COASTAL GEOMORPHOLOGY OF THE JERVIS BAY AREA

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Jervis Bay and St. Georges Basin are shallow water bodies within headlands composed predominantly of Permian sandstones. These rocks are gently folded with the axis of each embayment corresponding to the north-south trend of two separate synclines. Quartz-rich sandstones (Conjola Formation) occur as anticlinal cliffs at the entrance of Jervis Bay where there is some evidence of faulting. The sandstones are thickly bedded and vertically jointed. Softer rocks (Wandrawandian Siltstone) are found in low-lying terrain to the west of Jervis Bay and to the north of St. Georges Basin.

This paper aims to provide an explanatory description of the depositional geomorphology of the Jervis Bay - St. Georges Basin area in the context of the bedrock-controlled landscape described above.

The two embayments are distinctly different in that St. Georges Basin is a typical barrier estuary and is enclosed by a prominent sand barrier, whereas Jervis Bay is open to the sea. Sandy shoreline topography fringes Jervis Bay with narrow beaches being exposed to both oceanic refracted swell waves as well as wind-driven waves generated within the bay. Sand dunes mantle bedrock headlands and cliffs bordering both embayments.

The largest and most complex single barrier system in the region is the Bherwerre barrier which encloses St. Georges Basin. Bherwerre beach faces almost due south into Wreck Bay. It is 7km long. At the western end it is cut by a 6.4km long sinuous tidal channel, Sussex Inlet, which connects Wreck Bay to St. Georges Basin. This beach is exposed to the full force of southerly winds and waves and represents a high-energy dissipative beach type. The barrier itself is greater than 2km in width. Dune morphology predominates and at least three separate phases of dune activity can be recognised. Paterson (1975) stated that although the barrier is mainly of Holocene age, he thought the inner part of the Bherwerre system was a remnant of an older Pleistocene "inner barrier" (see also Walker, 1967). However, preliminary drilling conducted by the author and extrapolation of the stratigraphy from dune lakes to the east (see below), suggests that all surface deposits blocking the basin are of Holocene age. To the west, these deposits are composed of low-lying flood-tidal delta sands which are vegetated by *Casuarina glauca* .

A series of long-walled transgressive dunes covered by *Eucalyptus* forest reaches over 60m elevation above MSL at the eastern end of the barrier, blocking off two freshwater lakes, Lake McKenzie and Lake Windermere. These ridges are sub-parallel to the present shoreline. A mobile dune sheet, stabilized by planting marram grass in the 1970s, has been active in historic time. Drilling in the dune sands has revealed the existence of a Pleistocene sand surface at -12m MSL at the western end of the barrier. A unit of nearshore shelly sand occurs at the eastern end. Charcoal recovered from a depth of -19.8m MSL in this unit was dated at 8650 ± 440 ^{14}C yrs BP (SUA-193). Freshwater peat recovered below 23m of dune sand on the southern side of Lake Windermere at a height of 3m above MSL gave an age of 3280 ± 230 ^{14}C yrs BP (SUA-192). This date is 1000 ^{14}C years younger than SUA-208 obtained from a charcoal sample in a buried dune soil at the western end of the barrier (4310 ± 100 ^{14}C yrs BP). It is possible that dune mobilization continued for a lengthy period in this embayment. Shallow podzol soil development in dune sands bordering Lake McKenzie is generally consistent with a middle to late Holocene age of transgressive dunes (Thom *et al* ., 1981).

Lake Windermere, one of two dune barrage lakes blocked by high transgressive dunes, has been the subject of two separate geological studies (Thom *et al* ., 1981; Jacobsen and Schuett, 1984). A 4m core from the lake bottom has provided some information of aeolian activity. Nine dates have been obtained. They are mostly in sequence ranging from 7000 years at the base to 2000 years at -60cm. A 25cm fine sand layer is bracketed by two dates (SUA 959, 960), which cover the period 3500 to 4600 calendar years BP (*ie* 2340 to 4055 ± 100 ^{14}C yrs BP). This is in close agreement with the two other dates mentioned above, one from a buried soil to the west of the barrier, the other from a peat beneath dune sand at the edge of Lake Windermere. Furthermore, a thinner layer of fine sand occurs between -61 to 65cm. Here dates are inverted (SUA-957, 958). However, their 95% confidence limits overlap, suggesting aeolian activity about 1500 to 1800 calendar years ago. Again, a young aeolian surge is indicated which may correlate with those of the central NSW coast (Thom *et al* ., 1981). More work is planned on the biostratigraphy of this core.

Jacobsen and Schuett (1984) have investigated groundwater seepage and the water balance of Lake Windermere. They state:

> "Cyclical water-level fluctuations of up to 12m in Lake Windermere are a response to climatic variations with a period of several years. An appropriate water balance indicates that groundwater seepage is the most significant component (84%) of the outflow from the lake, whereas surface streams are the most significant

component (89%) of the inflow to the lake. Groundwater flows westwards from the lake through a highly permeable Pleistocene sand aquifer" (p. 645).

Our investigations have shown that this sand aquifer is more likely to be of Holocene age, not Pleistocene.

Paterson (1975) has identified "high level" sand dunes and sand sheets overlying areas of bedrock in the Jervis Bay - St. Georges Basin region. The generally leached appearance of the sands and the relationships between those deposits and the other Quaternary sediments suggests that these deposits are probably Pleistocene in age, although a certain amount of post Pleistocene reworking may have taken place. The sands are typically very light grey in colour (at least at the surface), fine to medium grained, with subangular to rounded grains and consist of quartz with minor feldspar. The deposits appear to have been formed by dominant south to southwesterly winds acting on abundant supplies of sandy sediment which accumulated on beaches within sections of coastline facing in a southerly direction. These have acted as a "trap" for sand being moved northwards along the coast at present and during periods of lower sea levels by longshore drift (Roy and Thom, 1981).

Maximum development of "high level" sand occurs on the Bherwerre Peninsula. This peninsula projects about 15km beyond the general coastline trend and has acted as a major sand trap. On the southern slopes of the peninsula the sand attains elevations over 100m above MSL as fixed dunes stabilized by ti-tree (*Leptospermum*) and *Eucalyptus* forest cover. The underlying bedrock topography is quite irregular and the thickness of sand is variable. The dunes are rather irregular in form, but there is a tendency for some of them to be oriented SSW-NNE. The sand has buried or blocked pre-existing stream valleys and in this way has formed many small dune depressions (e.g. west of Steamers Beach).

In the central part of the peninsula and on the eastern slopes, the sand cover is thinner and less continuous, occurring as low dunes and flat to gently undulating areas. In the central and northeastern part of the peninsula there are numerous scattered minor small dunes and areas of sand which have not been mapped in any detail (Jackson, 1969; Paterson, 1975).

One of the most remarkable dune features of the region occurs inland from Steamers Beach at the eastern end of the Bherwerre Peninsula. Here orange-coloured sand not only mantles a ledge of Permian sandstone, but also forms a nested set of parabolic dunes. These dunes face SSW and reach inland 2km where they attain elevations of 150 to 170m. The sand is carbonate rich. Steeply dipping aeolian bedding occurs in an outcrop of partially cemented sand ("aeolianite") above Steamers Beach. This location is similar to several other occurrences of aeolianite in N.S.W., viz. at south-facing embayments at the eastern end of a peninsula (e.g. Kurnell, see Roy and Crawford, 1981). At these sites there is an apparent dilution of the non-carbonate sand fraction permitting the accumulation and subsequent diagenesis of carbonate rich sands. The modern beach at the Steamers Beach locality is not as enriched in carbonate as the parabolic dunes to landward.

There exists an elongate belt of high-level dunes on the eastern side of the Beecroft Peninsula. These occur at the top of a sheer cliffline approximately 100m high. The sand appears to have reached the clifftop via deep fissures eroded along joint planes, principally the feature called "Devils Inlet" or "Devils Hole". This is a deep, narrow, vertical sided "slot", approximately 400m long and over 60m deep, which has been eroded along a joint plane. It opens out into a small, circular steep-sided depression (crater-like) at its western end, where it intersects a northerly trending fault plane (Paterson, 1975). The western side of this depression is blanketed by stabilized sand. The maximum thickness of sand developed within this area of high level dunes is in the immediate vicinity of this feature. These facts suggest that sand was moved into the fissure and piled by wind action against the western end, and by this means reached the surface of the peninsula, where it was distributed along the top of the cliffline by the dominant southerly winds (Paterson, 1975).

Well-podzolized dune features occur on the northern or landward side of St. Georges Basin at Macleans Point. At one site the sand partially buries a subdued bedrock cliff. This cliff is now a fossil landform and vegetated. The sand dune is perched as a mound on top of the cliff and is either a relic of a former Pleistocene high sea level, or was deposited during a lower sea level when Pleistocene sand flats beneath St. Georges basin were exposed to southerly or westerly winds. It is very rare to find cliff-top dunes on the inland side of lagoons of the barrier-estuary type of coastal embayment in NSW.

Jervis Bay is fringed by low-relief bay barriers and bay-head beaches and dunes. Each embayment within the bay possesses its own sandy beach tied to headlands composed of Permian sandstone or siltstone. The most distinctive trait of these sands is their white colour. They are usually quite fine grained and most probably derived from the Conjola Formation.

Barriers fringing Jervis Bay reach their maximum development on the northern side of the bay at Callala. Here the bay barrier is composed of a number of parallel beach or relict foredune ridges of relatively uniform height (+3m MSL). The barrier system is 3km long and 0.5km wide blocking off a prominent backbarrier swamp known as "The Black Swamp". A drill hole on the barrier at Callala encountered a nearshore shell sand overlying bedrock at -5m MSL. The shell assemblage includes a mixture of estuarine and open ocean species.

There is some evidence of Pleistocene "inner barrier" sands occurring in a small area 0.5km west of the mouth of Currambene Creek (Walker, 1967; Paterson, 1975). The sand is coarser and the ridges are quite low in relief. Their age and stratigraphy require further investigation, as does the outcrop of beach sand impregnated with humate near Murrays Beach (see exposure at boat ramp leading from excavated car park).

Other than at Callala, the beach and foredune sands of Jervis Bay are quite narrow. Typically, a high, well developed, scarped, established foredune vegetated by *Banksia, Leptospermum* and *Eucalyptus* trees overlooks a narrow incipient foredune "terrace" covered with *Spinifex* (e.g. Greenpatch, Long Beach). During 1974, the established foredune was extensively eroded by storm waves (Bryant and Kidd, 1975). Shoreline recession during storms continued into 1985. Under fair-weather conditions beaches within the bay are mostly low energy reflective in type with well developed cusps occurring in many places (e.g. the western end of Greenpatch).

There is a high stationary barrier blocking off the northern half of Jervis Bay. This barrier links the sandstone headland of Currarong with a number of outcrops to the north towards Culburra. This ridge is a complex feature possibly composite in character including a buried Pleistocene soil (humate-impregnated sand) at the southern end. The beach (Currarong Beach) faces NE and is composed predominantly of yellow iron-stained quartz sand similar to the "marine" sand of most open-ocean beaches in NSW. The foredune behind this beach locally exceeds 5m in elevation above MSL. A backbarrier flat slopes into Jervis Bay and is cut by a tidal creek system (Carama Inlet) fringed by an extensive stand of mangrove and saltmarsh. This creek drains into a low energy section of Jervis Bay known a Hare Bay. Locally there has been some wave and perhaps aeolián reworking of backbarrier sands enclosing swamps. A drill hole encountered backbarrier muddy sands with shells at 4.0m below MSL. Oxidised clay occurred at -17m MSL and bedrock at -21.5m MSL. Taylor (1971) cites Albani (pers. comm.) as suggesting a possible old river channel through Hare Bay to the sea. It is likely that very high energy storms locally washover the dune ridge into the bay behind Currarong Beach.

This brief account of the area's geomorphology summarizes much of what is known about the area. Systematic morphologic mapping, drilling, sediment analysis and dating remain to be undertaken. It is an area rich in Quaternary history especially when subaerial landforms are tied in with the history of the bay and basin as well as with that of sedimentary records from offshore (see Roy and Ferland, 1987).

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