White, S., 2000: Thermoluminescence dating of dune ridges in western Victoria. *Helictite* **36**(2):38-40.

Thermoluminescence dating of dune ridges in western Victoria

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Abstract

The absolute dating of the Pleistocene dune ridges of southwestern Victoria establishes a time frame for speleogenesis of syngenetic karst in such dune calcarenites.

Introduction:

The karst provinces of southeastern South Australia and southwestern Victoria have a remarkable series of calcareous coastal dunes which have been recognised as stranded beach dunes formed by a combination of successive sea-level high stands and tectonic uplift. The sequence of such dunes between Naracoorte and Robe, South Australia, has been dated using a variety of methods: uranium/thorium (Schwebel, 1984), palaeo-magnetism (Idnurm and Cook, 1980) and thermo-luminescence (TL) of quartz (Huntley, et al., 1993ab, 1994). The TL dates have been correlated to the oxygen isotopes ( ) records for high sea level stands (Huntley, et al., 1994).

Thermoluminescence (TL) dating has the ability to determine the date of burial of the quartz fraction in sediments such as dunes. The TL date is the time elapsed since the quartz grains were last exposed to sunlight. As such, TL dates do not provide a date for either dune lithification or karstification; merely the date of deposition of the sediment. In this sense TL ages provide an upper limit or maximum age for karstification which must be younger than the aeolian deposition of the dunes.

The remarkable dune sequence in the South Australian series has been subjected to relatively steady tectonic uplift in the area around the Glenelg River. The dunes have been dated at between 100 and 800 ka, although there is some discussion on the accuracy of the technique with respect to the oldest dunes especially the West Naracoorte Range (800 100 ka; Huntley, et al., 1994).

East of the Glenelg River the karst provinces show a more complex tectonic history. More disjointed tectonic uplift as indicated by the presence of faults eg. Kanawinka Fault, Swan Lake Fault, makes sea-level estimations more difficult to extrapolate along the dune ridges, as the distribution of the dune limestones is less regular. Between Portland and Warrnambool the dunes are predominantly restricted to a belt along the modern coast. The few older ridges further inland generally have little karst development.

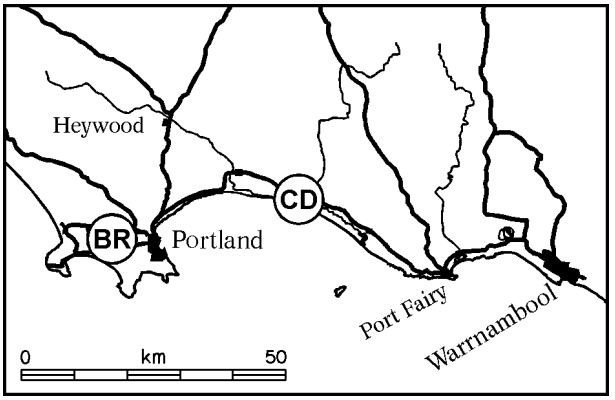

Figure 1: Location map of Codrington (CD) and Bats Ridge (BR).

Between the dune ridges are extensive swampy plains. These include old coastal flats and contain estuarine to lacustrine limestones, dolomites, marls and clays up to 13 m thick (Grimes, et al., 1999). In some cases such interdune areas have been incised into the dune limestone by solutional process indicating karstic development (White, 1994).

The dating of Victorian ridges has been more limited than for the major sequence in South Australia. Two ridges near Codrington (between Port Fairy and Portland) and at Bats Ridge (8km West of Portland) have now been dated using thermoluminescence of quartz. Locations are shown on Figure 1.

The Codrington ridge is approximately 1.5km inland from the present coast and the crest of the dune averages about 20m above present sea level. Samples for TL dating were collected from the dune from within two caves: CD 5 (827633) and CD 13 (813638 - Portland 7221). As the dune calcarenite contains up to 30% quartz, enough quartz grains of 125-180µm diameter were obtained by standard separation methods (Aitken, 1985) under red light for TL analysis. The samples were analysed at Latrobe University laboratory using the regenerative dose (total bleach) method, and the results are shown in Table 1.

The Bats Ridge dune is approximately 4 km inland, 8km west of Portland. The ridge is about 90 m above present sea level and the sample (BR6) was collected from a cave within the ridge at 432565. Quartz grains of 90-125µm diameter were extracted from this sample and were analysed at the Wollongong University TL Dating Laboratory (sample code W2231). The results are shown in Table 2.

Table 1: Codrington: Equivalent Doses, Dose Rates and TL Ages

Sample	Dose Rate Effective (Gy/ka)	Dose Rate (Gy/ka)	Dose Rate (Gy/ka)	Dose Rate Cosmic (Gy/ka)	Total Dose Rate	Equivalent Dose (Gy)	Plateau Temp Range (°C)	TL Age (ka)
CD-5	0.014 0.007	0.162 0.008	0.132 0.009	0.15 0.02	0.46 0.03	112 33	320-490	244 74
CD-13	0.015 0.007	0.208 0.016	0.153 0.015	0.15 0.02	0.53 0.04	125 22	310 - 450	238 45

Radioactive Nuclides and Water Concentrations

Sample	U (ppm)	Th (ppm)	K (%)	H2O (wt %)
CD-5	0.69 ± 0.05	50.68 0.15	0.08	1.0
CD-13	0.76 0.06	0.80 0.18	0.14	5.0

Notes:

- *Cosmic ray dose rate is assumed.*
- *U and Th measured by thick-source alpha counting and sealevel equilibrium is assumed.*
- *An alpha efficiency of 0.10 0.02 is assumed.*
- *K measured by XRF.*
- *Internal dose rate is assumed to be negligible, and has been ignored.*
- *For both samples, equivalent dose calculated from 335 – 400 C*

Table 2: Bats Ridge (BR6): Equivalent Doses, Dose Rates and TL Age.

Sample	Dose rate (Gy/ka)	Palaeodose (Gy)	Plateau Temp. Range C	TL Age ka
BR-6	572 05	0.166 0.13	275-500	290 34

Radioactive Nucleides and Water Concentrations

U + Th (Bg/kg)	K (%)	H_2O (Wt%)
16.4 0.5	0.080 0.005	1.4 3

Notes:

- *The equivalent dose was obtained by means of a combined additive dose and regenerative dose method (eg Huntley et al., 1993a).*
- *Cosmic ray dose rate is assumed as 0.15 0.05 Gy/ka.*
- *U and Th measured by thick-source alpha counting, and secular equilibrium is assumed for both decay chains.*
- *K measured by AES.*
- *Equivalent dose is calculated from 375 C*

The TL growth curve data were fitted by a saturating exponential and the equivalent dose was calculated by interpolation of the natural TL intensity.

All the samples were from within ridges and all are assumed to have been deposited under aeolian dune conditions. All three show good TL characteristics during the analysis and the dates are consistent with other TL dates for the aeolian calcarenites in coastal southwestern Victorian (Oysten, 1996)

The dunes appear, therefore, to have been deposited during the late mid Pleistocene and both sites exhibit extensive cave development. Nevertheless, the relationship of the caves to the current water table indicates that their major speleogenesis has occurred not under present-day water table conditions, but present-day modification of existing passages is occurring. The age of the dunes assists in establishing the time frame for speleogenesis in such calcarenite dunes and shows that

such karstification occurred simultaneously with dune lithification.

Acknowledgments:

The samples for Codrington were analysed by Ben Oyston,1996 at Latrobe University and for Bats Ridge by David Price at Wollongong Thermoluminescence Dating Laboratory.

I wish to thank Bert Roberts, LaTrobe University for constructive comments and assistance in interpretation of the TL analysis.

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