

**SERVICES & FACILITIES ANNUAL REPORT - FY April 2010 to March 2011**

<b>SERVICE</b> Cosmogenic Isotope Analysis Facility - CIAF	<b>FUNDING</b> Block	<b>AGREEMENT</b> R8/H10/42	<b>ESTABLISHED as S&amp;F</b> 2004	<b>TERM</b> 5 years
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**TYPE OF SERVICE PROVIDED:**

The application of cosmogenic isotope analysis to the study of geological and geomorphological processes is a growth area within the Earth Sciences. Denudation rates, ages of surface landforms, tectonic process rates and chronologies for climate records are fundamental issues that can be addressed with cosmogenic isotopes. Specifically, analysis of the long-lived cosmogenic radionuclides <sup>10</sup>Be, <sup>26</sup>Al and <sup>36</sup>Cl can be used as a direct method to quantify such processes on timescales from 10<sup>3</sup> to 10<sup>6</sup> years. Since its establishment in the late 1980s the use of terrestrial *in-situ* produced cosmogenic nuclides for geomorphological applications has been rapidly growing, and there is now a well-established community in the UK.

The NERC Cosmogenic Isotope Analysis Facility (CIAF) was set up at SUERC in 2004 in response to the rapidly growing demand for cosmogenic isotope data from UK researchers in the earth and environmental sciences as a strategic investment Facility following zero-based review. Located on the same site as the SUERC Accelerator Mass Spectrometer Laboratory, CIAF provides the UK Earth Sciences community with sample preparation facilities for <sup>10</sup>Be, <sup>26</sup>Al and <sup>36</sup>Cl and access to the 5 MV Pelletron accelerator mass spectrometer for measurement of these rare isotopes. Training is provided for PhD students, post-doctoral fellows and visiting scientists as a priority for the Facility.

SUERC is a geochronology centre of excellence, producing dates on timescales ranging from decades to billions of years. The Centre hosts a unique cluster of environmentally oriented analytical facilities. In particular, CIAF is complemented by the SUERC Noble Gas Geochemistry Laboratory whose capabilities include cosmogenic He and Ne isotope measurements. This offers opportunities for cross-validation and cross-calibration of cosmogenic nuclides as well as complementary analyses. In 2008, the AMS laboratory at SUERC gained the status of a NERC Recognised Facility. Mindful of the need for local infrastructure SUERC funded (in 2007 and 2008) a new ICP-OES and co-funded a collision-cell ICP-MS. In 2008 the Facility responded to the increasing demand for the analysis of low <sup>10</sup>Be concentrations (e.g. to determine high erosion rates) by developing low <sup>10</sup>Be/<sup>9</sup>Be beryllium carrier solutions for use in low background clean-laboratories. Low <sup>10</sup>Be samples have been successfully analysed by the Facility, demonstrating clean-laboratory conditions demonstrating that the CIAF laboratories have appropriate low background levels to make the most challenging measurements..

To date, the Steering Committee of the CIAF has received 101 grant applications which reflect the strong existing and sustainable demand (17 grant applications during the current FY) for its service. CIAF staff have been authors or co-authors on 29 published, peer-reviewed manuscripts since 2004. This publication record demonstrates sustained and high scientific output of work related to the CIAF. The high rate of co-authorship of Facility output reflects the commitment of Facility staff to contribute beyond the analytical process to ensure correct interpretation and proper presentation of the results by a community that is becoming accustomed to an exciting new range of isotopic tools.

**ANNUAL TARGETS AND PROGRESS TOWARDS THEM**

In 2010, six peer-reviewed manuscripts were published based on CIAF-related research with CIAF staff as author or co-author on all of them. Sample preparation throughput reached the annual capacity of the CIAF for Be-10 and Al-26. Even approved projects were finished in the FY10/11. High blank levels impacted on throughput for <sup>36</sup>Cl analysis requiring considerable additional work for Facility staff but we have demonstrated that the CI laboratory is capable of appropriate blank levels and the first CIAF paper containing <sup>36</sup>Cl data was published.

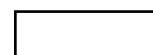
<b>SCORES AT LAST REVIEW (each out of 5)</b>				<b>Date of Last Review:</b>	March 2009
<b>Need</b>	<b>Uniqueness</b>	<b>Quality of Service</b>	<b>Quality of Science &amp; Training</b>	<b>Average</b>	
5.0	4.5	4.5	4.5	4.63	

<b>CAPACITY of HOST ENTITY FUNDED by S&amp;F</b>	<b>Staff &amp; Status</b>	<b>Next Review (March)</b>	<b>Contract Ends (31 March)</b>
100%	Dr Christoph Schnabel (Level 9), Dr Angel Rodes (Level 7) Allan Davidson (Technician Level 6) Joyce Wilcox (Technician Level 5; part-time: 80%)	2014	2015

<b>FINANCIAL DETAILS: CURRENT FY</b>						
<b>Total Resource Allocation</b> £k	<b>Unit Cost £0.2993k</b>			<b>Capital Expend</b> £k	<b>Income</b> £k	<b>Full Cash Cost</b> £k
	<b>Unit 1</b>	<b>Unit 2</b>	<b>Unit 3</b>			
371.37	Sample preparation 664 units 198.7	Manuscripts, Proposals 348 units 100.6	Admin/ Developm. 575 unit 172.1		33.0	471.37

<b>FINANCIAL COMMITMENT (by year until end of current agreement) £k</b>								
<b>2010-11</b>	<b>423.9</b>	<b>2011-12</b>	<b>420.7</b>	<b>2012-2013</b>	<b>437.1</b>	<b>2013-2014</b>	<b>451.3</b>	<b>2014-2015</b>

<b>STEERING COMMITTEE</b>	<b>Independent Members</b>	<b>Meetings per annum</b>	<b>Other S&amp;F Overseen</b>
<b>CIAF-SC</b>	5	2	None



**APPLICATIONS: DISTRIBUTION OF GRADES (current FY — 2010/11)**

	$\alpha 5$	$\alpha 4$	$\alpha 3$	$\alpha 2$	$\alpha 1$	$\beta$	R*/Pilot	Reject
NERC Grant projects*								
Other academic		7	1	1			3	
Students		3	2					
Pilot								
<b>TOTAL</b>	0	10	3	1	0	0	3	0

**APPLICATIONS: DISTRIBUTION OF GRADES (per annum average previous 3 financial years —2007/2008, 2008/2009 & 2009/2010)**

	$\alpha 5$	$\alpha 4$	$\alpha 3$	$\alpha 2$	$\alpha 1$	$\beta$	R*/Pilot	Reject
NERC Grant projects*								
Other Academic	0.33	5.33	0.67	1.67		0.33	1	
Students		3	0.67	0.33	0.33			
Pilot		0.67		0.67			1	
<b>TOTAL</b>	0.33	9	1.33	2.67	0.33	0.33	2	0

**PROJECTS COMPLETED (current FY – 2010/11)**

	$\alpha 5$	$\alpha 4$	$\alpha 3$	$\alpha 2$	$\alpha 1$	$\beta$	R*/Pilot
NERC Grant projects*	0	1	0	0	0	0	0
Other Academic	0	7	0	0	0	0	0
Students	0	1	1	0	0	0	0
Pilot	0	0	0	0	0	0	1

**Project Funding Type (current FY – 2010/11) (select one category for each project)**

Grand Total	Infrastructure					PAYG				
	Supplement to NERC Grant *	PhD Students NERC	Other	NERC C/S	Other	NERC Grant*	PhD Students NERC	Other	NERC C/S	Other
10	0	0	4	1	5					

**Project Funding Type (per annum average previous 3 financial years - 2007/2008, 2008/2009 & 2009/2010)**

Grand Total	Infrastructure					PAYG				
	Supplement to NERC Grant *	PhD Students NERC	Other	NERC C/S	Other	NERC Grant*	PhD Student NERC	Other	NERC C/S	Other
11	0.67	0.33	1.67	0.67	7.67					

**User type (current FY – 2010/11) (include each person named on application form)**

Academic	NERC Centre/Survey	NERC Fellows	PhD Students	Commercial
5	1	0	4	0

**User type (per annum average previous 3 financial years - 2007/2008, 2008/2009 & 2009/2010)**

Academic	NERC Centre/Survey	NERC Fellows	PhD Students	Commercial
7.67	0.67	0.67	2	0

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

Publications (by science area & type) (calendar year 2010)										
SBA	ES	MS	AS	TFS	EO	Polar	Grand Total	Refereed	Non-Ref/ Conf Proc	PhD Theses
0	8.5	0	0	0	0	1.5	10	6	4	0

**Distribution of Projects (by science areas) (FY 2010/11)**

Grand Total	SBA	ES	MS	AS	TFS	EO	Polar
10	0	8.5	0.2	0	0	0	1.3

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

Publications (by science area & type) (Calendar years 2007, 2008 & 2009)										
SBA	ES	MS	AS	TFS	EO	Polar	Grand Total	Refereed	Non-Ref/ Conf Proc	PhD Theses
0	12.83	0.67	0.33	0.33	0	0.5	14.67	7.67	6	1

**Distribution of Projects (by science areas) (FY 2007/2008, 2008/2009 & 2009/2010)**

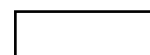
Grand Total	SBA	ES	MS	AS	TFS	EO	Polar
11	0	8.92	0.77	0	0	0	1.32

**Distribution of Projects by NERC strategic priority (current FY 2010/11)**

Grand Total	Climate System	Biodiversity	Earth System Science	Sustainable Use of Natural Resources	Natural Hazards	Environment, Pollution & Human Health	Technologies
10	3.35	0.2	5.9	0	0.05	0	0.5

\*Combined Responsive Mode and Directed Programme grants

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

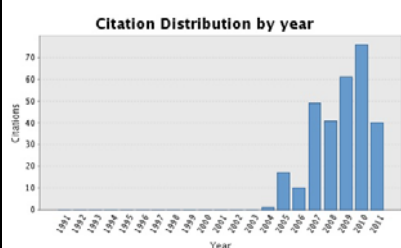


## OVERVIEW & ACTIVITIES IN FINANCIAL YEAR (2010/11):

**Analytical programme:** Though sample throughput in the CIAF was limited by systematic work on  $^{36}\text{Cl}$  blank levels and quality control work on  $^{36}\text{Cl}$  the outcome is a considerable improvement in our understanding of the sources of Cl blank. Equally, for much of FY10/11 CIAF operated with only one scientist but the full staff complement has now been restored with a Grade 7 appointment. Nevertheless, eleven projects have been finished in the FY10/11 and analytical results for 136 Be and 47 Al unknowns have been reported (plus blanks). These analyses included many challenging samples (e.g. low  $^{10}\text{Be}$  concentrations, fine-grained quartz and low quartz concentrations). In addition, several other projects are close to completion requiring only small numbers of outstanding analyses..

**Development work:** Aluminium analysis in quartz is being developed with the new ICP-OES at SUERC, complementing existing ICP-MS and AAS capability. Analysis of Fe, Mg, Al and Ti will be used to optimise ion chromatography for  $^{10}\text{Be}$  and  $^{26}\text{Al}$  analysis from quartz. Systematic blank studies for  $^{36}\text{Cl}$  showed a contribution to blank levels from the Milli-Q purified water system. In addition, a major contribution to the Cl blank appears enriched in  $^{37}\text{Cl}$  compared to natural Cl implying an anthropogenic atmospheric source that should be straightforward to isolate from the laboratory. Development of U, Th and Gd analysis, which are required calculation of  $^{36}\text{Cl}$  exposure ages, has begun by ICP-MS.

**Laboratory and building work:** The water purification system in the chlorine laboratory has been upgraded at SUERC's expense. A UV lamp was fitted to the high purification unit to destroy and remove organic chlorine compounds. In addition, the first purification step has been upgraded in order to maximise the lifetime of consumables in the system.



**Publications:** CIAF staff are authors and co-authors on 6 peer-reviewed publications on CIAF-project related work in international journals in the calendar year 2010. The publications also included the first CIAF paper in *Nature Geoscience* (Vermeesch et al., v.3, p.862-865 (2010)) and the first paper presenting  $^{36}\text{Cl}$  data (Vincent et al., *PGA* 121, p.24-31 (2010)). Since formation, CIAF has 54 publications with 295 citations, an H-Index of 10 and a strong upward citation trajectory (see figure).

**Conferences and workshops:** CIAF staff were co-authors on three presentations at *European Geosciences Union General Assembly (EGU)* in Vienna in 2010.

**Student training, training and visits:** S. Ilott (Plymouth) visited for more than four weeks in total for Be and Al preparation and depth-profile calculation training. Exeter PhD students R. Rixon and E. Rainsley, visited for  $^{10}\text{Be}$  and  $^{26}\text{Al}$  analysis. Miss Rixon also received training in the SUERC noble gas laboratory. M. Spagnolo (Aberdeen) and P. Vermeesch (Birkbeck) visited to discuss CIAF proposals and NERC grant applications. C. Fogwill (Exeter) discussed ongoing CIAF projects during his visit to SUERC. J. Barlow (postdoc in Durham) contributed to the sample preparation in the course of a one day visit to CIAF. H. Linge (Bergen, Norway) visited to discuss a manuscript to be submitted on  $^{36}\text{Cl}$  analysis at CIAF.

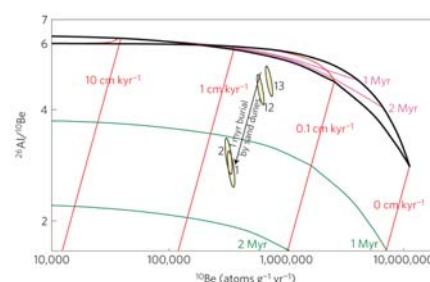
## SCIENCE HIGHLIGHTS:

### *One million year residence time of Namib dune sand from cosmogenic nuclides*

The Namib Sand Sea is one of the world's oldest and largest sand deserts, yet little is known about the source of the sand in this, or other, large deserts. In particular, it is unclear whether the sand is derived from local sediment or comes from remote sources. A combination of cosmogenic nuclide measurements and geochronological techniques allowed assessment of the provenance and migration history of sand grains in the Namib Desert. U–Pb geochronology of detrital zircons showed that the primary source of sand is the Orange River at the southern edge of the Namib. Burial ages obtained from measurements of the cosmogenic nuclides  $^{10}\text{Be}$ ,  $^{26}\text{Al}$  and  $^{21}\text{Ne}$  suggest that the residence time of sand within the sand sea is at least 1 Ma. We therefore conclude that, despite large climatic changes in the Namib region associated with Quaternary glacial–interglacial cycles, the area currently occupied by the Namib Sand Sea has never been entirely devoid of sand during the past million years. This work also led to a “back story” article by P. Vermeesch in *Nature Geoscience* (v.3, p.876)



Namib dune (Photo by Pieter Vermeesch)



Vermeesch, P., Fenton, C. R., Kober, F., Wiggs, G. F. S., Bristow, C. S., Xu, S. 2010. *Nature Geoscience*, 3, 862-865.

$^{26}\text{Al}$ - $^{10}\text{Be}$  isotopic signature of samples from Namib dunes suggest a minimum burial time of one million years.

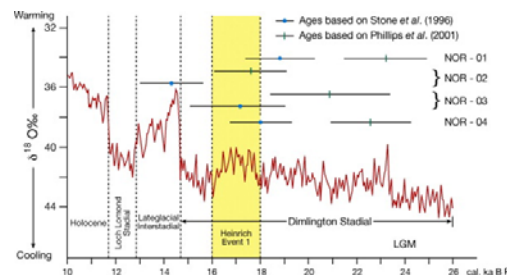
## ***Cosmogenic isotope ( $^{36}\text{Cl}$ ) surface exposure dating of the Norber erratics, Yorkshire Dales: further constraints on the timing of the LGM deglaciation in Britain***

Cosmogenic isotope ( $^{36}\text{Cl}$ ) surface exposure dating of four of the erratic boulders at Norber in the Yorkshire Dales National Park, NW England, gave mean ages of  $22.2 \pm 2.0$  ka and  $18.0 \pm 1.6$  ka for their emplacement. These two mean values derive from different  $^{36}\text{Cl}$  production rates used for exposure age calculation. The ages are uncorrected for temporal variations in production rates and may underestimate the true ages by 5–7%. The former age, although implying early deglaciation for this area of the British ice sheet, is not incompatible with minimum deglaciation ages from other contexts and locations in northwest England. However, the latter age is more consistent with the same minimum deglaciation ages and geochronological evidence for ice-free conditions in parts of the northern sector of the Irish Sea. Within uncertainties, the younger of the mean ages from Norber are consistent with boulder emplacement being associated with North Atlantic Heinrich event 1. This work was further publicised by an article by P. Wilson et al. in *Earth Heritage* (v.34, p.8-9).

Vincent, P.J., Wilson, P., Lord, T.C., Schnabel, C. and Wilcken, K.M. 2010. *Proceedings of the Geologists' Association* 121, 1, 24-31.



Four erratic boulders at Norber sampled for cosmogenic isotope surface exposure dating. Survey pole divisions are 20 cm.

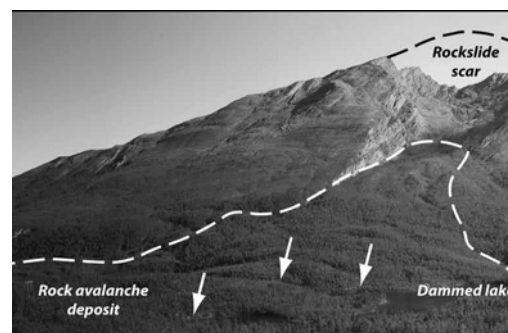


$^{36}\text{Cl}$  ages from the plotted against stages, events and the NGRIP ice-core data.

## ***Regional $^{10}\text{Be}$ production rate calibration for the past 12 ka deduced from the radiocarbon-dated Grøtlandsura and Russenes rock avalanches***

Two rock avalanches in Troms County - the Grøtlandsura and Russenes - were selected as CRONUS-EU natural cosmogenic  $^{10}\text{Be}$  production-rate calibration sites. They have reliable minimum radiocarbon ages of  $11424 \pm 108$  cal yr BP and  $10942 \pm 77$  cal yr BP ( $1\sigma$ ), respectively. Quartz samples ( $n=6$ ) from these two sites contained between  $4.28 \times 10^4$  and  $5.06 \times 10^4$  at  $^{10}\text{Be}/\text{g}$  using the  $1.387$  Myr  $^{10}\text{Be}$  half-life. Using the Stone scaling scheme, and accounting for snow- and moss-cover, we calculate an error-weighted mean total  $^{10}\text{Be}$  production rate of  $4.12 \pm 0.19$  at/g/yr ( $1\sigma$ ). These are in agreement within uncertainty with other  $^{10}\text{Be}$  production rates in the literature, but significantly are statistically lower than the global average  $^{10}\text{Be}$  production rate. Using the total  $^{10}\text{Be}$  production rate from our study, we determine an error-weighted mean surface-exposure age of a third rock avalanche in Troms County (the Hølen avalanche) to be  $7.5 \pm 0.3$  kyr ( $1\sigma$ ). This age suggests that the rock avalanche occurred shortly after the 8.2 kyr cooling event.

Fenton, C.R., Hermanns, R.L., Blikra, L.H., Kubik, P.W., Bryant, C., Niedermann, S., Meixner, A. and Goethals, M.M. In press. *Quaternary Geochronology* DOI:10.1016/j.quageo.2011.04.005.



Photograph of the Hølen rock avalanche.

### **FUTURE DEVELOPMENTS/STRATEGIC FORWARD LOOK**

1. Progress in solving the  $^{36}\text{Cl}$  blank problem is expected based on new efforts to isolate sample preparation from input of airborne  $^{36}\text{Cl}$ .
2. Elemental analysis of K, Ca and Fe with ICP-OES and U, Th, Gd with ICP-MS will be developed to provide in-house the elemental analysis needed for the interpretation of  $^{36}\text{Cl}$  concentrations as exposure ages.

*Non-Mandatory Facility-specific OPMs: utilisation, allocation of capacity etc*

