LATE NEOGENE TO QUATERNARY MARINE TERRACES AND AEOLIAN DEPOSITS, CAPE LIPTRAP, SOUTHEASTERN AUSTRALIA

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INTRODUCTION

The southeastern coast of Australia is an atypical passive margin with many attributes not commonly associated with passive continental margins (Figure 1 in Gardner, this volume). For example, in the past forty years, over 1100 earthquakes have been detected in Victoria, Australia (Gibson et al., 1981) supporting the idea of an uncharacteristic behavior of passive margins.

The relic topography in Cape Liptrap is ideal for mapping marine terraces and their associated Quaternary to late Neogene sedimentary deposits. The step-like remnant topography was formed by changes in eustatic sea level and vertical deformation. Fluctuations in eustatic sea level occur because of changes in water volume from glaciation or tectonic processes that change the shape of the ocean basins; or a combination of the two (Nakada and Lambeck, 1986).

Past studies have identified about ten marine terraces in east Gippsland, about 150 km northeast of Cape Liptrap, and determined that the landscape had been affected by slow tectonic uplift (Ward, 1985; Ward et al., 1971). This study identifies and maps marine terraces on Cape Liptrap in order to study landscape evolution and to detect any vertical deformation present along the coast.

Methods

Marine terraces and the overlying sedimentary deposits were mapped using a Trimble, real time corrected, Global Positioning System XRS-Pro receiver with up to ~1 m vertical accuracy. Transects were constructed perpendicular to the coast identifying key features of terraces, such as inner edges, outer edges, and treads. Bedrock strath- marine sediment contacts were identified for each of the marine terraces in at least one of the seven transects. Seven cross-sections were constructed from the terrace elevation data to allow correlation between transects and to constrain tectonic deformation on Cape Liptrap. A surficial geologic map of the study area (figure 1) was created from aerial photograph analysis supplemented by field observations.

Three optical stimulated luminescence (OSL) samples provide age control for the extensive linear and parabolic dune fields covering much of the study area. In addition to the OSL ages, a thick quartz gravel deposit is being cosmogenically dated to determine the formation age of Qt_6, the 16 m marine terrace. The age that is derived from this sample will allow at least one terrace to be correlated to a eustatic sea level highstand in order to determine an uplift rate for the area.

A eustatic sea level curve was compiled using oxygen isotope data for the Quaternary (Raymo, 1992) and from stratigraphic data offshore of the U.S. Atlantic passive margin for the middle to late Tertiary (Dowsett et al., 1997; Pazzaglia and Gardner, 1993, 1994; Kominz et al.,1998, 2002). Sea level highstands were graphically connected to terrace elevations by tie lines to determine an

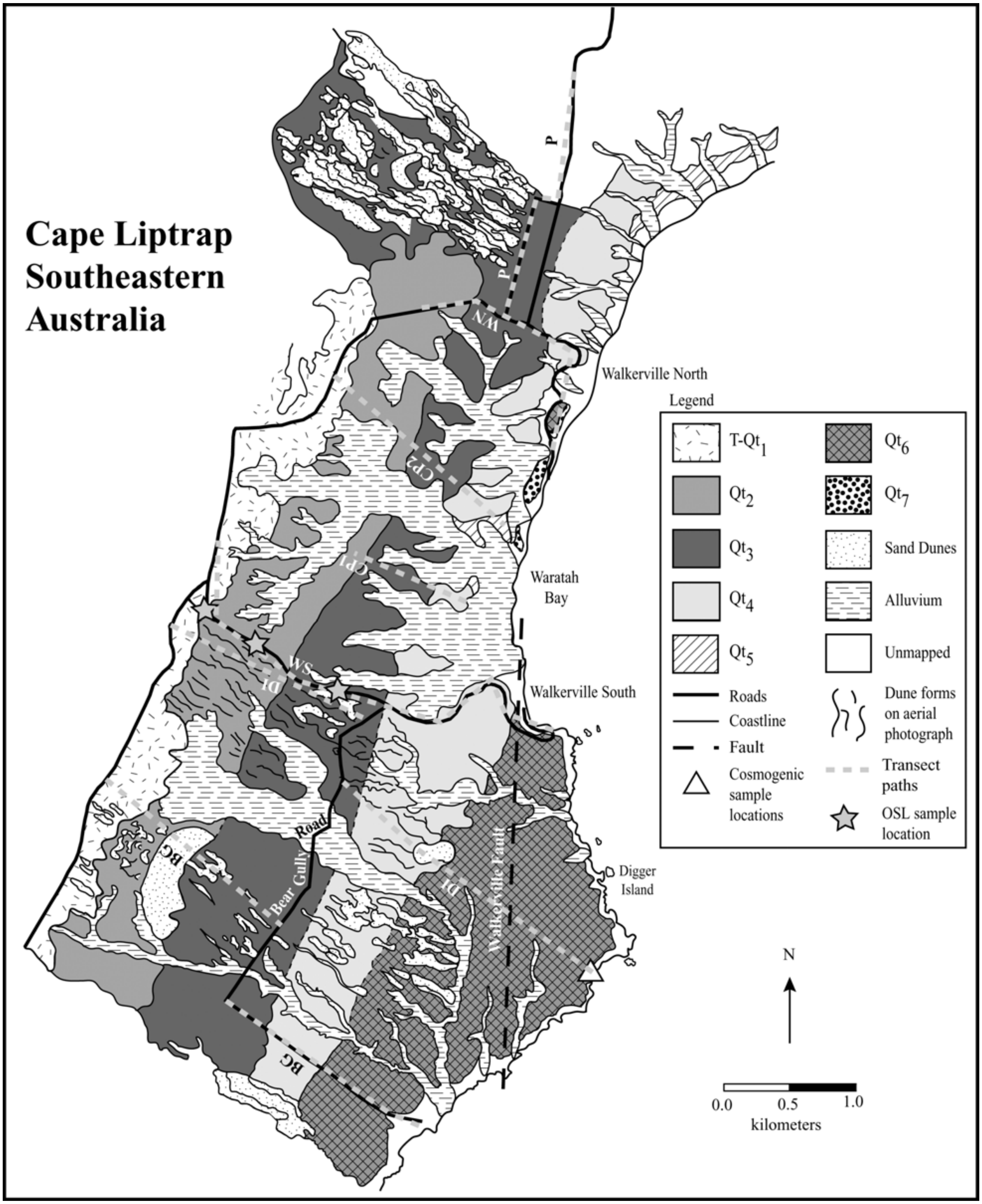

Figure 1: **Surficial geologic map of Cape Liptrap study area. Showing marine terraces, dune fields and alluvium. Transect positions are mapped with the initials: BG = Bear Gully transect; DI = Digger Island transect; WS = Walkerville South transect; CP1 = Coastal Park 1 transect; CP2 = Coastal Park 2 transect; WN = Walkerville North transect; and P = Paleovalley.**

appropriate uplift sequence. Uplift rates were then calculated from the equation:

uplift rate = (modern elevation – paleo sea level at the time of deposition)/ (age).

RESULTS

Seven marine terraces were identified in the study area (Figure 2). Not all marine terraces are present along all transects. Absent terraces may not have developed in the area or could have been eroded during subsequent terrace formation at lower elevations.

The geologic map (Figure 1) also illustrates the extensive linear and parabolic dune fields that cover the study area. The three OSL samples from the dunes yielded ages of 19 ± 1.8 ka, 21 ± 2 ka, and 22 ± 2 ka. These results indicate that a major aeolian phase occurred during the last glacial maximum. The orientation of these dunes is west-northwesterly in contrast to the southwesterly wind direction active at present for the southeastern Australian coast (Hill and Bowler, 1995).

The composition of the dunes in this part of Cape Liptrap is ~99% quartz. The quartz grains in the dunes display both angular and rounded grains in nearly equal amounts. This could signify at least two different provenances, either the Wilsons Promontory granitic batholith or the underlying Paleozoic sandstone basement rocks, were supplying the quartz.

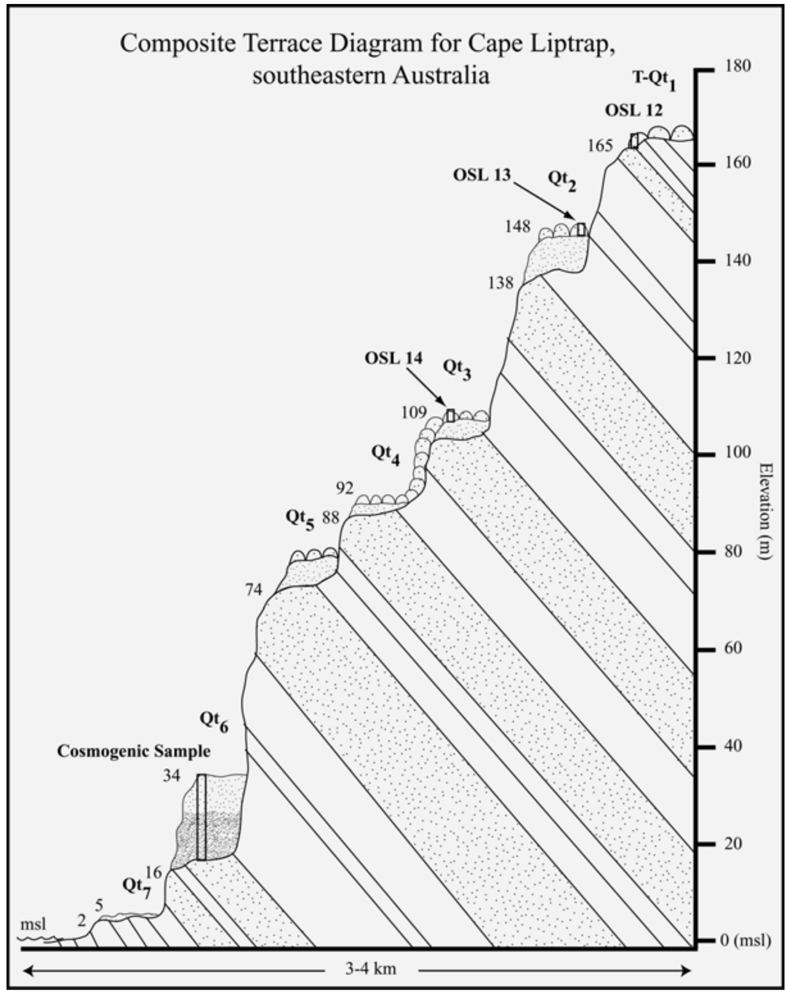

Figure 2: Composite terrace diagram displaying the flight of terraces in Cape Liptrap. Both the cosmogenic sample and the OSL samples locations are shown.

An age constraint has not yet been calculated for the marine terraces because high concentrations of aluminum in the quartz gravel sample from Qt_6 have delayed the dating process. Therefore, terraces were correlated by a trial and error process of connecting tie lines to sea level highstands that would yield a uniform uplift slope at any one section of the eustatic sea level curve. This method determined the possible limits of uplift permitted to produce the marine terraces. Bedrock strath elevations were used to determine a minimum uplift rate for the entire study area, because sediment thickness overlying the bedrock strath was too substantial to determine an accurate inner edge of the marine platform.

A large elevation gap between Qt_6 (16m) and Qt_5 (73m) could indicate that any terrace formed within this elevation range may not have developed significantly or was eroded down during the formation of Qt_6. The adjacent study area to the south (Tunnell, this volume) identified three separate terraces within this elevation range. Therefore, three additional inner edge elevations, taken from the project to the south, were used to calculate uplift rates.

An OSL age in Yanakie, north of Cape Liptrap, determined the lowest terrace in that area was formed approximately 124 ka. Therefore, Qt_6 was assigned to Oxygen Iosotope Stage 5e at approximately 124 ka. Each older terrace was assigned to a preceding highstand resulting in the oldest terrace formed around 2.5 m.y. These age assignments resulted in two distinct uplift rates that change around 530 ka. The uplift rate from the present to 530 ka is ~0.1 m/ ka and 0.08 m/ ka from 530 ka to 2.5 my. These results allow enough time for the terraces to form in this area but are not conclusive given the lack of radiometric age constraint. Results producing uplift rates of 0.2 m/ ka or higher would not allow enough time for all the terraces present to form, because there is not a sufficient number of highstands to form nine terraces with this uplift rate. In constrast, uplift rates of 0.01 m/ ka would place the oldest terrace around the mid-Miocene, a time of high sea levels. Until an age constraint can be obtained, uplift rates of 0.1 – 0.01 give a reasonable range for uplift rates around Cape Liptrap.

CONCLUSIONS

The purpose of this study was to map late Neogene to Quaternary marine terraces and aeolian deposits on Cape Liptrap to determine the landform evolution and to constrain any vertical deformation caused by the Walkerville Fault located within the study area. At least seven remnant marine terraces were identified in the study area. The extensive dune fields covering the area are dated at approximately 20 ka indicating significant aeolian activity during the last glacial maximum. The lack of a cosmogenic date for Qt_6 resulted in no radiometric age constraint for the marine terraces. Therefore, terraces were assigned to highstands to calculate uplift rates for the area. An uplift rate of around 0.1 m/ka would occur if Qt_6 were assigned to the Oxygen Isotope Stage 5e at 124 ka. If the oldest terrace was formed during the mid-Miocene 60m highstand, then the uplift rates could be as low as 0.01 m/ka which are also a possible interpretation for the landscape.

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