

Australian Archaeology



Archived at Flinders University: dspace.flinders.edu.au

Full Citation Details:

Mortlock, A.J. 1979. Thermoluminescence dating of objects and materials from the South Pacific region. 'Australian Archaeology', no.9, 12-17.

THERMOLUMINESCENCE DATING OF OBJECTS AND MATERIALS FROM THE SOUTH PACIFIC REGION

A.J. Mortlock

Summary

A general account is given of the results of the thermoluminescence dating of objects and materials from sites in Oceania. These include potsherds from Mailu Island off the south coast of Papua New Guinea, volcanic ash layers from near Mt Hagen in the Western Highlands of the same country, and fire hearths from ancient Aboriginal habitations at Lake Mungo, New South Wales. The differences between these results and corresponding radiocarbon ages are briefly discussed.

Introduction

A thermoluminescence dating facility has been in operation in the Physics Department at the Australian National University, Canberra, since about 1973. During the time between then and now a variety of objects and materials have been tested, mainly from sites in Oceania and Southeast Asia. Apart from relatively standard ceramic pottery it has been possible to extend the technique with apparent success to the baked sand/soil of ancient Aboriginal fire hearths from Lake Mungo in New South Wales and also volcanic ash layers from Papua New Guinea.

It is the purpose of this paper to report in a general way the results which have been obtained on the samples from the sites in Oceania. These results demonstrate the relatively wide range of applicability of the thermoluminescence dating technique and point the way for further research into the sources of variation between it and radiocarbon.

Potsherds from Mailu Island

Mailu Island is off the coast of Papua New Guinea southeast of Port Moresby. It has been for many years and is still a centre for the native production of baked ceramic pottery. This material is suitable for TL dating using standard fine grain techniques.

The early trade patterns for this pottery are under investigation by Dr G. Irwin, now of the Department of Anthropology,

University of Auckland, New Zealand. Potsherds have been uncovered on this island at various horizons below the surface. These have been associated with nearby charcoal which has been dated by H. Polach of the Radiocarbon Laboratory at the ANU.

An example which shows the relation between the two methods of dating is a potsherd recovered from 0.8m below the surface. The results obtained are:

<u>TL</u>	<u>C-14</u>
2015 y BP (ANU-TL-106)	1690 y BP (ANU-C14-1230)

The 16% discrepancy between the two results is partly due to the lack of samples of burial soil in the case of this potsherd. When this situation applies it is necessary to assume in TL dating that the radioactive impurities in the burial soil are the same in concentration as in the potsherd itself. The results here suggest that at least some of these concentrations in the burial soil are higher than in the potsherd.

Volcanic ash layers from Papua New Guinea

Approximately 14km northeast of Mt Hagen township in the Western Highlands of Papua New Guinea is a 280 hectare property known as Kuk which is partly under cultivation for tea. The area is drained swampland associated with the upper Wahgi River. Aerial photographs show old baret (drainage) systems over virtually the whole swamp area. These were introduced by the early natives who lived in the area to protect a moisture sensitive crop.

The early agricultural history of the area is under investigation by Professor J. Golson and others of the Department of Prehistory, Research School of Pacific Studies, ANU. This has been helped by the C-14 dating of materials such as charcoal, wood, peat etc. found at various horizons in the swamp.

There are also layered deposits of volcanic ash in the swamp area, perhaps 20 in number, which are spaced down through the same sequence. X-ray diffraction analysis of powdered samples from one of these layers shows it to be clay-like with traces of quartz, feldspar, calcite and chlorite. A typical glow curve obtained using such a sample is not dissimilar to that found with ordinary dense ceramic pottery. However, the low-temperature 110°C peak found with quartz could not be excited in this case suggesting that that mineral is not the main contributor.

Simple fading tests carried out on artificially irradiated samples from one of these layers did not show any significant effect of this nature. Furthermore plots of the ratio of natural TL to natural plus artificial TL as a function of temperature are reasonably flat in the region of temperature (375°C) where read-outs are made. There is also no evidence of saturation effects which might be expected with the older samples.

Determination of the annual dose rate was made using α -counting for U and Th and XRF for K_2O , assuming initially a uniform environment. Monitoring for evidence of non-uniformity is being carried out with $CaSO_4:Dy$ dosimeters mounted in small stainless steel capsules embedded 30cm behind the exploratory trench walls.

A preliminary set of TL dates have been computed and demonstrate a steady increase in apparent age as the depth of the ash layer below the surface increases. Samples are available corresponding to deeper ash layers which extrapolation indicates should be older than 40,000 y BP. Preliminary C-14 results due to H. Polach indicate that these tend to fall below the TL dates in the range so far explored. However, the order of magnitude of the discrepancy is not inconsistent with what one might expect from the well-known bristle-cone pine corrections necessary to convert radiocarbon years to true chronological years. It is possible to draw a smooth curve demonstrating the trend of TL age with depth for these volcanic ash layers.

At the time of writing the picture is far from complete. However, as the present measurements are finalised and additional available ash layers are measured also, this situation will change. The preliminary indication is that volcanic ash layers from this particular site seem amenable to TL dating by the standard fine grain method. It is hoped to carry out some confirmatory inclusion measurements in due course and to isolate the mineral responsible for the major part of the TL energy storage.

Fire hearths at Lake Mungo, New South Wales

Lake Mungo is an ancient dried up lake in southwestern New South Wales. It is approximately 100km northeast of the township of Mildura on the Murray River, and is one of a number of similar lakes constituting the Willandra Chain. The eastern edge of Lake Mungo is composed of a long sand dune or lunette called the Walls of China. Ancient Aboriginal man lived here many thousands of years ago when the lake was full, and artefacts associated with this habitation are to be found in and on this dune.

Some of these artefacts have become exposed in recent times due to erosion caused by wind and rain. Of particular interest are a number of ancient fire places used by the Aboriginals as the baked sand/soil of these seems able to be dated using thermoluminescence. There are also other fire residues present which are able to be dated using the C-14 technique. Thus a direct comparison between these two methods of dating becomes possible at a time which turns out to be $30-40 \times 10^3$ years BP. The fire hearths are in the form of small hummocks. The reason the sand/soil forms a hummock is that the centre of the fire place was protected to some extent from erosion by the presence of cooking stones and because of the hardened nature of hearth itself.

A discussion of some of the preliminary results obtained with measurements of this type has been given by G. Adams and

A.J. Mortlock (1974) and A.J. Mortlock (1974). Then it seemed as though the TL ages and those indicated by C-14 were in agreement and that one fire place (F7) was indeed 30,000 years old. The technique used in these TL measurements is known as fine grain and makes use of small (<8 μ m) mineral crystals derived from the baked sand/soil samples. This technique, however, is not specific to quartz which is the mineral which is particularly useful in TL-dating because, among other properties, it is virtually free of fading. In other words other minerals can be present which can produce TL signals which, because of fading, could confuse the picture.

For this reason further intensive measurements were carried out by T. Bell of this Laboratory using the inclusion technique, where large \sim 100 μ m grains of quartz are separated out magnetically and by sieving from the initial sample material. These crystals were also treated with hydrofluoric acid to remove the radiation dose due to short range α -particles which is restricted to the near-surface region.

The TL glow curves obtained using these samples were well-behaved in the sense that the plots of the ratio of natural radiation to natural plus artificial radiation dose were constant in the high-temperature region. Also, there was no evidence of saturation effects in the growth curves of TL with radiation dose. Analysing these and measuring the annual radiation dose using the standard techniques already mentioned yielded the following ages (rounded) for the designated fire places. Also listed are the corresponding radiocarbon ages referred to by M. Barbetti and M. McElhinny (1972) - ($T_{1/2}$ = 5730 y):

<u>Fire place</u>	<u>TL age</u>	<u>C-14 age</u>
F6	31,500 y BP	27,000 y BP
F7	36,800 y BP	31,700 y BP
F8	32,700 y BP	29,200 y BP
F9	33,300 y BP	28,400 y BP

It is seen that there is a systematic difference between the two estimates of the ages of the fire hearths, the C-14 age being lower by \sim 5 x 10³y. This significant discrepancy may be associated with a drop in the strength of the earth's magnetic field at that time (M. Barbetti 1972) which allows a greater cosmic ray flux to impinge upon the upper atmosphere. This in turn leads to an enhancement in the concentration of C-14 in the atmosphere reservoir and consequently to an underestimate of age based on this method. A discussion of this effect is to be found in M.J. Aitken (1975:67).

Further investigations to test this hypothesis are in progress at the time of writing using Aboriginal fire hearths from sites away from Lake Mungo and of different ages. A fuller account of this work will be published by T. Bell in due course.

Finally, it is worth noting that the magnitude of the discrepancy found for the fire hearths is consistent with other earlier measurements. Thus measurements at the 30,000 year-old Czechoslovak figurine site at Dolni Vestonice do not differ from

radiocarbon by more than 15%, D.W. Zimmerman and J. Huxtable (1971), the TL ages once again being higher. The fine grain method was used in this particular investigation and there is no mention of fading checks having been made. If fading has taken place, then this would increase the calculated TL ages making the discrepancy larger in this particular case.

Conclusions

It can be seen from what has been said that the technique of thermoluminescence dating has been applied with apparent success to a variety of materials and objects from sites in Oceania. In the cases described it has been possible to date associated carboniferous materials using the older C-14 technique. In some cases the difference between the ages obtained by the two methods seems to be able to be correlated with changes in the earth's magnetic field at these earlier times.

Acknowledgements

Dr R. Blong of Macquarie University, New South Wales, brought the existence of the volcanic ash layers in Papua New Guinea to the attention of the author and cooperated in recovering samples from the field. Mr T. Bell is a research student in the Physics Department at the ANU, and kindly allowed his results on the Lake Mungo fire places to be used here prior to their inclusion in his PhD thesis. Mr D. Price carried out the laboratory measurements in the case of the volcanic ash layers from Papua New Guinea and the potsherd from Mailu Island.

*Physics Department
ANU, Canberra*

References

- Adams, G. and A.J. Mortlock 1974 Thermoluminescent dating of baked sand from fire hearths at Lake Mungo, New South Wales. *Archaeology and Physical Anthropology in Oceania* 9(3):236-7, 1 table
- Aitken, M. 1975 *Physics in Archaeology*. Oxford: Clarendon, p.67, et seq.

- Barbetti, M. 1972 Geomagnetic field behaviour between 25,000 and 35,000 years BP and its effect on atmospheric radiocarbon concentration. *Proc. 8th Int. Conf. on Radiocarbon Dating* (eds T.A. Rafter and T. Grant-Taylor), Royal Soc. New Zealand, pp.98-107
- Barbetti, M. and M. McElhinny 1975 Evidence of a geomagnetic excursion 30,000 yr BP. *Nature* 239:327-330
- Mortlock, A.J. 1974 Archaeometry at Lake Mungo, New South Wales. *Australian Physicist* 11(11):213-5
- Zimmerman, D.W. and J. Huxtable 1971 Thermoluminescent dating of Upper Paleolithic fired clay from Dolni Vestonice. *Archaeometry* 13:53-8