

**SERVICES & FACILITIES ANNUAL REPORT - FY April 2009 to March 2010**

<b>SERVICE</b> Aberystwyth Luminescence Research Laboratory (ALRL)	<b>FUNDING</b>	<b>AGREEMENT</b>	<b>ESTABLISHED as Recognised S&amp;F</b> 1996	<b>TERM</b> 5
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**TYPE OF SERVICE PROVIDED:**

Luminescence dating of sediments relies upon the exposure of the mineral grains to daylight at the time of deposition – it is this event that is being dated. Thus, the method is most suitable for sediments from environments where exposure to daylight is likely, such as coastal and desert dunes, and wind blown dust (loess). One of the major improvements in the technique in recent years has been the application of single aliquot and single grain methods to allow the analysis of sediments where only a proportion of the grains were exposed to daylight at the time of deposition. This has made it possible to date fluvial, colluvial and even glacial sediments. However, such sediments remain more complex to analyse, more time consuming, and thus more expensive.

As a NERC “Recognised Facility”, Aberystwyth Luminescence Research Laboratory provides two types of opportunity:

1. For visiting research scientists or students it offers the opportunity to work in the laboratory to learn the technique and to undertake measurements.
2. A “Pay-As-You-Go” service for the measurement and dating of Quaternary sediments.

In each case, the work is undertaken on a collaborative basis with staff of ALRL assisting in the preparation of the results for publication and ensuring that data are reported appropriately and to the highest academic standards.

**ANNUAL TARGETS AND PROGRESS TOWARDS THEM**

In the calendar year 2009, ALRL staff published 13 papers in ISI listed journals and were involved in editing two special issues of international journals. These special issues were dedicated to papers exploring the application of luminescence dating to Geomorphology (published as Volume 109, Issues 1-2 of *Geomorphology*) and the application of luminescence dating to Quaternary tectonic movement and records of environmental change ( published as Volume 199 of *Quaternary International*).

SCORES AT LAST REVIEW (each out of 5)			Date of Last Review:	
Need 5.0	Uniqueness 4.0	Quality of Service 4.5	Quality of Science & Training 4.5	Average 4.50

CAPACITY of HOST ENTITY FUNDED by S&F	Staff & Status	Next Review (March)	Contract Ends (31 March)
%	Professor G.A.T. Duller – permanent academic staff Dr H.M. Roberts – permanent academic staff Ms H. Wynne - Laboratory Technician		

FINANCIAL DETAILS: CURRENT FY						
Total Resource Allocation £k	Unit Cost £k			Capital Expend £k	Income £k	Full Cash Cost £k
	Unit 1	Unit 2	Unit 3			
FINANCIAL COMMITMENT (by year until end of current agreement) £k						
2009-10	2010-11	2011-12	2012-2013	2013-2014		

STEERING COMMITTEE	Independent Members	Meetings per annum	Other S&F Overseen

**APPLICATIONS: DISTRIBUTION OF GRADES (current FY — 2009/10)**

	$\alpha 5$	$\alpha 4$	$\alpha 3$	$\alpha 2$	$\alpha 1$	$\beta$	R*/Pilot	Reject
NERC Grant projects*								
Other academic								
Students								
Pilot								
<b>TOTAL</b>								

**APPLICATIONS: DISTRIBUTION OF GRADES (per annum average previous 3 financial years —2006/2007, 2007/2008 & 2008/2009)**

	$\alpha 5$	$\alpha 4$	$\alpha 3$	$\alpha 2$	$\alpha 1$	$\beta$	R*/Pilot	Reject
NERC Grant projects*								
Other Academic								
Students								
Pilot								
<b>TOTAL</b>								

**PROJECTS COMPLETED (current FY – 2009/10)**

	$\alpha 5$	$\alpha 4$	$\alpha 3$	$\alpha 2$	$\alpha 1/\beta/R$	R*/Pilot	Not Graded
NERC Grant projects*							1
Other Academic							4
Students							3
Pilot							0

**USER PROFILE – funding type (current FY – 2009/10)**

Grand Total	Infrastructure				PAYG					
	Supplement to NERC Grant *	Student NERC	Other	NERC C/S	Other	NERC Grant*	Student NERC	Other	NERC C/S	Other
						1	2	2	2	2

**USER PROFILE - funding type (per annum average previous 3 financial years - 2006/2007, 2007/2008 & 2008/2009)**

Grand Total	Infrastructure				PAYG					
	Supplement to NERC Grant *	Student NERC	Other	NERC C/S	Other	NERC Grant*	Student NERC	Other	NERC C/S	Other
						0.5	1	2	0	4.5

**USER PROFILE – user type (current FY – 2009/10)**

Academic	Centre/Survey	NERC Fellows	PhD	Commercial
3	2	0	4	0

**USER PROFILE – user type (per annum average previous 3 financial years - 2006/2007, 2007/2008 & 2008/2009)**

Academic	Centre/Survey	NERC Fellows	PhD	Commercial
4.5	0	0	3	0

**OUTPUT & PERFORMANCE MEASURES (current year)**

Publications (by science area & type) (calendar year 2009)										
SBA	ES	MS	AS	TFS	EO	Polar	Grand Total	Refereed	Non-Ref/ Conf Proc	PhD Theses
2	13	0	0	0	0	0	15	13	2	0

Distribution of Projects (by science areas) (FY 2009/10)						
SBA	ES	MS	AS	TFS	EO	Polar
2	6	0	0	0	0	0

**OUTPUT & PERFORMANCE MEASURES (per annum average previous 3 years)**

Publications (by science area & type) (Calendar years 2006, 2007 & 2008)										
SBA	ES	MS	AS	TFS	EO	Polar	Grand Total	Refereed	Non-Ref/ Conf Proc	PhD Theses
3	13	1	0	0	0	0.5	17.5	14.5	3	0

Distribution of Projects (by science areas) (FY 2006/2007, 2007/2008 & 2008/2009)						
SBA	ES	MS	AS	TFS	EO	Polar
2.5	3	0.5	0	0	0	0

**Distribution of Projects by NERC strategic priority (current FY 2009/10)**

Climate System	Biodiversity	Earth System Science	Sustainable Use of Natural Resources	Natural Hazards	Environment, Pollution & Human Health	Technologies
6	0	2	0	0	0	0

\*Combined Responsive Mode and Directed Programme grants

NOTE: ALL metrics should be presented as whole or part of whole number NOT as a %

## OVERVIEW & ACTIVITIES IN FINANCIAL YEAR (2009/10):

The Mission Statement of Aberystwyth Luminescence Research Laboratory is to both undertake excellent science and in doing this to train the next generation of scientists. During this year we have continued to strive in both areas. ALRL has acted as host for visitors ranging from those who have been involved in luminescence dating for decades to those new to the subject, with a total of 10 person months during the year. Arising from these visits, a series of papers have been submitted for publication.

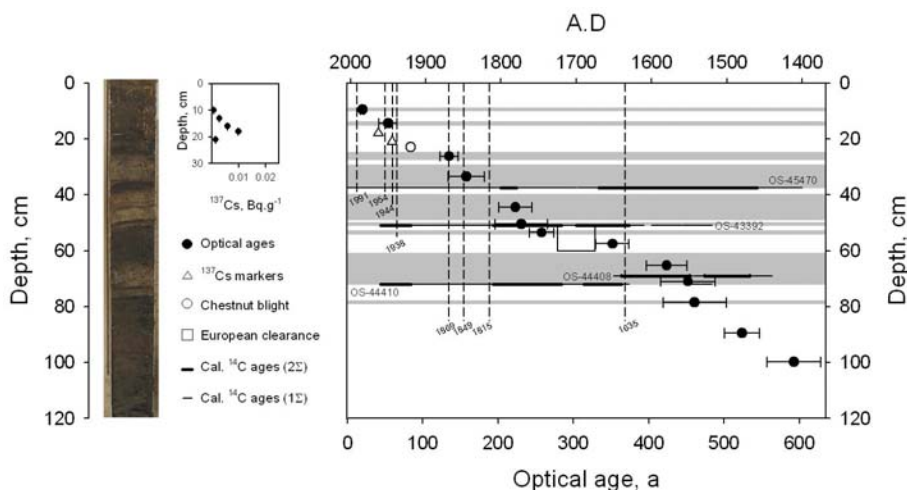
The financial year 2009-10 saw staff and students associated with the Aberystwyth Luminescence Research Laboratory (ALRL) contributing to a wide range of conferences, publishing a large number of papers, and helping to shape the future of luminescence dating through organisation of two Special Issues of ISI listed journals. Dr Helen Roberts was invited to give a keynote talk at the Loessfest meeting organised in Serbia. In September key staff and students from ALRL presented their work at the UK Luminescence and Electron Spin Resonance dating conference held at Royal Holloway, University of London. Although called the UK meeting, this conference brings together key individuals in the field of luminescence geochronology from around the world. In November, Professor Duller and Professor Wintle were invited to give talks at the 2<sup>nd</sup> Asia-Pacific Luminescence Dating workshop held in Ahmedabad, India. This brought together geochronologists from across Asia and the Pacific region. In December, Dr Helen Roberts convened a session at the American Geophysical Union (AGU) conference in San Francisco.

ALRL staff were also involved in a number of other projects that will shape the future of luminescence chronology and its application. Professor Duller was co-editor of two special issues devoted to showcasing the potential of luminescence dating methods for understanding tectonic processes (published in *Quaternary International*) and geomorphological processes (published in *Geomorphology*). Additionally, Professor Duller was invited to be part of an INQUA sponsored project collating a global database of ages for dune activity. The majority of these ages are derived using luminescence methods.

## SCIENCE HIGHLIGHTS:

### A) Direct dating of hurricane activity in north-eastern United State of America

Hurricanes are a major cause of destruction of property and threaten lives along the coast of southern and eastern United States of America. Although the majority of hurricanes strike the coast of the Gulf of Mexico, a significant proportion of hurricanes take a different trajectory, affecting the north-eastern coast of the USA. Predicting such events, and assessing the risk that they pose (and hence the insurance liability) is made difficult by the short record of such events. The earliest documentary record is from 1639, but systematic records are not available until the mid-19<sup>th</sup> century. A sedimentary archive of such events is preserved in back barrier salt marches along the New England coast where hurricanes lead to overtopping of the barrier and deposition of beach sands within the organic marsh. Scientists at the Woods Hole Oceanographic Institute (WHOI) have pioneered interpretation of this sedimentary archive, but dating such sediments is challenging. Radiocarbon is often of limited precision in the last 1000 years, and it cannot directly date the deposition of the hurricane related sediments. The potential for using optically stimulated luminescence (OSL) to date hurricane strikes was tested at Little Sippewissett Marsh, Massachusetts. A number of hurricanes are known to have affected this site (e.g. 1991, 1954, 1944, 1938) and provide an opportunity to assess the accuracy of OSL in this environment.



Madsen, A. T., Duller, G. A. T., Donnelly, J. P., Roberts, H. M. and Wintle, A. G. (2009). A chronology of hurricane landfalls at Little Sippewissett Marsh, Massachusetts, USA, using optical dating. *Geomorphology* 109: 36-45.

Davids, F., Duller, G. A. T. and Roberts, H. M. (in press). Testing the use of feldspars for optical dating of hurricane overwash deposits. *Quaternary Geochronology*

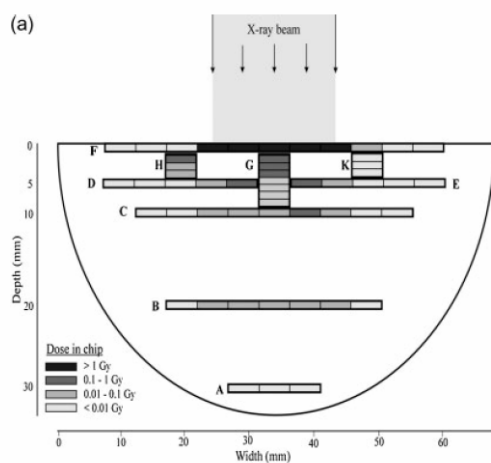
Sands resulting from hurricane strikes can be clearly discerned in the core and are shown as grey horizontal bands on the diagram. Radiocarbon determinations for organic sediments bracketing these hurricane events have very wide calibrated age ranges because of the complexity of the calibration curve in this period, and this limits their utility in determining a chronology. In contrast the luminescence ages have greater precision and directly date the hurricane events themselves rather than the bracketing materials. Comparison of the known ages of hurricanes and the luminescence ages obtained suggest that OSL has excellent potential in this setting, and a PhD project based upon this pilot project is nearing completion.

### B) Assessing the impact of 'non-destructive' X-ray core scanning upon OSL

An increasingly common method of obtaining high resolution sedimentological and geochemical data from sediment cores is the use of X-ray core scanning for X-radiographs and X-ray fluorescence. A number of manufacturers for such equipment now exist (e.g. Cox Systems ITRAX), and an increasing number of research laboratories in the UK (e.g. Institute of Geography and Earth Sciences, Aberystwyth and National Oceanographic Centre, Southampton) are routinely using such equipment to obtain high resolution

(~200 $\mu\text{m}$ ) geochemical data. These procedures are normally considered non-destructive, and are thus used routinely. However, such systems utilise X-rays which penetrate the entire core, and this will induce a luminescence signal. If the X-ray dose which these systems administer to cores is significant, then this will make sediments which have been measured on such systems yield luminescence ages that are older than they should be.

ALRL undertook a study to accurately measure the radiation dose delivered by a Cox ITRAX system during routine core scanning. Highly sensitive aluminium oxide dosimeters ( $\text{Al}_2\text{O}_3:\text{C}$ ) were buried at different depths within a core and these were the luminescence signal induced by X-ray exposure was then measured.



Davids, F., Roberts, H. M. and Duller, G. A. T. (2010). Is X-ray core scanning non-destructive? Assessing the implications for Optically Stimulated Luminescence (OSL) dating of sediments. *Journal of Quaternary Science* 25: 348-353.

The figure shows a cross section through a core, with the positions of the 53  $\text{Al}_2\text{O}_3:\text{C}$  chips shown. Each chip is shaded according to the radiation dose that it received during a typical X-ray core scan. The study found that on the surface of cores the dose could exceed 2.5 Gy. To put this value in context, adding this dose to a typical sediment would increase its OSL age by about a thousand years. In practise, the surface of the core would not be sampled for luminescence dating because it would have been exposed to daylight during scanning. Instead the upper 2-5 mm of sediment would be removed and material from the centre of core used. As shown above, the radiation dose in this part of the core is much lower, and the doses measured here would increase the luminescence age by ~100-200 years. Such an increase in age would be acceptable if the sediments were many tens of thousands of years old, but would produce an unacceptable error if the sediments were from the last 1000-2000 years. A paper based on this study has been accepted for publication in the *Journal of Quaternary Science* to make as wide a community as possible aware of this problem. Additionally this work has been presented at a number of Quaternary conferences, including a conference specifically focussed on the use of this new generation of X-ray core scanning equipment.

### C) Characteristics of the thermally transferred optically stimulated luminescence signal in quartz

Recent work in ALRL, highlighted in last year's report, has explored the potential of a new signal in quartz. The thermally transferred optically stimulated luminescence (TT-OSL) in quartz is unusual in that it continues to grow at radiation doses (>5000 Gy) far in excess of that for the conventional OSL signal (typically ~100-200 Gy). This gives the TT-OSL signal the potential to date quartz back to a million years. However, research undertaken in ALRL has highlighted that the thermal stability of the TT-OSL signal may be a limiting factor. Previous work failed to accurately characterise the source of the TT-OSL signal. Work at ALRL has both identified the position of the peak in regular TL measurements, and has then gone on to assess the kinetic parameters of the trap responsible for the TT-OSL signal. These kinetic parameters for the TT-OSL signal yield a lifetime for charge in the trap of 4.5 Ma at a storage temperature of 10°C. This lifetime implies that samples 1 Ma in age would give TT-OSL ages that underestimated the true age by 10%. If ambient temperatures were higher the underestimate would be significantly higher. A priority area for future study will be to test this calculation of the lifetime by dating sediments of known age. A PhD project is planned to assess the potential of TT-OSL and other luminescence signals for extending the age range covered by luminescence methods.

Adamiec, G., Duller, G. A. T., Roberts, H. M. and Wintle, A. G. (in press). Improving the TT-OSL SAR protocol through source trap characterisation. *Radiation Measurements*

### FUTURE DEVELOPMENTS/STRATEGIC FORWARD LOOK

ALRL has been involved for a number of years with a project funded by the European Space Agency to assess the potential for luminescence dating of sediments on the surface of Mars. In the coming years this project will attempt to build a low mass (~600 g) and low power consumption (~5 W) luminescence dating system with the potential for planetary exploration. Such a system also has enormous potential for development as a portable dating system for use on Earth.

A second priority area will be to continue the search for methods of extending the age range over which luminescence can be applied. TT-OSL is one such signal, but a variety of others, including potassium-rich feldspars, will also be investigated.

A number of important projects where luminescence is being used to provide a chronology are approaching completion, including a major project to provide the first chronology for the late Quaternary of the United Arab Emirates, and two projects assessing the history of the river Nile, one focussing on Lake Tana, the source of the Blue Nile, and another looking at the Nile immediately below the confluence of the Blue and White Nile.