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Analysis of lithic artefact microdebitage for chronological determination of archaeological sites

George J. Susino
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Analysis of Lithic Artefact Microdebitage for Chronological Determination of Archaeological Sites

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Analysis of Lithic Artefact Microdebitage for Chronological Determination of Archaeological Sites

George J. Susino, *BA (Hons), MSc*

A thesis submitted to the University of Wollongong in fulfilment of the requirements for the award of the degree of Doctor of Philosophy in the School of Earth and Environmental Sciences.

2004

In memory of
Malcolm John Head
1943-2003
mentor and friend

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Abstract

This study explores the use of several different techniques to isolate and determine the age of lithic microdebitage in relation to archaeological deposits and associated sediments. Quartz microdebitage was identified on the basis of surface features and roundness index by applying scanning electron microscopy (SEM) and optical stereomicroscopy to archaeologically relevant sediments. Characteristics of the quartz microdebitage were compared with quartz grains from the same sedimentary layer. The observation of diagnostic features on quartz grains made it possible to discriminate between microdebitage and sedimentary background.

This investigation has established that microdebitage particles under 500 μm diameter are not easily resolved under optical stereomicroscopy, requiring the aid of SEM to discern between microdebitage and sedimentary quartz. It was also ascertained that no adverse effects on the optically stimulated luminescence (OSL) signal are measurable after exposure to SEM, provided that the electron beam is kept at, or under, 10 keV.

Sedimentary material previously excavated from the Jinmium rockshelter (Northern Territory) and Mushroom Rock West (Queensland) was used to determine the age of quartz microdebitage from the archaeological layers by applying the OSL dating technique. The microdebitage OSL signal behaves similarly to that of sedimentary quartz grains, and is subject to the same problems. The OSL single-aliquot regenerative-dose protocol (SAR) was successfully applied to the age determination of microdebitage. The modifications used for the dose rate (due to particle size and shape) and for the calibration of the beta source (due to particle size) did not produce any inconsistencies or anomalous results. In the investigation of two archaeologically relevant sediment layers from the Jinmium rockshelter deposit, the minimum OSL age at 68 cm depth for the microdebitage was estimated as 4100 ± 900 years ($12,600 \pm 4000$ years using the central age model estimate, with 73% over-dispersion on the palaeodose), and, for the sedimentary material, a central age model of 5300 ± 800 years (with a minimum age model estimate of 1900 ± 400 years, and, 78% over-dispersion). At 115 cm in the deposit, the OSL central age model estimate for the microdebitage is $10,200 \pm 1100$ years, with a minimum age model of 4500 ± 600 years (and an over-

dispersion of 56%). In the case study of Mushroom Rock West rockshelter, the OSL central age model estimate for microdebitage at 268 cm depth into the archaeological deposit is $21,200 \pm 3100$ years (with a minimum age model estimate of $10,500 \pm 5200$ years, and 60% over-dispersion), compared to a central age model estimate for the sedimentary quartz grains of $31,500 \pm 3100$ years (with a minimum age model estimate of $11,100 \pm 1500$ years, and 67% over-dispersion). For the archaeological layer situated at 441 cm depth, the microdebitage yielded an OSL age of $27,400 \pm 2200$ years. This sample of microdebitage produced the lowest over-dispersion (0.1%) on the palaeodose of any of the samples analysed, lending confidence to the accuracy of the palaeodose determination. The sedimentary quartz from the same sample produced an OSL minimum age model estimate of $33,500 \pm 5600$ years (and a central age model estimate of $46,900 \pm 3400$ years). Relationships between microdebitage and sediment OSL ages are discussed.

Direct OSL dating of the unheated quartz derived from the manufacture of lithic tools now provides an alternative to the reliance on sedimentary quartz as the primary source information regarding the age of archaeological deposits. This knowledge may be applied also to archaeological sediments previously excavated, for identifying episodes of lithic manufacture in temporal relation to other evidence of cultural activity. The ages of the two archaeological sites analysed differ widely, and this difference was also represented in the ages obtained from the microdebitage. None of the OSL age determinations of microdebitage was found to be unrealistically outside the boundaries of pre-existing age control. This is one indication of the validity of the novel experimental approach applied here.

Certification

I, George James Susino, declare that this thesis, submitted in fulfilment of the requirements for the award of Doctor of Philosophy, in the School of Earth and Environmental Sciences at the University of Wollongong, is wholly my own work unless otherwise referenced or acknowledged. The document has not been submitted for qualifications at any other academic institution.

George J. Susino
29th October 2004

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Abbreviations and acronyms

^{14}C	Conventional radiocarbon dating technique
Al	Aluminium
AMS	Accelerator mass spectrometry (radiocarbon technique)
Au	Gold
BP	Before Present (A.D. 1950)
Bq	Becquerels (1 Bq = 1 disintegration/s ⁻¹)
CRM	Cultural resources management
D_0	No dose given
D_e	Equivalent dose (Palaeodose)
D_i	Given dose
D_n	Natural dose (also 'N')
D_R	Dose rate
DRT	Dose recovery test
D_t	Test dose
EDAX	Energy dispersive x-ray analysis
ESEM	Environmental SEM
Gy	Grays (1 Gy = 1 J Kg ⁻¹)
HCl	Hydrochloric acid
HF	Hydrofluoric acid
J	Joules
K	Potassium
ka	Thousand years
keV	Kilo-electron volts (SEM electron beam intensity measurement)
LED	Light emitting diodes
LGM	Last glacial maximum
L_i	OSL signal measured
Ma	Million years
mb	Millibar (1 mb= 100 Pa)
Multiple-aliquot	Many grains on a single disc
OSL	Optically stimulated luminescence
Pb	Lead
PM	Photomultiplier tube
Pt	Platinum
R_1/R_x	Double regeneration cycle (R_1 is the first, R_x is cycle x)
Ra	Radium
Rd	Rubidium
Red illumination	Filtered red light (Lee 106 acetate filters)
R_x	Regeneration cycle (x = regenerative dose no.)
SAR	Single-aliquot regenerative-dose protocol
SEM	Scanning electron microscopy
Si	Silica
Single-aliquot	100 single-grains individually analysed on one disc
Single-grain	One grain on a single disc.
SiO ₂	Quartz
Th	Thorium
T_i	Test dose OSL signal
TL	Thermoluminescence
U	Uranium
Wt	Weight