pleistocene terraces are recognised in some of the west coast valleys (Inset 2 on the map). The alluvial deposits all merge downstream with coastal deposits.

Lake deposits (Ql): A number of lakes occur in the dune fields of Fraser Island and in the Cooloola area. The lakes are of two types, watertable lakes and perched lakes, and their origin is discussed in the section on PHYSIOGRAPHY. Deposits in the lake floors are generally sands derived from the surrounding dunes, with varying admixture of organic muds. Ward and others (1977, p 27) reported 0.6 m of black organic mud in the deepest part of Lake Boomanjin, but most of the lake bottom was sand or sandy mud. There is a shallow marginal terrace around this and other lakes on Fraser island, which may have been formed by wave action. Some of the lakes also show cuspate spits, formed by wind-generated longshore transport of sand along the lake shores. Many lakes have crescentic 'beachridges' on their northwestern, downwind side (**Qhlc**). These are analogous to the beachridges of the sea coast, formed by a combination of wave and wind action. The elevation of some of these ridges suggests higher water levels in times past.

Dunefields (Qpd, Qd, Qhd): The bulk of Fraser Island and the Cooloola Sandmass is built up from large sand dunes. Their topography has been discussed in the section on PHYSIOGRAPHY. The sand dunes are composed of uniform, moderately to well sorted, medium to fine-grained quartzose sand. The quartz sands extend to depths of up to -100 m below sea level at the northern end of the island, and on average to about -40 m in the southern area (Grimes, in preparation). However, it is difficult to be sure to what extent the subsurface sands are dune-formed, and to what extent they are marine sands.

The older 'coloured' sands have a significant fine component (up to 25% silt and clay) which might be the product of weathering of labile grains, and concentration of the fines in the B horizons of the giant podsols. This fine component, together with the humic content, provides additional binding strength to sand, allowing the formation of steep-walled gullies and cliff exposures.

At Double Island Point there are three dune hills (**Qhd^{k}**) which have a different composition — calcarenaceous quartz sand. Though still dominantly quartzose, they contain varying proportions of coarse sand-sized shell fragments and the shellier beds have been weakly cemented by carbonate. These cemented beds accentuate the foreset bedding of the dunes, which is well displayed in the low sea cliffs at their base (Figure 8). At the tops of the dunes the carbonate has apparently been leached out, leaving a thick blanket of soft quartz sand (Thompson & Moore, 1984, p 49).

Table 3 – Quaternary Morphostratigraphic Units

Group	Symbol	Morphological type	Geomorphology	Lithology	Age
ALLUVIAL PLAINS	Qa	Alluvial plain	Flat to undulating flood plains and stream channels	Silt, clay, sand, gravel; pure quartz sand on Fraser Island	Quaternary, divided into Qha and Qpa
	Qha	Alluvial plain	Lower stream terraces	Silt, clay, sand, gravel; pure quartz sand on Fraser Island	Holocene, two levels in Mary River
	Qpa	Alluvial plain	Higher stream terraces	Silt, clay, sand, gravel; pure quartz sand on Fraser Island	Pleistocene, two levels on Fraser island
	Qaw	Alluvial swamps	Swamps within alluvial plains on Fraser Island	Quartz sand, peat	Quaternary
LAKES	Ql	Lakes	Permanent lakes within the dunefields	Quartz sand, organic material	Quaternary
	Qhic	Lake shore beach ridge	Linear to arcuate ridges on lake shores. Built up by a combination of wave and wind action	Quartz sand	Quaternary, mainly Holocene
DUNE FIELDS	Qhd, Qd, Qpd	Sand dunes	Parabolic dunes. Younger dunes are sharp, older dunes are progressively more rounded, and modified by stream channels	Quartz sand, small areas of calcarenaceous sand at Double Island Point	Quaternary: 4 Holocene units (Qhd); 1 Holocene to Pleistocene unit (Qd); 3 Pleistocene units (Qpd)
	Qdw	Swamps within dunefields	Flat swampy depressions, deflation hollows	Quartz sand, peat	Quaternary

COASTAL PLAINS	Qc,Qhc, Qpc, TQc	Coastal plain (undifferentiated)	Low-lying coastal flats. Undifferentiated alluvial, estuarine, aeolian and marine deposits	Sand, silt, muddy sand, mud, minor gravel. Humicrete in the older units	Quaternary: undifferentiated (Qc); Holocene (Qhc) on Fraser Island; Pleistocene (Qpc) at Tin Can Bay; Pliocene to Pleistocene (TQc) at Poona
	Qcw	Coastal swamp	Low lying swampy flats in the coastal plains	Sand, peat, mud, humicrete	Quaternary
	Qhct	Intertidal and subtidal flats	Flat to undulating areas covered at high tide	Sand, mud, sandy mud, muddy sand, minor gravel	Holocene
	Qhcb	Beach ridges	Low sharp linear ridges, parallel to present or older coastlines, built up by a combination of wave and wind action	Quartz sand. Shelly quartzose to sublabile sand and minor gravel on Hervey Bay mainland	Holocene
	Qpcb	Beach ridges	Low broad sand ridges	Quartz sand, humicrete	Pleistocene (last interglacial)
ESTUARINE	Qhec	Estuarine channels	Channel of the Mary River	Quartzose to sublabile sand, silt, gravel	Holocene
MARINE	Qhmt	Marine tidal delta, channels and spits	Banks and channels moulded by tidal currents in Great Sandy Strait. Breaksea Spit is formed by a combination of longshore drift and tidal currents	Sand, gravel, mud	Holocene

TABLE 4 – Features of dune and beachridge units

(after Ward & Grimes, 1987)

Geol Map Unit	Ward's (1977) nomenclature	Land forms	Common soil type	Depth of bleached top (m)	Vegetation
Qhd_0, $Qhcb_0$	Modern dune and beach sand	A,B	1	Absent	Bare sand or open low coastal scrub
$Qhcb_1$	Hook beach sand	H	1	Absent	Low coastal heath and scrub
Qhd_1	Cape dune sand	B	1	Absent	Low heath and scrub
$Qhcb_2$	Rooney Point beach sand	H	2	Absent	Dense coastal heath and scrub
Qhd_2	Station Hill dune sand	B	2	0.25 - 0.5	Dense scrub, low forest
$Qhcb_3$	Bool Creek beach sand	H	3	0.45 - 0.6	Dense coastal heath and scrub
Qhd_3	Triangle dune sand	C	3	0.8 - 1.2	Medium forest, some scrub
$Qhcb_4$	Wathumba beach sand	H,I	4	1.0 - 1.6	Dense scrub and forest
Qhd_4	Garawongera dune sand	C	3	0.9 - 1.6	Medium forest, some rainforest
$Qhcb_5$	Woorim beach sand	I	3	1.8 - 2.0	Dense scrub and forest
Qd	Bowarrady dune sand	D, some E	3a	2.5 - 5.0	Rainforest, forest
$Qpcb_1$	Bribie beach sand	J	4a	2.0*	Open scrub and forest, low scrub
$Qpcb_2$	Poyungan beach sand	J	4a	2.5*	Open scrub and forest, low scrub
Qpd_1	Yankee Jack dune sand	D,E	3a	6.0 - 7.5	Forest and open scrub
Qpa	Ungowa beach (?) sand	K	4a	2.5*	Open scrub and heath
Qpc	Older coastal plains	K	4a	2.5*	Open scrub and heath
Qpd_2	Awinya dune sand	some F,G	3a	9.5 - 13	Open scrub, heath, some forest
Qp_3	Cooloola dune sand	G	3a,4a	13.0	Open scrub and heath

Dune forms: A – active dune sands without vegetation; B – sharp-crested dunes; C – strong dune relief without water-scoured channels; D – strong dune relief with water-scoured channels; E – subdued dune relief; F – degraded sands with very few dune remnants; G – degraded sands without obvious dune relief.

Beachridge forms: H – fresh, sharp, narrow, parallel foredunes; I – narrow, parallel foredunes, somewhat smoothed, in places a single ridge; J – degraded, broad, parallel ridges; K – strongly degraded ridges to smooth sandplains without diagnostic forms.

Soil type: 1 – Skeletal soil (Quartzipsamment); 2 – Rudimentary podsol (Spodic Quartzipsamment); 3 – Normal or giant Podsol (Orthod); 4 – Humus rich groundwater podsol (Humod); a – greater or commonly greater than 2 m deep.

* High water tables interfere with soil development in the older beachridges, making differentiation difficult in many places.

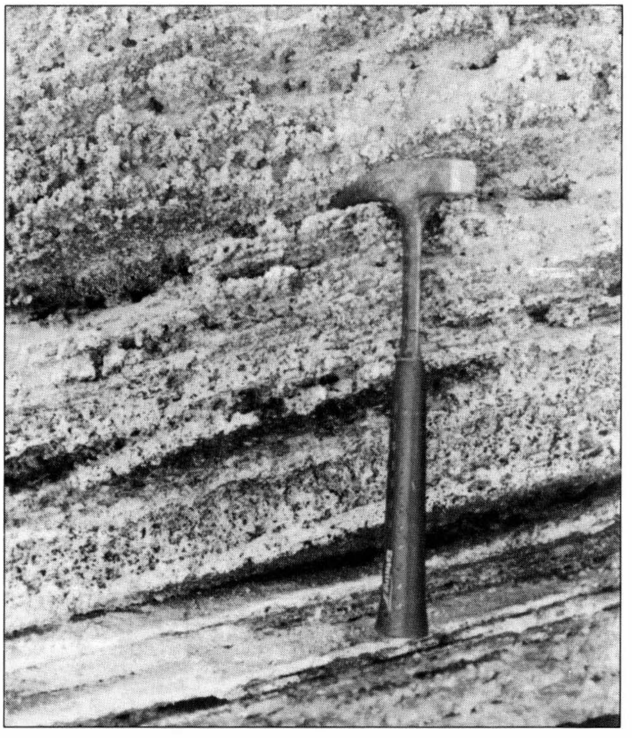


Figure 8: Aeolian crossbedding in calcarenaceous dune unit near Double Island Point

Calcarenaceous dunes are very rare on the Queensland coast. This occurrence must reflect a local source of calcareous grains, possibly from an offshore shell bank which was exposed during a period of reduced sea level. The age of these dunes is uncertain. The additional strength resulting from the cement makes them more resistant to erosion and prevents a morphostratigraphic interpretation. The unusual composition means that the soil cannot be used as a reliable guide. Their general setting and relationship to the Holocene dunes, together with the requirement for an exposed source of shell fragments, suggests a late Pleistocene to early Holocene age.

Coastal plains: The coastal plains in the area include belts of beachridges (**Qhcb**, **Qpcb**), coastal swamps (**Qcw**), intertidal and subtidal flats (**Qhct**) and undifferentiated plains, which are probably built up from a combination of alluvial, estuarine, aeolian and marine deposits. There are two major lithological groupings of deposits in these areas — the uniform marine quartz-sand body, which has been transported northwards up the Queensland coast by long-shore drift and currents during the Quaternary, and the more varied sediments which were derived from the immediate hinterland and introduced to the coastal system by the local creeks and rivers, in particular the Mary River.

The dunes and coastal plains of Fraser Island and the Rainbow Beach area are composed of the quartz sands derived from the marine sand body of the continental shelf. The coastal flats on the mainland side of Great Sandy Strait are mainly of locally derived fluvial sands with some admixture from the quartz sand body, especially at the Wide Bay end. The mainland coastal plains of Hervey Bay are mainly built from reworked river sands, and the beachridges there are more shelly, more labile, and have a larger amount of fine-grained material than those derived from the marine sand body (Stephens & others, 1988). The morphostratigraphic units are similar, in spite of the lithological differences, but one cannot use the soil character to make detailed correlations between the beachridge sequences in the different lithologies.

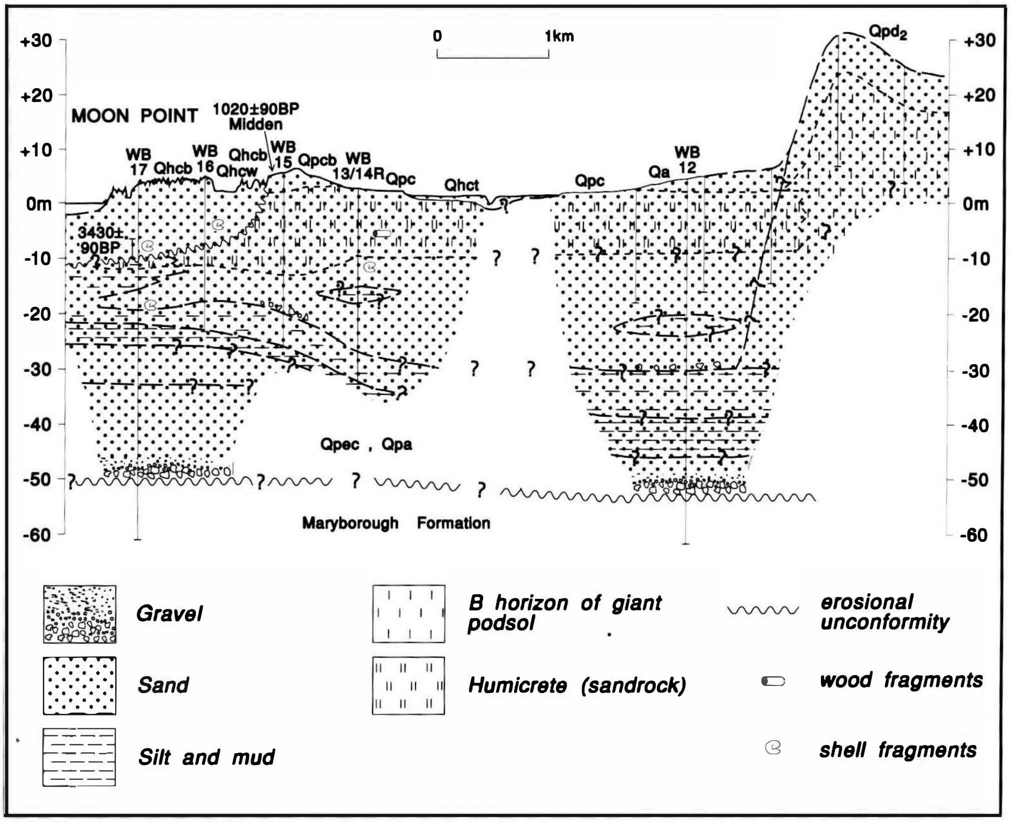


Figure 9: Cross-section of coastal sediments at Moon Point

Figure 9 shows a cross section through the coastal plain at Moon Point, illustrating its subsurface character. The **Qpec** unit shown near the base of this section, between -25 and -50 m, is a muddy sand and gravel unit which is interpreted as being an estuarine or fluvial deposit derived from the mainland. Above this is a quartz sand unit with only minor mud which would be derived from the adjacent dunes. This unit has a well developed humicrete or sandrock within it which suggests a Pleistocene age. At the western edge of the section the humicrete has been removed by erosion and a younger Quaternary marine and beachridge sequence deposited.

The term **beachridge (Qhcb,Qpcb)** is used here for the linear ridges that are built parallel to the shoreline on a prograding coast. Their depositional environments grade from nearshore marine at the base into beach deposits (sensu stricto) and up into foredune deposits; but they form a single geomorphic unit and the components cannot be readily identified in drill holes. In the higher beachridges, the dune component probably forms the bulk of the ridge, but in the lower ridges the foredune would be only a thin capping.

The **coastal swamps (Qcw)** occupy the low lying areas in the coastal plains — the swales between beachridges, and low areas behind beachridge barriers or stream levees. The lithology is similar to that of the surrounding plains, though commonly with a higher proportion of fine-grained material. Thin peat deposits are common.

Tidal Flats (Qhct): The tidal flats vary from sand to mud, with all mixtures between, and locally have some gravel. They are best developed in Great Sandy Strait. Water depth ranges from the upper limit of the Spring high tides (the bare salt flats) through the intertidal bare and mangrove covered flats and out to major banks visible below the low water mark, which have also been included in this unit. Sedimentation is active at present.

Estuarine channels (Qhec): These are the quartz to sublabile riverine sands, silts and gravels of the Mary River and other major coastal streams. They are active modern sediments and grade into the marine deposits of Great Sandy Strait.

Marine deposits (Qhmt): This unit includes the tidal channels and banks of Great Sandy Strait, the tidal delta banks at each end of the strait, and offshore spits and banks elsewhere. The composition is of varied combinations of sand, gravel and mud. The deposits at the Hervey Bay end of the strait have been studied by Stephens and others (1988). Breaksea Spit, at the northern end of Fraser Island, is composed of quartz sand which has been moulded by a combination of longshore drift and tidal currents. At depth it might include some submerged Pleistocene dune and coastal sands. Other marine deposits of the continental shelf are not shown on the map, but are summarised in the regional studies of Marshall (1977, 1980), Kudrass (1982) and Stephens (1982b). Nearshore marine deposits west of Point Vernon have been studied by Stephens and others (1988).

Structure

Maryborough Basin

The Maryborough Basin is a north-northwesterly trending Mesozoic structure about 130 km wide and 300 km long. It extends offshore with a probable northeastern boundary at the Bunker Ridge, near Sandy Cape (see structural inset on map). Its southeastern end also lies offshore and is not defined — it may have been truncated by the continental slope. Some continuity with the Nambour Basin to the south is likely. The thickness in its deepest, offshore part is not known, but probably exceeds 5000 m. The basin formed by sagging that followed a Late Triassic thermal doming event. Its evolution was in three stages, each comprising a period of deposition followed by tectonic movement (Ellis, 1968; Cranfield, in preparation b).

The first stage involved deposition of up to 1000 m of Late Triassic to Jurassic sediments of the Duckinwilla Group, and was terminated by deformation along north-northwest axes. The second stage involved a volcanic period in which the Grahams Creek Formation was deposited on an uneven erosional surface in the Late Jurassic and Early Cretaceous. Some fault movement may have been contemporaneous with the volcanicity.

Following uplift and some further faulting, a short period of erosion was terminated by the start of the third stage in which a marine transgression deposited the Cretaceous marine Maryborough Formation, and a subsequent regression was followed by deposition of the fluvial Cretaceous Burrum Coal Measures. These sediments, and the earlier deposits, were folded in the Late Cretaceous along north-northeast axes as a consequence of a rising thermal anomaly which preceded the crustal breakup that formed the offshore Cato Trough and Tasman Abyssal Plain in the Late Cretaceous and Palaeocene. The folds of all three stages are coaxial.

Two areas of tight folding and associated faulting are found in the sheet area. In the southwest, the Duckinwilla Group has large north-northwest trending isoclinal folds and a series of major faults with similar trends. An axial plane cleavage has been developed on these rocks. These structures may be a result of folding in all three stages. In the Point Vernon – Urangan area there are numerous small scale folds and faults forming a series of synclinoria and anticlinoria in the Maryborough Formation and Burrum Coal Measures. These folds would have formed in the Late Cretaceous. Between these two areas the Mesozoic is poorly exposed but appears to have only broad folds such as the Susan Anticline.

The narrow belt of Grahams Creek Formation might be fault bounded in places (Cranfield, personal communication) — this would explain the occurrence of outcrops of Duckinwilla Group on both sides of it near Poona Creek. Geophysical information suggests that there may be several large faulted horsts and troughs beneath Fraser Island (Smith, 1965).

Tertiary Shelf

The bulk of the Tertiary sediments lies offshore on the continental shelf and forms a uniform northeasterly dipping wedge of marine and continental sediments and interbedded volcanics. This dipping wedge is a consequence of the steady subsidence of the shelf during the late Tertiary, although in detail there were some interruptions in sedimentation due to sea level fluctuations and possibly due to a gentle upwarp during the northward drift of the area over a postulated mantle 'hot spot' in the Oligocene (Grimes & others, 1984). Some relative upwarp may have occurred on the Bunker Ridge which was originally a Mesozoic structure bounding the Maryborough Basin.

The onshore, fluvial Tertiary sediments are discontinuous valley-filling sequences within the sheet area, but further to the northwest, the Elliott Formation forms a broad sheet which probably spread across a coastal plain. The Waddy Point Volcanics are the northernmost and oldest (about 29 Ma) member of a belt of volcanic centres which includes the Glass House Mountains. They formed as the Australian plate migrated northwards over the mantle 'hot spot'. The onshore basalts are of several ages spread through the Tertiary, and not related to the 'hot spot'.

Geological Evolution

The history of the pre-Jurassic basement was summarised by Ellis (1968) and Cranfield (1990). The Mesozoic history of the Maryborough Basin has been reported by Ellis (1968) and Cranfield (1989, in preparation a). The Late Cretaceous and Cainozoic history was presented by Grimes and others (1984). The evolution of the Quaternary coastal deposits has been discussed by Ward (1977), Thompson (1983), and Ward and Grimes (1987). Figure 10 illustrates the geological evolution of the area up to the end of the Tertiary and Figure 11 shows the evolution of Fraser Island during the fluctuating sea levels of the Quaternary.

The basement in the sheet area may comprise Permian and Early Triassic sediments and volcanics of the Gympie Block, but their exact nature is unknown. These would have been folded and metamorphosed during a compressional phase in the Early to Middle Triassic, when the Australian plate was moving to the east. An extensional event in the Middle to Late Triassic caused thermal doming, granitic intrusions and uplift followed by erosion.

The Maryborough Basin was formed by post-thermal crustal sagging during the latest Triassic to Middle Jurassic. Quartzose and labile fluvial sediments derived from uplifted and eroding areas to the west were deposited in the basin to form the Duckinwilla Group. A period of uplift with folding and faulting and accompanying erosion in the Middle to Late Jurassic preceded the eruption of a line of andesitic volcanoes (Grahams Creek Formation) in the Late Jurassic to Early Cretaceous; fluvial sediments derived from these were deposited in the basin to the northeast. After minor movements and a brief hiatus, the sea flooded the basin in the late Neocomian and the shallow marine Maryborough Formation was deposited. In the Albian, a regression of the sea caused a change in environment to fluvial and swamp deposits of the Burrum Coal Measures.

The basin was uplifted and folded in the Late Cretaceous as a consequence of a rising thermal anomaly which preceded the crustal breakup that formed the offshore Cato Trough and Tasman Abyssal Plain in the latest Cretaceous and into the Palaeocene.

Since then, the shelf has been slowly subsiding, but with local uplifts superimposed on the overall trend. Fluvial deposition (the 'older' Elliott Formation) occurred in the early Tertiary on parts of the western shelf at least, but much of the area may have been erosional. The net result of this erosion was the formation of a mid-Tertiary surface of gently undulating relief which was deeply weathered.

In the Oligocene the shelf may have suffered some uplift, reversing its overall subsidence, as it appears to have been passing over a 'hot spot' at this time.

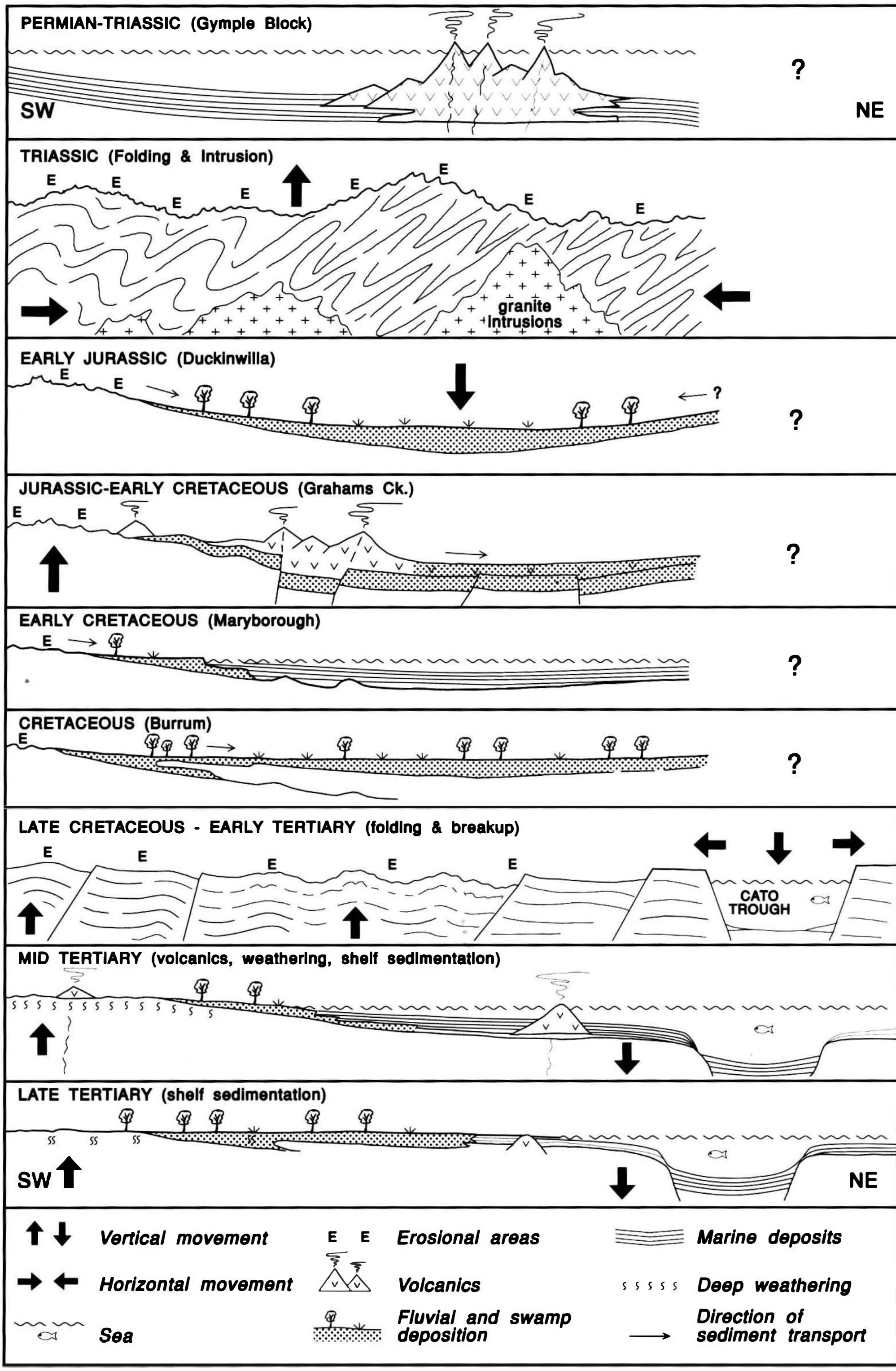


Figure 10: Geological evolution of the Fraser Island map area

The trachytes of the Waddy Point Volcanics were probably erupted just before the first flooding of the subsiding shelf by the sea in the late Oligocene. This marine transgression was interrupted in the Sandy Cape area by a thick sequence of basaltic lava flows (**Tos**), which built up above the advancing sea. The upper part of these volcanics was deeply weathered before burial by later sediments.

A short period of deltaic and coastal deposition, recorded in the Sandy Cape area, was followed by marine deposits of the main early Miocene transgression (**Tms**). A belt of terrigenous deposits was laid down on the inner shelf, with eastward excursions at times of lower sea levels. The outer shelf received mainly marine carbonate deposits. Deposition on the shelf was interrupted by a major regression of the sea in the late Miocene followed by a transgression in the Pliocene. The Pliocene shelf deposits (**Tps**) were similar in character to the Miocene sequence.

Onshore there may have been uplift in the Miocene and much of the topography of the present onshore region was initiated by erosion in the late Tertiary. The mid-Tertiary land surface and deeply weathered 'older' Elliott Formation were dissected, or partly buried near the coast by the fluvial 'younger' Elliott Formation and its equivalents. Basaltic vulcanism occurred at Dundowran. The younger sediments were also deeply weathered, which makes them difficult to distinguish from the older deposits.

During the Quaternary the prime control of sedimentation was glacioeustatic sea level fluctuations (Figure 11). These, and the related climatic fluctuations, were responsible for the terraced alluvial deposits in the river valleys, the strandline deposits near the present coast, and an alternation of fluvial, aeolian and marine deposition offshore. As the seas rose and during the subsequent times of high sea levels (the interglacial stages) a large body of quartz sand, derived from the rivers of northern New South Wales, was moved north by littoral drift and deposited on the Queensland shelf. Wave action transported this sand onshore to form beaches, and wind blew it inland to form dunes.

When the sea levels were low (during the glacial stages), wind action continued to move this sand and piled up large stacks of superimposed dunes. The highest of these stayed above the ocean to form Fraser Island and the Cooloola Sandmass when the sea level rose again, and were further modified by wind and waves. This sequence of alternating, glacially controlled high and low sea levels was repeated many times during the Quaternary.

Of the two main sets of beachridges and associated coastal deposits seen at present, the older set probably formed mainly during the highstand of the sea in the last interglacial, about 100 000 to 120 000 years ago, although some might date back to earlier interglacials. The 'former coastline' shown on the geological map (inset 4) is a line of old sea cliffs, partly buried by younger dunes, that probably dates from the last interglacial. The postglacial transgression flooded Great Sandy Strait about 6000 to 7000 years ago, and the younger set of beachridges and coastal deposits has formed since then.

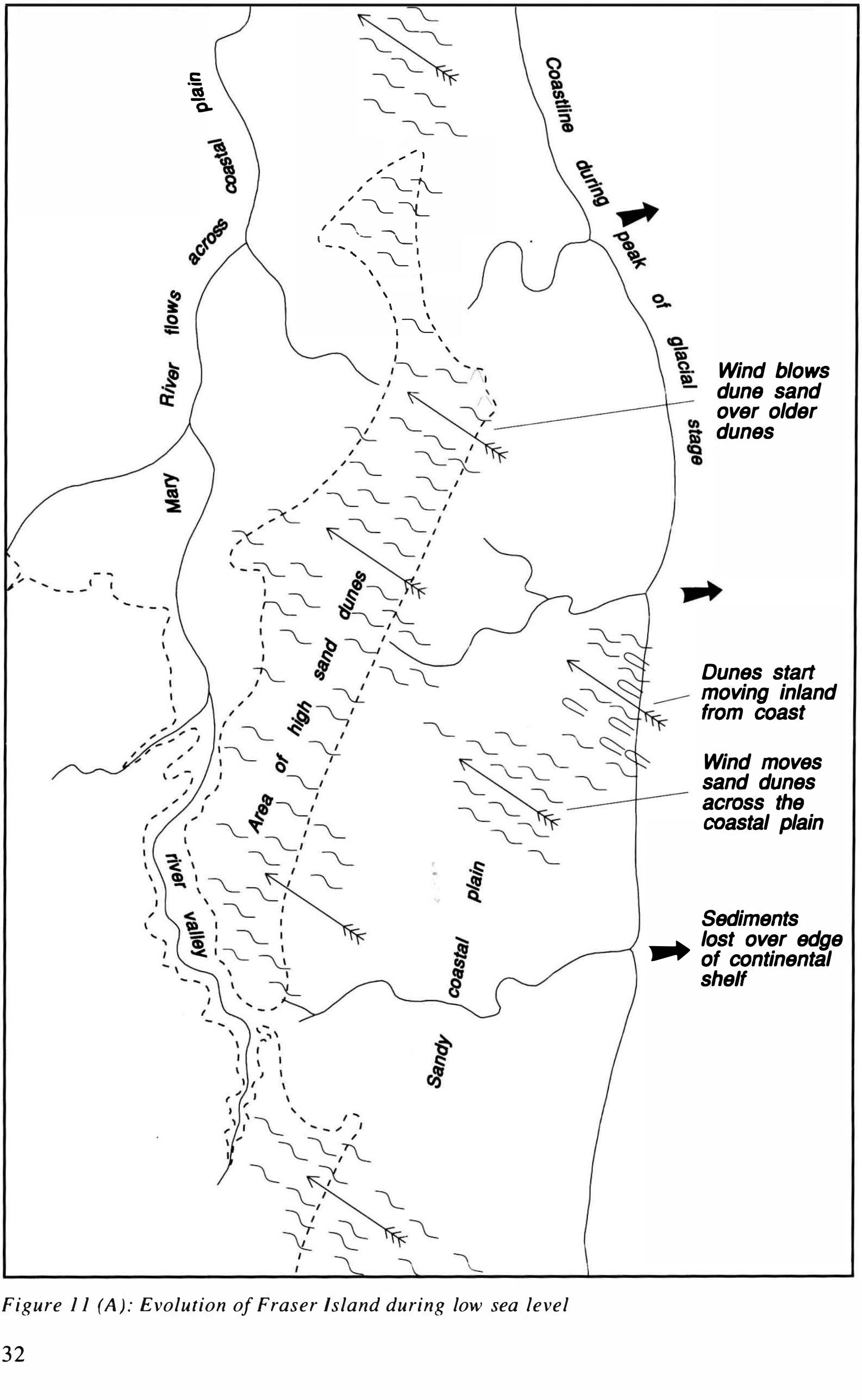


Figure 11 (A): Evolution of Fraser Island during low sea level

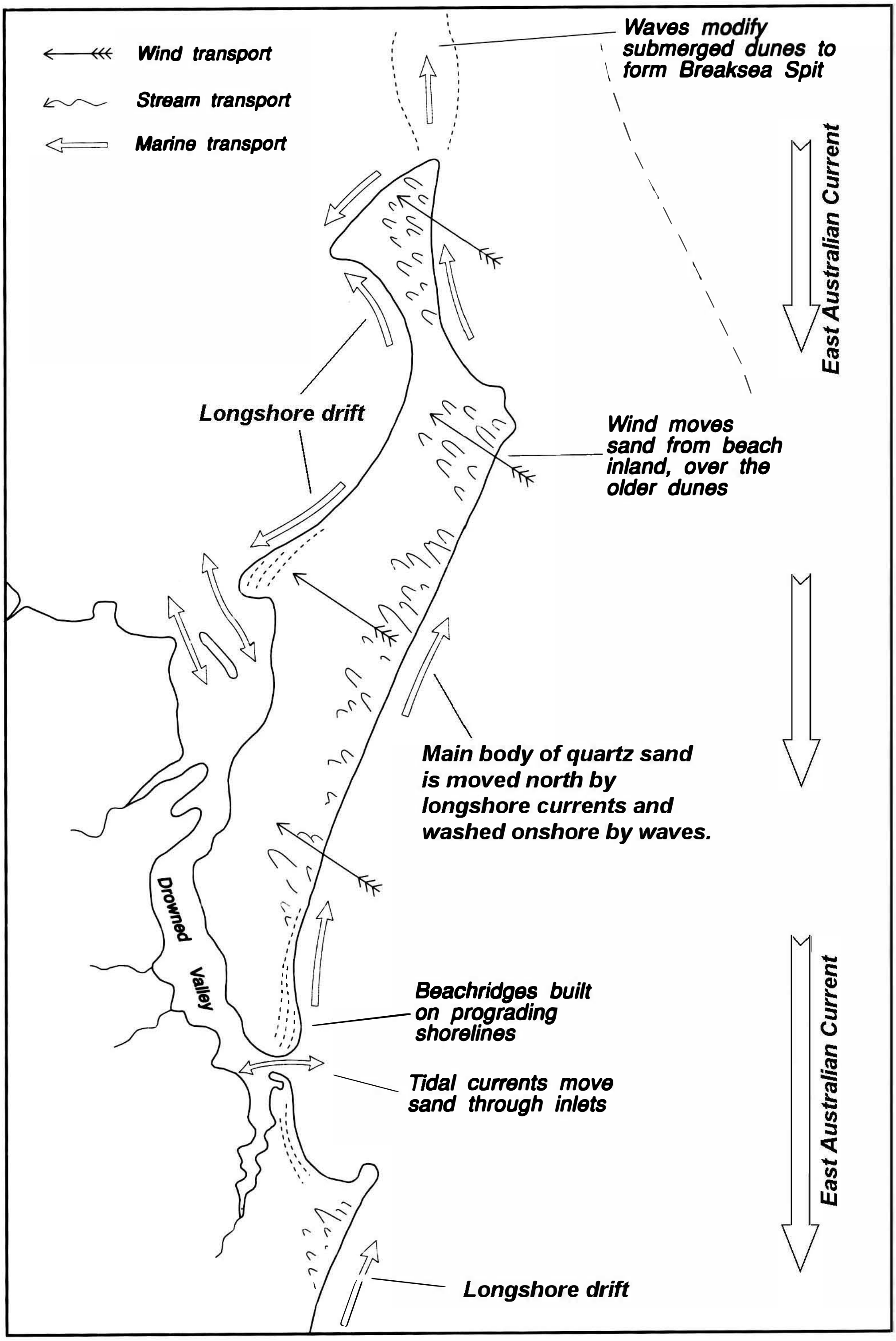


Figure 11 (B): Evolution of Fraser Island during high sea level

NB this figure has been modified (in 2014) to clarify the difference between the northerly longshore drift and the main ocean current.

Economic Geology

Mineral resources of the area have been tabulated by the Geological Survey of Queensland (1981) and the reserves of industrial materials on the mainland have been documented by Robertson (1981a, b). Mineral exploration in the Maryborough 1:250 000 Sheet area has been summarised by McLeod (1979) and Cranfield and Garrad (1991).

Coal: Exploration and production of coal within the Maryborough Basin has declined in recent years. The productive member of the Burrum Coal Measures does not extend into the sheet area. Exploration within the Tiaro Coal Measures has not revealed any areas of significant reserves (Thornton, in press).

Petroleum: Petroleum exploration has given disappointing results. A dry exploration well, LSD 2 (Susan River), was drilled in the sheet area on the Susan Anticline in 1955 (Geological Survey of Queensland, 1960). Shell Development (Australia) carried out a number of onshore and offshore seismic surveys between 1962 and 1970 and analysed aeromagnetic and gravity surveys of the area (Bruce & Thomas, 1964; Smith, 1965; see other references in Grimes, 1977a). The seismic surveys generally gave poor results but allowed speculation as to the subcrop pattern of the .Mesozoic beneath the Cainozoic cover which is shown on the structural inset on the geological map, and indicated that there was significant faulting through much of the basin. There has been little petroleum exploration within the area in recent times.

Heavy Minerals: Mining of heavy minerals in the coastal sands at Rainbow Beach and at the southern end of Fraser Island occurred between 1966 and 1976, at which time further mining was prevented by a Commonwealth Government decision made on the recommendation of an environmental inquiry (Krosch, 1977; Hicks & Hookey, 1977).

Heavy mineral reserves on Fraser Island were estimated in 1976 at 793 000 t of rutile, and 832 000 t of zircon (Hicks & Hookey, 1977). The bulk of the reserves were in beachridges and dunes on the eastern side of the island. On the mainland, Connah (1961) estimated reserves in the beachridge sequence south of Inskip Point of about 500 000 t of heavy mineral concentrate. This area was mined between 1965 and 1971. Production included 89 000 t of rutile and 73 000 t of zircon. The mined areas have all been rehabilitated.

Silica sand: Silica sand for use in foundry mouldings is mined from the Pleistocene beachridges in the Coonarr area to the west of the sheet area (Robertson, 1981a). Similar sand could be found in the leached A_2 horizons of the older dune and beach sands on Fraser Island and at Cooloola (Sawers & Cooper, 1985).

Water: Resources of water on the mainland were studied by Laycock (1969, 1975). In 1981, the Queensland Water Resources Commission drilled a number of deep holes in the high dunes of Fraser Island as part of a groundwater study. There is good quality groundwater in the dune sands, in the 'younger' Elliott Formation beneath the Boonooroo Plain, and in the basalts at Nikenbah.

Groundwater is also found in alluvium and coastal deposits (although excessive pump rates in the latter could result in salt water intrusion), and in fractures in the Mesozoic rocks. The Takura beds and 'older' Elliott Formation have little potential within the area because they generally lie above the water table.

Clay: Ceramic clay resources of the area are described by Siemon (1980) and the Geological Survey of Queensland (1981). Structural clays are widespread in weathered parts of the Grahams Creek and Maryborough Formations, the Burrum Coal Measures, and the Elliott Formation.

Extractive materials: Resources of extractive materials have been described by Robertson (1981a and b) and the Geological Survey of Queensland (1981).

Quarry rock: Basalt is quarried at Dundowran.

Road construction materials: Common sources are from the silicified ridges of the Maryborough Formation and Takura beds near Pialba, from the quartzites, conglomerates and silicified shales of the Duckinwilla Group near Tin Can Bay, and from conglomerates within the 'older' Elliott Formation near Pialba. Ironstone gravel (nodular ferricrete) from the Tertiary duricrust is also an important source.

Sand and gravel: Extensive deposits of fine to medium sand occur on the coastal plains and in the dunefields. Sand has been dredged from the channel of the Urangan boat harbour for local use.

Tourism and recreation

An increasingly important industry in the area is tourism and recreation. The dunefields, lakes and beaches of Fraser Island and the mainland are major resources for these activities.

References

BARNBAUM, D., 1976: The geology of the Burrum Syncline, Maryborough Basin, southeast Queensland. *University of Queensland, Department of Geology, Papers* **7**(3), 1-45.

BRUCE, I.D. & THOMAS, J.S., 1964: Final report: Pialba - Fraser Island seismic survey, Maryborough Basin, Qld., A to P 70P. Shell Development (Aust) Pty. Ltd. Unpublished report, held by the Queensland Department of Resource Industries as CR 1300.

BUREAU OF MINERAL RESOURCES, 1989: Maryborough total magnetic intensity. Preliminary edition, 88/09/16 Maryborough, Qld 22–1/G56–06/1, Commonwealth of Australia.

CONNAH, T.H., 1961: Beach sand heavy mineral deposits of Queensland. *Geological Survey of Queensland, Publication* **302**.

CRANFIELD, L.C., 1982: Stratigraphic drilling in the southern Maryborough Basin, 1978-1980. *Queensland Government Mining Journal* **83,** 15-29.

CRANFIELD, L.C., 1989: New and revised Mesozoic stratigraphic units in the Maryborough 1:250 000 Sheet area, southeast Queensland. *Queensland Government Mining Journal* **90**, 163-174.

CRANFIELD, L.C., 1990: The Gympie Group and other Permian strata of the Gympie Composite Terrain. *In: Proceedings of the Pacific Rim Congress 90, Volume III*, Australasian Institute of Mining & Metallurgy, Parkville, Victoria, 99-108.

CRANFIELD, L.C., in preparation a: Stratigraphic units of the Maryborough Basin, southeast Queensland.

CRANFIELD, L.C., in preparation b: Maryborough, Queensland 1:250 000 Geological Series. Department of Resource Industries, Explanatory Notes SG56/06.

CRANFIELD, L.C. & GARRAD, P., 1991: Mines and prospects in the Maryborough 1:250 000 Sheet area. *Queensland Resource Industries Record* 1991/3.

DRAPER, J.J., 1971: The geology of the Urangan Syncline and recent sediments of Great Sandy Strait. University of Queensland, Department of Geology, B.Sc. Honours Thesis (unpublished).

ELLIS, P.L., 1968: Geology of the Maryborough 1:250 000 Sheet area. *Geological Survey of Queensland, Report* **26**.

EWART, A., 1982: Petrogenesis of the Tertiary anorogenic volcanic series of southern Queensland, Australia, in the light of trace element geochemistry and O, Sr, and Pb isotopes. *Journal of Petrology* **23,** 344-382.

GEOLOGICAL SURVEY OF QUEENSLAND, 1960: Occurrence of petroleum and natural gas in Queensland. *Geological Survey of Queensland, Publication* **299**.

GEOLOGICAL SURVEY OF QUEENSLAND, 1981: Mineral resources of the Wide Bay - Burnett region. *Queensland Government Mining Journal* **82**, 153-178.

GREEN D.C. & WEBB A.W., 1974: Geochronology of the northern part of the Tasman Geosyncline. *In* Denmead, A.K., Tweedale, G.W. & Wilson, A.F. (Editors): *The Tasman Geosyncline – A Symposium*. Geological Society of Australia, Queensland Division, Brisbane, 191-200.

GRIMES, K.G. 1977a: Pre-Quaternary geology of Fraser Island. *In* Day, R.W. (Editor): *1977 Field Conference, Lady Elliot Island – Fraser Island – Gayndah – Biggenden*. Geological Society of Australia, Queensland Division, Brisbane, 50-53.

GRIMES, K.G., 1977b: The volcanic rocks of the Waddy Point – Indian Head area. *In* Day, R.W. (Editor): *1977 Field Conference, Lady Elliot Island – Fraser Island – Gayndah – Biggenden*. Geological Society of Australia, Queensland Division, Brisbane, 54-59.

GRIMES, K.G., 1982: Stratigraphic drilling report, GSQ Sandy Cape 1-3R. *Queensland Government Mining Journal* **83,** 224-233.

GRIMES, K.G., 1988: Cainozoic geology, southeast Queensland. *In* Hamilton, L.H. (Editor): *Field Excursions Handbook for the Ninth Australian Geological Convention*. Geological Society of Australia, Queensland Division, Brisbane, 53-80.

GRIMES, K.G., in preparation: Shallow stratigraphic drilling in the Wide Bay area. *Queensland Resource Industries Record,* 1991/30.

GRIMES, K.G., SEARLE, D.E. & PALMIERI, V., 1984: The geological setting of the Capricornia Section, Great Barrier Reef Marine Park. *In* Ward, W.T. & Saenger, P. (Editors): *The Capricornia Section of the Great Barrier Reef: Past, Present and Future*. Royal Society of Queensland, Brisbane, 5-16.

HICKS, A.B. & HOOKEY, J., 1977: Fraser Island Environmental Inquiry, Final Report of the Commission of Inquiry. *Parliament of the Commonwealth of Australia, Parliamentary Paper* **333/1976**.

JAMES, P.M., 1980: The high dune provinces, southeast Queensland, geohydrology and engineering geology. *Institute of Engineers Australia, Queensland Division Technical Papers* **21**(28), 25-30.

KROSCH, N.J., 1977: Heavy mineral sand deposits of Fraser Island. *In* Day, R.W. (Editor): *1977 Field Conference, Lady Elliot Island – Fraser Island – Gayndah – Biggenden*. Geological Society of Australia, Queensland Division, Brisbane, 34-36.

KUDRASS, H-R., 1982: Cores of Holocene and Pleistocene sediments from the east Australian continental shelf (SO-15 Cruise 1980). *Geologisches Jahrbuch* **D 56**, 137-163.

LAYCOCK, J.W., 1969: Mary Valley groundwater investigations, hydrological report on the area between Tiaro and Pialba. Geological Survey of Queensland, Record 1969/7.

LAYCOCK, J.W., 1975: Mary Valley groundwater investigations, drilling and testing sand-gravel aquifer — Boonooroo area. Geological Survey of Queensland, Record 1975/22.

MARSHALL, J.F., 1977: Marine geology of the Capricorn Channel area. *Bureau of Mineral Resources, Geology and Geophysics, Australia, Bulletin* **163.**

MARSHALL, J.F., 1978: Morphology and shallow structure of the continental shelf of southern Queensland and northern New South Wales. Bureau of Mineral Resources, Geology and Geophysics, Australia, Record 1978/100.

MARSHALL, J.F., 1980: Continental shelf sediments, southern Queensland and northern New South Wales. *Bureau of Mineral Resources, Geology and Geophysics, Australia, Bulletin* **207.**

MARSHALL, J.F. & THOM, B.G., 1976: The sea level in the last interglacial. *Nature* **263**, 120-121.

McLEOD, R.L., 1979: Mineral exploration in the Maryborough 1:250 000 Sheet area. *Queensland Government Mining Journal* **80**, 572-581.

MURPHYORES INC., 1967: A to P 201M — Fraser island, final report. Unpublished report, held by the Queensland Department of Resource Industries as CR 2690.

PALMIERI, V., 1984: Neogene foraminiferida from GSQ Sandy Cape 1-3R bore, Queensland, a biostratigraphic appraisal. *Palaeogeography, Palaeoclimatology, Palaeoecology* **46,** 165-183.

RIDLEY, W.F., 1957: A sedimentary formation of Tertiary age between Maryborough and Bundaberg, Queensland. *Proceedings of the Royal Society of Queensland* **68**(2), 11-17.

ROBERTSON, A.D., 1979: Revision of the Cainozoic geology between the Kolan and Elliott Rivers. *Queensland Government Mining Journal* **80,** 350-363.

ROBERTSON, A.D., 1981a: Extractive minerals in the Pialba 1:100 000 Sheet area. *Queensland Government Mining Journal* **82,** 131-142.

ROBERTSON, A.D., 1981b: Workings of construction materials in the Maryborough 1:100 000 Sheet area. *Queensland Government Mining Journal* **82,** 591-602.

ROY, P.S. & THOM, B.G., 1987: Cainozoic shelf sedimentation in southeastern Australia. *In: The Cenozoic of the Australian Region: Program and Abstracts, December, 1987.* Warnambool Institute of Advanced Education (abstract).

SAWERS, J.D. & COOPER, W., 1985: Some Queensland industrial minerals. *Queensland Government Mining Journal* **86,** 188-195.

SIEMON, J.E., 1980: Ceramic resources of the Maryborough region. Geological Survey of Queensland, Record 1980/36.

SMITH, R., 1964: A note on gravity observations in the Maryborough Basin. Shell Development (Aust) Pty Ltd. Unpublished report, held by the Queensland Department of Resource Industries as CR 1359.

SMITH, R., 1965: Hervey Bay regional seismic survey, Maryborough Basin, Qld. Shell Development (Aust) Pty Ltd. Unpublished report, held by the Queensland Department of Resource Industries as CR 1761.

SQUANCE, G.T., 1968: Investigation of heavy mineral occurrences below sea level, Fraser Island, Qld. CRA Exploration. Unpublished report, held by the Queensland Department of Resource Industries as CR 2500.

STEPHENS, A.W., 1971: The geology of the Point Vernon area, Hervey Bay. University of Queensland, Department of Geology, B.Sc. Honours Thesis (unpublished).

STEPHENS, A.W., 1982a: Quaternary coastal sediments of southeast Queensland. *Geologisches Jahrbuch* **D 56**, 37-47.

STEPHENS, A.W., 1982b: Surficial sediments of the southern Queensland shelf; Southport – Point Lookout and Fraser Island areas. *Geologisches Jahrbuch* **D 56**, 125-135.

STEPHENS, A.W., HOLMES, K.H. & JONES, M.R., 1988: Modern sedimentation and Holocene shoreline evolution of the Hervey Bay coast. *Queensland Department of Mines, Marine & Coastal Investigations Project report* **MA12.**

THOMPSON, C.H., 1983: Development and weathering of large parabolic dune systems along the sub-tropical coast of eastern Australia. *Zeitschrift fGr Geomorphologie, N.F. Suppl.-Bd.* **45**, 205-225.

THOMPSON, C.H. & BOWMAN, G.M., 1984: Subaerial denudation and weathering of vegetated coastal dunes in eastern Australia. *In* Thom, B.G. (Editor): *Coastal Geomorphology in Australia,* Academic Press, Sydney, 263-290.

THOMPSON, C.H. & MOORE, A.W., 1984: Studies in landscape dynamics in the Cooloola – Noosa River area, Queensland. *CSIRO Division of Soils, Divisional Report* **73.**

THORNTON, M.P., in press: Maryborough Basin. *In* Ward, C.R. (Editor): *Geology of Australian Coal Basins,* Bureau of Mineral Resources/Geological Society of Australia Coal Geology Specialist Group.

WARD, W.T., 1977: Sand movement on Fraser Island, a response to changing climates. *University of Queensland, Department of Anthropology, Papers* **8,** 113-126.

WARD, W.T., 1985: Correlation of east Australian Pleistocene shorelines with deep-sea core stages, a basis for a coastal chronology. *Geological Society of America Bulletin* **96,** 1156-1166.

WARD, W.T. & GRIMES, K.G., 1987: History of coastal dunes at Triangle Cliff, Fraser Island, Queensland. *Australian Journal of Earth Sciences* **34,** 325-333.

WARD, W.T., LITTLE, I.P. & THOMPSON, C.H., 1979: Stratigraphy of the two sandrocks at Rainbow Beach, Queensland, Australia, and a note on humate composition. *Palaeogeography, Palaeoclimatology, Palaeoecology* **26,** 305-316.

WARD, W.T., STEPHENS, A.W. & McINTYRE, N., 1977: Brisbane's north coast and Fraser Island from the air. *In* Day, R.W. (Editor): *1977 Field Conference, Lady Elliot Island – Fraser Island – Gayndah – Biggenden.* Geological Society of Australia, Queensland Division, Brisbane, 14-30.

WELLMAN, P. & McDOUGALL, I., 1974: Cainozoic igneous activity in eastern Australia. *Tectonophysics* **23**, 49-65.

WHITEHOUSE, F.W., 1968: Fraser Island — geology and geomorphology. *Queensland Naturalist* **19,** 3-9.

NOTES

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