NATURE AND EXTENT OF PLIOCENE STRANDLINES ON THE DUNDAS TABLELAND, SOUTHWESTERN VICTORIA

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INTRODUCTION

Recent investigations into the origin of ferruginous duricrusts exposed on the Dundas and Merino Tablelands in southwestern Victoria suggest that at least some of the parent or host materials include ferruginised equivalents of the Loxton-Parilla sands and Dorodong Sands (Paine 1995, Quinn 1997, Dahlhaus *et al*. 2000, Paine 2002, Morand *et al*. 2002). These findings were based in part on the assumption that curvilinear Th anomalies evident on radiometric imagery over much of southwestern Victoria were spatially and genetically related to littoral sediments (strandlines) associated with these units. These studies, however, were generally undertaken on a relatively local scale and often recommended further work to confirm this relationship and to better understand the origin of the duricrusts in question. The following abstract responds to these recommendations.

GEOLOGICAL SETTING

The study was undertaken in the in the southwestern corner of Victoria (Figure 1) and includes a large part of the Hamilton 1:250,000 map sheet. The basement rocks here are dominated by a variety of Cambro-Ordovician sedimentary and metamorphic rocks along with syn- and post-compressional plutons and Cambrian greenstone belts (Morand *et al*. 2002). Younger Palaeozoic rocks include the Devonian Rocklands Volcanics Group, associated granites and scattered Permian fluvioglacial deposits. Mesozoic rocks are dominated by Cretaceous Otway Group sediments that are poorly exposed in the Merino-Casterton-Coleraine area where they comprise the Merino Tableland (Figure 1). Jurassic alkalic volcanic rocks of the Coleraine Volcanic Group are scattered throughout the Dundas Tableland (Morand *et al*. 2002).

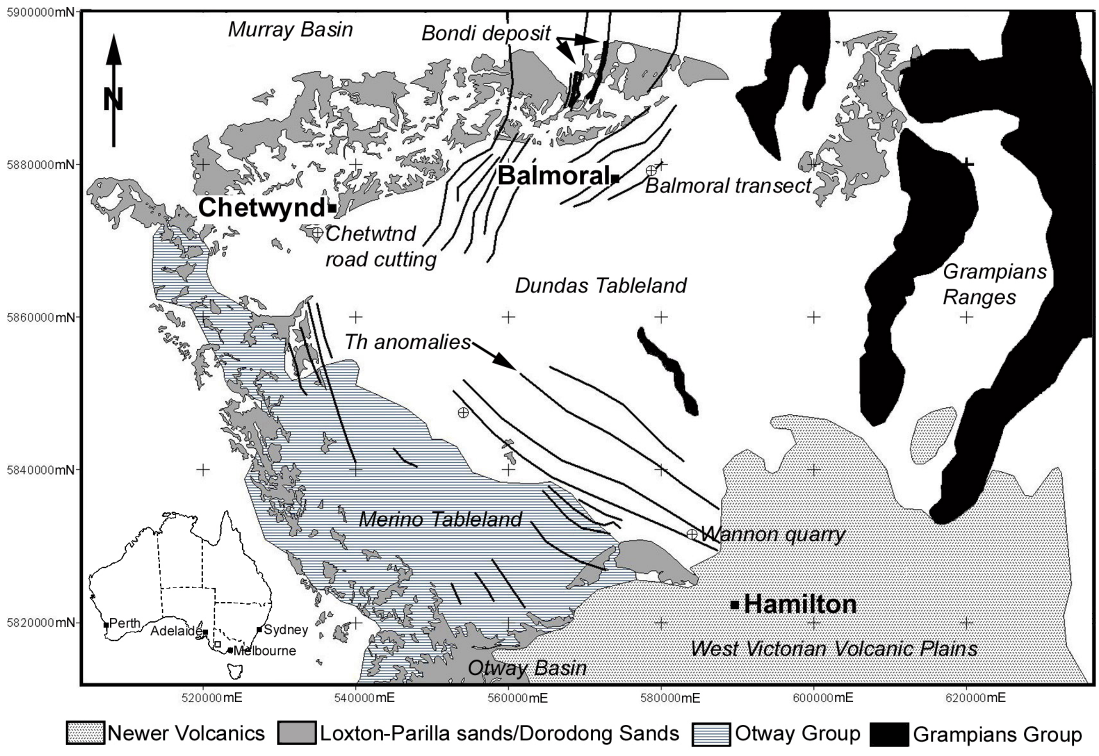

Figure 1. Location of study area showing relevant lithologies derived from the Hamilton 1: 250,000 Geological Map Sheet. Linear Th anomalies traced from radiometric imagery provided by the Geological Survey of Victoria.

Cainozoic sediments in southwestern Victoria are concentrated in the Murray and Otway Basins, which in the study area are separated by the topographically higher Dundas Tableland. In the Murray Basin the Cainozoic succession comprises at least three major disconformity-bound sequences: the Renmark Group; the Murray Group; and various Pliocene and Quaternary units including the Loxton-Parilla sands. In the Gambier and Tyrendarra Embayments of the Otway Basin, the Cainozoic succession includes the Wangerrip Group and the overlying Heytesbury Group, while post-Heytesbury Group sediments including the Grange Burn Formation and the Dorodong Sands. Specific to this study are the Loxton-Parilla sands as defined by Brown & Stephenson (1989) and their Otway Basin equivalents the Dorodong Sands. These sediments are variably exposed along the dissected margins of the Dundas Tableland (Figure 1) and previously represented the limit of the Pliocene marine transgression into southwestern Victoria (see Hamilton 1:250,000 Geological Map Sheet). The sediments here comprise deeply ferruginised, quartz-rich sands that are typically poorly exposed at the break of slope. Both marginal-marine and fluvial components have been recognised in the surrounding basins and are considered to have been deposited in association with the regressive phase of a short-lived marine incursion into the Murray and Otway Basins (Brown & Stephenson 1989).

Physiographically, the study area can be subdivided into the Dundas Tableland, which is characterised by flat to domed surfaces of regionally inconsistent elevation that have been variably dissected largely by the Glenelg and Wannon rivers and their tributaries. It, along with the Merino Tableland, forms part of the West Victorian Uplands (Jenkin 1988). The Merino Tableland, which is juxtaposed against the southeastern margin of the Dundas Tableland along the Konong Wootong Monocline, represents a deeply weathered and dissected landscape developed on dominantly Lower Cretaceous sediments. Plio-Pleistocene basalt flows in the southeastern portion of the study area form the western edge of the West Victorian Volcanic Plains and typically overlie Otway Basin sediments. This flat to undulating plain is dominated by Pliocene to Recent basaltic lava flows dotted with scoria cones, lava cones and maars that form prominent hills up to a few tens of metres high.

SPATIAL DISTRIBUTION OF THORIUM ANOMALIES

Curvilinear Th anomalies are evident on radiometric imagery over much of southwestern Victoria and their spatial and probable genetic relationships with Pliocene strandlines have been noted by Quinn (1997), Dahlhaus *et al.* (2000), Paine (2002) and Morand *et al.* (2002). Within the study area these linear features adopt locally similar but regionally variable orientations (Figure 1) and have been discussed below accordingly. The source of the Th remains unclear but given that 90% of gamma rays emanate from the top 300-450 mm of the regolith (Gregory & Horwood 1961) it is likely that the ferruginous gravels, which commonly overlie the strandline sediments, are the dominant source. The host of the Th within these gravels is likely to be detrital minerals such as zircon and monazite which commonly accumulate in placer deposits and/or the clays and iron oxides that comprise the ferruginous gravels (Dickson & Scott 1997, Wilford *et al*. 1997).

Wannon area

Arcuate linear Th anomalies in the southeastern portion of the Dundas Tableland have a dominant northwesterly trend (Figure 1) and throughout most of the area corresponding exposures of the Dorodong Sands nonconformably overlie Rocklands Volcanic Group rocks. Generally, these exposures become progressively thinner and more ferruginised to the north. The anomalies are typically truncated at their southeastern ends where the Dorodong Sands are overlain by the Newer Volcanics. Towards the northwestern ends of the strandlines, the Th response diminishes markedly in areas of deeper dissection where patchy exposures of the Dorodong Sands unconformably overlie Permian fluvioglacial deposits and Cambrian granites. On the adjacent Merino Tableland (Figure 1), Dorodong Sand exposures coincident with Th anomalies occupy the top few meters of north-northwest trending ridges that sit within the surrounding deeply dissected, relatively Th poor Otway Group sediments.

Balmoral-Harrow area

In the northern Dundas Tableland, Th anomalies adopt a more irregular trend than their dominantly north-trending counterparts in the adjacent southern Murray Basin. Around Balmoral, exposures of the Loxton-Parilla sands corresponding with the northeasterly-trending anomalies typically overlie older Cainozoic sediments, Rocklands Volcanic Group rocks or Cambrian metasediments and granites. The northeast-trending strandlines here appear to have influenced the “z” shaped course of the Glenelg River in the Balmoral area (Figure 1). Further west, in the north central parts of the Dundas Tableland, the linear Th anomalies adopt a NNE-trend (Figure 1) and here the Loxton-Parilla sands typically overlie Palaeozoic granites and Permian fluvioglacial sediments at their southern ends. The relatively steep-sided Glenelg River valley truncates most of the anomalies at their northern ends although one can linear feature can be tentatively traced across the valley and into the adjacent Murray Basin where it adopts a more northerly trend (Figure 1). By utilising the chronological framework established by Kotsonis (1995) an approximate age of around 4 Ma for this strandline was estimated.

Chetwynd area

Strandlines studied and mapped in the Chetwynd area are not evident on radiometric imagery as distinct curvilinear Th anomalies. To the west of Chetwynd this may be explained by the presence of an extensive dune field of Malanganee Sands, which, being dominated by unconsolidated quartz-rich sand, presumably masks any radiometric signature generated from the underlying variably ferruginised and locally heavy mineral-bearing Dorodong Sands. Curvilinear Th anomalies to the south of this area, however, show a north-northwest orientation and consequently a similar trend is envisaged for the strandlines underlying the Malanganee Sands dune field.

DETAILED STUDY SITES

Following re-plotting of the arcuate Th anomalies onto 1:25,000 scale topographic maps, field studies were undertaken to confirm the sedimentary origin of the coincident ferruginised sand exposures. Three main sites where selected for further study from around 80 visited exposures.

Wannon quarry (Figure 2A)

Occurring at the eastern end of an arcuate Th anomaly, the Wannon quarry is situated on the southern bank of the Wannon River approximately 10 km northwest of Hamilton (Figure 1). The top of the exposure occurs at approximately 195 m ASL. Here, ferruginised clayey sands are best exposed in the southern wall of the quarry where they nonconformably overlie saprolite developed from Rocklands Volcanic Group rocks. The Rocklands Volcanic Group has been subdivided into a number of units by Simpson (1997) and exposures at the quarry are grouped with the Nigretta Ignimbrite. The jointed ignimbrite is characterised by quartz and plagioclase phenocrysts set in a grey matrix which grades upwards into a mottled saprolite where goethite-rimmed red ferruginous mottles characteristically occur at the centre of joint-separated blocks. A sharp, irregular contact separates the ignimbrite from the overlying ferruginised sediments. In the basal portions of the unit ferruginous mottles are typically lenticular and dominantly horizontal. Higher in the profile the clayey sands are pervasively ferruginised, and traversed by cylindrical root holes filled with post depositional clayey sands and occasional carbonaceous material. On exposure this fill is often removed resulting in a hackly cellular facade on aged pit wall exposures. Dismantling and collapse of the cellular ferruginised substrate in the upper portions of the unit has lead to a concentration of ferruginous nodules that are further reworked and concentrated into a nodule- and pisolith-rich lag at the top of the unit. In thin section the mottled clayey sands are characterised by moderately sorted, matrix supported, subrounded, medium quartz sands set in a variably goethitised clay matrix. Marine fossils that have been replaced by goethite, first observed by Cajetan Phang (*pers. comm.*), include echinoid spines and plates.

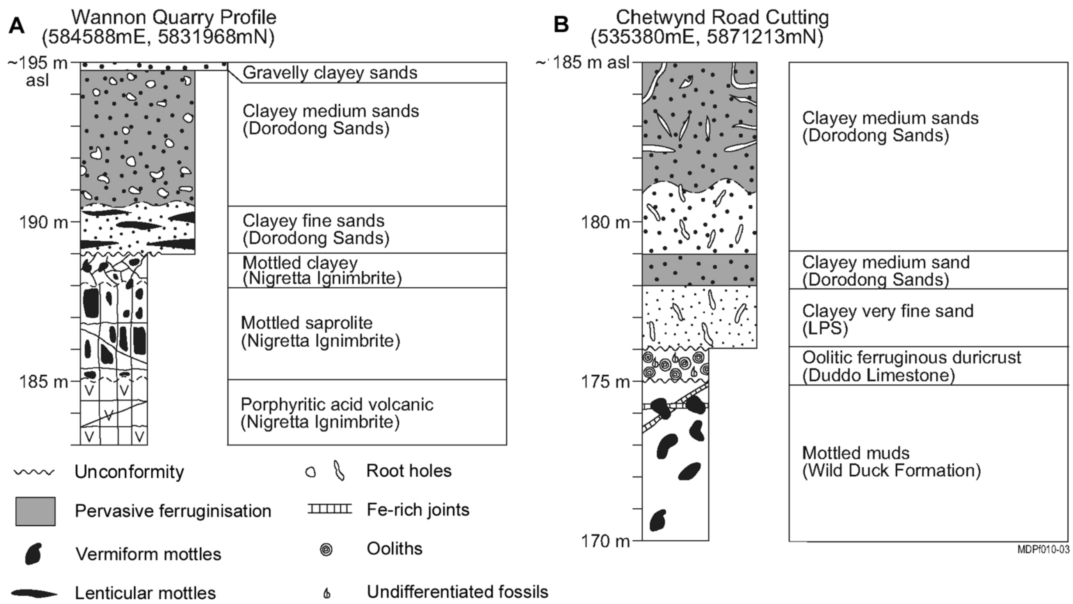

Figure 2. Vertical stratigraphic sections for the (A) Wannon quarry and (B) Chetwynd road cutting.

Chetwynd road cutting (Figure 2B)

The Chetwynd road cutting occurs approximately 3 km south of Chetwynd on the Casterton-Edenhope Road, slightly east from the extension of an approximately north-trending Th anomaly on the Merino Tableland to the south (Figure 1). Here, the cutting, with surface elevations ranging from 170 m ASL to 185 m ASL, provides exposures of Permian fluvioglacial deposits that are unconformably overlain by ferruginised sediments. Ferruginisation of the Permian sediments is evident particularly in the upper portion of the unit where a boxwork fabric has formed as Fe-rich joint fills form positive relief features on the exposed face of the cutting. The remainder of the unit is characterised by diffuse fawn coloured mottles that increase in concentration towards the top of the unit. Overlying this unit is a thin, ferruginous oolith-rich clay that is grouped here with the Duddo Limestone. This poorly exposed unit is characterised by <1 mm ooliths and various ferruginised bryozoan and echinoid fragments set in dark brown clay. In thin-section the ooliths are charatecrised by a series of concentrically-banded cutans arranged around a variety of cores including goethetised bryozoan or echinoid fragments, quartz grains or earlier homogenous ferruginous ooliths. Overlying the Duddo Limestone is a fine to medium quartz-rich sand that is grouped here with the Dorodong Sands. At the cutting this unit can be subdivided into a number of facies based largely on grain size. The basal unit comprises well-sorted, very fine clast-supported quartz sand with other minor detrital minerals including muscovite, tourmaline and ilmenite. The overlying unit is *characterised* by clast-supported, bimodal, fine to medium quartz sands. Accessory detrital minerals, which form a greater percentage of the mineral suite than the enveloping units, include tourmaline, rutile, ilmenite and zircon. This unit is relatively Fe-rich in comparison with the surrounding sediments and in the exposure has an irregular hackly facade. The uppermost unit in the exposure comprises moderately sorted medium quartz sand. Detrital minerals throughout the unit are weakly cemented by goethite-stained clays that partly fill the available pore space.

Balmoral transects

A series of transects were undertaken from the southern bank of the Glenelg River to a northeast trending high (Figure 1) along which the Rocklands Road has been constructed. Palaeozoic basement rocks exposed in the banks of the Glenelg River include Rocklands Volcanic Group rocks and schists of the Glenelg River Metamorphic Complex. These are locally overlain by quartz-rich conglomerates that occupy spurs that project into the Glenelg River ascribed by Morand *et al.* (2002) to the Renmark Group. Further upslope, overlying sediments include previously unrecognised black fossiliferous duricrusts that are grouped here with the Duddo Limestones. These occupy small breaks in slope at approximately 200 m ASL and typically exhibit a gross subhorizontal fabric. In thin-section the ferruginised Duddo Limestones are goethite-rich and include around 5% very fine to fine sand sized quartz grains and occasional fine muscovite. The unit is rich in goethetised bryozoans with lesser echinoid spines and plates. At or near the ridge crest, isolated exposures of quartz-rich sands occur that have been mapped as Loxton-Parilla Sands (Morand *et al.* 2002). These are best exposed in a disused gravel quarry on the southern side of the Rocklands Road where mottled clayey sands are overlain by gravelly clayey sands. In thin-section this unit is characterised by well sorted, clast-supported fine- to medium-grained quartz-rich sands that are weakly cemented by Fe-stained clays. Trace heavy mineral concentrations include ilmenite and rutile.

CONCLUSIONS

The curvilinear anomalies (typically Th) evident on radiometric imagery for southwestern Victoria are spatially and genetically related to the marginal marine sediments of the Dorodong Sands and the Loxton-Parilla sands. The extent of these curvilinear anomalies, and consequently that of the Pliocene sea onto the Dundas Tableland the adjacent West Victorian Volcanic Plains, was much further than previously recognised.

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