

WILSONS PROMONTORY, VICTORIA

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INTRODUCTION

The landscape of Wilsons Promontory is one of the most dramatic in Australia. Approximately 200 km southeast of Melbourne, it forms the southern-most part of the Australian mainland, and part of the southern edge of the South Victorian Uplands. Granitic mountains rise from the waters of Bass Strait and host a wide array of granitic weathering and landscape features. Furthermore, the coastal lowlands contain a great diversity of marine, aeolian, colluvial and alluvial sediments that reflect a dynamic Cenozoic environmental history.

PHYSICAL SETTING

Geology

A composite batholith of Devonian granite constitutes most of the bedrock at the promontory (Wallis, 1981; 1998). Ordovician metasediments occur immediately to the north and are exposed at Red Bluff on the Yanakie Isthmus. Prominent northeast-southwest and northwest-southeast trending joints and faults have a strong control on the topographic relief and occurrence of deep weathering profiles. Many of these structures extend into, or are sub-parallel to, equivalent structures in the adjacent Gippsland and Bass Basins and are likely to have similar, ongoing tectonic histories (Hill and Joyce, 1995a). A series of east-west and north-south trending structures also have prominent landscape expressions. Mesozoic and Cenozoic sediments of the Gippsland and Bass basins surround the granitic inlier (Douglas, 1988; Hocking, 1988). These sediments mostly consist of volcanoclastic Late Jurassic to Early Cretaceous sediments (Strzelecki Group), Late Cretaceous to Cenozoic predominantly quartzose and kaolinitic fluvial-deltaic sediments (Latrobe Valley Group), Late Palaeogene to Neogene shelf carbonates (Seaspray Group), and Neogene terrigenous clastics (e.g. Haunted Hill Formation).

Geomorphology

Wilsons Promontory broadly consists of granitic mountains and hills flanked by lowlands with colluvial, alluvial, aeolian, and coastal deposits (Figure 1). The peaks of Mt Latrobe (754 m), Mt Ramsay (679 m), Mt Wilson (705 m), and Mt Oberon (558 m) form the highest parts of the central uplands of the promontory. Areas of mountains and hills also occur at the southern end of the promontory including Mt Norgate (419 m) and Mt Boulder (501 m), and at the northeastern end of the promontory within the Singapore Peninsula, which includes the peaks of Mt Singapore (147 m), Mt Margaret (218 m), Mt Roundback (316 m) and Mt Hunter (347 m). The low-lying area that includes Corner Inlet and the Yanakie Isthmus separates the upland areas of Wilsons Promontory from the South Gippsland Uplands to the north (Figure 1). An east-west trending lowland extends across the southern margin of the central uplands of the promontory between

Oberon Bay on the west coast and Waterloo Bay on the east. The promontory extends southwards into the waters of Bass Strait. It forms the exposed northern section of the Bassian Rise, which is for the most part a submarine ridge extending southwards from the South Gippsland Uplands to northeast Tasmania, dividing the Gippsland Basin to the East and the Bass Basin to the West. A major north-south trending drainage divide forms a central “spine” extending along the length of the promontory, with smaller interfluves mostly trending east-west along spurs which terminate as coastal headlands between coastal embayments.

Climate

The climate of Wilsons Promontory is generally cool and mild, with few extremes. A considerable variation in rainfall across the promontory is shown by the average annual rainfall for Tidal River and Southeast Point of 1083 mm and 1050 mm respectively, while at Yanakie it is only 808 mm. The wettest months are in the winter. The mean maximum temperatures at Tidal River range from 24°C in February to 13°C in July, and the mean minima range from 13°C in February to 6°C in August (Ashton and Webb, 1977). Winds are predominantly from the southwest.

Vegetation

The vegetation is extremely diverse (Conn, 1993; Chesterfield, 1998), including: wet sclerophyll forest dominated by *Eucalyptus obliqua*; *Nothofagus cunninghamii*-dominated cool temperate rainforest; warm temperate rainforest dominated by *Acemena smithii*; dry sclerophyll forest dominated by *Eucalyptus baxteri*; *Banksia integrifolia* and *Eucalyptus baxteri* woodlands; *Allocasuarina*–*Leptospermum*, *Melaleuca* and *Kunzea* heathlands and thickets; *Juncus kraussii* – *Samolus repens* saltmarsh; *Avicennia marina* mangroves; and, *Poa poiformis*-dominated closed tussock grasslands. The regolith substrate and landscape setting are major controls on the distribution and form of these vegetation communities, in particular the presence of granite outcrops, and the variations in the lithology and drainage of coastal sands (e.g. Parsons, 1966; Ashton and Webb, 1977), although fire history is another important control.

REGOLITH–LANDFORM RELATIONSHIPS

A map of regolith–landform features at 1:50,000 scale was produced from aerial photographs, field mapping, and aerial survey (Hill, 1992). As weathered granite characterises a large part of the promontory a new approach for mapping the regolith–landform expression of these areas emphasised top and bedrock exposure morphology as a further basis for mapping sub-division (Hill, 1992; Hill and Joyce, 1995a; 1995b). The main regolith–landform units can be broadly sub-divided into two major groups: weathered bedrock (*in situ* regolith); and, transported regolith.

Weathered bedrock

Variably weathered bedrock forms most of the upland areas and coastal headlands on the promontory. Exposures of weathering profiles extend up to 50 m deep at sites such as the Mt Oberon Quarry (Hill and Joyce, 1995b), however, it appears that weathering profiles were previously much deeper and more widespread. The sides of many of the valley systems feature systematic decreases in tor size and angularity over elevations of several hundred metres. This is interpreted to reflect the former extent of weathering profiles that have since had much of the saprolite stripped, and the corestones of less weathered rock are now exposed at the landsurface as tors (Hill *et al.*, 1995). Extensive areas of granite saprolite also occur on elevated plains such as within the Vereker Range and east of Mt Norgate. Tafoni, honeycomb weathering, rillenkarren, flared footslopes and caves are common surface and near surface weathering features of the granite exposures (Hill, 1994).

Transported regolith

Transported regolith mostly characterises the lower relief, low-lying parts of the promontory, particularly across the Yanakie Isthmus, along the margins of Corner Inlet, and in the immediate hinterland of major coastal embayments. Initial sub-division is based on interpreted genetic processes and include: alluvial sediments, colluvial sediments, aeolian sediments, and marine sediments. Further sub-division for mapping is based on landform expression (Hill, 1992; Hill and Joyce, 1995b).

Alluvial sediments are associated with the contemporary drainage network, and as eroded exposures in highly-elevated landscape positions within the Singapore Peninsula (e.g. the cassiterite-bearing gravels at Mt Hunter) and deeply buried beneath Corner Inlet and parts of the Yanakie Isthmus. Contemporary alluvial deposition is restricted to the narrow valley floors within deeply incised, high-relief areas, however, closer to the coast most alluvial systems form broad alluvial swamps, typically confined by dune and beach systems at their coastal margins (e.g. Sealers, Five Mile, Growlers, Darby, and Waterloo Swamps and Cotters Lake).

Colluvial sediments are widespread across the area, particularly flanking hills and mountains, typically extending across the adjacent lowlands where they are mostly buried. The colluvial sediments are largely derived from slope creep, although there are examples of rock-fall, land-slides, debris flow and sheet-flow. Large slides and debris flows are particularly well developed in areas with steep slopes and thick regolith cover, such as between Mt Oberon and Little Oberon Bay, between Waterloo Bay and South-east Point, and within the central mountains (especially downslope of the Tidal River Road near Darby Saddle). Recently active debris flows are expressed as prominent “scars” devoid of vegetation with exposure of the local basal weathering front. Older areas of slope instability typically include an irregular surface arrangement of tors and convex-concave slope profiles.

Aeolian sediments are most extensive in low-lying and coastal areas. They occur along the west coast of the promontory and

Yanakie Isthmus as parabolic dunes. The axes of these dunes suggest a derivation mostly from southwest onshore winds (Hill and Bowler, 1995). Tuddenham (1970) subdivided the dunes into a series of four main phases based on degree of lithification and pedogenesis. In contrast, further from the coast, linear dunes, sand sheets, and lunettes have axes suggesting a derivation from predominantly westerly continental winds (Hill and Bowler, 1995).

Beach and marine deposits are well developed along coastal embayments and the margins of Corner Inlet and Yanakie Isthmus. Series of beach ridges, sub-parallel to the contemporary coastline, extend inland from many beaches. The lowland area on the northeastern part of the Singapore Peninsula between Hunter Point and Entrance Point hosts over 80 beach ridges extending eastwards for up to 2.5 km from an abandoned bluff cut into weathered granite (Tuddenham, 1970). Tidal flats and mud deposits occur along the northern coast between Chinaman and Telegraph Swamps particularly in association with mangrove and sea grass communities, and in more localised occurrences such as along the lower reaches of Tidal River.

REGOLITH CHARACTERISATION

Weathered bedrock

Detailed examination, including 1:10 scale vertical profile mapping, field- and micro-morphology, and X-ray Diffraction mineralogical determinations of weathering profiles on two of the granite lithologies exposed in the Mt Oberon Quarry have been made (Hill, 1992; Hill and Joyce, 1995b). Kaolin-group clays with minor smectite, vermiculite, hematite and goethite are the main secondary minerals in the granitic saprolite, with quartz and minor tourmaline the main resistant primary minerals. Throughout the promontory there is marked differential weathering of the various granite lithologies, largely attributed to the extent of jointing, micro-fractures, crystal size and modal mineralogical variations (Hill, 1996). The abundance of biotite and to a lesser degree plagioclase feldspar are major controls on the extent and style of granite weathering. Soils developed within areas of weathered granite are mostly dermosols and chromosols.

Transported regolith

Alluvial sediments associated with modern streams contain a mixture of quartzose sand, kaolinitic clays and fresh clasts of feldspar and granitic lithic fragments. Older (high-level and deeply buried) deposits predominantly consist of quartz sands and gravels with minor cassiterite, tourmaline, zircon and corundum sands (Birch, 1998), and kaolinitic clay. Swampy sites are mostly hosts to hydrosols. Minor and irregular silicification is also a feature of some of the older deposits. Hill (1999) interpreted the broad regional changes in sediment lithology over the landscape history to reflect progressive erosion of deep weathering profiles in areas such as Wilsons Promontory.

Aeolian sediments can be subdivided on the basis of lithology into: (i) siliceous sands; and, (ii) calcareous sands. The siliceous sands

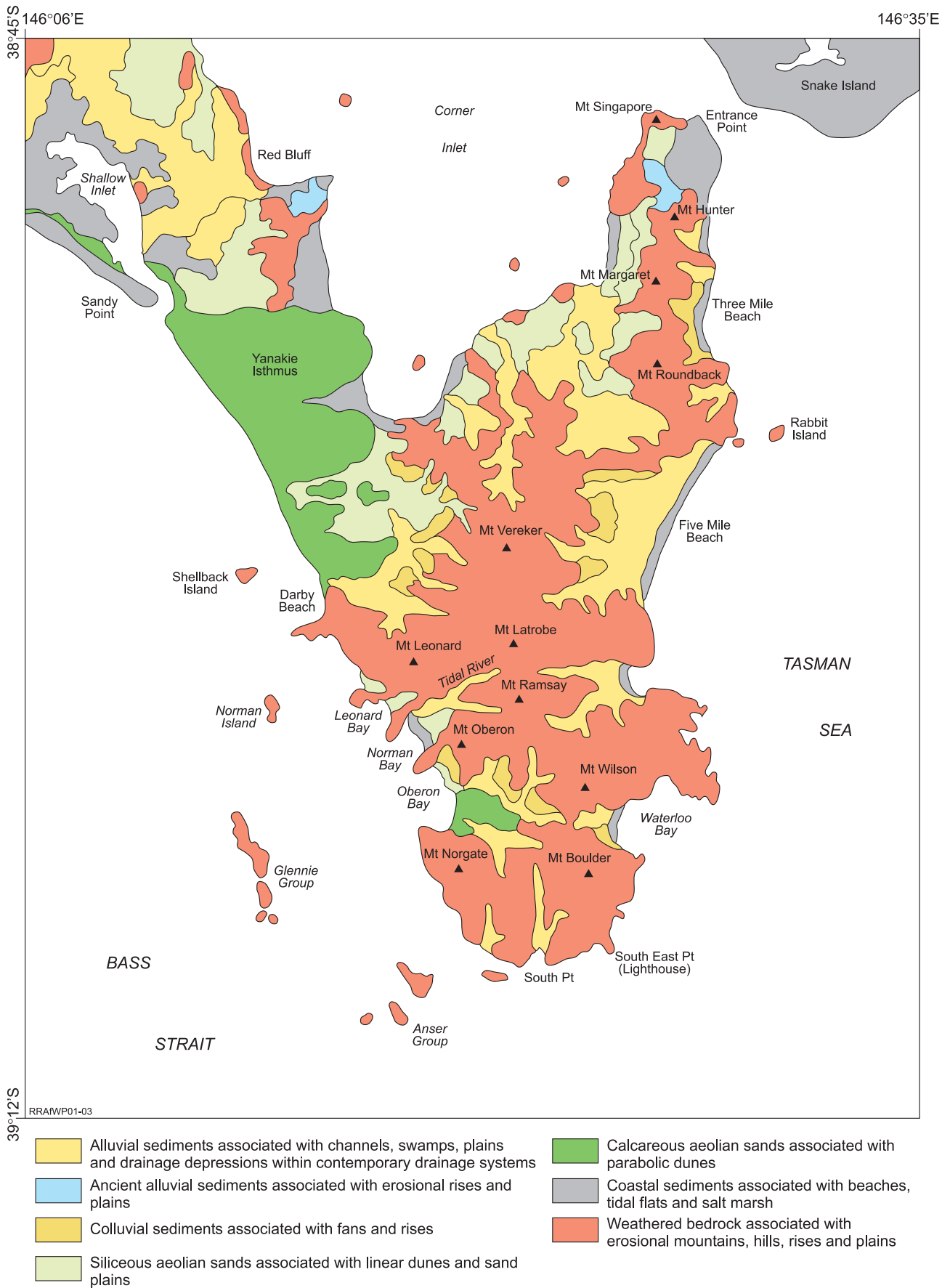


Figure 1. Simplified regolith-landform map of Wilsons Promontory. (After Geological Survey of Victoria, 1971; and, Hill, 1992).

are composed of well-rounded and well-sorted fine quartzose deposits in the form of linear dunes, sand sheets, and lunettes (Hill and Bowler, 1995). Podsol (parapanic, humosesquic, aeric) soils are widely developed, with vertosols in more poorly drained sites such as depressions near creeks. The calcareous dunes are composed of degraded shell and bryozoan fragments with a minor quartzose sand component. Rhizomorphic, nodular, hardpan, boulder and 'pipe-like' regolith carbonate accumulations are common in the calcarosol soils, with palaeosols previously described as terra rosas and rendzinas (Tuddenham, 1970; Oyston, 1988).

Wilsons Promontory marks a major division in the composition of *coastal sands* in southeastern Australia. The east coast of the promontory features siliceous beach sands, whereas the beaches on the western side are mostly dominated by calcareous sands except where the sea is eroding into older siliceous sand dunes (such as at Squeaky Beach and Little Oberon Bay). Degraded shoreline cliffs, probably related to the last interglacial shoreline, extend along the west coast of the Yanakie Isthmus inland of Cotter Lake and the southern foreshore of Corner Inlet.

Colluvial sediments consist of granite-derived detritus, including kaolinite, quartz, feldspars, micas and granitic lithic fragments (some up to 20 m in long axis diameter; Hill and Joyce, 1995a). Fragments of charcoal are also locally abundant, suggesting a possible association between slope instability and the incidence of fire, although slope instability in the contemporary landscape can occur independent of fire.

DATING

The granitic bedrock has been dated by K/Ar determinations on biotite at 379 ± 15 Ma (Richards and Singleton, 1981).

Demitru *et al.* (1991) and Duddy and Green (1992) show some Apatite Fission Track Thermochronology (AFTT) results from Wilsons Promontory and adjacent islands, with maximum ages between 157.6 ± 8.3 Ma and 269 ± 23.5 Ma. These analyses showed a significant population of short track lengths, and a significant spread in single grain ages from around 100 Ma to over 300 Ma (Duddy and Green, 1992). These results have been interpreted as being compatible with regional cooling at around 90 to 100 Ma, possibly related to regional, kilometre-scale denudation (Duddy and Green, 1992).

Direct dating of regolith and landscape-related features have been limited at Wilsons Promontory. The long-term landscape evolution of Wilsons Promontory has been broadly related to the sedimentation history of the adjacent Gippsland and Bass basins (Hill *et al.*, 1995; Hill and Joyce, 1995a; Hill, 1999). This supports a regional model of landscape evolution that includes major denudation of a highly weathered landscape initiated in the middle Cretaceous. Some of the most ancient weathering at Wilsons Promontory would therefore pre-date this, but weathering has also taken place throughout the history of landscape development up to the present day.

The age of the high-level alluvial gravels on the Singapore Peninsula is poorly constrained. Lithologically similar gravels in the Toora region to the north, both pre-date and post-date 'Older Volcanics' basalts most probably from the Palaeogene (Spencer-Jones, 1955). The presence of corundum in gravels near Yanakie suggests that some gravels in the Corner Inlet area are at least post-basaltic (Birch, 1998). Bolger (1991) found possible Wilsons Promontory-derived granitic detritus in Neogene fluvial gravels (Haunted Hills Formation) to the north within the South Gippsland Uplands. The Singapore Peninsula gravels may be equivalent to at least some of these.

The most extensively dated dunes sequences in the area are from the radiocarbon dating of charcoal and wood fragments associated with palaeosols at Darby Beach (Coutts, 1967; Tuddenham, 1970). The results show that although the lower palaeosols are from $>42,000$ years b.p. some of the palaeosols from the top of the 'older dune series' are from between $3,060 \pm 100$ years b.p. to $6,550 \pm 100$ years b.p.. Charcoal from a palaeosol with well developed pedogenic carbonate accumulations was from $25,300 \pm 1,300$ years b.p. (Coutts, 1967). Radiocarbon dating of samples from peat accumulations across the wider area range between $2,820 \pm 100$ years b.p. at Three Mile Beach (Tuddenham, 1970), $5,890 \pm 90$ years b.p. at Darby Beach (Hope, 1974), to $6,980 \pm 190$ years b.p. and $11,450 \pm 230$ years b.p. at Five Mile Beach Swamp (Ladd, 1979). Parsons (1966) reports a radiocarbon date of $6,230 \pm 430$ years b.p. for marine shells from the Tidal River Swamp.

REGOLITH EVOLUTION

Some of the important features of the history of regolith evolution at Wilsons Promontory include:

1. The potential for landscape facets with origins of great antiquity to exist alongside areas of rapid geomorphological activity. For example weathering profiles and low relief landsurfaces can occur on the margins of steeply and deeply incising valley systems. This can be accounted for when the landscape is recognised as a mosaic of landscape facets, with the rates of different landscape processes varying on a range of spatial and temporal scales. At Wilsons Promontory this is facilitated by the highly irregular topographic relief largely initiated by tectonics and lithological controls on variations in the weathering front (and later bedrock exposure). The expression and locations of regional knickpoints, and hence the extent and local rates of denudation or the preservation potential of ancient landscape facets, are therefore irregular and variable across the promontory. This is in contrast to landscape evolution models that include broad regional extrapolations based on an incomplete and poorly constrained palaeolandscape record.
2. The continual evolution and inter-relationships between basin sedimentation and the landscape evolution of hinterland areas, extending from the Mesozoic to the present day.

3. The important lithological controls (in particular structure and mineralogy) on differential weathering and landscape expression of granites, in particular due to modal biotite and plagioclase feldspar abundance and large-scale and micro-fractures.
4. The great potential for Quaternary deposits and landforms to reflect a dynamic environmental history, in particular the aeolian sediments. Further work is needed on these, in particular the development of a chronological framework such as by luminescence dating.

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