Tests of luminescence dating making use of paleomagnetic reversals

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Introduction

Since the beginning of sediment dating the necessity of testing techniques on samples of known age has been recognized. The purpose of this note is to summarize the results obtained from samples independently dated making use of palaeomagnetic field reversals for which our tests have been successful.

Samples are rare for which a sufficient light exposure has occurred at the time of deposition and for which ages over 60,000 years are well established, due to the shortage of suitable dating techniques beyond the range of radiocarbon dating. One can make some use of the known time scale of climatic variations; however the best clear time marker is the reversal of the direction of the Earth's magnetic field, and hence the magnetization of sediments, that occurred at 0.78 Ma. This marker is referred to as the Brunhes-Matuyama (or B/M) boundary as it is the dividing point between the period of present normal polarity (Brunhes epoch) and the last major period of reversed polarity (Matuyama epoch) of the geomagnetic field. The reversed Matuyama period occurred from 2.60 to 0.78 Ma, except for 3 periods of normal polarity, the most recent of which was from 1.05 to 0.98 Ma which is called the Jaramillo event (the dates quoted here are from Cande and Kent (1992).

When making use of the Brunhes-Matuyama, or any other reversal, one has to establish its identity and take care that one does not confuse it with a reversal associated with a short polarity excursion which may only be found locally. Thus a single observation of reversed polarity is quite inadequate for identification; a suite of observations, such as can be made in deep ocean sediments, or in continuous loess deposits, provides the required confidence. Alternatively, as in the present paper, reliable dates on associated material may help with establishment of the identity of the reversal.

The samples on which we are reporting come from the stranded dune sequence of south-east South Australia and from a peat deposit. The dune sequence has been described in detail elsewhere (Huntley *et al.* 1993a and references therein). Here we shall simply note that the dunes can be matched to high sea-stands and that all the dunes are normally magnetized except for the East Naracoorte dune which is reversed (Idnurm and Cook, 1980). This places the B/M reversal between the West Naracoorte and East Naracoorte dunes. Detailed matching to the $\delta^{18}O$ curve leads to an age of 0.69 or 0.78 Ma for West Naracoorte, and of 0.95 Ma for East Naracoorte (these differ from our earlier figures as the time scale prior to 0.62 Ma has since been revised; Shackleton *et al.* 1990, Spell and McDougall, 1992).

The Salmon Springs peat is part of a non-glacial sequence of (from bottom to top) volcanic ash, silt and peat located in northwestern Washington, U.S.A. The lower part of the silt layer has reversed magnetic polarity whereas the upper part has normal polarity, indicating that a palaeomagnetic reversal occurred during deposition of the silt (Easterbrook *et al.*, 1981). A fission-track age of 0.84 ± 0.22 Ma has been obtained on zircon from the ash. Fission-track ages on the same (Lake Tapps) tephra at other localities are 0.87 ± 0.30 Ma (zircon) and 1.06 ± 0.11 Ma (glass)

Table

Sample	laboratory identification	reference	D_{eq} Gy	dose rate Gy ka^{-1}	Age ka
thermoluminescence dating, quartz					
East Naracoorte dune	SESA-63	a	455 ± 44	0.63± 0.02	720 ± 70
West Naracoorte dune	SESA-74	b	327 ± 30	0.41± 0.03	800 ± 100
optical dating, 1.4 eV, inclusions in quartz					
West Naracoorte dune	SESA-74	c	280 ± 50	0.41± 0.03	680 ± 130
optical dating, 1.4 eV, 4-11 μm polymineral grains					
Salmon Springs peat	SSP2-6	d	250 ± 30	0.37± 0.05	660 ± 120

a = Huntley *et al.* 1993a
b = Huntley *et al.* 1994
c = Huntley *et al.* 1993b (for method)
d = Lian *et al.* in preparation. Most of the details can be found in Hu (1994).
These are: additive dose, 7 day 140°C preheat, detection with EMI 9635 with BG-39 filter, no anomalous fading test.

(Westgate *et al.* 1987). The peat must therefore have been deposited shortly after the start of the Brunhes epoch at 0.78 Ma or shortly after the start of the Jaramillo event at 1.05 Ma, the latter seeming the more likely. A TL age of > 0.48 ± 0.06 Ma for this peat was reported earlier by Huntley *et al.* (1983); the lower limit was given because of the observation of anomalous fading.

Results

The table summarizes our results. A variety of methods was used and these are indicated in the table in which specific references are given.

The TL date for West Naracoorte is in accord with the known age while that for East Naracoorte may be considered to be a little low for the age of 0.95 Ma. As we have noted elsewhere the dosimetry for both samples is not as secure as for others in the sequence, due to inhomogeneities, and this may be the cause of any inaccuracies. Huntley *et al.* (1993a) reported on a different West Naracoorte sample which did not exhibit a satisfactory TL behaviour, and we have since then found several samples of this age or older for which the N+dose and regeneration data do not meet our criterion for acceptance. We thus regard the TL ages for the West and East Naracoorte dunes to be at the limit of what can be done with this method on this quartz.

The optical age for West Naracoorte, obtained using 1.4 eV excitation, is encouraging because it indicates that this method can be used on samples as old as this, and that the thermal lifetime of the traps appears not to be a limiting feature. Using the same method and regeneration data we have obtained an age of 1.2 ± 0.1 Ma (sample NL1, D_{eq} = 900 ± 40 Gy, $\dot{D}$= 0.75 ± 0.04 Gy ka^{-1}) on a quite different sample, of unknown age but classified as older than 1 Ma on geological grounds.

The optical age of the Salmon Springs peat was obtained using 1.4 eV excitation of 4-11 μm polymineral grains separated from the peat. Additive dose measurements similar to those described in Huntley *et al.* (1993b) were used. Details will be published elsewhere. The optical age is concordant if the true age is 780 ka, but is decidedly too young if the true age is 1.05 Ma.

In contrast with the above, an earlier attempt (by DJH) to test fine-grain TL dating on samples of loess from Tadzhikistan, which straddled the Brunhes-Matuyama reversal, gave apparent ages that were significantly too low.

In conclusion we note that three different methods, TL dating of quartz, optical dating of inclusions in quartz, and possibly optical dating of fine grains, all appear to be capable of yielding correct ages up to 800,000 years at some sites and with appropriate procedures. Berger *et al.* (1992, 1994) have previously shown this to be true for TL dating of fine grains.

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These results take us well beyond the half-million year mark that seemed ambitious only a few years ago; they will be encouraging news for all in the luminescence community, notwithstanding the qualification ".... at some sites and with appropriate procedures." The concordant optical age obtained for inclusions in quartz from West Naracoorte is of particular interest since, along with the referenced results of Berger, it indicates that there are other minerals besides quartz with a clean bill of health, intrinsically, as far as fading is concerned.