OPTICAL LUMINESCENCE DATING OF SANDS FROM THE GREAT VICTORIA DESERT; SOUTH AUSTRALIA'S OLDEST DESERT DUNE SYSTEM?

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As part of a programme to evaluate methods of sampling from the regolith for the purposes of mineral exploration, we have determined optically stimulated luminescence ages for samples of quartz extracted from dune sediments at sites close to the Transcontinental Railway in the Barton and Ooldea Ranges of the Great Victoria Desert (western Gawler Craton, Figure 1, Plate 1). The dating method presupposes that the luminescence clock has been reset by exposure to sunlight during deposition of the sediment. This expectation is normally fulfilled in Australian dune systems and the present determinations appear to be no exception.

Plate 1: Aerial view W over Immarna Siding, Transcontinental Railway, and the Great Victoria Desert Quaternary longitudinal dunes. The dunes here overly the Palaeogene Ooldea Range barrier sands. Photo courtesy of M.C. Benbow.

Plate 2: Ooldea Range (W. of Immarna Siding) dune sand displaying rounded to subrounded quartz grains with a dusting of carbonate and clay. Plate scale 2.8 x 2.25 mm. (Sample IA1/3.5, R2142810).

Quartz grains were extracted from the dunes by hand augering, carried out beneath a black shroud to avoid sample sunlight exposure, each ~1 kg sample was sealed within a light tight metal container. Sand grain forms are displayed in Plates 2 and 3, and their degrees of sorting are presented in Figure 2. The sampling profile at Immarna rail cutting is displayed in Figures 3, 4 and Plate 4. In the laboratory, subsamples were extracted, then 2.4 eV (green light) excitation was applied and the 3.4 eV (ultraviolet) luminescence emission measured.

Radiation dose rates were calculated from measured concentrations of radioisotopes, the cosmic-ray intensity and water contents. The relevant radioisotopes are ^{40}K and those in the decay chains of ^{238}U, ^{235}U and ^{232}Th. Potassium contents were determined by both XRF and *in-situ* gamma spectrometry, and were found to be in good agreement. Uranium and Th contents were determined by delayed-neutron analysis, neutron-activation analysis, *in-situ* gamma-ray spectroscopy and thick-source alpha counting. These different techniques measure activities of different parts of the U and Th decay chains, thus differences in results can be attributed to a lack of secular equilibrium in the chains, which is important to the calculation of the dose rates. There were no differences of any consequence in the results from the different methods, thus no allowance for disequilibrium was made.

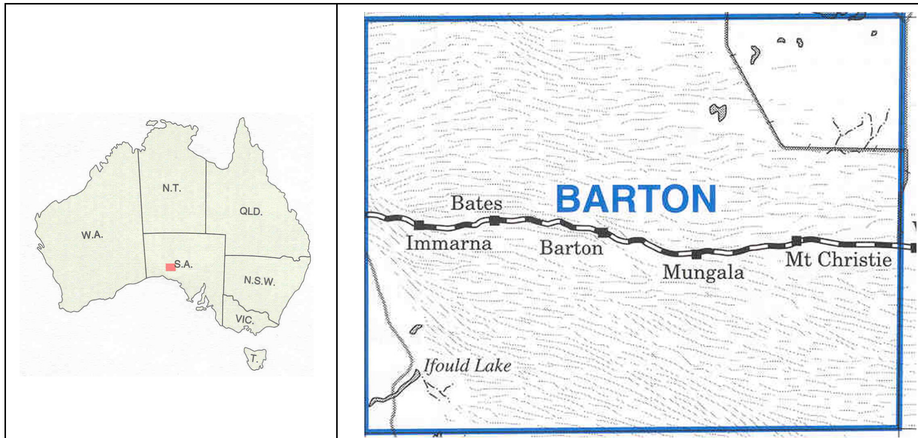

Figure 1: Study area on LHS indicated by solid rectangle. On RHS plan, an outline border to the BARTON 1:250,000 map sheet, displaying Great Victoria Desert dune pattern, the Transcontinental Railway, and sampling localities – Immarna and Barton.

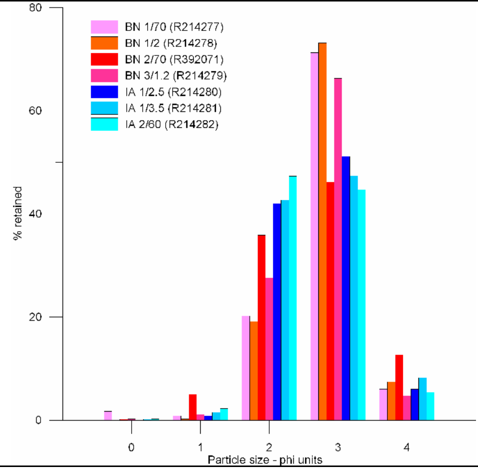

Figure 2: Sand sized grain dimensions distribution for the dated subsurface samples. Samples had carbonate removal prior to analysis.

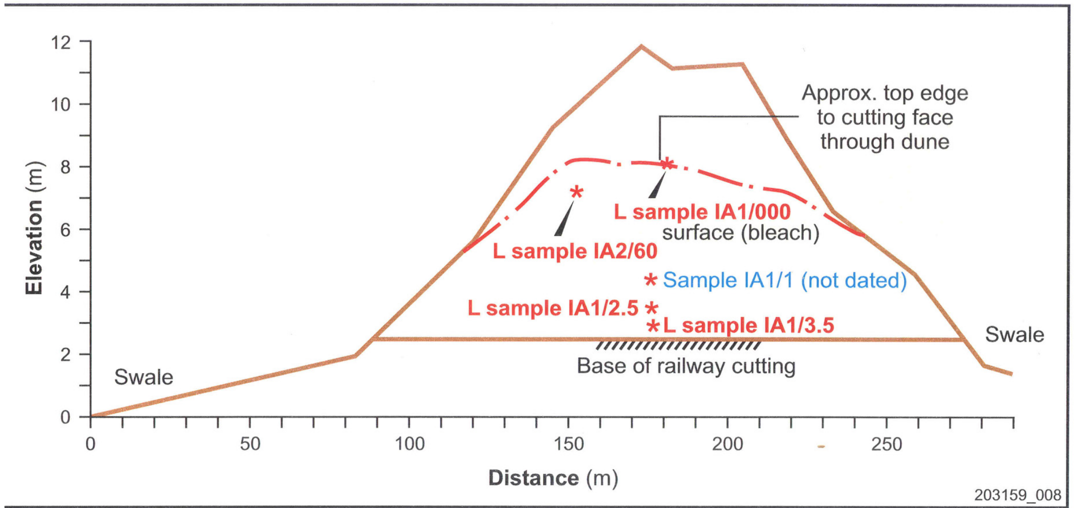

Figure 3: Ooldea Ranges area, Immarna railway cutting dune profile section with OSL sampling points indicated (<u>sample ID/sample depth</u> in either cm or decimal m).

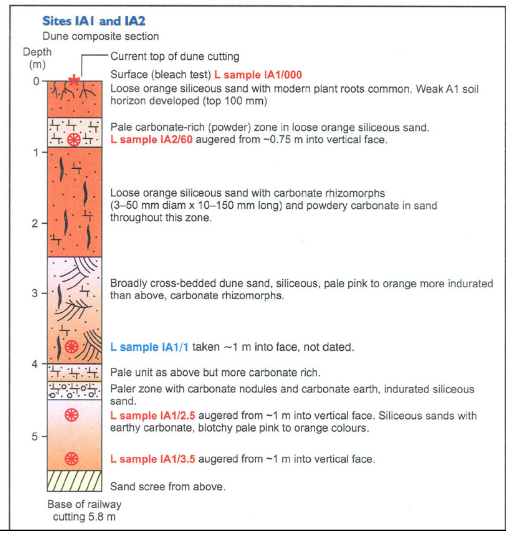

Figure 4: Immarna cutting dune log with OSL sampling points indicated.

Plate 3: Barton Range (E of Barton Siding) dune sand displaying rounded to subrounded Fe-stained quartz grains with a dusting of carbonate and clay. Plate scale 2.8 x 2.25 mm. (Sample BN2/70, R392071).

Plate 4: Two of three horizontal optical dating sampling holes in the Immarna rail cutting. Hole 3, lowest, is hidden by the excavation spoil pile. Scale staff is 3 m long.

Optical ages were determined by dividing the equivalent doses by the dose rates. Initially it was anticipated that all the samples would be post-glacial, *i.e.* under 20,000 years old. Preliminary experiments however, showed this not to be the case and led to the use of a regeneration method for determining past radiation doses, as the dose response curves show that the older samples were approaching saturation (Prescott *et al*., 1993; Sheard *et al*. 2006). The implied dose rate shift to 102.38 Gy indicates the correct ages should be increased by 7% for all samples except BN1/70 (age 105±8 ka) where the correction is 4%.

Ooldea Range, ~12 km W. of Immarna Siding, Plate 3, Figures 3, 4), a site 0.7 m below the present dune surface (eroded) gave an age of 22±3 ka and two samples in the same dune, 1 m apart and ~5 m lower than the previous sample, gave ages of 188±14 and 215±15 ka (dates are uncorrected for saturation). The latter site is 2.3 m above the swale level (Sheard *et al*. 2006).

For Barton Range, ~16 km E. of Barton Siding, a dune age of 71±8 ka (sample from an auger hole ~2 m below the dune crest); and ages of 105±8 and 197±14 ka (dates are uncorrected for saturation), samples were vertically 1.3 m apart, from a borrow pit face within the same dune, ~10 m below the crest and just above the swale. An adjoining swale's clayey sand, gave a 'pilot age' suggesting that its age is probably beyond the range of luminescence dating for this location (>250 ka; Sheard *et al*. 2006).

These ages were initially regarded as unexpectedly old and they indicate long-term stability of the dune pattern, a conclusion that has been drawn by Pell *et al*. (1999) on different grounds. However, recent work by Rhodes *et al*. (2004), Nanson *et al*. (1992) and Hesse, *et al*. (2004) have confirmed three and possibly four dune building phases prior to 70 ka in the Strzelecki and Tirari Deserts of eastern South Australia. Hesse, *et al*. (2004) indicates that Luminescence dated longitudinal dunes from Australia's southern Arid Zone yield dune building phases within the following time ranges: ~115-135 ka, ~145-155 ka, ~185-205 ka and ~225-235 ka. Younger dune building episodes occupy ages centred on: ~21 ka, ~36 ka, ?~43 ka, and ~68 ka (Rhodes *et al*., 2004), ~89-99 ka (Gardner *et al*., 1987: English, *et al*., 2001). Our new optical dates therefore do fit within or close to those recently recognised dune building episodes (Table 1). Further optical dating in conjunction with thermoluminescence dating along an extended west-east transect (parallel to dune long axies) is required to demonstrate whether there are more definable dune building phases and if there is a measurable west to east diachronous character developed within this desert's dune system, as implied by Wasson (1989).

Table 1: Late Quaternary dune building intervals in southern Australia.

Episodes previously dated by others using TL & OSL (ka)	Episodes OSL dated, this paper [corrections applied] (ka)
~21	23±3
~36	–
~43	–
~68	76±8
~89-99	109±8
~145-155	–
~185-205	201±14, 211±14
~225-235	220±15

Establishing the age of the dunes is significant in the context of regolith geochemistry; in particular, with the sampling of calcrete for anomalous gold signatures which may have been geochemically transported into the regolith cover. Dune or swale sand must be older than any calcrete formed in it. Since the terrain over the Gawler Craton is unevenly covered with dunes, it is important to know whether the dunes themselves have been in position long enough for any calcrete formed within them to acquire a gold signature and whether sampling these materials is likely to prove advantageous. Work by Lintern *et al*. (2002), Lintern (2004) and Lintern and Rhodes (2005) has established that gold signatures do exist within dunes and at some locations that gold has maximised its levels within those dunes in only 10 to 20 ka.

These OSL dates for Great Victoria Desert dunes demonstrate a long-term dune pattern stability spanning times where climate changes have been numerous and significant. These OSL dates are also amongst the oldest ages thus far determined for South Australian deserts.

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