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

SERVICE	FUNDING	AGREEMENT	ESTABLISHED as S&F	TERM
NERC Isotope Geosciences Laboratory (NIGL)	Direct from Swindon via BGS	SLA	1987	5 years

TYPE OF SERVICE PROVIDED:

Purpose NIGL is a comprehensive stable and radiogenic isotope laboratory facility focusing on Environmental Change, Chronology, and Science-based Archaeology, in a collaborative research environment, including a strong focus on PhD student training. The science addressed is interdisciplinary, aligned with NERC priorities, and involves problems where isotope analysis is pivotal. NIGL serves many RAE grade 4 and 5 academic departments in the UK, and several NERC institutes, including the British Antarctic and Geological Surveys. NIGL was reviewed by SRG in January 2008 with a score of 4.75/5.0 and was renewed for 5 years until 2014.

The Facility and its equipment and expertise NIGL comprises two groups of analytical facilities complemented by a skilled scientific and technical staff:

Stable Isotope Facility: isotope analysis of waters, carbonates, biogenic silica, phosphates, biomass in both organic and inorganic materials for the isotopes of H, C, N, O, S, and Si by gas-source stable isotope mass spectrometry.

Radiogenic Isotope Facility: high precision U-Th-Pb dating using TIMS, and in situ dating using laser-ablation using plasma ionisation mass spectrometry (PIMMS); high precision isotope (U, Pb, Hf, Nd, Sr) analysis of solids and solutions using both solution and laser-ablation PIMMS, and TIMS.

Leading capabilities in the UK comprise: U-Th-Pb high precision (TIMS) and *in situ* (LA-ICP-MS) chronology; climate change research using C, H, O, and Si isotopes in waters, carbonates, organic materials and biogenic silica especially in the terrestrial environment; N isotopes in gases, soils, plants, waters and ice; high precision measurement of isotopes of U in environmental materials; Hf, Sr, Nd and Pb isotopes using laser microsampling in geological and environmental materials; very high precision Hf-Sr-Nd-Pb isotopes in geological materials using either TIMS or PIMMS, and most recently U-series dating for carbonate materials <450,000y, and U-Pb dating on carbonate materials of Pliocene-Quaternary age. NIGL has world-leading capabilities in several of these protocols (especially U-Th-Pb chronology and biogenic silica oxygen and silicon isotope analysis in palaeoclimate research), and students receiving training are exposed to the best approaches and methods available. Analytical innovation and efficiency are ongoing goals of our development work in support of the programme, and also the concept that complex problem-solving requires multiple isotopic methods. It is the integrated laboratory philosophy that remains a very strong and unique aspect of NIGL. The NIGL operates a total of 13 mass spectrometers in addition to chemical and sample preparation laboratories.

ANNUAL TARGETS AND PROGRESS TOWARDS THEM

NIGL had an excellent intake of high quality projects, especially climate studies, pollution research and those addressing the dynamics of the young mountains systems and modern erosion. The approved programme is comparable in resource terms to the financial allocation, demonstrating strong demand for the facility. NIGL continues to win grants and commissions that assist with co-funding of capital equipment. With the exception of the Axiom instrument, the Thermo253 and GV IsoPrime, equipment has performed very well this year. NIGL co-hosted two major workshops this year in support of climate science and will refine procedures for improved U-series dating of terrestrial carbonates in the coming year. Publication output has continued to be strong, with 62 papers published during the calendar year of 2009, and 35 published or in press by April 2010, 9 PhD theses completed, and 23 conference proceedings. In total 41 PhD students (24 University-funded, 9 NERC, 1 University-funded CASE, 3 NERC CASE, 4 BGS-NERC BUFI), 1 University-funded Post Doc, 3 NERC Post Docs, 1 University-funded Fellow and 5 NERC Fellows received training.

SCORES AT LAST REVIEW (each out of 5)			Date of Last Review:	2008
Need	**Uniqueness**	**Quality of Service**	**Quality of Science & Training**	**Average**
5.0	**4.5**	**4.5**	**5.0**	**4.75**

CAPACITY of HOST ENTITY FUNDED by S&F	Staff & Status	Next Review (March)	Contract Ends (31 March)
60%	**16** NERC BGS Staff supported c.**15-80%** with S&F funds Administration-management provided by BGS BGS and commissions support PDRAs and remainder of staff	**2013**	**2014**

FINANCIAL DETAILS: CURRENT FY						
Total Resource Allocation £k	**Unit Cost £k**			**Capital Expend £k**	**Income £k**	**Full Cash Cost £k**
	Unit 1 staff half day cost	**Unit 2 Student/fellow half day cost**	**Unit 3**			
656	**305**	**76**	**N/A**	**378K**	**339K**	**1524K**

FINANCIAL COMMITMENT (by year until end of current agreement) £k				
2010-11 £731K	**2011-12 £760K**	**2012-13 £791K**	**2013-2014 £823K**	**2014-2015 857K**

STEERING COMMITTEE	Independent Members	Meetings per annum	Other S&F Overseen
NIGFSC	8	2	AIF, ICSF, OUUF

APPLICATIONS: DISTRIBUTION OF GRADES (current FY — 2009/10)								
	α5	α4	α3	α2	α1	β	R*/Pilot	Reject
NERC Grant projects*	0	5	0	0	0	0	3	0
Other academic	0	4	1	3	0	0	2	7
Students	0	3	9	0	0	0	2	0
Pilot	0	3	2	0	0	0	3	2
TOTAL	0	15	12	3	0	0	10	9
APPLICATIONS: DISTRIBUTION OF GRADES (per annum average previous 3 financial years —2006/2007, 2007/2008 & 2008/2009)								
	α5	α4	α3	α2	α1	β	R*/Pilot	Reject
NERC Grant projects*	0	3.00	0.33	0	0	0	1.33	0.33
Other Academic	0	7.67	2.67	0.67	0.33	0	3.33	0.67
Students	0.33	7.67	7.33	0.67	0	0	4.33	2.00
Pilot	0	0	0	0	0	0	0.67	0
TOTAL	0.33	18.32	10.33	1.33	0.33	0	9.67	3.00

PROJECTS COMPLETED (current FY — 2009/10)							
	α5	α4	α3	α2	α1	β	R*/Pilot
NERC Grant projects*	0	1	0	0	0	0	1
Other Academic	0	5	0	0	0	0	1
Students	0	5	6	1	0	0	1
Pilot	0	0	0	0	0	0	0

USER PROFILE - funding type (current FY — 2009/10)											
Grand Total	Infrastructure					PAYG					
	Supplement to NERC Grant *	Student		NERC C/S	Other	NERC Grant*	Student		NERC C/S	Other
		NERC	Other				NERC	Other		
145.00	13	32	29	0	21	1	0	0	20	31
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 C/S	Other	NERC Grant*	Student		NERC C/S	Other
		NERC	Other				NERC	Other		
161.67	11.00	23.67	28.00	7.67	32.67	0.33	0.33	0.33	22.00	36.00

USER PROFILE – user type (current FY — 2009/10)				
Academic	Centre/Survey	NERC Fellows	PhD	Commercial
34	20	7	54	31
USER PROFILE - user type (per annum average previous 3 financial years —2006/2007, 2007/2008 & 2008/2009)				
Academic	**Centre/Survey**	**NERC Fellows**	**PhD**	**Commercial**
43.67	**12.00**	**4.00**	**49.33**	**33.33**

OUTPUT & PERFORMANCE MEASURES (current FY — 2009/10)									
Publications (by science area & type) (calendar year 2009)									
SBA	ES	MS	AS	TFS	EO	Polar	Grand Total	Refereed	Non-Ref/ Conf Proc	PhD Theses
15	61	4	1	9	0	4	**94**	**62**	**23**	**9**

Distribution of Projects by NERC science area (current FY — 2009/10)						
SBA	ES	MS	AS	TFS	EO	Polar
18.70	55.65	9.80	1.00	17.75	0.00	4.10

OUTPUT & PERFORMANCE MEASURES (per annum average previous 3 financial years —2006/2007, 2007/2008 & 2008/2009)									
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
9.0	45.7	7.3	1.3	19.7	0.7	3.3	87.1	59.7	19.7	7.7

Distribution of Projects (by science areas) (financial years — 2007/2008, 2008/09 & 2009/2010)						
SBA	ES	MS	AS	TFS	EO	Polar
17.07	65.67	11.67	1.00	23.97	1.33	2.50

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
8.65	9.85	79.35	2.00	0.00	3.35	3.80

**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 NERC Isotope Geosciences Facilities Steering Committee (NIGFSC) approved 27 new projects with a mean grade of α4. During the last financial year 107 projects were worked on, most of a multi-year nature, and more than 41 PhD students received training. Three post-doctoral researchers supported by NERC standard grants were appointed at NIGL.

U-series and U-Pb carbonate Quaternary dating capability (by isotope dilution) together represent important growth areas for NIGL. Cold water coral, speleothem and tufa studies are ongoing, with several nearing completion and others coming on stream. U-Th and U-Pb are being exploited together wherever possible and applicable, the latter particularly benefitting from our existing silicate U-Pb geochronology expertise, together with recent interpretative and analytical advances at NIGL and elsewhere. Sample screening using the NuPlasma HR LA-U-Pb capability is proving very useful, improving the effectiveness of our subsequent isotope dilution U-series - U-Pb dating by both TIMS and ICP-MS. A continuing long-term aim is to integrate this Quaternary dating capability with stable isotope projects in this same science theme.

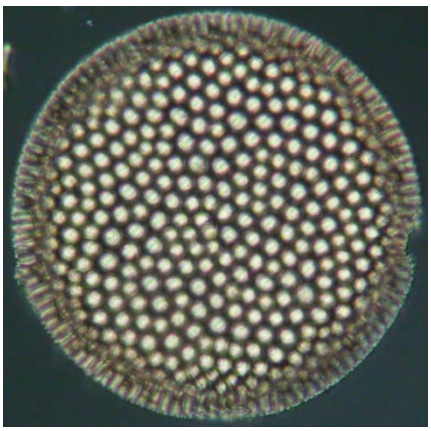
In the PIMS Facility, an ESI (New Wave Research Division) UP193FX 193nm short pulse width excimer laser ablation system was installed in July 2009. The AttoM SC-ICP-MS underwent a major re-installation of key components at the end of the financial year, driven by a collaborative development effort between NIGL and Nu Instruments, to allow its full potential to be realised. NIGL has continued lead the EARTHTIME effort of improving the U-Pb chronometer, not only ID-TIMS but also LA-ICP-MS as demonstrated by a very successful two day workshop held prior to the fall AGU meeting which was co-organised and led by Horstwood. In 2009-2010 we have built upon the EARTHTIME tracer calibration exercise turning our efforts to the isotopic ($^{238}U/^{235}U$) characterisation of reference materials used in U-Pb and U-series geochronology. These new results provide a new set of values for several key U reference materials. During March 2010 NIGL led a week-long short course on mass-spectrometry and radio-isotopic dating.

With external colleagues as collaborators or as co-I's, NIGL has been very successful in winning 3 NERC grants, in addition to AHRC and Leverhulme grants, all of which will begin in 2010. These will support additional research fellows and PhD students and add further momentum to the science and development programme of NIGL. Several of these will be making proposals to the NIGFSC for grant-related analytical support. Professor Randy Parrish was awarded the 2010 Schlumberger Medal of the Mineralogical Society. This annual award recognizes scientific excellence in mineralogy and its applications. In addition Professor Parrish was elected Fellow of the Geological Society of America for innovative development and application of geochronology and geochemistry to tectonics and crustal evolution.

SCIENCE HIGHLIGHTS:

The potential of diatom oxygen isotopes in palaeoceanography

Measurements of diatom oxygen isotopes hold the potential to provide an important additional source of palaeoceanographic information in regions depleted in carbonates. However only a handful of studies have applied $\delta^{18}O_{diatom}$ in marine reconstructions. Here the historical development and current state of affairs concerning the usage of $\delta^{18}O_{diatom}$ in palaeoceanography is reviewed. This includes a summary of sample purification and analytical techniques, existing palaeoceanographic reconstructions, vital effects and secondary isotope exchanges; and a review of the current and future developments required to improve the reliability of $\delta^{18}O_{diatom}$ based reconstructions in palaeoceanography.



Swann, G.E.A. and Leng, M.J. 2009. A review of diatom $\delta^{18}O$ in palaeoceanography. Quaternary Science Reviews, 28, 384-398.

A modern calibration of oxygen and hydrogen isotopes from sub Arctic lake waters

Lakes in sub-Arctic regions have the potential of retaining many different aspects of water isotope composition in their sediments which can be used for palaeoclimate reconstruction. It is therefore important to understand the modern isotope hydrology of these lakes. Here we discuss the significance of variations in water isotope composition of a series of lakes located in north-west Swedish Lapland. Climate in this region is forced by changes in the North Atlantic which renders it an interesting area for climate reconstructions. We compare $\delta^{18}O_{lake}$ and $\delta^{2}H_{lake}$ collected between 2001 and 2006 and show that lakes in this sub-Arctic region are currently mainly recharged by shallow groundwater and precipitation which undergoes little subsequent evaporation, and that the $\delta^{18}O$ and $\delta^{2}H$ composition of input to the majority of the lakes varies on a seasonal basis between winter precipitation (spring thaw) and summer precipitation.

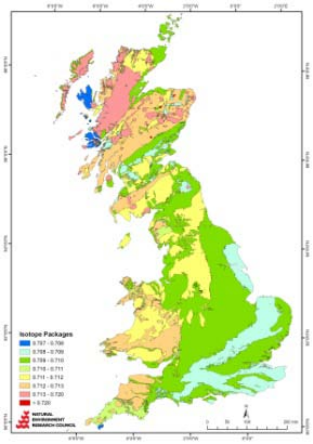
Jonsson, C.E., Leng, M.J., Rosqvist, G.C., Seibert, J. Arrowsmith, C. 2009. Stable oxygen and hydrogen isotopes in sub-Arctic lake waters from northern Sweden. Journal of Hydrology, 376, 143-151.

A sub-Arctic lake in Northern Sweden in the summer months.

New resource for human migration and provenance studies

The first $^{87}Sr/^{86}$ isotope domain map of a country was published this year (Evans et al 2010). The map was based on direct measurements of the $^{87}Sr/^{86}Sr$ isotope composition of plants from across Britain. These data were used to characterize the major lithologies and a domain map was produced. This is now available as a reference data source for archaeological and forensic studies in Britain.

Evans, J.A. Montgomery, J. Wildman, G. & Boulton, N., 2010. Spatial variations in biosphere $^{87}Sr/^{86}Sr$ in Britain. Journal of Geological Society, 167, 1-4.



Monsoonal rainfall frequency near the East African equator

This study has produced the first reconstruction of long-term variation in hydrological balance from near the Equator of 25,000 years in length, the data and age control yield insight into how tropical climate systems responded to the combination of changes in equatorial solar insolation and long-distance influence of high-latitude climate regimes. The location of this climate record in equatorial East Africa is crucial: the climate archive which accumulated in the bottom sediments of Lake Challa near Mt. Kilimanjaro registered the dynamics of monsoon rainfall over the western Indian Ocean, where the zone of convergence between northern and southern hemisphere air flows undergoes the largest seasonal migration north and south of the equator.

Verschuren, D. et al. 2009. Half-precessional dynamics of monsoon rainfall near the East African equator. Nature, 462, 637-641.

Isotope evidence shows decapitated individuals to be of Scandinavian origin.

In June 2009 a burial pit was unearthed that contained the remains of 51 decapitated individuals. The men were carbon-14 dated to between AD 910 and AD 1030 a period of frequent Viking raids on Britain. Isotope analysis done at NIGL showed that all the individuals measured in this study had oxygen isotope tooth enamel values that were "too cold" to be British and consistent with Scandinavian origin. It represents one of the largest Viking-age assemblages to be worked on. Up until now there have only been one or two confirmed Scandinavians of this period, found in the UK, using isotope techniques.

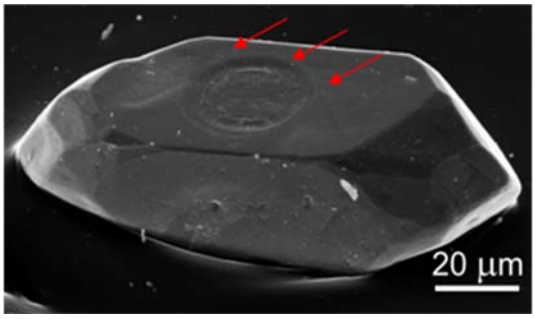
Chenery, C.A., and Evans, J.A. 2010. Isotopes results for teeth from ten decapitated individuals from Weymouth Ridgeway Burial Pit. NIGL report 274.

Decapitated torso remains.
© Dorset County Council.

Dating ultra-thin zircon rims using single shot laser ablation

We have developed a novel approach to laser ablation Pb/U geochronology that allows accurate determination of isotope ratios from a single pulse of a 193 nm laser. Data from reference zircons indicate that it is possible to consistently measure $^{206}Pb/^{238}U$ and $^{207}Pb/^{206}Pb$ ratios with external reproducibilities of 2% and 2.8% (2SD) respectively, using a similar amount of material to standard static ablation protocols. This technique offers a new opportunity to identify complexities within accessory minerals that were previously beyond the spatial resolution of laser based geochronology methods.

Cottle, J.M., Horstwood, M.S.A. & Parrish, R.R. 2009. A new approach to single shot laser ablation analysis and its application to in situ Pb/U geochronology. Journal of Analytical Atomic Spectrometry, 24, 1355-1363.

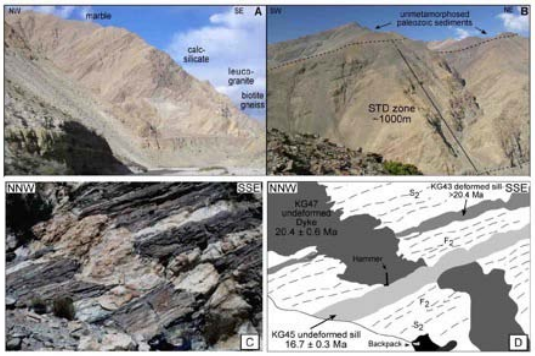


Zircon with shallow ablation pit (highlighted).

Constraining the timing of metamorphism, melting and tectonics in the Everest region, southern Tibet.

U(-Th)-Pb dating of zircon, monazite, and xenotime from metamorphic and igneous rocks at two outcrops along a north-south transect in the Mount Everest region of southern Tibet provide new constraints on the timing and duration of thermal events associated with channel flow and the ductile extrusion of the Greater Himalayan Series (GHS). Data from this study constrain the timing of metamorphism to 20 Ma melting slightly earlier, 23-20 Ma. These data allow tectonic models for the extrusion of rocks from mid-crustal

Cottle, J.M., Searle, M.P., Horstwood, M.S.A. & Waters, D.J. 2009. Timing of mid-crustal metamorphism, melting, and deformation in the Mount Everest region of southern Tibet revealed by U(-Th)-Pb geochronology. Journal of Geology, 117, 634-664.

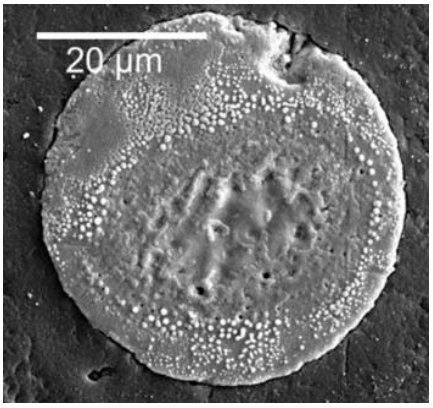


Deformation and melting recorded in the geology of the Everest region.

The distribution of depleted uranium contamination around a munitions processing factory in up state New York.

Uranium oxide particles were dispersed into the environment from a factory in Colonie (NY, USA) by prevailing winds during the 1960's and '70's. The contamination footprint has been mapped northward from site, and at least one third of the uranium in a soil sample from the surface 5 cm, collected 5.1 km NNW of the site, is DU. The distribution of contamination within the surface soil horizon follows a trend of exponential decrease with depth. Considering this distribution, the total mass of uranium contamination emitted from the factory is estimated to be c. 4.8 tonnes.

Lloyd, N.S., Chenery, S.R. & Parrish, R.R. 2009. The distribution of depleted uranium contamination in Colonie. Science of the Total Environment, 408, 397-407.



Uranium oxide particle.

Export of iron from glacial terraines

Waters draining heavily glaciated terraines could provide polar oceans with an important source of iron – a possible limiting nutrient for phytoplankton. In one of the first studies of iron in glacial runoff, we examined waters draining a maritime Antarctic glacier basin on Signy Island. Using $^{34}S/^{32}S$ and $^{18}O/^{16}O$ isotope data we demonstrated that the oxidation of pyrite (FeS_2) was both a source of sulphate and of soluble iron. 80% of sulphate in water draining tallus and lateral moraines was found to be derived from pyrite oxidation (rather than atmospheric deposition), by bacterially-mediated reactions under sub-oxic conditions. Our study therefore identified specific environments (ice-marginal talus and moraine sediments) and conditions (sub-oxic waters associated with periods of low flow) as favourable for export of iron to the ocean.

Hodson, A et al. 2009. Chemical weathering and solute export by meltwater in a maritime Antarctic glacier basin. Biogeochemistry, 10.1007/s10533-009-9372-2.


Signy Island, where specific conditions were identified for export of iron to the ocean (Photo. A. Hodson)

FUTURE DEVELOPMENTS/STRATEGIC FORWARD LOOK

With NERC co-funding, a new MC-ICP-MS was ordered late in the 2009-10 FY. The Neptune Plus will replace the Axiom which is likely to be decommissioned and broken down for parts for the user community. The Neptune Plus is a high-precision, high-sensitivity MC-ICP-MS which will be equipped with an effective multiple-ion counting capability and will be focussed on delivering NIGL's U-series and Quaternary U-Pb carbonate capability. After much development work in collaboration with the manufacturer, the AttoM SC-ICP-MS has finally undergone a refit of key components which will realise its capability in enhancing NIGL's laser ablation geochronology programme. This will be the key focus of this instrument in 10-11. The clumped isotope initiative, which would require supplemental mass spectrometry capacity, will be further monitored for demand and feasibility in the next year. It is likely that one of the Optima instruments will need to be replaced by a modern instrument to ensure the capacity for carbonate analysis on an ongoing basis. This will be evaluated in the coming year further, with possible purchasing action, as laid out in the renewal award for 2009-2014. U-series and U-Pb Quaternary dating is now available to the community, and with further evaluation of methods, it is likely that it will make demands on both TIMS (for Pb, some U) and PIMS (for U and Th). We anticipate growth in project demand continuing. Combined Si and O isotope measurements on diatoms and biogenic silica is likely to grow in response to environmental questions concerning productivity and climate parameters. The approved programme of isotope apprenticeships pioneered by NIGL will continue with appropriately motivated candidates wishing to pursue a career in some aspect of mass spectrometry, and we anticipate that effort to be oversubscribed. It has been very successful to date with all 5 apprentices so far going on to research positions. We have begun to augment the 'hands-on' training programme with the development of a series of short courses and development of online media (textbooks) and believe that combined these will offer an effect series of mechanisms for both providing training to users of isotopes in environmental research, and providing vital experience to the next generation of practitioners.

Non-Mandatory Facility-specific OPMs: utilisation, allocation of capacity etc.
See the annexes accompanying the submission of this summary, lodged with S&F.

NATURAL ENVIRONMENT RESEARCH COUNCIL

ISOTOPE GEOSCIENCES LABORATORY

ANNUAL REPORT

for the period

1ST APRIL 2009 to 31ST MARCH 2010

Prof R R Parrish, Head NIGL

11 October 2011

NERC/IF/317 Contents

Annex 1
Mission Statement

To provide isotopic analysis and scientific support, through collaborative research endeavours, to scientists within the UK academic community in line with NERC's policy on improving quality of life and wealth creation;

To provide isotopic analysis and scientific support to NERC institutes engaged in science budget or commissioned research and allied activities;

To provide training in isotope analysis and interpretation techniques to postgraduate students at UK universities and other institutions of higher learning;

To promote awareness of the application of appropriate isotope systems to the earth and environmental science community;

Within a collaborative research environment, to make NIGL facilities and training in their use available to NERC institute staff and UK academics (including their research personnel), to undertake their own analytical work for their research programme;

To undertake research and development into the application of isotopic analytical techniques to the earth and environmental sciences in order to provide state of the art methods and to meet evolving requirements of NERC user communities.

In order to achieve its objectives NIGL will:

Monitor user satisfaction on a regular basis;

Maintain its equipment and monitor its performance using Quality Assurance and Quality Control procedures;

Work with HEI and NERC Institute colleagues to promote only the best science, through development of projects aimed at peer review via the NERC Isotope Geosciences Facilities Steering Committee;

Maintain relevant technical and scientific documentation and make it available to visiting scientists;

Maintain a high professional level of staff, including, when appropriate, the initiation of research by NIGL staff in the framework described above;

Inform the users' community of development in methodologies and applications and maintain an awareness of the users' requirements;

Disseminate such information to the scientific community via publications, conference presentations, seminars, etc.;

Seek commissioned research to supplement the Science Budget allocation.

User Communities:

The NERC Isotope Geosciences Laboratory exists to provide specialised research facilities for earth and environmental scientists in NERC institutes and the UK Higher Education sector. The research of the facility is relevant to the sustainable development, the educational sector, and the wider governmental and industrial community concerned with the implications of climate change and natural resource issues.

Annex 2
Steering Committee membership and Terms of Reference

2.1 Steering Committee Membership and Fields of Expertise

Chairman:

Prof J E Andrews	School of Environmental Sciences, University of East Anglia, Norwich. *Carbonate and organic isotope geochemistry, sedimentology.*

Members:

Prof S Bottrell	School of Earth and Environment, University of Leeds *Stable isotopes in surface and groundwaters, soils, wetlands, marine and coastal sediments, ore deposits.*
Prof S A Bowring	Massachusetts Institute of Technology. Cambridge. Massachusetts, USA. *Geochronology, radiogenic isotope geochemistry, crustal evolution.*
Prof A. Chamberlain	Department of Archaeology, University of Sheffield. *Science-based Archaeology.*
Dr S Davies	Institute of Geography and Earth Sciences, Aberystwyth University. *Stable isotope analysis in palaeolimnology.*
Dr C Macpherson	Department of Earth Sciences, Durham University. *Magmatism and tectonics, stable isotopes, ion microprobe applications.*
Prof. Jim Marshall	School of Earth and Ocean Sciences, University of Liverpool, Liverpool. *Stable isotopes in sediments – palaeoclimate and sediment diagenesis.*
Dr R Mills	National Oceanography Centre, Southampton. *Isotope and elemental geochemistry of marine hydrothermal and sedimentary systems.*

Ex-officio:

Dr A J Boyce	Manager, Isotope Community Support Facility, Scottish Universities Environmental Research Centre, East Kilbride, Glasgow.
Dr R L F Kay	Head, Scientific Services Management Team, NERC, Swindon.
Prof M J Leng	Manager, Stable Isotopes Facility, NERC Isotope Geosciences Laboratory, Keyworth.
Prof R R Parrish	Head, NERC Isotope Geosciences Laboratory, Keyworth.
Dr F M Stuart	Head, Argon Isotope Facility, Scottish Universities Environmental Research Centre, East Kilbride, Glasgow.
Dr P van Calsteren	Head of Open University U-Series Facility, Dept of Earth Sciences, Open University, Milton Keynes.

Secretary:	Dr I L Millar, NERC Isotope Geosciences Laboratory, Keyworth. (2008-)
Administration:	Ms B I Bullock-von Moos, NERC Isotope Geosciences Laboratory, Keyworth (2008-)
Papers only:	Dr M Schultz, Director, Science and Innovation Funding, NERC, Swindon.

2.2 Remit

The NERC Isotope Geosciences Facilities Steering Committee exists to:

review applications for usage of the NERC Isotope Geosciences Laboratory (NIGL) and also for the Argon Isotope Facility (AIF) , the Isotope Community Support Facility (ICSF) and the Open University U-Series Facility (OUUSF);

monitor outputs from the four Facilities;

provide advice to NERC Director Science and Innovation on aspects of the operations of the Facilities.

Director Science and Innovation, in turn, provides advice to the Science and Innovation Strategy Board of Council on Services and Facilities relevant to their remit.

2.3 Terms of Reference for the NIGFSC

1. To review applications and establish priorities for the Heads of the Facilities, for the allocation of those of the facilities' resources funded from the Services and Facilities Science Budget, taking into account recommendations made through the NERC peer-review mechanisms.
2. To review the scientific quality of work undertaken by users of the Facilities, based on reports and publications.
3. To monitor the levels of user-satisfaction with the facilities and to analyse their user-bases.
4. To give guidance to the Heads of Facility on improvement of the facilities' equipment, and on their service function.
5. To receive annually a report from each Head of Facility. To report annually to the Director Science and Innovation and to provide advice at other times as appropriate.
6. To advise NERC Director Science and Innovation on:
    a. the level and direction of the internal R&D programme for the Facility;
    b. anticipated changes in requirements from the Facility and the consequential anticipated levels of future demand for the Facility;
    c. other matters as appropriate.

2.4 Membership constraints

Membership of the Committee will be decided by the Director of Science and Innovation with any advice from the Science and Innovation Strategy Board and suggestions from the Committee itself. It will include the Superintending Officers of the Facilities and a representative from Scientific Facilities and Technology Group, NERC Swindon Office.

Members, other than *ex-officio* members will be invited to serve for a term of up to four years with a maximum extension of a further two years. The Chairperson will serve a maximum of four years.

Annex 3
Equipment Inventory

Capital Equipment held by the NERC Isotope Geosciences Laboratory 2009- 2010

Date	Item	Manufacturer	Asset#	Cost
Extraction Lines				
1989	Extraction lines, fluorination, for silicate O and Si	NIGL	007838	£90000
1990	Extraction line, carbonate	NIGL	011231	£7000
1990	Extraction line, vacuum (was nitrogen)	NIGL	011233	£10000
1991	Extraction line, vaccum outgassing	NIGL	011235	£10000
1991	Extraction line, vacuum, mini (was fluid inclusion)	NIGL	011234	£11000
1995	Extraction line, laser fluorination	NIGL	011241	£15000
Laboratory Equipment				
1995	Centrifuge (Megafuge 1.0)	Heraeus	004474	£3917
2001	Gds style panel	HAC Technical Gas		£2097
2001	Fume extraction	Dustraction Ltd	111240	£3019
2001	Gas cabinet and manifold	BOC	109782	£6078
2003	Water pretreatment system (Elix)	Millipore	114723	£21013
2003	Liquid argon tank	Wessington Cryogenics	114056	£5657
2003	Still	Picotrace	114014	£12796
2003	Induction generator	Stanelco	114427	£13037
2007	CEM MARSXpress microwave	CEM	118314	£14497
2007	Micromill	New Wave		£23913
2008	Elemental analyser ECS4010	Costech instruments	119782	£24969
2008	Plasma Asher K1050X	Emitech	119575	£15381
Laser Systems				
1989	Laser delivery system / microscope	Leica	007843	£14000
1994	Laser (CO2 laser 10)	Synrad	011239	£10000
1997	Laser delivery system	Merchantek	011464	£4113
1999	Laser ablation system, 266nm, UV	VG Elemental		£91538
2003	Laser ablation system upgrade, Nd-YAG	Spectron	011464	£11759
2003	Laser ablation system, upgrade to Microprobe II	VG Elemental		£12367
2005	Laser ablation system 193nm UV	New Wave	116626	£117500
Mass Spectrometer Peripherals				
1989	Isoprep 18 upgrade	VG	011226	£80000
1995	Turbomolecular pump	Balzers	007722	£5251
1997	Desolvating nebulizer sample introduction system	Cetec Technologies		£20232

Date	Item	Manufacturer	Asset#	Cost
	(MCN6000)			
1997	Turbomolecular pump	Edwards	011379	£7467
1997	Turbomolecular pump (EXT250)	Edwards	011499	£4047
2002	Turbomolecular pump (EXT555H)	Edwards	114041	£5953
2007	Liquid autosampler HT300A	Eurovector	118515	£6404
2008	Desolvating Nebuliser DSN/100	Nu Instruments	120277	£7990
Mass Spectrometers				
1987	Mass Spectrometer, stable isotope, Sira 10	VG	011230	£100000
1990	Mass Spectrometer, thermal ionisation (MAT262)	Finnigan Mat	000392	£350000
1993	Mass Spectrometer, stable isotope (Optima) + Manifold	VG	000750	£136770
1993	Mass Spectrometer, stable isotope (Optima) + EA/IsoCARB	VG	000751	£162495
1999	Mass Spectrometer, multicollector ICP (Axiom)	GV Instruments	011248	£300000
2001	Mass Spectrometer, stable isotope (Delta Plus+Conflo+Flash EA+TC/EA)	Thermo-Finnigan	110760	£107891
2002	Mass Spectrometer, stable isotope (Dual inlet Isoprime with Multiprep)	GV Instruments	113732	£172725
2003	Mass Spectrometer, upgrade to MAT262	Spectromat	000392	£41088
2003	Mass Spectrometer, thermal ionisation (Triton)	Thermo-Finnigan	115000	£414000
2004	Mass Spectrometer, stable isotope (MAT253)	Finnigan Mat	115911	£221785
2005	Mass Spectrometer, thermal ionisation (Triton)	Thermo-Electron	116592	£395102
2005	Mass Spectrometer, multicollector ICP (Nu Plasma)	Nu Instruments	116182	£326062
2007	Mass Spectrometer, stable isotope (Isoprime + Europyroh + Ref gas box)	GVI	113132	£96548
2008	Mass Spectrometer, single collector sector field (ATTOM)	NU Instruments		£191525
Microbalances				
1992	Microbalance with remote weighing chamber	Cahn Instrument Co.	007841	£8500
1992	Microbalance	Sartorius	000575	£7481
2001	Microbalance	Progen Scientific	109420	£7667
2004	Microbalance (CP2P)	Sartorius	115093	£7344
2008	Microbalance, Sartorius CPAZP	Sartorius	120214	£8043
Microscopes				
1990	Petrographic microscope	Leica	007840	£5000
1991	Binocular microscope (SMZ-10)	Nikon	000417	£3854
1997	Binocular microscope (SMZ-U)	Nikon	011723	£5463
1997	Binocular microscope (SMZ-U)	Nikon	012262	£5463

Date	Item	Manufacturer	Asset#	Cost
2002	Petrographic microscope + digital camera (Eclipse Nomarski DIC)	Nikon	111540	£15653
2002	Binocular microscope (SMZ-1500)	Nikon	111540	£5000
2009	Binocular microscope (SMZ-1500)	Nikon		£9000
2009	Inverted binocular microscope + micropanipulator device	Zeiss	121453	£22,000
Miscellaneous				
1990	Chiller	Cryocool	011227	£6000
2000	Desolvating nebulizer sample introduction system (Aridus)	Cetec technologies	107240	£14256
2003	Autosampler, zero-blank (Costech)	Pelican Scientific	110760	£5630
2003	Lens stack and sample turret for Triton mass spectrometer	Thermo-Finnigan	000392	£10904
2009	Chiller (Intercooler 2p/2s)	Polyscience	Pending	£6750
Sample Preparation				
1989	Magnetic separator (Magnetic barrier separator)	Frantz	011242	£3500
1989	Magnetic Separator (Magstream)	Intermagnetics Corp	007844	£22900
1989	Disk mill	Fritsch	011244	£3000
1991	Mineral separation table (Gemini)	Gisco	007845	£4400
1997	Mortar, tungsten carbide	Torrington Precision	011340	£3895
2003	Freezer mill	Spex	114015	£11883
2004	Jaw Crusher (Pulverisette Model II)	Fritsch	114763	£8762
2004	Freeze drier (Alpha 1-4)	Christ	115707	£8135

Annex 4
Future Developments

The 2009-10 year was the first year of new 5 year funding term, which was renewed in 2009 with significantly improved scores on previous years. NIGL's capabilities cover three main science areas: climate and pollution studies, geochronology; and Science-based Archaeology. Stable isotope capabilities have continued to develop biogenic silicon isotopes and their application to environmental research. The chronology capability has continued to develop U-series and Quaternary U-Pb dating techniques. In the future, we expect U-series and Quaternary geochronology to continue to develop in terms of both projects and methodological development. Training of both students and research fellows has always been at the core of NIGL's remit and we continue to develop this through the apprenticeship scheme, short courses and other training materials. Demand for isotope support remains very strong. Below are more details on specific facilities.

Plasma Ionisation Multi-collector Mass Spectrometry

The installation of a new MC-ICP-MS during FY 2010-2011 will be a significant development for both the PIMS facility and the U-Th geochronology program. The purchased instrument is state-of-the-art but developed on a mature platform, and therefore we expect it to be operational shortly after installation. The new instrument will relieve pressure on the TIMS instruments for U isotopic measurements, and will greatly improve the quality of U-Th mass spectrometry. High sensitivity U and Th analyses will permit smaller sample sizes. We will seek to exploit these developments in NIGFSC supported projects.

Thermal Ionization Mass Spectrometry

Developments of the U-Pb ID-TIMS capability continue as part of the international EARTHTIME Initiative, with NIGL taking a leading role. A significant NIGFSC supported project to examine the uranium isotopic composition of U-bearing accessory minerals will be completed in the forthcoming year. This dataset, combined with the recent work on the EARTHTIME tracer calibration, synthetic reference solutions and isotopic composition of uranium reference materials will allow the community to recommend new values for several key constants ($^{238}U/^{235}U$, $\lambda^{235}U$) for use in U-Pb geochronology.

U-Pb (ID-TIMS) work will continue to focus 'timescale' type applications as demand for constraints in this field is high, and increasingly researcher who focussed on a single technique (i.e., astrochronology) are increasingly realising that a multi-chronometer approach will yield the more robust age model. This will include work on intervals of major environmental change (Archean-Proterozoic transition; the Neoproterozoic-Early Cambrian; PETM; Cretaceous OEA's; Eocene-Oligocene transition).

U-series dating involved analysis of U and Th mainly by ICP-MC-MS methods supplemented by TIMS for U analysis on relatively straightforward U-series dating of clean carbonate (speleothems and cold water corals) and tufas. The U-Pb carbonate Quaternary dating procedures evolved through the year, with the final successful protocols involving U and Pb purification from ^{205}Pb-$^{233\text{-}235}U$ spiked samples in the U-Pb chemistry laboratory followed by U and Pb solution-mode analysis by PIMMS using the Nu HR. TIMS analysis of these materials was abandoned because of the relative intolerance to matrix elements, with PIMMS proving sufficiently low blank with excellent overall data quality. LA-PIMMS was also developed as a reconnaissance tool for young carbonates, and in some cases useful isochrons were obtained that will be supported by isotope-dilution work to provide accuracy.

Training

In March 2010 NIGL lead a short course focussed on 'radio-isotopic dating and mass spectrometry' held as a requirement of the GTSnext Marie Curie ITN. Although aimed at members of the ITN several NERC funded PhD students and post-doctoral researchers attended. It is intended to develop a series of UK based short courses, building upon this effort and the earlier 'U-Th-Pb Masterclass' workshops held in 2006 and 2001. The first UK based workshop is likely to focus on 'Fundamentals of mass spectrometry' and plans are being made to hold this during winter 2010-2011.

Opportunities for hands on experience via the isotope apprenticeship programme will continue in 2010-2011.

In addition to these two training effort we are working with partners in other institutions (largely as an outgrowth of EARTHTIME) to develop online training materials to underpin the hands-on experiences. We are exploring ways of developing such materials however a likely development will be to use existing platforms such as the WikiBooks and WikiUniversity in order to facilitate impact, education and training. A prototype geochronology textbook is already in development - http://en.wikibooks.org/wiki/Introduction_to_Geochronology.

The facility also contributes to an annual short course in stable isotopes in palaeoclimate (with UCL).

Staff issues

The classical carbonate system was run by an isotope apprentice (Dr Tanya Knowles) from April 2009 till December 2009 when she left to take up a post at Imperial College. A replacement apprentice (Dr Adam Young, recently completed UCL PhD) started with us in January 2010.

Mrs Carolyn Chenery left in February 2010 after a year with us covering maternity leave. She has recently been awarded Honorary Research Associate status within BGS for 3 years.

Mr Joseph Warham, a BUFI funded PhD Student with the University of Bradford and BGS, continued his PhD studies at NIGL through 2009-2010.

Ms Diana Sahy started a Marie-Curie PhD with the University of Leicester and NIGL in 2009.

Dr George Swann continues as a NERC Postdoctoral Fellow (2008-2011).

Dr Adam Martin was appointed in September 2009 and will work on research as part of a NERC Standard Grant held at NIGL.

Dr Andrea Snelling appointed in June 2009 and will work on research as part of a NERC Standard Grant held at NIGL.

Dr Laura Bracciali was appointed in September 2009 and will work on research as part of a NERC Standard Grant held at NIGL.

Dr Angela Lamb (who will return from maternity leave in April 2010) and Ms Vanessa Pashley are employed on reduced weekly hours.

Isotope Apprentice Dr Jon Cottle worked with us until May 2009, helping with development on the AttoM mass spectrometer. Isotope Apprentice Dr Nick Lloyd replaced Dr Cottle, providing support in the MC-ICP-MS laboratory from June 2009 until January 2010.

Dr Quentin Crowley continued his leave of absence while working at Trinity College, Dublin. In August 2009, he resigned his position at NIGL, and continues to be employed in Dublin.

Dr Nicola Atkinson was employed on a short term contract to cover for Dr Quentin Crowley's leave of absence. She has now transferred to a 2-year contract to provide technical and analytical support in the U-Th-Pb laboratory.

Miss Laura Howell and Miss Elouise Haywood were employed on short-term contracts providing technical support, between September 2008 and August 2009. Miss Sarah Tatham was hired on a 6 week contract to provide technical support in July and August 2009. Mr Paul Whitling was hired on a 6 month contract to provide technical support from September 2009 to February 2010.

Annex 5
Summary of Performance Information

5.1 NIGFSC Applications received 2009-10

NIGFSC No	Short Title	Project Leader	University / Institute	Grant Number	Grade
IP-1092-0509	Isotopic constraints on nitrogen sources and sinks in the European High Arctic	Dr A J Hodson	University of Sheffield	University funded Studentship and EC Marie Curie ITN Ref 215503	R*
IP-1093-0509	A new method for sea-level reconstruction based on bulk carbon isotope analysis of intertidal environments	Dr Jeremy Lloyd	University of Durham		α3H
IP-1094-0509	Late Quaternary environmental and climatic change in the United Arab Emirates, southeast Arabia	Prof Adrian Parker	Oxford Brookes University	University funded Studentship and BGS award 2K08E014	α3L
IP-1096-0509	Climate change and associated human responses in the Cuatro Cienegas Basin, NE Mexico, from the Late Pleistocene to the present	Prof Silvia Gonzalez	Liverpool John Moores University	NERC Studentship NE/F006772/1	α3H
IP-1097-0509	High latitude Pliocene seasonality and sea ice extent preserved in fossil Austrochlamys bivalves from the northern Antarctic Peninsula	Dr Mark Williams	University of Leicester		α2
IP-1098-0509	Examining the extent and longevity of Indian Ocean-type mantle from Tethyan ocean crust	Dr Tiffany Barry	The Open University, Milton Keynes	NERC Fellowship NE/F016352/1	α4L
IP-1099-0509	Early Modern Human migration out of Ethiopia: stalagmite isotopic evidence of a climatic forcing during 130-60 ka	Prof Andy Baker	University of Birmingham		α4H
IP-1100-0509	Investigating millennial scale climatic variability in the northen hemisphere tropics through stable isotopes & mineralogical analysis of sediments from the syula basin in western Mexico	Prof Sarah Metcalfe	University of Nottingham	University funded Studentshiph and NERC/BGS 2K06E005 BUCS S140	α4L
IP-1101-0509	Calibrating the fractionation of stable oxygen and silicon isotopes in diatom silica through laboratory culture experiments	Dr Jonathon Tyler	The Natural History Museum, London	NERC Fellowship NE/F014708/1	A4M
IP-1102-0509	Forensic applications of strontium and oxygen isotope composition of tooth enamel, in modern UK populations, for human identification	Dr Tal Simmons	University of Central Lancashire		R
IP-1103-0509	Identifying the initiation of the last British ice-sheet via a combined study of isotope composition of ice-rafted debris (IRD) with environmental magnetic analysis	Dr William Austin	University of St Andrews	University funded Studentship, NERC Grant NE/D012279/1 and BGS/St Andrews	α4L
IP-1104-0509	Variations in the intensity of low-latitude monsoonal circulation in response to the onset of Northern Hemisphere glaciation	Prof Mark A Maslin	University College London	NERC Studentship NE/F008635/1	α3H
IP-1105-0509	Investigating the Suitability of Porcine Enamel for Strontium (87Sr/86Sr) Isotope Analysis	Dr Jacqui Mulville	Cardiff University	University funded Studentship and AHRC Doctoral Award 2007/131798	α3H

NIGFSC No	Short Title	Project Leader	University / Institute	Grant Number	Grade
IP-1107-0509	Reconstructing Late Pleistocene and Holocene lake level changes at Ioannina, northwest Greece	Dr Ian Lawson	University of Leeds	NERC Studentship NER/S/A/2006/14152	α3H
IP-1108-0509	Pliocene climate and oceanography of the North Atlantic region	Dr Andrew Johnson	University of Derby	University funded Studentship and BUFI Award S157	α3H
IP-1111-0509	Tectonomagmatic origin of Trinidad and Tobago: implications for Caribbean tectonic evolution	Dr Andrew Kerr	Cardiff University	NERC Studentship NE/F00219X/1	α3H
IP-1112-0509	Dietary adaptations and responses to environmental change in prehistoric nomadic pastoralists of Mongolia	Prof Andrew Chamberlin	University of Sheffield	University funded Studentship	α3H
IP-1113-0509	High resolution organic isotope geochemistry of the varved sediments of Lake Suigetsu: evidence for millenial scale cyclicity during marine isotope stages 3 and 2	Dr Jonathon Tyler	The Natural History Museum, London	NERC Fellowship NE/F014708/1 and NERC Grant NE/D000289/1	R*
IP-1116-0509	Fingerprinting volcanic ash deposits using isotopes: a new aid for correlation of geologic marker beds on a regional scale	Dr Victoria Smith	University of Oxford		α2
IP-1117-0509	Quantifying climate change in the South Island, New Zealand through the last Glacial - Interglacial transition	Dr Matthew Jones	University of Nottingham		R
IP-1118-0509	The origins of nomadic pastoralism: A stable isotope study of caprine management in the Neolithic Levant	Dr Jessica Pearson	University of Liverpool	University funded Studentship and AHRC Doctoral Award 2007/131690	α4L
IP-1122-0509	Palaeo-ecological records of terrestrial run-off and sediment influence on coral reef ecosystems: a case study from King Reef, Northern Queensland, Australia	Prof Chris Perry	Manchester Metropolitan University	University Studentship CASE Studentship with Natural History Museum	α4M
IP-1123-0509	Inherited structural geometry and geomorphic controls in a multiple spillpoint, carbonate dominated lacustrine basin: The Mayran Formation, Northeast Mexico	Dr Robert L Gawthorpe	University of Manchester	University funded Studentship , CONACYT (153083) and SGM (4003)	R* Pilot
IP-1124-0509	Testing the phylogeny of Early Cambrian animals with a precise geochronology	Dr Mark Williams	University of Leicester	NERC Grant NE/FO10834/1	α4M
IP-1125-0509	Strontium Isotopes as Geochemical Tracers in Freshwater Ecosystems: Are trout a key to understanding our deteriorating river systems?	Dr Ian McCarthy	University of Wales, Bangor		R*
IP-1127-1109	Variability of the Denmark Strait Overflow	Karen Heywood	University of East Anglia	University funded Student NE/F013329	R*
IP-1128-1109	Synoptic Antarctic Shelf-Slope Interactions Study (SASSI)	Karen J. Heywood	University of East Anglia	University-Academic NE/E012965/1	R*
IP-1129-1109	Petrogenesis of Kimberlites and Lamproites: Palaeotectonic Implications and Clues to Diamond Formation.	Dr Tom Argles	The Open University, Milton Keynes	NERC Studentship NE/F008805/1	α3H

NIGFSC No	Short Title	Project Leader	University / Institute	Grant Number	Grade
IP-1130-1109	High resolution record of Holocene climate and vegetation from an Antarctic moss bank	Professor Howard Griffiths	University of Cambridge	University funded Studentship and NERC algorithm studentship	R*
IP-1131-1109	Implications of groundwater-surface water connectivity for nitrogen transformations in the hyporheic zone	Dr Kate Heppell	Queen Mary University of London	NERC Grant NE/F0047531/1	α4L
IP-1133-1109	Influence of subglacial processes on chemical exports and nutrient dynamics in the polar environment	A.J. Hodson	University of Sheffield	Academic / European Commission, Marie Curie ITN Ref 215503	α4L
IP-1134-1109	Testing climate models through multiproxy reconstruction of East Asian Monsoon variability	Dr Rachel Flecker	University of Bristol	University funded and NERC Grant NE/F009089/1	α3H
IP-1135-1109	Palaeoenvironment and U-series Dating of a Speleothem from Pontnewydd Cave, North Wales: A Lower Palaeolithic Neanderthal Site	Silvia Gonzalez	John Moores University		R
IP-1136-1109	Speleothems as records of environmental change	Julian Andrews	University of East Anglia	University funded Studentship and NE/G524095/1	α4L
IP-1137-1109	River capture in the Easternmost Himalaya: Testing erosion-tectonic feedback models using palaeo-Brahmaputra deposits of the Bengal Basin, Bangladesh	Randall Parrish	University of Leicester	NERC Grant NE/F017588/1	R*
IP-1138-1109	Climate Change and human activity in the Fazzan Basin, Libya	Dr Sue McLaren	University of Leicester	Academic / The Society for Libyan Studies and HSBC Research Grant RGS-IBG	R
IP-1139-1109	Characterisation of symbiont populations in mussels from the Mid-Atlantic Ridge using sulphur isotopes	Hilary Kennedy	Bangor University		R
IP-1141-1109	Pliocene-Pleistocene Paleoceanography and Climate History of the Bering Sea - IODP Expedition 323	Melanie Leng	University of Nottingham	Academic / UK IODP Rapid Response Grant	α4L
IP-1144-1109	Reconstructing Holocene climate variability using a diatom-based d18O record from Lone Spruce Lake, southern Alaska: assessing the role of the Aleutian Low	Andrew Henderson	University of Glasgow	University-Academic NSF EAR 0823522	α2
IP-1145-1109	Technological Change or Consistency? An investigation of Faience Produced from the Middle to the New Kingdom at Abydos, Egypt	Matthew J. Ponting	University of Liverpool	University funded Studentship	R*
IP-1146-1109	Tracing the links between elephants, humans, and land use during the 19th century East African caravan trade: a bioarchaeological study	Matthew Collins	University of York	University funded Studentship and EC Marie Curie Excellence Grant HEEAL	R
IP-1147-1109	Hunter-gatherer mobility and subsistence strategies in Late-glacial peninsular Italy	Dr Randolph E. Donahue	University of Bradford	Academic / Leverhulme Trust F/0 0235/I	R
IP-1148-1109	Fingerprinting volcanic ash deposits using isotopes: a new aid for correlation of geologic marker beds on a regional scale	Victoria Smith	University of Oxford		R

NIGFSC No	Short Title	Project Leader	University / Institute	Grant Number	Grade
IP-1150-1109	The end of the world? Famine, plague and climate change in 14th century London	Dr. Janet Montgomery	University of Bradford	University funded Studentship and AHRC Collaborative Doctoral Studentship / No. CDA07/162	R
IP-1151-1109	Late Quaternary variations in the nutrient flux from the River Nile to the Mediterranean: silicon-isotope evidence from lacustrine diatoms	Professor F.A. Street-Perrott	University of Wales, Swansea	University funded Student and NE/G524352/1	α4L
IP-1155-1109	Pliocene climate and oceanography of the North Atlantic region	Dr Andrew L.A. Johnson	University of Derby	University funded Student and BUFI award S157	α3H
IP-1157-1109	Radio-Isotopic age constraints for an integrated age model for the Paleocene-Eocene Thermal Maximum	Dr. Ian C. Harding	University of Southampton		α4H
IP-1158-1109	Strontium Isotopes as Tracers of Fish in Freshwater Ecosystems	Dr Ian McCarthy	University of Wales, Bangor		Pilot

5.2 NIGFSC Applications supported in 2009-2010 expressed as a % of α grade science

α5	α4H	α4M	α4L	α4	α3H	α3M	≤α3L	Pilot	Total number of Applications
0	2	3	10	0	10	0	0	2	27
0.00%	7.41%	11.11%	37.03%	0.00%	37.03%	0.00%	0.00%	7.41%	100%

22 proposals were graded below the cut off grade of α4 (α3M for proposals involving a PhD student), and therefore were not supported.

5.3 Distribution of supported α grade projects by Science Areas

Atmospheric Science	Earth Science	Earth Observation	Marine	Polar	Science based Archaeology	Terrestrial & Freshwater	Total # Applications
0.5	15.8	0	3.5	0.9	3.5	2.8	27
1.85%	58.51%	0	12.96%	3.33%	12.96%	10.37%	100%

5.4 Distribution of supported α grade projects in related to Categories

Archaeology	Chronology	Environmental Change	Total # Applications
3	7	17	27
11.10%	25.92%	62.95%	100%

5.5 Distribution of supported α grade projects related to Science Priority Areas

Biodiversity	Climate System	Earth System Science	Environment, Pollution & Human Health	Natural Hazards	Sustainable use of Natural Resources	Technologies	Total number of Applications
1.65	6.55	18.2	0.6	0	0	0	27
6.11%	24.25%	67.39%	2.22%	0	0	0	100%

Annex 6
Publication details for the calendar year 2009

6.1 Papers published in 2009

ABRAHAMSEN, E.P., MEREDITH, M.P., KENISON FALKNER, K., TORRES-VALDES, S., LENG, M.J., ALKIRE, M.B., BACON, S., LAXON, S.W., POLYAKOV, I. AND IVANOV, V., 2009. Tracer-derived freshwater composition of the Siberian continental shelf and slope following the extreme Arctic summer of 2007. Geophysical Research Letters 36(7): L07602, 5pp.

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6.5 NIGL Internal Reports 2009

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Annex 7
Targets & Milestones (Facility Reports)

Notes on the running of facilities, analytical output, and notable developmental work are listed below. Selected scientific highlights arising from work in the facilities are outlined in Appendix 15.

7.1 Gas Source Mass Spectrometry

The gas source mass spectrometry facility comprises:

i. A VG Optima dual inlet mass spectrometer. This mass spectrometer is also connected to a Costech ECS4010 elemental analyser with VG triple cryogenic trap for organic $^{13}C/^{12}C$ and C/N analysis.

ii. VG Optima dual inlet mass spectrometer with 20 port manifold for $^{13}C/^{12}C$ and $^{18}O/^{16}O$ analysis of CO_2 produced off line from bulk carbonates.

iii. A VG SIRA dual inlet mass spectrometer with 48 port Isoprep 18 and Multiport manifold for $^{18}O/^{16}O$ analysis of waters.

iv. A Micromass Isoprime mass spectrometer with EuroPyrOH using continuous flow, for $^{2}H/^{1}H$ analysis of waters.

v. A Micromass Isoprime dual inlet mass spectrometer with Multiprep, for $^{13}C/^{12}C$ and $^{18}O/^{16}O$ analysis of small carbonates.

vi. A Finnigan MAT 253 dual inlet mass spectrometer with manifold for off-line $^{18}O/^{16}O$, $^{30}Si/^{28}Si$, and $^{29}Si/^{28}Si$ analysis of biogenic silica.

vii. Two automated on-line elemental analysers linked to a Finnigan Delta+XL continuous-flow mass spectrometer. The systems employ both oxidative combustion, and high temperature reductive pyrolysis to provide $^{13}C/^{12}C$ ratios of bulk organic matter, $^{15}N/^{14}N$ and $^{34}S/^{32}S$ ratios in a variety of both organic and inorganic materials, and $^{18}O/^{16}O$ ratios of sulphates, nitrates, and phosphates.

Analytical output (1 April, 2009 to 31 March, 2010)

Type of analysis	No. of analyses	Approx. % standards, blanks, tests, duplicates etc.
Micro-carbonate $^{13}C/^{12}C$, $^{18}O/^{16}O$	4220	30
Bulk carbonate $^{13}C/^{12}C$, $^{18}O/^{16}O$	2230	20
Water $^{18}O/^{16}O$	9000	25
Water D/H	15000	75 (analysis in triplicate)
Silicate $^{18}O/^{16}O$	905	25
Silicate $^{30}Si/^{28}Si$ and $^{29}Si/^{28}Si$	220	25
$^{13}C/^{12}C$ + C/N (organic)	7200	30
$^{15}N/^{14}N$ + $^{13}C/^{12}C$ (collagen)	1680	30
$^{15}N/^{14}N$ (nitrates, ammonium, organic)	1995	25
$^{18}O/^{16}O$ (nitrate, phosphate, sulphate,)	1745	60
$^{34}S/^{32}S$ (sulphates, sulphides, organic)	950	25

The strength of the facility lies in its ability to analyse a wide variety of materials. This has been made possible by establishing and continuously developing a broad range of sample preparation facilities. However, much of our work continues to be centred on $^{13}C/^{12}C$ and $^{18}O/^{16}O$ analysis of carbonates, $^{18}O/^{16}O$ and D/H analysis of ice cores and contemporary waters, $^{13}C/^{12}C$ and C/N analysis of organics and $^{18}O/^{16}O$, $^{30}Si/^{28}Si$ and $^{29}Si/^{28}Si$ analysis of biogenic silica, as well as analysing an array of solid, aqueous and gas samples for measurement of ammonium sulphate (for ammonium or nitrate $^{15}N/^{14}N$), barium sulphate (for sulphate $^{34}S/^{32}S$ and $^{18}O/^{16}O$), collagen (for bone $^{13}C/^{12}C$ and $^{15}N/^{14}N$), hair keratin ($^{13}C/^{12}C$ and $^{15}N/^{14}N$), silver nitrate (for nitrate $^{15}N/^{14}N$ and $^{18}O/^{16}O$), silver phosphate (for biogenic phosphate $^{18}O/^{16}O$), and silver sulphide (for whole rock or sulphide $^{34}S/^{32}S$) for pollution and archaeological studies.

The facility has the benefit of skilled technical staff that keep the instrumentation running and provide the majority of the analytical output. Output continues to be high. Long term skilled technical support is vital for the maintenance of the aging SIRA and Optima mass spectrometry systems. The SIRA and two Optimas are running almost continuously, and both have a number of problems related to age and heavy usage. However, there were no substantial losses of analysis time through equipment failure of these instruments. However the MAT 253 and IsoPrime mass spectrometers were out o action for large parts of 2009, although throughput was not compromised largely due to the ability to use other equipment.

Staffing of the facility is much the same with 2 senior scientists (band 4), 3 at band 6, and 1 band 8. In addition we have had 2 consecutive casual staff (Tanya Knowles (to December 2009), and Adam Young (from January 2010)) who covered a band 7 post, they were both recently completed PhD's and worked effectively as "isotope apprentices", learning techniques and mass spectrometry. Adam Young will continue to work with us till October 2010 or until he gains a post doctoral post. Carolyn Chenery worked on a casual basis from April 2009 till February 2010 covering a maternity absence. George Swann (NERC postdoctoral fellow) started his 3 year fellowship research in September 2008 and is with us till Sept 2011. A research assistant (Andrea Snelling, band 7) was appointed in June 2009 to work on NERC Grant "Diatom Silica Oxygen Isotope Records from the Late Quaternary Antarctic Margin" (2009-2011) with Cardiff University.

A large amount of nitrate isotope ($^{15}N/^{14}N$ + $^{18}O/^{16}O$) analyses were completed for several DEFRA and university projects, and a start made on a new project utilising nitrate and $^{34}S/^{32}S$ analyses in a Marie Curie studentship. Protocols for $^{15}N/^{14}N$ analysis of sediments and other low-N materials have also now been established, and it is likely that $^{15}N/^{14}N$ data will become a more routine addition to some of the laboratory's existing $^{13}C/^{12}C$ and C/N work on sediments. Methods for $^{34}S/^{32}S$ analysis of plants have been adapted to analysis of collagen, to add to the existing $^{13}C/^{12}C$, $^{15}N/^{14}N$ and $^{18}O/^{16}O$ portfolio of stable isotope methods in high demand for science-based archaeology projects.

Other large grants that we continue to work on include NERC Standard grant "Last millennium climate reconstruction in Ethiopia using multiple stalagmite parameters" with Birmingham University; NERC Small grant "Freshwater Export from the Weddell Gyre: Magnitude, Variability and Impacts" with BAS, and Danish Agency for Science, Technology and Innovation in Copenhagen grant "Coupling land and ocean climate variability – a 10,000 year perspective using the present as a link to the past" with a PDRA in Denmark.

7.2 Plasma Ionisation and Thermal Ionisation Mass Spectrometry

The plasma and thermal ionisation mass spectrometry facilities undertake research in uranium-thorium-lead geochronology, environmental isotope tracer studies, and science-based archaeology, and share access to the following resources:

i. Plasma ionisation mass spectrometry laboratory, housing two laser ablation systems (193nm excimer and 193nm Nd:YAG's from New Wave Research), and three plasma-ionisation mass spectrometers (VG Elemental Axiom & Nu Instruments Nu Plasma HR), and AttoM single-collector sector-field (SC-SF)-ICP-MS).

ii. Thermal ionisation mass spectrometry (TIMS) laboratory, housing two Thermo-Electron Triton mass spectrometers and a Finnigan MAT262 instrument.

iii. Clean chemical laboratory suite, comprising a dedicated laboratory for U-Th-Pb geochronology, two shared laboratories for Sr, Nd, Pb, and Hf isotope analysis, and one laboratory for U-Series and DU analysis.

iv. A separate laboratory for microwave dissolution and handling of high-pressure dissolution vessels for U-Th-Pb geochronology.

v. A microscopy lab with binocular and petrographic - differential interference contrast microscopes with networked digital camera system.

vi. Rock crushing and mineral separation laboratories

The strength of the facility lies in the complimentary application of Plasma-Ionisation Mass Spectrometry (PIMS) and Thermal Ionisation Mass Spectrometry (TIMS), which together allow us to generate high precision isotope data for a wide range of geochronology and tracer studies. U-Th-Pb geochronology forms an important part of our work, using isotope dilution TIMS analysis for the highest precision applications and PIMMS for rapid laser-ablation analysis at high spatial resolution. We undertake a wide range of isotope tracer analyses ($^{87}Sr/^{86}Sr$, $^{143}Nd/^{144}Nd$, $^{176}Hf/^{177}Hf$, common Pb, depleted uranium) in environmental, archaeological, and geological studies, using both plasma- and thermal-ionisation mass spectrometry as appropriate.

The facility generates high precision isotope data for a wide range of tracer isotope studies, covering pollution/environmental, solid Earth geochemistry and archaeological science. The particular strength of the Facility is the capability of the plasma mass spectrometers to provide high-quality laser ablation isotope data on a variety of materials to a high spatial resolution, as well as high precision data for elements that are beyond the normal scope of traditional TIMS.

One NERC standard grant and one NERC small grant were awarded funding during this reporting period:

NERC Standard: The Svalbard exemplar of Neoproterozoic glaciation (lead PI – Fairchild, Birmingham).

NERC Small grant: Dating the "Taung Child" Australopithecus africanus type specimen through U-Pb measurements of associated calcite crystals (Parrish).

Detailed reports of the plasma- and thermal-ionisation mass spectrometry facilities follow.

Analytical output (1st April 2009 to 31st March 2010)

Type of analysis	No. of analyses	% standards
Plasma Ionisation Mass Spectrometry (PIMS)		
Laser ablation U-Th-Pb	5318	48[1]
Laser ablation Hf	2856	45[1]
Solution U	1013	52[2]
Solution Pb	579	58
Solution Hf	152	40
Thermal Ionisation Mass Spectrometry (TIMS)		
U-Pb – Triton 2	2339	46[3]
U (U-Series and high precision 235/238)	380	15
Sr –Triton 1	893	25
Nd – Triton 1	380	26
Sm – Triton 1	120	7

1 c.50% standards is typical for a laser ablation protocol.
2 c.65% standards is normal for this protocol to characterise the set-up well enough to achieve high data quality
3 Includes total procedural blanks and standards associated with normal geochronology batches and extensive tests on loading blanks, reagent blanks, standards run to verify and long-term monitor SEM performance

7.2.1 Plasma Ionisation Mass Spectrometry (PIMS)

This year has seen significant time investment in the PIMS Facility to enhance and increase its capability and productivity for the rest of the funding period. A new laser ablation system (ESI-New Wave Research UP193FX) was installed in July 2009 and the 4.5yr old UP193SS was refurbished over the latter half of this year. These two laser ablation systems, both short pulse width systems enabling enhance control of laser-induced inter-element fractionation, now provide NIGL with extensive capability and and capacity in laser ablation applications. The Nu Plasma HR underwent a concerted series of reassessment tests over the summer of 2009 to ensure peak operation capability at high-precision. Developments efforts continued on the AttoM SC-ICP-MS in conjunction with the manufacturer and March 2010 saw the final stage of reinstallation of a number of key components which will allow the full potential of this instrument to be realised. The AttoM will spear-head the laser ablation geochronology programme in the coming year and work has already begun on characterising a promising new allanite reference material in support of a number of NIGFSC, commercial and NERC-grant supported projects. Finally, at the end of the 09-10 FY, a new MC-ICP-MS was ordered to replace the Axiom which has reached the end of its useful lifetime for NIGL. The Neptune Plus (from ThermoFisher Scientific) will lead the U-series and Quaternary U-Pb carbonates science programmes for NIGL. The high sensitivity of this instrument (transmission efficiency >2% for U) promises to open avenues of research in small volume, high spatial resolution U-Pb and U-series geochronology not previously possible.

In conjunction with the instrumentation changes, staff fluctuations in the PIMS Facility have been significant. Isotope Apprentice John Cottle left in May '09 to take up a position in University of California, Santa Barbara. In replacement, former BGS-Leicester-NIGL PhD student Nick Lloyd was employed as an Isotope Apprentice and trained as lab support. Nick's expertise in analysing small uranium oxide particles by laser ablation and solution mode ICP-MS, led to him gaining employment with Thermo. Collaborations with Thermo and Nick will form part of the PIMS Facility activities this year to further the analytical and scientific capabilities in this field. Another Isotope Apprenticeship will begin in May 2010 with former Leicester-NIGL PhD student Nick Roberts replacing Nick Lloyd. Laboratory Manager Vanessa Pashley now spends one week each month working on science projects in Science-based Archaeology.

All of these changes have had no significant impact on the external service provided to community users but has impacted overall productivity this year. Analytical output is down 30% on 08-09 but with all the changes now largely in place (excepting the installation of the Neptune Plus) it is expected that productivity will be recovered and probably surpassed in 2010-11.

7.2.2 Thermal Ionisation Mass Spectrometry (TIMS)

TIMS laboratory Triton mass spectrometers continued to perform well with little downtime, again facilitating a large number research projects and new technique development initiatives. As in the past two reporting years, the high productivity levels achieved in 2009-2010 were facilitated to a significant degree by remote running, with the instruments kept busy almost year-round and full advantage of this was taken, particularly for the analysis of difficult archaeological Sr samples, U-Pb geochronology, and U for U-series geochronology. U-Pb geochronology instrument time is particularly at a premium and once U series requirements are factored in, virtually no spare capacity is available on the instrument. All of the above requires remote monitoring and operation of the Triton mass spectrometers by staff during the evening and at weekends in order to allow us to maintain a high throughput of delicate samples, which cannot be reliable run automatically. Of particular note has been the high performance of the Triton 2 secondary electron multiplier system (SEM), whose design resulted from a NIGL-Thermo-Mascom collaboration, which has now exceeded 4 lifetimes of a typical SEM.

The MAT 262, now 20 years old, was generally inactive during the reporting year mainly due to SEM problems caused by a succession of poor-performing SEM's. Work progresses as and when permitted by staff availability.

The most exacting work done in the TIMS laboratory during the reporting year involved high-precision $^{238}U/^{235}U$ measurements on commonly used uranium standard materials using the IRMM 3636 high purity tracer solution. Following on from instrument performance checks of Triton 2, significant instrument time was expended on calibrating CRM 112a, 950a, U500, and HU-1, verifying IRMM 184 as a check, but exceptional data was obtained. Our CRM 112a data overlap within error of data (better than 100 ppm) obtained in some key laboratories worldwide (e.g. IRMM, Universities of Minnesota, Frankfurt, and National University of Taiwan, Lawrence Livermore National Labs). Standards measured at NIGL (all of the above) and MIT (U500) now have $^{238}U/^{235}U$ ratios that are known to better than ± 0.02%, far better than the original certified uncertainties for the older CRM's. For the first time, with the exception of IRMM 184 and U500, the $^{238}U/^{235}U$ ratio of these CRM's is traceable back to SI units rather than to a "consensus" $^{238}U/^{235}U$ value. The work was a joint NIGL-MIT initiative supported by NIGFSC , the results of which will be very useful to all laboratories using these materials for instrument and tracer calibration, as well as an impact on the absolute age of all materials dated by U-Pb and Pb-Pb methods.

U-series work centred on two student projects examining Quaternary climate change in northeastern Mexico and the chronology of Holocene cold water corals, respectively, and a joint BGS-NIGL project on landscape evolution. These studies are in progress, with >50% of the analytical work was completed during 2009-2010. Uranium was mainly analysed on Triton 2 while Th was measured either on the Axiom or Nu HR.

Annex 8 Finance

Annual spend v income for the NIGFSC-funded portion of NIGL (~60% capacity).

Income Category	(£, 000s)
Baseline allocation from Services and Facilities	1347.0
Minor Capital approved by Facilities and Services Swindon	13.3
Partial payment for new 193nm excimer laser	20.0
Carry-over funds from previous fiscal year	139.0
Facilities contribution to new MC-ICP-MS (Neptune) upon order	200.0
Total Income	1719.3
Indirect costs transferred to BGS	659
Capital payments, minor and major item contributions	378.3
Salaries inc SA and NI payments, S&F allocation (60% of NIGL capacity)	550.0
Laboratory recurrent including T&S, from S&F allocation	132.0
Total expenses	1707.3
Balance to carry over to FY 2009-10	0.0

Note 1:- These figures do not include additional commission/grants/administrative funding support that are outside of the funding envelope for NIGL, according to the revised funding algorithm as enshrined in the current Service Level Agreement.

Annex 9
Service Management

University of Leicester employee (not supported by S&F allocation)

Prof RR Parrish, Professor of Isotope Geology & Head of NIGL
(80% secondment via contract between NERC/BGS and University of Leicester to manage NIGL and conduct collaborative project research).

Administrative support (not supported by S&F allocation)

Mrs BI Bullock-von Moos, PA to Prof RR Parrish, NIGL Administrator, NIGFSC Administrator.

Open-ended employees of NERC (British Geological Survey) supported in part by S&F allocation

Ms Carol Arrowsmith, Band 6, Isotope Scientist.

Mr Neil Boulton, Band 7, Isotope Support Scientist.

Dr Dan Condon, Band 5, Research Scientist.
Head of Chronology research.

Dr Quentin Crowley, Band 5, Isotope Scientist (on leave August 2008 – Sept 2009 / resigned Sept 2009).

Dr Jane Evans, Band 4, Research Scientist.
Head of Science-based Archaeology.
Honorary Research Fellow, Department of Archaeology, University of Nottingham.

Dr Tim Heaton, Band 4, Research Scientist.

Dr Matt Horstwood, Band 4, Research Scientist.

Mr Chris Kendrick, Band 8, Isotope Support Scientist.

Dr Angela Lamb, Band 6, Isotope Scientist (on leave May 2009 – April 2010).

Prof Melanie Leng, Band 4, Research Scientist and Deputy Head of NIGL.
Stable Isotope Facility Manager.
Head of Environmental Change Research.
Professor of Isotope Geosciences (20% secondment via contract between NERC/BGS and University of Nottingham). Visiting Professor, University of Leicester.

Dr Ian Millar, Band 4, Research Scientist.
Radiogenic Isotope Facility Manager.
Secretary to NERC Isotope Geosciences Facilities Steering Committee.

Dr Steve Noble, Band 4, Research Scientist.

Ms Vanessa Pashley, Band 7, Isotope Support Scientist.

Ms Hilary Sloane, Band 6, Isotope Scientist.

Mr Aaran Sumner, Band 7, Isotope Support Scientist.

Mr Adrian Wood, Band 8, Isotope Support Scientist.

Other isotope staff based at NIGL

Dr Nicola Atkinson, Technical Laboratory Assistant (Jan 2009-Nov 2009, casual / Dec 2009-Nov 2011 new contract).

Dr Laura Bracciali, NERC Grant Research Scientist (Sept 2009-Aug 2012), NIGL and Lancaster University.

Mrs Carolyn Chenery, Isotope Support Scientist (April 2009-Feb 2010, casual).

Dr John Cottle, Scientific and Technical support (Jan 2008-May 2009, Isotope Apprentice).

Ms Elouise Haywood, Technical Laboratory Assistant (Oct 2008-Aug 2009, casual).

Ms Laura Howell, Technical Laboratory Assistant (Sept 2008-July 2009, casual).

Dr Tanya Knowles, Scientific and Technical Support Scientist (Apr 2009-Nov 2009, Isotope Apprentice).

Dr Nicholas Lloyd, Scientific and Technical Support Scientist (Jul 2009-Dec 2009, Isotope Apprentice).

Dr Adam Martin, NERC Grant Research Scientist (Sept 2009-Sept 2012).

Dr Andrea Snelling, NERC Grant Research Scientist (May 2009-Apr 2011).

Ms Sarah Statham, Technical Laboratory Assistant (Jul 2009-Aug 2009, casual).

Dr George Swann, NERC Postdoctoral Fellow (Sept 2008-2011 – not supported by S&F allocation).

Mr Paul Whitling, Technical Laboratory Assistant (Sept 2009-Feb 2010, casual).

Dr Adam Young, Scientific and Technical Support Scientist (Jan 2010-Nov 2010, Isotope Apprentice).

Affiliated University/BGS PhD Students based at NIGL (not supported by S&F allocation)

Ms Qiong Li, BUFI funded PhD Student, University College London/BGS (2007-2008).

Mr Joseph Warham, BUFI funded PhD Student, University of Bradford/BGS (2007-2010).

Ms Diana Sahy, Marie Curie Early Stage Researcher, University of Leicester/NIGL (Oct 2009-Oct 2012).

BGS Honorary Research Associates (not supported by S&F allocation)

Mrs Carolyn Chenery (2010-2012).

Mrs D P Fiona Darbyshire (2006-2011).

Prof Sarah E. Metcalfe (2009-2011).

Dr Robert J Pankhurst (2002-2011).

Dr Tom Shepherd (2003-2011).

Annex 10
OPMs not covered elsewhere

Media highlights

Professor Randy Parrish: Tracking time of the Earth and Solar System, Geological Society of London: Shell London Lecture Series, 13th May 2009.
The current estimate of the age of the earth (and the accretion of the other planets) is close to 4,567 million years before present, a value that has been refined progressively since the discovery of radioactivity and its implications to the evolution of the earth. The science (and to some extent art) of geo- and cosmo-chronology underpins this ancient age and involves a huge array of technical and scientific achievements where more precise estimates increasingly depend upon ever more precise measurement of tiny amounts of rare terrestrial and extraterrestrial material. The reliability of the measurements and their evolution of techniques can be traced back to metrology, or the science of measurement. Much of what we know about the earth and its evolution is made possible because of geochronology, without which the duration and rate of events cannot be determined with any certainty in the geological record. In fact testing hypotheses regarding the synchronicity of global events (extinctions, rapid climate excursions, etc.) and determining cause and effect (bolide impact leading to extinctions…) is crucially dependent on further refinements of precision and accuracy in geochronology. The lecture will wander through earth and cosmic events and highlight some of the more interesting advances in thinking and method that have shaped our view of the antiquity of the earth and its methods of time keeping.

June 2009 - PlanetEarth News - Burned grains hold clues to ancient farms
A granary that burned down 2300 years ago stored wheat from a single, carefully farmed harvest, research suggests. The findings are based on chemical comparisons of old and modern wheat grains and give new insights to Bronze Age farming practices.
A granary at Assiros Toumba in Greece was burned to the ground around 1300 BC, during the Bronze Age, together with large quantities of grain stored in clay bins and jars. It was a large facility and the fire was undoubtedly a catastrophic accident for the people whose grain was stored there. The reasons for the fire are unknown. Archaeologists also did not know what kind of wheat was in store at Assiros Toumba: was it all from the same year, or from different harvests? Was it the product of local farmers or a regional storage centre? One way to answer these questions is to look at the wheat grain's carbon stable isotopes. The analyses of the old wheat grains show that the carbon isotope ratios are very similar and the differences are within the natural variations observed in a single modern wheat field. The lack of variation suggests that all the wheat in Assiros Toumba comes from a single year's harvest gathered over a small area, write the authors in the report published this week in the Journal of Archaeological Science. The ancient carbon isotope ratios also suggest that the Assiros Toumba wheat grew with plenty of water. As there is no evidence for higher rainfall during the Bronze Age, the findings suggest that the crops were well watered by the farmers, who also kept the fields free from weeds that might have competed with the wheat for moisture. The results help to provide a better understanding of farming practices in the Assiros Toumba region during the Bronze Age. Farmers kept intensive, well-watered and weed free wheat fields and stored the harvest in communal storage rooms, perhaps controlled by ruling elites.
Tim H.E. Heaton, Glynis Jones, Paul Halstead, Taxiarchis Tsipropoulos. Variations in the 13C/12C ratios of modern wheat grain, and implications for interpreting data from Bronze Age Assiros Toumba, Greece. Journal of Archaeological Science. Available online 21 June 2009

June 2009 - Nature Geoscience research highlight
J. Geophys. Res. 114, D08102 (2009): The last glacial period was punctuated by abrupt transitions to interstadial (warm) conditions. An analysis of an event 38,000 years ago — as recorded in the ice core from the North Greenland Ice Core Project — reveals that mid-latitude climate change preceded Greenland warming by several years. *Elizabeth Thomas of the British Antarctic Survey and colleagues (including Carol Arrowsmith of NIGL) used multiple proxies to reconstruct climatic conditions during this abrupt warming, one of the most prominent of the last glacial period.* The ice core's annual layers showed that the approximately 11°C warming over Greenland occurred over about 26 years. However, the team also found that a few years before the warming kicked in, the dust supply from Asia declined, which they relate to a strengthening of the summer monsoon. At about the same time, there was a shift in the hydrogen and oxygen isotopes of the ice, suggesting a northward migration of the polar front. The lag between the strengthening of the Asian monsoon and Greenland warming could point to a trigger for glacial abrupt climate change in the tropics or the Southern Hemisphere, rather than the north.

July 2009 - PlanetEarth News - Malta has a serious nitrate pollution problem. But where is it all coming from?
The Summer 2009 edition of *Planet Earth* reports on a project in which NIGL joined BGS hydrologists to conduct an isotope and geochemical survey of groundwater in Malta.
The country is one of the most densely populated in the world, with over 80% of the land either built upon or used for intensive arable and livestock farming. Our detailed $^{15}N/^{14}N$ and $^{18}O/^{16}O$ survey demonstrated that these activities have led to Malta's groundwater having the most widespread nitrate pollution in the EU.

September 2009 - Nature "News and Views"
One of our recent papers was highlighted in Nature: *Chepstow-Lusty, A.J., Frogley, M.R., Bauer, B.S., Leng, M.J., Boessenkool, K.P., Caarcaillet, C., Ali, A.A., Gioda, A. 2009. Putting the rise of the Inca Empire within a climatic and land management context. Climate of the Past, 5, 375-388.* Archaeology: Maya, Khmer and Inca, page 479. Past societies have struggled against environmental problems similar to those that beset us today. This publication illuminates the outcomes for tropical civilizations during the period AD 700–1600.

October 2009 - PlanetEarth Online NEWS: Bronze Age cattle travelled long distances
Show me your teeth and I'll tell you where you're from: archaeologists analysing isotopes in tooth enamel from cattle buried at two Bronze Age barrows have found that at least some of the animals originated from elsewhere, revealing long-distance trading networks in ancient Britain. *Jacqueline Towers, Janet Montgomery, Jane Evans, Mandy Jay, Mike Parker Pearson. An investigation of the origins of cattle and aurochs deposited in the Early Bronze Age barrows at Gayhurst and Irthlingborough. 2009 doi: 10.1016/j.jas.2009.10.012*

November 2009 - Bronze Age cattle travelled long distances
There was a discussion of a Bronze age cattle provenancing study including isotope data by Jane Evans on "*Up All Night BBC 5 Live*".

January 2010 – PlanetEarth Online
NERC Isotope Geosciences Laboratory's Dr Jane Evans talked to Planet Earth *online* about teeth, isotopes and archaeology.

March 2010 – Decapitated bodies - isotopes show they were Vikings
The decapitated individuals found in a mass grave in Dorset last year are of Scandinavian origin. Isotope analysis of tooth enamel and dentine from ten individuals was carried out at NIGL for Oxford Archaeology and Dorset County Council. The results show that they all came from a region with a colder climate than Britain, such as Norway or Sweden. Their diet matches better with Scandinavian medieval diets than with Anglo Saxon ones. The isotope results show considerable variation, indicating that these individuals came from a number of different locations within Scandinavia. *This research was highlighted by BBC-online*.

NIGL Website

The NIGL web site (http://www.bgs.ac.uk/NIGL) has an average hit rate of ~3600/day from 140 visitors. With a total of 1.3million+ hits from 50000+ visitors last year from over 160 countries worldwide. This is clearly a useful method of conveying information on our capabilities, both to the UK academic user community (25% of visitors) and also to the overseas community (75% of visitors). (Figures were supplied by BGS web managers).

Committee Representation

Dr THE Heaton

NERC Life Sciences Facilities Steering Committee (Chair, 2007 – present).

Prof MJ Leng

Editorial board for Quaternary Science Reviews (2004-present).

NERC Peer Review College (2007-2010).

Editorial board for SILICON (2009-2011).

NERC Isotope Geosciences Facilities Steering Committee (Ex-officio).

BGS, Scientific Facilities Steering Committee (2009-present).

BGS, National GeoEnvironmental Laboratories Steering Committee (2010-present)

Prof RR Parrish

Earth Sciences Panel Expert, Norwegian Research Council (2005- present).

NERC Ion Microprobe Facility Steering Committee (2005-2010/Chair, 2010-2014).

Editor, *Precambrian Research* (2007 – present)

Associate Editor, *Earth and Planetary Science Letters* (2009-present).

NERC Cosmogenic Isotope Facility Steering Committee (2008-2012).

NERC Isotope Geosciences Facilities Steering Committee (ex-officio).

NERC Peer Review College (2009-present).

Dr MSA Horstwood

BELAC (Belgium accreditation service (UKAS equivalent), Technical Expert for Institute of Reference Materials and Measurements accreditation for Isotope Dilution ICP-MS according to ISO17025 (2008-present).

Dr DJ Condon

Theme editor, *Geochemistry, Geophysics, Geosystems* on EARTHTIME (2008-present).

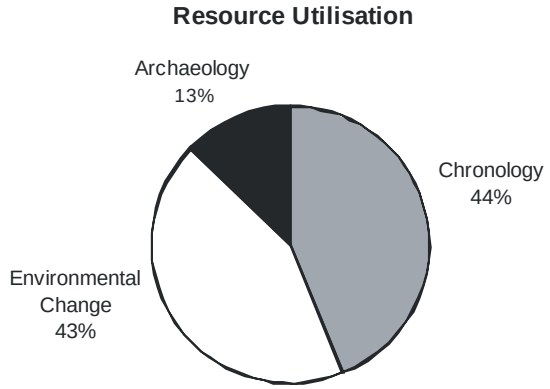
Dr JA Evans

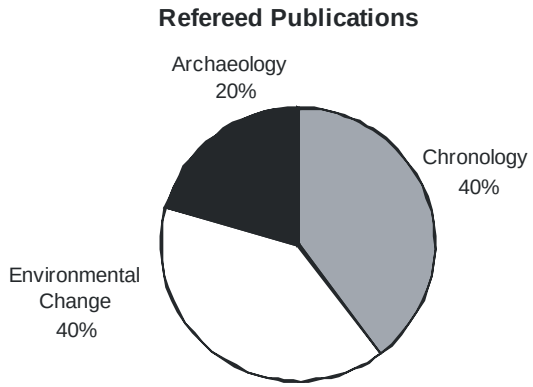
BGS Trustee for the South Wolds Community School, Nottinghamshire Learning Partnership Trust (2009-present).

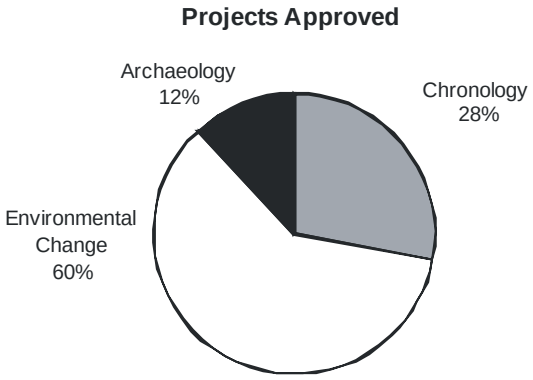
Annex 11
Additional information

In the renewal application of NIGL for 2009-2014, a proposal was made to SRG to harmonize the renewal anniversary dates of the existing facilities served by the NIGFSC, in an effort to more fully integrate the capabilties and programmes of these three services. This arrangement has now been implemented, and the four facilities served by the NIGFSC (NIGL, AIF, ICSF and OUUSF) will now be assessed for renewal in 2014.

In the following chart, the principle science applications of the facility are shown as percentages of the total cash resource allocated to NIGL. Also shown for each science category are the percentages of refereed publications and the precentage of projects approved by the NIGFSC. Also shown are estimates of the percentage utilisation of each analytical methodology by each science application, illustrating that isotope applications aimed at solving problems require multiple instrumental approaches and that it is wrong to think of facilities simply as single varieties of mass spectrometers.







Chronology:
50% TIMS, 50% PIMS

Environmental Change:
90% GSMS, 10% TIMS

Science-based Archaeology:
20% GSMS, 70% TIMS, 10% PIMS

The outputs of each of these components in terms of publications and 2009-2010 approved projects are tablulated in the following table, with associated resources.

Output metrics according to science application

Science Category	Instrumentation	Resource % in 2008-2009	Refereed Publications Conference Proceedings/ Theses in 2009	Refereed Publications %	Projects approved % 2009-2010
Chronology	TIMS & PIMS	44	23/14/2	40	28
Environmental Change	GSMS & TIMS	43	23/7/6	40	60
Science-based Archaeology	GSMS, TIMS & PIMS	13	12/2/1	20	12

Notes: GSMS, gas source mass spectrometry (H-C-N-O-S-Si); TIMS, thermal ionisation mass spectrometry (Sr, Nd, U-Th-Pb); PIMS, plasma ionisation mass spectrometry, Sr-Nd-Hf-Pb-U-Th-Pb and other elements. The Resource equates to actual proportion of funding committed to these science areas, whereas the Projects Approved column is the percentage approved in each category as a proportion of the total number of projects approved, and is not weighted according to the resource commitment required. Some projects are much more resource-intensive than others and these figures do not necessarily equate to the actual percentage demand for resource.

Annex 12 (optional)
Projects supported

Stage reached : N = not started; 1 = field work done; 2 = samples received; 3 = sample prep. completed; 4 = analytical work started; 5 = 50% analyses completed; 6 = analytical work completed; 7 = report completed; 8 = completed

Costs are calculated using 2009/2010 time allocation reports and the 2009/2010 TAR cost and include costs for capital depreciation and infrastructure. ■□

Please note: Does not include NIGL method development/innovation, public understanding of science and training programme

Project Type	Short Title	Project Leader	University / Institution	NIGFSC No	N	1	2	3	4	5	6	7	8	Staff Time	Facil. Time	Cost £
Institute Projects																
40133	U-Pb geochronology of the Charnian Supergroup	Carney Dr J N	British Geological Survey - Keyworth	IP/564/ 0998	■	■	■	■	■	■	■	□	□	11	0	75847
40162	Provenancing of the Monian Supergroup, North Wales	Horak Dr J	National Museum and Gallery of Wales	IP/726/ 1001	■	■	■	■	■	■	■	■	■	10	0	5323
40163	Generation of a Biogenic Phosphate Reference	Chenery Mrs C	British Geological Survey - Keyworth	IP/711/ 1001	■	■	■	■	■	■	■	□	□	6	0	1996
40165	Distribution and uptake of isotopes into biosphere	Evans Dr J	British Geological Survey - Keyworth	IP/735/ 1001	■	■	■	■	■	■	■	■	■	16	0	5323
40187	Silicon isotopes	Leng Prof M J	University of Nottingham	IP/811/ 0504	■	■	■	■	■	■	■	■	■	10	0	4325
															Total Institute Projects	**92812**
In-house Research																
50000	Personal development	Horstwood Dr M S A	British Geological Survey, Keyworth	N/A	■	■	■	■	■	■	■	■	■	14	0	4657
															Total In-house Research	**4657**
University Projects																
20247	Titanites from syenites and granites,Transbaikalia	Saunders Prof A D	University of Leicester	IP/566/ 0998	■	■	■	■	■	■	■	■	■	2	0	998
20286	Climate change in Lake Baikal	Mackay Dr A W	University College London	IP/635/ 0300	■	■	■	■	■	■	■	□	□	5	0	1996
20291	Distribution of shorebirds	Bryant Prof D M	University of Stirling	IP/646/ 0300	■	■	■	■	■	■	■	■	■	32	0	17298
20320	Caledonian intrusion-related hydrothermal activity	Rice Dr C M	University of Aberdeen	IP/683/ 0301	■	■	■	■	■	■	■	■	■	12	0	6321
20383	South Georgia lakes	Davies Dr S J	University of Wales, Aberystwyth	IP/779/ 0503	■	■	■	■	■	■	■	□	□	58	0	25282
20391	Lochnagar	Jones Dr V J	University College London	N/A	■	■	■	■	■	■	■	■	■	9	0	2994
20402	Tsangpo capture NIGFSC application	Najman Dr Y	Lancaster University	N/A	■	■	■	□	□	□	□	□	□	6	0	1996
20407	The provenance of plant ash glass in Middle East	Henderson Prof J	University of Nottingham	IP/817/ 0504	■	■	■	■	■	■	■	■	■	6	0	2994
20409	Anglo-Saxon childhood diet II	Chamberlain Prof A T	University of Sheffield	IP/819/ 0504	■	■	■	■	■	■	■	□	□	13	0	6986
20415	Multi-stalagmite climate reconstruction from N Turkey	Baker Dr A	University of Birmingham	IP/877/ 1105	■	■	■	■	■	■	■	□	□	8	0	3659
20418	Mexican monsoon Juancatlan	Davies Dr S J	University of Wales, Aberystwyth	IP/827/ 1104	■	■	■	■	■	■	■	■	■	78	0	33931
20420	Graptolite carbon	Zalasiewicz Dr J	University of Leicester	IP/830/ 1104	■	■	■	■	■	■	□	□	□	20	0	8649
20421	Palaeodiet of macaques	Elton Dr S	University of Hull	IP/831/ 1104	■	■	■	■	■	■	■	■	■	6	0	2994

Project Type	Short Title	Project Leader	University / Institution	NIGFSC No	N	1	2	3	4	5	6	7	8	Staff Time	Facil. Time	Cost £
20429	Makalu - Kangshung? Kharta region South Tibetan Himalaya	Searle Dr M P	University of Oxford	IP/846/0505	■	■	■	■	■	■	■	■	■	17	0	8982
20435	Stable isotope systematics of lakes	Leng Prof M J	University of Nottingham	IP/855/0505	■	■	■	■	■	■	■	□	□	6	0	2329
20436	Late Jurassic-early Cretaceous high latitude climates	Price Dr G D	University of Plymouth	IP/856/0505	■	□	□	□	□	■	■	■	■	10	0	4325
20437	North-west China's drylands	Holmes Dr J A	University College London	IP/858/0505	■	■	■	■	■	■	■	■	■	20	20	10312
20438	Holy water project	Montgomery Dr J	University of Bradford	IP/859/0505	■	■	■	■	■	■	■	□	□	12	0	6321
20444	Bryozoans in Pliocene	Williams Dr M	University of Portsmouth	IP/872/1105	■	■	■	■	■	■	■	■	■	66	0	28942
20449	Pearl Estuary	Zong Dr Y	University of Durham	IP/883/1105	■	■	■	■	■	■	■	■	■	10	20	14637
20450	Ugandan lakes	Ryves Dr D	Loughborough University	IP/884/1105	■	■	■	■	■	■	■	■	■	14	0	5988
20456	DU in the environment	Brewer Dr T S	University of Leicester	IP/892/1105	■	■	■	■	■	■	■	■	■	35	10	18296
20457	Makalu	Searle Dr M P	University of Oxford	IP/893/1105	■	■	■	■	■	■	■	■	■	1	0	333
20458	Marine Isotope Stage 11 in the Benguela Current region	Maslin Prof M	University College London	IP/894/0506	■	■	■	■	■	■	■	□	□	4	4	1996
20461	British ice sheet to climate forcing	Austin Dr W	University of St Andrews	IP/898/0506	■	■	■	■	■	■	■	□	□	96	0	41915
20463	Palaeolakes from the Libyan Sahara	McLaren Dr S	University of Leicester	IP/904/0506	■	■	■	■	■	■	■	□	□	20	0	8649
20464	Post-medieval glass in Britain and Western Europe	Henderson Prof J	University of Nottingham	IP/905/0506	■	■	■	■	■	■	■	□	□	14	0	7319
20465	Microbeam (SIMS and LA-PIMMS) U-Pb geochronology	Condon Dr D J	NIGL	IP/913/0506	■	■	■	■	■	□	□	□	□	6	0	2994
20468	Constraints from the sediment record, Indus Molasse, Ladakh Himalaya	Najman Dr Y	Lancaster University	IP/959/1106	■	■	■	■	■	■	■	□	□	10	0	4657
20469	Freshwater in the Atlantic	Meredith Dr M	British Antarctic Survey	IP/919/1106	■	■	■	■	■	■	■	□	□	5	0	1996
20470	Carbon in Miocene	Lear Dr C	Cardiff University	IP/920/1106	■	■	■	■	■	■	■	□	□	10	0	4325
20473	Iranian bronze	Weeks Dr L	University of Nottingham	IP/924/1106	■	■	■	■	■	■	■	□	□	4	0	1996
20476	Mangrove spieces diversity	Kennedy Dr H	University of Wales, Bangor	IP/928/1106	■	■	■	■	■	■	■	□	□	10	0	4325
20477	Quaternary of Tanzania	Marchant Dr R	University of York	IP/931/1106	■	■	■	■	■	■	■	■	■	16	0	6986
20478	Seasonal rainfall Ethiopia	Baker Dr A	University of Newcastle	IP/932/1106	■	■	■	■	■	■	■	■	■	121	0	52893
20479	Siberian Traps	Reichow Dr M K	University of Leicester	IP/933/1106	■	■	■	■	■	■	□	□	□	10	0	5323
20480	Sr in modern sheep teeth	Montgomery Dr J	University of Bradford	IP/935/1106	■	■	■	■	■	■	□	□	□	1	0	333
20482	Erosimin Burma	Robinson Dr R	University of St Andrews	IP/943/1106	■	■	■	■	■	■	■	□	□	25	34	31104
20483	Productivity in African mountains	Barker Dr P	Lancaster University	IP/944/1106	■	■	■	■	■	■	■	■	■	10	10	5156
20485	Bitter Springs Ethiopia	Jenkin Dr G	University of Leicester	IP/947/1106	■	■	■	■	■	■	■	■	■	40	0	20292
20487	Subfossil record for interpreting extinctions	Turvey Dr S	Institute of Zoology	IP/950/1106	■	■	■	■	■	■	■	■	■	18	0	9647
20497	¿atalh¿y¿k sheep movement	Martin Dr L	University College London	IP/967/0507	■	■	■	■	■	■	■	□	□	21	0	11310
20498	Meditarranean climate - last 2 millennia	Jones Dr M D	University of Nottingham	IP/968/0507	■	■	■	■	■	■	■	■	■	22	0	9647
20501	European glass	Henderson Prof J	University of Nottingham	IP/974/0507	■	■	■	■	■	■	■	□	□	8	8	4990
20503	Influence of active uptake and efflux on rice Si isotope values	Bol Dr R	Institute of Grassland and Environmental	IP/1076/1108	■	■	■	■	■	□	□	□	□	6	0	2329

Project Type	Short Title	Project Leader	University / Institution	NIGFSC No	N	1	2	3	4	5	6	7	8	Staff Time	Facil. Time	Cost £
			Research													
20511	LA-ICP-MC-MS dating techniques and application - southwest Norway	Parrish Prof R R	University of Leicester	IP/994/1107	■	■	■	■	■	■	■	□	□	43	50	53725
20512	Southern Hemisphere maar lakes	Street-Perrott Prof F A	University of Wales Swansea	IP/995/1107	■	■	■	■	■	■	□	□	□	20	0	8649
20513	Belemnites and Mesozoic climate	McArthur Prof J M	University College London	IP/996/1107	■	■	■	■	■	■	■	□	□	11	0	4990
20514	Durrington Wales cattle	Albarella Dr U	University of Sheffield	IP/999/1107	■	■	■	■	■	■	■	■	□	22	0	11643
20516	Permo-Triassic sills and dikes	Saunders Prof A D	University of Leicester	IP/1003/1107	■	■	■	■	■	■	□	□	□	19	0	9980
20519	EARTHTIME Proof of Concept	Condon Dr D J	NIGL	IP/1011/1107	■	■	■	■	■	■	□	□	□	37	0	19294
20521	U/Pb dating of biogenic aragonite	McArthur Prof J M	University College London	IP/1069/1108	■	■	■	■	■	■	■	□	□	41	0	21956
20522	Temperature and precipitation proxies from recent lake archives in Patagonia	Langdon Dr P	Southampton Oceanography Centre	IP/1014/0508	■	■	■	■	■	■	■	■	■	2	0	665
20524	Trade, mobility and culture contact amongst the Early Medieval communities	Chamberlain Prof A T	University of Sheffield	IP/1017/0508	■	■	■	■	■	■	■	□	□	42	35	43828
20525	Late Quaternary climate change from southeast Arabia	Parker Dr A	Oxford Brookes University	IP/1020/0508	■	■	■	■	■	■	■	□	□	8	0	3659
20527	Variability of 235U-238U in accessory minerals	Condon Dr D J	NIGL	IP/1028/0508	■	■	■	■	■	□	□	□	□	170	0	86159
20528	The evolution of herding practices in Neolithic Çatalhöyük, Central Anatolia	Thomas Prof K D	University College London	IP/1039/0508	■	■	■	■	■	■	■	■	■	4	0	1996
20529	Biogeochemistry of the Mars Oasis ecosystem, Antarctica	Hodson Dr A J	University of Sheffield	IP/1041/0508	■	■	■	■	■	■	□	□	□	8	0	3659
20534	Culture, crops and climate	Jones Dr M D	University of Nottingham	IP/1051/0508	■	■	■	■	■	■	□	□	□	28	0	12308
20536	The genesis of major mountain belts	Warren Dr C	Open University	IP/1054/0508	■	■	■	■	■	■	□	□	□	20	36	32601
20537	Characterisation of symbiont populations in mussels	Kennedy Dr H	University of Wales, Bangor	IP/1057/0508	■	■	■	■	■	■	■	■	□	10	0	4325
20538	Using tooth wear to impose ecological constraints	Purnell Dr M A	University of Leicester	IP/1059/0508	■	■	■	■	■	■	■	■	■	11	0	5988
20539	The sources and pathways of nitrate-N in drainage water	White Dr S	Cranfield University	IP/1060/0508	■	■	■	■	■	■	□	■	□	34	0	14970
20540	Felsic volcano in NW Ethiopia	Prave Dr A R	University of St Andrews	IP/1024/0508	■	■	■	■	■	■	□	■	□	19	0	9647
20544	Sea level change in the Antarctica	Bentley Dr M	University of Durham	IP/1063/1108	■	■	■	■	■	■	■	■	■	92	0	40252
20545	South Africa speleothems	Hopley Dr P	University College London	IP/1065/1108	■	■	■	■	■	□	□	■	□	14	0	7319
20547	Exhumation in Eastern Alps	Bickle Prof M J	University of Cambridge	IP/1068/1108	■	■	■	■	■	■	□	■	□	23	30	30438
20548	Biodiversity in the Galapagos	Willis Prof K	University of Oxford	IP/1091/1108	■	■	■	■	■	■	■	■	■	28	0	12308
20550	Cuatrocienegas environmental change	Gonzalez Prof S	Liverpool John Moores University	IP/1096/0509	■	■	■	■	■	■	□	□	□	37	40	38589
20551	Environmental change in prehistoric nomadic pastoralists of Mongolia	Chamberlain Prof A T	University of Sheffield	IP/1112/0509	■	■	■	■	■	■	■	□	□	29	0	15302
20552	Drake Passage Mantle Gateway	Pearce Dr J A	University of Durham	IP/1077/1108	■	■	■	■	■	■	□	□	□	23	0	11976
20554	Coastal change in Denmark	Ryves Dr D	Loughborough University	IP/1080/1108	■	■	■	■	■	■	□	□	□	5	0	1996
20556	Asian Monsoon	Lloyd Dr J	University of Durham	IP/1083/1108	■	■	■	■	■	■	■	■	■	59	0	25615
20557	Extent and longevity of Indian Ocean-type mantle	Barry Dr T	Open University	IP/1098/0509	■	■	■	■	■	□	□	□	□	45	0	23952
20558	Subarctic Atlantic during the last glacial cycle	Swann Dr G	NIGL	IP/1072/1108	■	■	■	■	■	□	□	□	□	8	0	3659

Project Type	Short Title	Project Leader	University / Institution	NIGFSC No	N	1	2	3	4	5	6	7	8	Staff Time	Facil. Time	Cost £
20559	Environmental reconstruction in Olduvai Gorge	Marshall Prof J D	University of Liverpool	N/A	■	■	■	■	■	□	□	□	□	5	17	3077
20562	Early Modern Human migration out of Ethiopia	Baker Dr A	University of Birmingham	IP/1099/ 0509	■	■	■	■	■	■	□	□	□	17	16	15635
20563	Climatic variability in the northen hemisphere tropics	Metcalfe Prof S	University of Nottingham	IP/1100/ 0509	■	■	■	■	■	■	□	□	□	72	0	31270
20564	Calibrating the fractionation of stable in diatom silica	Tyler Dr J	Natural History Museum	IP/1101/ 0509	■	■	■	□	□	□	□	□	□	29	0	12641
20565	Identifying the initiation of the last British ice-sheet	Austin Dr W	University of St Andrews	IP/1103/ 0509	■	■	■	■	■	■	■	□	□	54	0	28942
20566	Low-latitude monsoonal circulation in response to the onset of Northern Hemisphere glaciation	Maslin Prof M	University College London	IP/1104/ 0509	■	■	■	■	■	■	□	□	□	19	10	13473
20568	Lake level changes at Loannina, northwest Greece	Lawson Dr I	University of Leeds	IP/1107/ 0509	■	■	■	■	■	■	■	□	□	29	0	12641
20569	Pliocene climate and oceanography of the North Atlantic region	Johnson Dr A L A	University of Derby	IP/1108/ 0509	■	■	■	■	■	■	■	□	□	15	24	18962
20570	Tectonomagmatic origin of Trinidad and Tobago	Kerr Dr A C	Cardiff University	IP/1111/ 0509	■	■	■	■	■	■	□	□	□	19	20	22288
20571	The origins of nomadic pastoralism	Pearson Dr J	University of Liverpool	IP/1118/ 0509	■	■	■	□	□	□	□	□	□	21	30	29441
20572	Palaeo-ecological records of terrestrial run-off and sediment influence on coral reef ecosystems	Perry Prof C	Manchester Metropolitan University	IP/1122/ 0509	■	■	■	■	■	■	□	□	□	27	20	21956
20574	Testing the phylogeny of Early Cambrian animals	Williams Dr M	University of Leicester	IP/1124/ 0509	■	■	■	■	■	■	■	■	■	34	0	15968
20576	Nitrogen in hyporheic zone	Heppell Dr K	Queen Mary, University of London	IP/1131/ 1109	■	■	■	■	■	□	□	□	□	4	0	1663
20577	NSINK subglacial processes	Hodson Dr A J	University of Sheffield	IP/1133/ 1109	■	□	□	□	□	□	□	□	□	1	0	333
20579	Speleothems as records of environmental change	Andrews Prof J E	University of East Anglia	IP/1136/ 1109	■	■	■	■	■	□	□	□	□	4	17	12724
20583	Svalbard PETM	Harding Dr I C	University of Southampton	IP/1157/ 1109	■	■	■	■	■	□	□	□	□	10	0	5323
20586	Evolution of the Eastern (Namche Barwa) Himalayan Syntaxis	Searle Dr M P	University of Oxford	N/A	■	□	□	□	□	□	□	□	□	20	30	9148
															Total University Projects	**1,273,676**

Annex 13 (optional)
Visiting Scientists and Students

Al Dughairi, Ahmed (Dr)	University of Leicester
Amezcua, Natalia	University of Manchester (PhD student)
Anderson, John (Prof)	University of Loughborough
Anderson, Morton (Dr)	University of Bristol
Andrews, Jonathan	University of Nottingham (PhD student)
Ault, Gregory	University of Nottingham (BSc student)
Austin-Giddings, Wendy	University College London (PhD student)
Badenszki, Eszter (Dr)	University College Dublin, Ireland
Bailey, Elizabeth (Dr)	University of Nottingham
Balaram, V (Prof)	National Geophysical Research Institute Hyderabad, Andhra Pradesh, India
Barker, Phil (Dr)	University of Lancaster
Barry, Tiffany (Dr)	Open University, Milton Keynes
Bird, Annemarie	University of Derby (PhD student)
Boogard, Amy (Dr)	University of Oxford
Brezina, Cynthia	University of St. Andrews (PhD student)
Brodie, Christopher	University of Durham (PhD student)
Chamberlain, Andrew (Prof)	University of Sheffield
Cheluk-Barton, Tracey	University of Leicester (BSc student)
Clark, Nicola	University of Leicester (BSc student)
Collard, David	University of Nottingham (PhD student)
Connelly, Jim (Prof)	Geological Museum, Copenhagen, Denmark
Cooper, Francis (Dr)	Arizona State University, Arizona, USA (Post Doc)
Crowley, Stephen (Dr)	University College Liverpool
Curtis, Chris (Dr)	University College London
Darren, Mark (Dr)	Scottish Universities Environmental Research Centre, Glasgow
Dean, Jonathan	University of Nottingham (BSc student)
Dewit, Liam	South Wolds Community School, Keyworth (Work experience)
Douarin, Melanie	The Scottish Association for Marine Science, Argyll (PhD student)
Eagan, Katherine	University of Oxford (PhD student)
Elton, Sarah (Dr)	University of Hull
Fanning, Mark	The Australian National University, Canberra, Australia
Feldstead, Nick	John Moores University Liverpool (PhD student)
Fitches, William (Dr)	Aberystwyth University
Fraser, Rebecca (Dr)	University of Oxford
Gärtner, Claudia	University of Münster, Germany (PhD student)
Gledhill, Andrew (Mr)	University of Bradford
Grenwood, Lucy	University of Cambridge (PhD student)
Hadley, Dawn (Dr)	University of Sheffield
Hammond, Matthew (Dr)	University of Leicester

Harvey, Tom (Dr)	University of Leicester
Hastie, Alan (Dr)	Cardiff University (PhD student)
Hemer, Katie	University of Sheffield (PhD student)
Henderson, Julian (Prof)	University of Nottingham
Heredia, Benjamín	University of Aarhus, Aarhus, Denmark (MSc student)
Hong, Jiao	University of Nottingham (PhD student)
Horak, Jana (Dr)	Museum of Wales, Cardiff
Jamieson, Rachel	University of Edinburgh (PhD student)
Jay, Mandy (Dr)	University of Bradford
Jenkin, Gawen (Dr)	University of Leicester
Jex, Catherine (Dr)	University of Birmingham
Jones, David (Dr)	University of Leicester
Jones, Matthew (Dr)	University of Nottingham
Kanstrup, Marie	University of Oxford (PhD student)
Kellett, Dawn	Dalhousie University Halifax, Nova Scotia, Canada (PhD student)
Kincaid, Laura	University of Nottingham (BSc student)
Lawley, Chris	University of Durham (PhD student)
Lewis, Jon (Dr)	Central Science Laboratory, York
Li, Qiong	University College London (PhD student)
Liu, Alexander	University of Oxford (PhD student)
Lloyd, Nicholas	University of Leicester (PhD student)
Ma, Hongjiao	University of Nottingham (PhD student)
Machicek, Michelle	University of Sheffield (PhD student)
Madgwick, Richard	Cardiff University (PhD student)
Mason, John	Aberystwyth University
McLaren, Sue (Dr)	University of Leicester
Meek, Andrew (Dr)	University of Nottingham
Metcalfe, Sarah (Prof)	University of Nottingham
Miller, Holly	University of Liverpool (PhD student)
Montgomery, Janet (Dr)	University of Bradford
Müldner, Gundula (Dr)	University of Reading
Najman, Yani (Dr)	University of Lancaster
Neill, Iain	Cardiff University (PhD student)
Nesbitt, Robert (Prof)	University of Southampton
O'Regan, Hannah (Dr)	John Moores University Liverpool
Palin, Richard	University of Oxford (PhD student)
Patwardhan, Siddharth (Dr)	Trent University Nottingham
Paull, James	University of Nottingham (BSc student)
Pike, Jennifer (Dr)	Cardiff University
Ponting, Matthew (Dr)	University of Liverpool
Prissik, Simon	University of Southampton (BSc student)

Ramsay, Alice	University of Wales, Bangor (PhD student)
Rayner, Max	University of Nottingham (BSc student)
Reichow, Marc (Dr)	University of Leicester
Richards, David (Dr)	University of Bristol
Riley, David	University of Leicester (PhD student)
Roberts, Nicholas	University of Leicester (PhD student)
Roche, Ronan	Manchester Metropolitan University (PhD student)
Rushworth, Elizabeth	University of Liverpool (PhD student)
Ryves, David (Dr)	University of Loughborough
Sahy, Diana	BOKU University Vienna, Austria (PhD student)
Searle, Michael (Prof)	University of Oxford
Sears, Adam	Royal Holloway University London (MSc student)
Sherlock, Sarah (Dr)	Open University, Milton Keynes
Singer, Brad (Prof)	University of Wisconsin, Madison, USA
Smye, Andrew	University of Cambridge (PhD student)
Stanislawska, Maya	Trinity College Dublin
Streule, Michael	University of Oxford (PhD student)
Styring, Amy	University of Bristol (PhD student)
Thomson, Craig	Ferwood School, Nottingham
Tyler, Jonathan (Dr)	University of Oxford
Vandenbroucke, Thijs (Dr)	Université de Lille 1, Gent, Belgium
Wallace, Michael	University of Sheffield (PhD student)
Warren, Clare (Dr)	Open University, Milton Keynes
Watcham, Emma	University of Durham (PhD student)
Water, Dick (Dr)	Museum of Wales, Cardiff
Webb, Karen	University of Nottingham (PhD student)
Weeks, Lloyd (Dr)	University of Nottingham
Wheely, James (Dr)	University of Birmingham
Wickens, Leretta	University of East Anglia, Norwich (PhD student)
Williams, Mark (Dr)	University of Leicester
Wilson, Katy	University College London (PhD student)
Young, Adam	University College London (PhD student)
Young, Scott (Dr)	University College Nottingham
Zwalasiewicz, Jan (Dr)	University of Leicester

Annex 14 (optional)
Selected Abstracts Highlighting Current Research

ABRAHAMSEN, E.P., MEREDITH, M.P., KENISON FALKNER, K., TORRES-VALDES, S., LENG, M.J., ALKIRE, M.B., BACON, S., LAXON, S.W., POLYAKOV, I. AND IVANOV, V., 2009.

Tracer-derived freshwater composition of the Siberian continental shelf and slope following the extreme Arctic summer of 2007.

Geophysical Research Letters 36(7): L07602, 5pp.

http://nora.nerc.ac.uk/6378/

We investigate the freshwater composition of the shelf and slope of the Arctic Ocean north of the New Siberian Islands using geochemical tracer data (δ18O, Ba, and PO4*) collected following the extreme summer of 2007. We find that the anomalous wind patterns that partly explained the sea ice minimum at this time also led to significant quantities of Pacific-derived surface water in the westernmost part of the Makarov Basin. We also find larger quantities of meteoric water near Lomonosov Ridge than were found in 1995. Dissolved barium is depleted in the upper layers in one region of our study area, probably as a result of biological activity in open waters. Increasingly ice-free conditions compromise the quantitative use of barium as a tracer of river water in the Arctic Ocean.

ANGIOLINI, L., JADOUL, F., LENG, M.J., STEPHENSON, M.H., RUSHTON, J., CHENERY, S. & CRIPPA, G., 2009.

How cold were the Early Permian glacial tropics? Testing sea-surface temperature using the oxygen isotope composition of rigorously screened brachiopod shells.

Journal of the Geological Society, London, 166: 933-945.

http://nora.nerc.ac.uk/8059/

Brachiopod carbonate from Early Permian brachiopod shells from low palaeolatitude north Iran and higher palaeolatitude Pakistan Karakorum were screened for diagenesis and analysed for oxygen isotope ratios to derive seawater palaeotemperatures. Screening techniques employed included SEM ultrastuctural analysis, cathodoluminescence (CL), image analysis of CL images, trace-element (Sr, Mn, Fe) determinations, and carbon and oxygen stable-isotope determinations. The Karakorum shells were found to be diagenetically altered, but those from north Iran were judged to be pristine. Using data from pristine material, two distinct time slices were analysed: the early and middle Asselian. The maximum calculated temperatures in the middle Asselian are about 2 oC lower than those for the early Asselian. The average temperature for both time slices is similar to modern tropical sea-surface temperatures, indicating that low-latitude Early Permian ocean waters in Iran did not undergo significant cooling during the final Glacial III episode of Gondwanan glaciation. This confirms other evidence based on biotic provinces, which suggests that during the Permo-Carboniferous glaciation, the low-latitude warm belt became narrower and confined to the western Tethys and Cathaysian provinces, and was not subject to a reduction in temperature, but rather a reduction in size.

BUGLER, M.J., GRIMES, S.T., LENG, M.J., RUNDLE, S.D., PRICE, G.D., HOOKER, J.J. & COLLINSON, M.E., 2009.

Experimental determination of a Viviparus contectus thermometry equation.

Rapid Communications in Mass Spectrometry 23(18): 2939-2951.

Experimental measurements of the (18)O/(16)O isotope fractionation between the biogenic aragonite of Viviparus contectus (Gastropoda) and its host freshwater were undertaken to generate a species-specific thermometry equation. The temperature dependence of the fractionation factor and the relationship between DELTA(18)O ((delta(18)O(carb.) - delta(18)O(water)) and temperature were calculated from specimens maintained under laboratory and field (collection and cage) conditions. The field specimens were grown (Somerset, UK) between August 2007 and August 2008, with water samples and temperature measurements taken monthly. Specimens grown in the laboratory experiment were maintained under constant temperatures (15 degrees C, 20 degrees C and 25 degrees C) with water samples collected weekly. Application of a linear regression to the datasets indicated that the gradients of all three experiments were within experimental error of each other (+/-2 times the standard error); therefore, a combined (laboratory and field data) correlation could be applied. The relationship between DELTA(18)O (delta(18)O(carb.) - delta(18)O(water)) and temperature (T) for this combined dataset is given by: T = - 7.43(+ 0.87, - 1.13)*DELTA18O + 22.89(+/- 2.09) (T is in degrees C, delta(18)O(carb.) is with respect to Vienna Pee Dee Belemnite (VPDB) and delta(18)O(water) is with respect to Vienna Standard Mean Ocean Water (VSMOW). Quoted errors are 2 times standard error).Comparisons made with existing aragonitic thermometry equations reveal that the linear regression for the combined Viviparus contectus equation is within 2 times the standard error of previously reported aragonitic thermometry equations. This suggests there are no species-specific vital effects for Viviparus contectus. Seasonal delta(18)O(carb.) profiles from specimens retrieved from the field cage experiment indicate that during shell secretion the delta(18)O(carb.) of the shell carbonate is not influenced by size, sex or whether females contained eggs or juveniles.

CHAN, G.H., WATERS, D.J., SEARLE, M.P., AITCHISON, J., HORSTWOOD, M.S.A., CROWLEY, Q.G., LO, C.-H. & CHAN, J.S.-L., 2009.

Probing the basement of southern Tibet: evidence from crustal xenoliths entrained in a Miocene ultrapotassic dyke.

Journal of the Geological Society, London, 166: 45-52.

http://nora.nerc.ac.uk/5717/

A variety of felsic and mafic granulites and ultramafic rocks occur as xenoliths within a 12.7 Ma ultrapotassic dyke intruding Xigaze flysch immediately to the north of the Yarlung–Tsangpo suture zone in southern Tibet. Garnet–clinopyroxene–plagioclase–quartz thermobarometry on mafic granulite xenoliths gives temperatures of 1130–1330 °C and pressures between 22 and 26 kbar indicating equilibration in the high-pressure and ultrahigh-temperature granulite field and defining a geotherm of *c*. 16 °C km^{-1}. Ultramafic xenoliths consist mainly of hornblende and biotite, probably of restitic crustal rather than mantle origin, and attained peak metamorphic conditions of 920–1130 °C and 17–24 kbar, whereas felsic granulites equilibrated at 870–900 °C at an inferred pressure of 17 kbar. *In situ* U–(Th)–Pb laser ablation inductively coupled plasma mass spectrometry dating of zircons shows that protoliths may include Proterozoic basement rocks, Late Cretaceous calc-alkaline tonalites of the Gangdese batholith root and/or remnants of a Neo-Tethyan oceanic arc. Certain zircons from a felsic granulite and an ultramafic xenolith have mean $^{206}Pb/^{238}U$ ages of 16.8 ± 0.9 Ma and 15.6 ± 0.6 Ma, respectively, and monazites from a micaceous xenolith yielded a mean $^{208}Pb/^{232}Th$ age of 14.4 ± 0.4 Ma. These results show that the southern Tibet basement reached a thickness of *c*. 80 km by 17–14 Ma at the latest and has remained unchanged until the present day.

CHEPSTOW-LUSTY, A.J., FROGLEY, M.R., BAUER, B.S., LENG, M.J., BOESSENKOOL, K.P., CAARCAILLET, C., ALI, A.A. & GIODA, A., 2009.

Putting the rise of the Inca Empire within a climatic and land management context.

Climate of the Past, 5: 375-388.

The rapid expansion of the Inca from the Cuzco area of highland Peru (ca. AD 1400-1532) produced the largest empire in the New World. Although this meteoric growth may in part be due to the adoption of innovative societal strategies, supported by a large labour force and a standing army, we argue that it would not have been possible without increased crop productivity, which was linked to more favourable climatic conditions. We present a multi-proxy, high-resolution 1200-year lake sediment record from Marcacocha, 12 km north of Ollantaytambo, in the heartland of the Inca Empire. This record reveals a period of sustained aridity that began from AD 880, followed by increased warming from AD 1100 that lasted beyond the arrival of the Spanish in AD 1532. These increasingly warmer conditions would have allowed the Inca and their immediate predecessors the opportunity to exploit higher altitudes (post-AD 1150) by constructing agricultural terraces that employed glacial-fed irrigation, in combination with deliberate agroforestry techniques. There may be some important lessons to be learnt today from these strategies for sustainable rural development in the Andes in the light of future climate uncertainty.

CLEMENS, J.D., DARBYSHIRE, D.F.P. & FLINDERS, J., 2009.

Sources of post-orogenic calcalkaline magmas: the Arrochar and Garabal Hill-Glen Fyne complexes, Scotland.

Lithos, 112: 524-542.

http://nora.nerc.ac.uk/8480/

The 425 Ma Arrochar and Garabal Hill–Glen Fyne complexes of highland Scotland are examples of post-orogenic magmatism accompanying extensional collapse of an orogen, in this case the Caledonian. The rocks are dominantly high-K series, but range from medium-K to shoshonitic. Mantle upwelling, melting and the intrusion of large volumes of mafic magma into the crust are inferred to have accompanied lithospheric thinning, and to have provided the heat source for melting of young arc crust accreted during the preceding subduction epoch. Fluids evolved from the subducting slab are inferred to have caused high degrees of enrichment in the overlying mantle wedge. Deep in the crust, the mantle-derived, K-rich mafic to intermediate magmas mixed with felsic crustal melts to form the spectrum of magmas intruded in the two complexes. Microgranular enclaves in the granitic rocks represent mafic magmas derived from the enriched mantle and hybridised by reaction, diffusion and mechanical mixing with their host felsic magmas, but they do not form part of the evolutionary series that produced the host magmas. Rather than inheriting its LILE-enriched character directly from crustal melts, or from crustal assimilation by mafic magmas, the high-K series may commonly owe at least part of its potassic character to the involvement of mantle (highly metasomatised by slab-derived fluids) as a major magma source. Enclave suites, though prominent in some granitic rocks should not be assumed to represent magmas that played a significant role in the production of the chemical variations in their host magmas.

COLOMBO, F., BALDO, E.G.A., CASQUET, C., PANKHURST, R.J., GALINDO, C., RAPELA, C.W., DAHLQUIST, J.A. & FANNING, C.M., 2009.

A-type magmatism in the sierras of Maz and Espinal: A new record of Rodinia break-up in the Western Sierras Pampeanas of Argentina.

Precambrian Research, 175(1-4): 77-86.

http://nora.nerc.ac.uk/8717/

Two orthogneisses have been recognized in the sierras of Espinal and Maz (Western Sierras Pampeanas, NW Argentina) that were emplaced within a Grenvillian metasedimentary sequence. Microcline, plagioclase and quartz are the main rockforming minerals, with accessory zircon, apatite-(CaF), magnetite, biotite (Fe/(Fe+Mg) = 0.88-0.91), ferropargasite (Fetotal/(Fetotal + Mg) = 0.88-0.89), titanite (with up to 1.61 wt.% Y2O3) and an REE-rich epidote. REE-poor epidote and zoned garnet (Ca and Fe3+- rich) are metamorphic minerals, while muscovite, carbonates and chlorite are secondary phases. Texture is mylonitic. Two representative samples are classified as granite (from Sierra de Espinal) and granodiorite/tonalite (from Sierra de Maz) on the grounds of immobile trace elements. Some trace element contents are rather high (Zr: 603 and 891 ppm, Y: 44 and 76 ppm, 10000*Ga/Al: 2.39-3.89) and indicate an affiliation with A-type granites (more specifically, the A2 group). Both samples plot in the field of within-plate granites according to their Y and Nb contents. Concordant crystallization ages (zircon U-Pb SHRIMP) are 842 ± 5 and 846 ± 6 Ma respectively. $87Sr/86Sr_i$ (845) ratios are 0.70681 and 0.70666; ε_{Ndi} (845) values are -1.5 and +0.3 and depleted mantle Nd model ages (2TDM*) are 1.59 and 1.45 Ga respectively. These values indicate the involvement of an isotopically evolved source. 2TDM* values are compatible with the presence of inherited zircon crystals of up to 1480 Ma in one of the rocks, thus implying that magmas incorporated material from Mesoproterozoic continental source. This is also indicated by the relatively high contents of Y, Ga, Nb and Ce compared to magmas derived from sources similar to those of oceanic-island basalts. These orthogneisses represent a period of extension at ca. 845 Ma affecting the Western Sierras Pampeanas continental crust that was already consolidated after the Grenvillian orogeny (1.2 – 1.0 Ga). They are thus a record of the early stages of Rodinia break-up. Metamorphic conditions during the subsequent Famatinian orogenic cycle (ca. 420 Ma, SHRIMP U-Pb on zircon) attained 7.7 ± 1.2 kbar and 664 ± 70ºC.

COTTLE, J.M., HORSTWOOD, M.S.A. & PARRISH, R.R., 2009.

A new approach to single shot laser ablation analysis and its application to in situ Pb/U geochronology

Journal of Analytical Atomic Spectrometry, 24(10): 1355-1363.

http://nora.nerc.ac.uk/9489/

A novel approach to laser ablation Pb/U geochronology is presented that allows accurate determination of isotope ratios from a single pulse of a 193 nm laser. Data are acquired using a low volume ablation cell that facilitates: (1) production of a high density particle stream; and (2) a short (c. 0.5 s) sample washout time. Isotope ratios from an individual laser pulse are calculated by integrating the baseline-subtracted total number of counts for the entire pulse and assigning an internal uncertainty based on counting statistics. This 'total signal integration' method eliminates the effects of differing detector response times, particularly in multi-collector-inductively coupled plasma-mass spectrometry (MC-ICP-MS), providing an alternative means to quantify transient signals. Data from reference zircons indicate that it is possible to consistently measure $^{206}Pb/^{238}U$ and $^{207}Pb/^{206}Pb$ ratios with external reproducibilities of 2% and 2.8% (2SD) respectively, using a similar amount of material to standard static ablation protocols. Decreasing sample consumption to similar to 14 ng zircon (similar to 75% less than the 'normal' ablated mass) results in only a modest increase in the uncertainty to similar to 5% on the $^{206}Pb/^{238}$ U ratio. By analysing consecutive laser pulses from the same ablation site, isotopic depth profiles can be generated with a depth resolution of similar to 0.1 mu m pulse(-1). This technique offers a new opportunity to identify complexities within accessory minerals that were previously beyond the spatial resolution of laser based geochronology methods.

COTTLE, J.M., JESSUP, M.J., NEWELL, D.L., HORSTWOOD, M.S.A., NOBLE, S.R., PARRISH, R.R., WATERS, D.J. & SEARLE, M.P., 2009.

Geochronology of granulitized eclogite from the Ama Drime Massif: implications for the tectonic evolution of the South Tibetan Himalaya.

Tectonics, 28: TC1002, *doi:10.1029/2008TC002256*

http://nora.nerc.ac.uk/7149/

The Ama Drime Massif (ADM) is an elongate north-south trending antiformal feature that extends similar to 70 km north across the crest of the South Tibetan Himalaya and offsets the position of the South Tibetan Detachment system. A detailed U(-Th)-Pb geochronologic study of granulitized mafic eclogites and associated rocks from the footwall of the ADM yields important insights into the middle to late Miocene tectonic evolution of the Himalayan orogen. The mafic igneous precursor to the granulitized eclogites is 986.6 +/- 1.8 Ma and was intruded into the paleoproterozoic (1799 +/- 9 Ma) Ama Drime orthogneiss, the latter being similar in age to rocks previously assigned to the Lesser Himalayan Series in the Himalayan foreland. The original eclogite-facies mineral assemblage in the mafic rocks has been strongly overprinted by granulite facies metamorphism at 750 degrees C and 0.7-0.8 GPa. In the host Ama Drime orthogneiss, the granulite event is correlated with synkinematic sillimanite-grade metamorphism and muscovite dehydration melting. Monazite and xenotime

ages indicate that the granulite metamorphism and associated anatexis occurred at < 13.2 +/- 1.4 Ma. High-grade metamorphism was followed by postkinematic leucogranite dyke emplacement at 11.6 +/- 0.4 Ma. This integrated data set indicates that high-temperature metamorphism, decompression, and exhumation of the ADM postdates mid-Miocene south directed midcrustal extrusion and is kinematically linked to orogen-parallel extension.

COTTLE, J.M., SEARLE, M.P., HORSTWOOD, M.S.A. & WATERS, D.J., 2009.

Timing of midcrustal metamorphism, melting, and deformation in the Mount Everest region of Southern Tibet revealed by U(-Th)-Pb geochronology

Journal of Geology, 117(6): 634-664.

http://nora.nerc.ac.uk/9490/

U(-Th)-Pb dating of zircon, monazite, and xenotime from metamorphic and igneous rocks at two outcrops along a north-south transect in the Mount Everest region of southern Tibet provide new constraints on the timing and duration of thermal events associated with channel flow and the ductile extrusion of the Greater Himalayan Series (GHS). At the southernmost outcrop in the Kangshung Valley, Th-Pb ages from monazite indicate that prograde metamorphism associated with crustal thickening following the India-Asia collision occurred at least as early as 38.9 +/- 0.9 Ma. A subsequent sillimanite-grade metamorphic event at 28.0 +/- 1.2 Ma was followed by two phases of leucogranite emplacement at 20.8 +/- 0.8 and 16.7 +/- 0.4 Ma. At Thongmon, similar to 40 km to the northeast of the Kangshung Valley, prograde metamorphism was occurring at c. 25.4 Ma and lasted until 16.1 +/- 0.1 Ma, reaching similar to 740 degrees C and 5 kbar at 22.4 +/- 0.2 Ma. Immediately following metamorphism, two phases of leucogranite were emplaced at 15.2 +/- 0.2 and 12.6 +/- 0.2 Ma, with an intervening phase of ductile deformation. These data combined with ages from the Rongbuk glacier and Ama Drime range, north and east of Everest and the North Himalayan Mabja dome 100-140 km to the northeast, suggest that GHS metamorphism lasted similar to 20 m.yr. and that migmatization and south-directed channel flow peaked around similar to 23-20 Ma and ended by similar to 16 Ma. The youngest leucogranites crosscut all ductile fabrics related to the Miocene channel flow.

DOMINGO, L., LÓPEZ-MARTÍNEZ, N., LENG, M.J. & GRIMES, S.T., 2009.

The Paleocene-Eocene Thermal Maximum record in the organic matter of the Claret and Tendruy continental sections (South Central Pyrenees, Lleida, Spain).

Earth and Planetary Science Letters, 281: 226-237.

http://nora.nerc.ac.uk/6983/

The Carbon Isotope Excursion (CIE) associated with the Paleocene-Eocene Thermal Maximum (PETM) has been detected for the first time in the total organic carbon (TOC) contained within the continental sediments of the Tremp Formation (South Central Pyrenees, Lleida, Spain). The δ13CTOC magnitude of the CIE is ~4.3‰ in the Claret section and ~3.0‰ in the Tendruy section with minimum values of –27.6‰ and –26.7‰, respectively. Previous studies have detected the CIE in the South Central Pyrenees in both marine carbonates and within continental soil carbonate nodules. These studies have located the onset of the CIE either above or within the Claret Conglomerate, interpreted as a megafan produced by a profound change in the precipitation regimen at the beginning of the PETM. Our higher resolution δ13CTOC study in the Claret and Tendruy sections places the onset of the CIE below the base of the Claret Conglomerate and therefore suggests a 4 to 9 kyr time lag between the onset of the CIE and an increase in intense seasonal precipitation rates. Furthermore, this study suggests that the CIE took place ~30–55 kyr after the deposition of important late Cernaysian Tremp mammalian sites (Claret-4, Tendruy-V, Tendruy and Palau) which contain the youngest known occurrence of endemic Paleocene mammalian taxa in Europe before the Mammalian Dispersal Event (MDE, migration of new mammal groups, such as perissodactyls, artiodactyls, primates, marsupials, carnivores, creodonts and rodents). The first immigrant mammals in Europe are recorded at Dormaal (Belgium) above a hiatus, the base of which has been dated to around the start of the CIE. Our data indicate that the MDE might have in fact occurred in Europe within a time interval of about 67 kyr around the CIE onset.

ECKARDT, H., CHENERY, C., BOOTH, P., EVANS, J.A., LAMB, A. & MÜLDNER, G., 2009.

Oxygen and strontium isotope evidence for mobility in Roman Winchester.

Journal of Archaeological Science, 36: 2816-2825.

http://nora.nerc.ac.uk/8472/

Artefacts and burial rites in the late Roman cemetery at Lankhills School, Winchester, southern England, were used by Clarke (1979) to distinguish between local Romano-British individuals and migrants thought to be from the Danube region, a suggestion tested through isotope analysis by Evans et al. (2006a,b). This paper reports strontium ($^{87}Sr/^{86}Sr$) and oxygen ($\delta^{18}O$) isotope data for tooth enamel sampled from a further 40 individuals from more recent excavations on the same site. Results suggest that up to a quarter of the sampled Lankhills individuals were incomers, with several individuals possibly originating from the Hungarian Basin and the Southern Mediterranean. However, there was no clear link between isotopic signature and archaeological origin attribution, suggesting that in many cases burial practice was dictated by factors other than 'ethnicity', such as kinship, marriage or cultural and political preferences.

EVANS, J.A. & BULLMAN, R., 2009.

$^{87}Sr/^{86}Sr$ isotope fingerprinting of Scottish and Icelandic migratory shorebirds.

Applied Geochemistry, 24: 1927-1933.

http://nora.nerc.ac.uk/8179/

Biosphere Sr isotope composition data from Iceland and Scotland suggest that terrestrially feeding birds from these two countries will have significantly different $^{87}Sr/^{86}Sr$ isotope composition in their tissues. The aim of this study is to test if these differences can be measured within the bone and feather of migratory wading birds, who feed terrestrially as juveniles, thus providing a provenance tool for these birds. The study shows that birds can be distinguished on the basis of the Sr isotope composition of their bone. The field for Icelandic birds is defined by data from juvenile common redshank (Tringa totanus) and whimbrel (Numenius phaeopus) which give 0.7056 ± 0.0012, (2r, n = 7). The majority of Scottish birds in this study are from coastal regions and have a signature close to that of seawater of 0.7095 ± 0.0006 (2σ, n = 9). The Sr ratios in the body tissue of these two populations of all Icelandic and Scottish adult and juvenile birds analysed are significantly different ($p < 0.001$, at 95% confidence limits). Scottish birds from inland areas such as a common snipe (Gallinago gallinago) record $^{87}Sr/^{86}Sr$ values as high as 0.7194 which reflect their non-marine diet. Icelandic redshank (Tringa totanus robusta) that have flown to Scotland and returned to Iceland show the effect of the Scottish contribution to their diet with elevated values of 0.7086 ± 0.0004, (2r, n = 6). Redshank found in Scotland that cannot be classified on the basis biometric analysis are shown to be of Icelandic origin and analysis of the primary feathers from two birds demonstrates that isotope variation between feathers could be used to track changes in diet related to the timing of individual feather growth.

EVANS, J.A., MONTGOMERY, J. & WILDMAN, G., 2009.

Isotope domain mapping of 87Sr/86Sr biosphere variation on the Isle of Skye, Scotland.

Journal of the Geological Society, London, 166: 617-631.

http://nora.nerc.ac.uk/7960/

The potential of $^{87}Sr/^{86}Sr$ isotope composition for tracking and determining the origin of material, whether it is humans, animals, water or wine can be fully realized only if high-quality reference datasets are available against which to compare the unknowns. This is currently not the case. Despite the rapid increase in $^{87}Sr/^{86}Sr$-based provenance studies of biosphere materials there are no well-documented maps available. Most researchers resort to generating reference maps from a variety of geological datasets plus the analysis of sparse 'environmental' samples. A major reason for this lack of reference material is the investment needed to undertake systematic sampling and analysis over large areas. A further problem is associated with the choice of proxy material, as organisms differ in their habitat and exploitation of resources. In this paper various approaches to isotope biosphere sampling are considered, some of the problems are assessed, the precision required for the study of human populations is discussed, and a first attempt is made to condense all of the available information into an 'isotope package' map. The work is based on a study undertaken on the Isle of Skye, in the Inner Hebrides, and reduces the complexity of geological and isotope data into five main $^{87}Sr/^{86}Sr$ packages: Package 1 (northern area) = 0.705–0.7092; Package 2 (NE coast) = 0.7082–0.7102; Package 3 (granitic rocks) = 0.716–0.720; Package 4 (metamorphic rocks) = 0.7092–0.7188; Package 5 (seawater) = 0.7092 ± 0.005% (2). The approach of trying to constrain the isotope composition of certain areas and/or lithologies offers the possibility of extrapolating to other similar areas without having to sample at the original density.

EVANS, J.A., ZALASIEWICZ, J.A. & CHOPEY-JONES, A., 2009.

Facies effects on the behaviour of Nd and Sr isotope systems in turbidite mudrocks during diagenesis.

Sedimentology, 56: 863-872.

http://nora.nerc.ac.uk/7818/

A detailed Sm/Nd, epsilon Nd and Rb/Sr profile through a 30-cm thick section of Silurian (Llandovery) interbedded turbiditic and hemipelagic mudrocks from the central Wales Basin shows well-marked chemical and isotopic trends. The variations reflect an interplay of depositional mode and diagenetic fractionation. Sm and Nd values are substantially higher and Sm/Nd ratios tend to be lower in the organic-rich hemipelagite layers due to diagenetic concentration in the hemipelagites. There is a corresponding depletion in the turbidite mudstones. Epsilon Nd values range from −6·8 to −7·1 and this is attributed to diagenetic modification of Sm/Nd ratios causing scatter in back-calculated epsilon values. Rubidium–strontium ratios in this succession fall within a narrow range, due to homogenization during diagenesis. By contrast, data from a hemipelagite-dominated (condensed) succession near the northern margin of the Welsh Basin show a lower range of epsilon Nd values and a higher scatter of Rb/Sr values, consistent with less fluid throughput during burial compaction and hence less diagenetic redistribution in these rocks. These patterns demonstrate the sensitivity of mudrock trace element and isotope compositions to both small-scale sedimentary structure and large-scale basin architecture.

FINCH, J.M., LENG, M.J. & MARCHANT, R.A., 2009.

Late Quaternary vegetation dynamics in a biodiversity hotspot, the Uluguru Mountains of Tanzania.

Quaternary Research 72: 111-122

http://nora.nerc.ac.uk/7677/

Late Quaternary vegetation history and environmental changes in a biodiverse tropical ecosystem are inferred from pollen, charcoal and carbon isotope evidence derived from a 48,000-yr sedimentary record from the Uluguru Mountains, a component of the Eastern Arc Mountains of Kenya and Tanzania. Results indicate that Eastern Arc forest composition has remained relatively stable during the past 48,000 yr. Long-term environmental stability of the Eastern Arc forests has been proposed as a mechanism for the accumulation and persistence of species during glacial periods, thus resulting in the diverse forests observed today. The pollen and isotope data presented here indicate some marked changes in abundance but no significant loss in moist forest taxa through the last glacial maximum, thereby providing support for the long-term environmental stability of the Eastern Arc. Anthropogenic activities, including burning and forest clearance, were found to play a moderate role in shaping the mosaic of forest patches and high-altitude grasslands that characterise the site today; however, this influence was tempered by the inaccessibility of the mountain.

FLOWERDEW, M.J., CHEW, D.M., DALY, J.S. & MILLAR, I.L., 2009.

Hidden Archaean and Palaeoproterozoic crust in NW Ireland? Evidence from zircon Hf isotopic data from granitoid intrusions.

Geological Magazine, 146(6): 903-916.

http://nora.nerc.ac.uk/8844/

The presence of major crystalline basement provinces at depth in NW Ireland is inferred from in situ Hf isotope analysis of zircons from granitoid rocks that cut structurally overlying metasedimentary rocks. Granitoids in two of these units, the Slishwood Division and the Tyrone Central Inlier, contain complex zircons with core and rim structures. In both cases, cores have average εHf values that differ from the average {epsilon}Hf values of the rims at 470 Ma (the time of granitoid intrusion). The Hf data and similarity in U–Pb age between the inherited cores and detrital zircons from the host metasedimentary rocks suggests local contamination during intrusion rather than transport of the grains from the source region at depth. Rims from the Slishwood Division intrusions have average {epsilon}Hf470 values of –7.7, consistent with a derivation from juvenile Palaeoproterozoic crust, such as the Annagh Gneiss Complex or Rhinns Complex of NW Ireland, implying that the deep crust underlying the Slishwood Division is made of similar material. Rims from the Tyrone Central Inlier have extremely negative εHf470 values of approximately –39. This isotopic signature requires an Archaean source, suggesting rocks similar to the Lewisian Complex of Scotland, or sediment derived wholly from it, occurs at depth in NW Ireland.

HASTIE, A.R., KERR, A.C., MITCHELL, S.F. AND MILLAR, I.L., 2009.

Geochemistry and tectonomagmatic significance of lower Cretaceous island arc lavas from the Devils Racecourse Formation, eastern Jamaica.

In: K.H. JAMES, M.A. LORENTE AND J. PINDELL (Editors), Geology of the area between North and South America, with focus on the origin of the Caribbean Plate. Geological Society, London, Special Publications. 328, pp. 339-360

The Benbow Inlier in Jamaica contains the Devils Racecourse Formation, which is composed of a Hauterivian to Aptian island arc succession. The lavas can be split into a lower succession of basaltic andesites and dacites/rhyolites, which have an island arc tholeiite (IAT) composition and an upper basaltic and basaltic andesite sequence with a calc-alkaline (CA) chemistry. Trace element and Nd–Hf isotopic evidence reveals that the IAT and CA lavas are derived from two chemically similar mantle wedge source regions predominantly composed of normal mid-ocean ridge-type spinel lherzolite. In addition, Th-light rare earth element/high field strength element–heavy rare earth element ratios, Nd–Hf isotope systematics, $(Ce/Ce^*)_{n\text{-}mn}$ and Th/La ratios indicate that the IAT and CA mantle wedge source regions were enriched by chemically distinct slab fluxes, which were derived from both the altered basaltic portion of the slab and its accompanying pelagic and terrigenous sedimentary veneer respectively. The presence of IAT and CA island arc lavas before and after the Aptian–Albian demonstrates that the compositional change in the Great Arc of the Caribbean was the result of the subduction of chemically differing sedimentary material. There is therefore no evidence from the geochemistry of this lava succession to support arc-wide subduction polarity reversal in the Aptian–Albian.

HEATON, T.H.E., JONES, J., HALSTEAD, P. & TSIPROPOULOS, T., 2009.

Variations in the 13C/12C ratios of modern wheat grain, and implications for interpreting data from Bronze Age Assiros Toumba, Greece.

Journal of Archaeological Sciences, 36: 2224-2233.

http://nora.nerc.ac.uk/9128/

Variations in the $^{13}C/^{12}C$ ratios of wheat grain at different spatial and temporal scales are examined by analysis of modern samples, including harvests of einkorn and durum wheat from Greece, and serve as a guide to interpreting data for Bronze Age grains from Assiros Toumba. The normal distribution and low variability of $\delta^{13}C$ values of einkorn from 24 containers in the Assiros storerooms are consistent with pooling of local harvests, but less likely to represent the harvest of several years or include grain imported from further afield. Correlation between emmer and spelt $\delta^{13}C$ values provides strong support for other evidence that these were grown together as a maslin crop. ^{13}C discrimination (Δ) for the Bronze Age samples is estimated to be 2.5‰ larger than at present, and would be consistent with an intensive, horticultural regime of cereal cultivation, possibly involving some watering.

HEIER, A., EVANS, J.A. & MONTGOMERY, J., 2009.

The potential of carbonized grain to preserve biogenic $^{87}Sr/^{86}Sr$ signatures within the burial environment.

Archaeometry, 51: 277-291.

Carbonized grains survive for millennia in many archaeological contexts. Their stable structure raises the possibility that they preserve biogenic strontium isotope signatures. This hypothesis was investigated using short-term, laboratory experiments with modern grain immersed in Chalk solution. HCl leaching removed > 95% of secondary alteration from charred grain, and isotope ratios close to the starting value were recovered. This could not be achieved with uncharred grains. HCl leaching of archaeological carbonized grains produced comparable levels of decontamination. Although preliminary, these results suggest that strontium isotope analysis of archaeological carbonized grains from calcareous burial contexts could be used to investigate ancient trade and agriculture.

HENDERSON, J., EVANS, J.A. & BARKOUDAH, Y., 2009.

The roots of provenance: glass, plants and isotopes in the Islamic Middle East.

Antiquity, 83(320): 414-429.

http://nora.nerc.ac.uk/9176/

Glass - one of the most prestigious materials of the early Islamic empire - was traded not only as vessels and bangles but as raw glass blocks. One of its raw materials, plant-ash, was also traded. This means that tracking the production of this precious commodity is especially challenging. The authors show that while chemical composition can relate to vessel type, it is a combination Of chemical compositions with strontium and neodymium isotope ratios that is most likely to lead to (a geological) provenance for its manufacture. The materials used by the glassmakers were local sand and plant ashes. Reported here is the first application of the method to the glass made at the primary glass making centre of al-Raqqa, Syria in an environmental context.

HODGSON, D.A., ROBERTS, S.J., BENTLEY, M.J., CARMICHAEL, E.L., SMITH, J.A., VERLEYEN, E., VYVERMAN, W., GEISSLER, P., LENG, M.J., SANDERSON, D.C.W. & SUGDEN, D.E., 2009.

Exploring former subglacial Hodgson Lake, Antarctica. Paper II: palaeolimnology.

Quaternary Science Reviews 28(23-24): 2310-2325.

http://nora.nerc.ac.uk/8453/

Direct exploration of subglacial lakes buried deep under the Antarctic Ice Sheet has yet to be achieved. However, at retreating margins of the ice sheet, there are a number of locations where former subglacial lakes are emerging from under the ice but remain perennially ice covered. One of these lakes, Hodgson Lake (7200.5490S, 06827.7080W) has emerged from under more than 297–465 m of glacial ice during the last few thousand years. This paper presents data from a multidisciplinary investigation of the palaeolimnology of this lake through a study of a 3.8 m sediment core extracted at a depth of 93.4 m below the ice surface. The core was dated using a combination of radiocarbon, optically stimulated luminescence, and relative palaeomagnetic intensity dating incorporated into a chronological model. Stratigraphic analyses included magnetic susceptibility, clast provenance, organic content, carbonate composition, siliceous microfossils, isotope and biogeochemical markers. Based on the chronological model we provisionally assign a well-defined magnetic polarity reversal event at ca 165 cm in the lake sediments to the Mono Lake excursion (ca 30–34 ka), whilst OSL measurements suggest that material incorporated into the basal sediments might date to 93 9 ka. Four stratigraphic zones (A–D) were identified in the sedimentological data. The chronological model suggests that zones A–C were deposited between Marine Isotope Stages 5–2 and zone A during Stage 1, the Holocene. The palaeolimnological record tracks changes in the subglacial depositional environment linked principally to changing glacier dynamics and mass transport and indirectly to climate change. The sediment composition in zones A–C consists of fine-grained sediments together with sands, gravels and small clasts. There is no evidence of overriding glaciers being in contact with the bed reworking the stratigraphy or removing this

sediment. This suggests that the lake existed in a subglacial cavity beneath overriding LGM ice. In zone D there is a transition to finer grained sediments characteristic of lower energy delivery coupled with a minor increase in the organic content attributed either to increases in allochthonous organic material being delivered from the deglaciating catchment, a minor increase in within-lake production or to an analytical artefact associated with an increase in the clay fraction. Evidence of biological activity is sparse. Total organic carbon varies from 0.2 to 0.6%, and cannot be unequivocally linked to in situ biological activity as comparisons of $\delta^{13}C$ and C/N values with local reference data suggest that much of it is derived from the incorporation of carbon in catchment soils and gravels and possibly old CO_2 in meteoric ice. We use the data from this study to provide guidelines for the study of deep continental subglacial lakes including establishing sediment geochronologies, determining the extent to which subglacial sediments might provide a record of glaciological and environmental change and a brief review of methods to use in the search for life.

HODGSON, D.A., ROBERTS, S.J., BENTLEY, M.J., SMITH, J.A., JOHNSON, J.S., VERLEYEN, E., VYVERMAN, W., HODSON, A.J., LENG, M.J., CZIFERSZKY, A., FOX, A.J., SANDERSON, D.C.W. & SUGDEN, D.E., 2009.

Exploring former subglacial Hodgson Lake, Antarctica. Paper I: site description, geomorphology and limnology.

Quaternary Science Reviews 28(23-24): 2295-2309.

http://nora.nerc.ac.uk/8454/

At retreating margins of the Antarctic Ice Sheet, there are a number of locations where former subglacial lakes are emerging from under the ice but remain perennially ice-covered. This paper presents a site description of one of these lakes, Hodgson Lake, situated on southern Alexander Island, west of the Antarctic Peninsula (72 00.5490 S, 68 27.7080 W). First, we describe the physical setting of the lake using topographic and geomorphological maps. Second, we determine local ice sheet deglaciation history and the emergence of the lake using cosmogenic isotope dating of glacial erratics cross-referenced to optically stimulated luminescence dating of raised lake shoreline deltas formed during ice recession. Third we describe the physical and chemical limnology including the biological and biogeochemical evidence for life. Results show that the ice mass over Hodgson Lake was at least 295 m thick at 13.5 ka and has progressively thinned through the Holocene with the lake ice cover reaching an altitude of c. 6.5 m above the present lake ice sometime after 4.6 ka. Thick perennial ice cover persists over the lake today and the waters have remained isolated from the atmosphere with a chemical composition consistent with subglacial melting of catchment ice. The lake is ultra-oligotrophic with nutrient concentrations within the ranges of those found in the accreted lake ice of subglacial Lake Vostok. Total organic carbon and dissolved organic carbon are present, but at lower concentrations than typically recorded in continental rain. No organisms and no pigments associated with photosynthetic or bacterial activity were detected in the water column using light microscopy and high performance liquid chromatography. Increases in SO_4 and cation concentrations at depth and declines in O_2 provide some evidence for sulphide oxidation and very minor bacterial demand upon O_2 that result in small, perhaps undetectable changes in the carbon biogeochemistry. However, in general the chemical markers of life are inconclusive and abiotic processes such as the diffusion of pore waters into the lake from its benthic sediments are far more likely to be responsible for the increased concentrations of ions at depth. The next phases of this research will be to carry out a palaeolimnological study of the lake sediments to see what they can reveal about the history of the lake in its subglacial state, and a detailed molecular analysis of the lake water and benthos to determine what forms of life are present. Combined, these studies will test some of the methodologies that will be used to explore deep continental subglacial lakes

HODGSON, D.A., VERLEYEN, E., VYVERMAN, W., SABBE, K., LENG, M.J., PICKERING, M.D. & KEELY, B.J., 2009.

A geological constraint on relative sea level in Marine Isotope Stage 3 in the Larsemann Hills, Lambert Glacier region, East Antarctica (31 366–33 228 cal yr BP).

Quaternary Science Reviews, 28: 2689-2696.

http://nora.nerc.ac.uk/8445/

In this paper we present geological evidence from the Larsemann Hills (Lambert Glacier – Amery Ice Shelf region, East Antarctica) of marine sediments at an altitude of c. 8 m a.s.l., as revealed by diatom, pigment and geochemical proxies in a lake sediment core. The sediments yielded radiocarbon dates between c. 26 650 and 28 750 14C yr BP (31 366–33 228 cal yr BP). This information can be used to constrain relative sea level adjacent to the Lambert Glacier at the end of Marine Isotope Stage 3. These data are compared with the age and altitude of Marine Isotope Stage 3 marine deposits elsewhere in East Antarctica and discussed with reference to late Quaternary ice sheet history and eustatic sea-level change.

JOHNSON, A.L.A., HICKSON, J.A., BIRD, A., SCHÖNE, B.R., BALSON, P.S., HEATON, T.H.E. & WILLIAMS, M., 2009.

Comparative sclerochronology of modern and mid-Pliocene (c. 3.5 Ma) Aequipecten opercularis (Mollusca, Bivalvia): an insight into past and future climate change in the north-east Atlantic region

Palaeogeography, Palaeoclimatology, Palaeoecology, 284: 164-179.

Records of environment contained within the accretionarily deposited tissues of fossil organisms afford a means of detailed reconstruction of past climates and hence of rigorous testing of numerical climate models. We identify the environmental factors controlling oxygen and carbon stable-isotopic composition, and microgrowth-increment size, in the shell of modern examples of the Queen Scallop, Aequipecten opercularis. This understanding is then applied in interpretation of data from

mid-Pliocene A. opercularis from eastern England. On the basis of oxygen-isotope evidence we conclude that winter minimum seafloor temperature was similar to present values (typically 6–7 °C) in the adjacent southern North Sea and that summer maximum seafloor temperature was a few degrees lower than present values (typically 16–17 °C). This contrasts with evidence from other proxies that winter and summer temperatures were higher than present. The pattern of seasonal variation in microgrowth-increment size suggests the existence of intense thermal stratification in summer. We therefore conclude that summer surface temperatures were much higher (maxima well over 20 °C) than those recorded isotopically on the seafloor and that the annual range of surface temperature (probably over 14 °C) was greater than now at the times in the mid-Pliocene when the investigated A. opercularis were alive. Taken in conjunction with other proxy evidence of warmer winters as well as summers, the data point to substantial fluctuation (up to 10 °C) in winter minimum temperatures during the mid-Pliocene in the north-east Atlantic region. This fluctuation may be attributable to variation in the strength of the Gulf Stream/North Atlantic Drift. Since the Pliocene has been widely used as a test-bed for numerical models of a greenhouse Earth, the results have implications for prediction of future climate in the north-east Atlantic region under the influence of anthropogenic global warming.

JONSSON, C.E., LENG, M.J., ROSQVIST, G.C., SEIBERT, J. & ARROWSMITH, C., 2009.

Stable oxygen and hydrogen isotopes in sub-Arctic lake waters from northern Sweden

Journal of Hydrology 376(1-2): 143-151.

http://nora.nerc.ac.uk/8444/

Lakes in sub-Arctic regions have the potential of retaining many different aspects of water isotope composition in their sediments which can be used for palaeoclimate reconstruction. It is therefore important to understand the modern isotope hydrology of these lakes. Here we discuss the significance of variations in water isotope composition of a series of lakes located in north-west Swedish Lapland. Climate in this region is forced by changes in the North Atlantic which renders it an interesting area for climate reconstructions. We compare $\delta^{18}O_{lake}$ and $\delta^{2}H_{lake}$ collected between 2001 and 2006 and show that lakes in this sub-Arctic region are currently mainly recharged by shallow groundwater and precipitation which undergoes little subsequent evaporation, and that the $\delta^{18}O$ and $\delta^{2}H$ composition of input to the majority of the lakes varies on a seasonal basis between winter precipitation (spring thaw) and summer precipitation. Seasonal variations in the isotopic composition of the lake waters are larger in lakes with short residence times (<6 months), which react faster to seasonal changes in the precipitation, compared to lakes with longer residence times (>6 months), which retain an isotopic signal closer to that of annual mean precipitation. Lake waters also show a range of isotope values between sites due to catchment elevation and timing of snowmelt. The lake water data collected in this study was supported by isotope data from lake waters, streams and ground waters from1995 to 2000 reported in other studies.

KÖSTER, J.R., BOL, R., LENG, M.J., PARKER, A.G., SLOANE, H.J. & MA, J.F., 2009.

Effects of active silicon uptake by rice on ^{29}Si fractionation in various plant parts.

Rapid Communications in Mass Spectrometry, 23: 2398-2402.

http://nora.nerc.ac.uk/7937/

Rice (Oryza sativa L.) accumulates large amounts of silicon which improves its growth and health due to enhanced resistance to biotic and abiotic stresses. Silicon uptake and loading to xylem in rice are predominantly active processes performed by transporters encoded by the recently identified genes Lsi1 (Si influx transporter gene) and Lsi2 (Si efflux transporter gene). Silicon deposition in rice during translocation to upper plant tissues is known to discriminate against the heavier isotopes ^{29}Si and ^{30}Si, resulting in isotope fractionation within the plant. We analyzed straw and husk samples of rice mutants defective in Lsi1, Lsi2 or both for silicon content and ^{29}Si using isotope ratio mass spectrometry (IRMS) and compared these results with those for the corresponding wild-type varieties (WT). The silicon content was higher in husk than in straw. All the mutant rice lines showed clearly lower silicon content than the WT lines (4-23% Si of WT). The 29Si was lower in straw and husk for the uptake defective mutant (lsi1) than for WT, albeit ^{29}Si was 0.3 higher in husk than in straw in both lines. The effect of defective efflux (lsi2) differed for straw and husk with higher ^{29}Si in straw, but lower ^{29}Si in husk while WT showed similar ^{29}Si in both fractions. These initial results show the potential of Si isotopes to enlighten the influence of active uptake on translocation and deposition processes in the plant.

LAMB, A.L., GONZALEZ, S., HUDDART, D., METCALFE, S.E., VANE, C.H. & PIKE, A.W.G., 2009.

Tepexpan Palaeoindian site, Basin of Mexico: Multi-proxy evidence for environmental change during the Late Pleistocene-Late Holocene

Quaternary Science Reviews, 28(19-20): 2000-2016.

http://nora.nerc.ac.uk/8150/

The Tepexpan Palaeoindian skeleton was discovered in 1947 close to the former Lake Texcoco margin, in the Basin of Mexico. The find has been the object of considerable interest and discussion over the last 60 years regarding its real age and archaeological interpretation. Here we report new AMS radiocarbon dates associated with the sedimentary succession at Tepexpan with ages between 19,110 ± 90 and 612 ± 22 14C years BP and a new uranium-series date for the skeleton with an age of 4700 ± 200 years BP that indicates a mid Holocene age. The sedimentary succession was studied in detail using:

stable isotopes, diatoms, organic geochemistry and tephrochronology. The multi-proxy evidence suggests large changes around the margins of Lake Texcoco in terms of the balance between aquatic and terrestrial plants, C3 and C4 plants, saline, alkaline and freshwater conditions, volcanic activity, marginal reworking of lake sediments and input from the drainage basin through the late Pleistocene–late Holocene. These changes had large impacts on the prehistoric human populations living by the lake shores since the late Pleistocene in the Basin of Mexico.

LEACH, S., LEWIS, M., CHENERY, C., MULDNER, G. & ECKARDT, H., 2009.

Migration and Diversity in Roman Britain: A Multidisciplinary Approach to the Identification of Immigrants in Roman York, England.

American Journal of Physical Anthropology, 140: 546-561.

Previous anthropological investigations at Trentholme Drive, in Roman York identified an unusual amount of cranial variation amongst the inhabitants, with some individuals suggested as having originated from the Middle East or North Africa. The current study investigates the validity of this assessment using modern anthropological methods to assess cranial variation in two groups: The Railway and Trentholme Drive. Strontium and oxygen isotope evidence derived from the dentition of 43 of these individuals was combined with the craniometric data to provide information on possible levels of migration and the range of homelands that may be represented. The results of the craniometric analysis indicated that the majority of the York population had European origins, but that 11% of the Trentholme Drive and 12% of The Railway study samples were likely of African decent. Oxygen analysis identified four incomers, three from areas warmer than the UK and one from a cooler or more continental climate. Although based on a relatively small sample of the overall population at York, this multidisciplinary approach made it possible to identify incomers, both men and women, from across the Empire. Evidence for possible second generation migrants was also suggested. The results confirm the presence of a heterogeneous population resident in York and highlight the diversity, rather than the uniformity, of the population in Roman Britain.

LEAT, P.T., FLOWERDEW, M.J., RILEY, T.R., WHITEHOUSE, M.J., SCARROW, J.H. & MILLAR, I.L., 2009.

Zircon U-Pb dating of Mesozoic volcanic and tectonic events in north-west Palmer Land and south-west Graham Land, Antarctica.

Antarctic Science, 21(6): 633-641.

http://nora.nerc.ac.uk/8695/

New whole rock Rb-Sr and zircon U-Pb geochronological data and Sm-Nd isotopic data are presented from the central magmatic arc domain of the Antarctic Peninsula in the area of northwest Palmer Land and southwest Graham Land, Rb-Sr isochrons indicate an age of 169±6 Ma for basement orthogneisses and 132±9 to 71±9 Ma for plutons. A U-Pb age of 183 ± 2.1 Ma, with no detectable inheritance, on zircons from an orthogneiss from Cape Berteaux provides the first reliable age for the orthogneisses, which are interpreted as metamorphosed silicic volcanic rocks, and Sm-Nd data indicate derivation in a mature volcanic arc. The age indicates they may be correlatives of the Jurassic 'Chon Aike' volcanism of the eastern Antarctic Peninsula. A U-Pb zircon age of 107 ± 1.7 Ma on a terrestrial volcanic sequence overlying an uncomformity strongly suggests a mid-Cretaceous age for the extensive volcanic cover of northwest Palmer Land that was previously thought to be Jurassic. The unconformity is interpreted to have been a result of compressional uplift related to the Palmer Land event. This is the first date for the event in the western part of the central magmatic arc terrane of the Antarctic Peninsula.

LENG, M.J., SWANN, G.E.A., HODSON, M.J., TYLER, J.J., PATWARDHAN, S.V. & SLOANE, H.J., 2009.

The potential use of silicon isotope composition of biogenic silica as a proxy for environmental change.

Silicon, 1: 65-77.

http://nora.nerc.ac.uk/8612/

Silicon isotope geochemistry is a relatively new branch of environmental change research. Here we review the recent developments in the preparation of materials, analytical methods and applications of stable silicon isotope geochemistry in the most common types of biogenic silica currently being analysed. These materials are: diatom, radiolarian and siliceous sponges in lake and ocean sediments and plant phytoliths which are preserved in soils. Despite analyses of Si isotopes being carried out on rocks and minerals since the 1950's and the increasingly widespread use of Si isotopes since the 1990's, to date only a relatively small number of studies have applied Si isotope ratios to environmental change. In lake and ocean sediments the analysis of Si isotope ratios from biogenic materials hold potential to provide an important source of palaeoenvironmental information, especially where carbonates are not preserved. In plants and soils few studies have used Si isotopes, but important advances have recently been made in the understanding within plant fractionations. These may be useful in the application of Si isotopes in phytoliths to archaeological and palaeoenvironmental contexts.

LEWIS, A.R., MARCHANT, D.R., ASHWORTH, A.C., HEDENAS, L., HEMMING, S.R., JOHNSON, J.V., LENG, M.J., LACHLUS, M.J., NEWTON, A.E., RAINE, J.I., WILLENBRING, J.K., WILLIAMS, M. & WOLFE, A.P., 2009.

Mid-Miocene cooling and the extinction of tundra in continental Antarctica.

Proceedings of the National Academy of Sciences of the United States of America, 105: 10676-10680.

http://nora.nerc.ac.uk/4499/

A major obstacle in understanding the evolution of Cenozoic climate has been the lack of well dated terrestrial evidence from high-latitude, glaciated regions. Here, we report the discovery of exceptionally well preserved fossils of lacustrine and terrestrial organisms from the McMurdo Dry Valleys sector of the Transantarctic Mountains for which we have established a precise radiometric chronology. The fossils, which include diatoms, palynomorphs, mosses, ostracodes, and insects, represent the last vestige of a tundra community that inhabited the mountains before stepped cooling that first brought a full polar climate to Antarctica. Paleoecological analyses, 40Ar/39Ar analyses of associated ash fall, and climate inferences from glaciological modeling together suggest that mean summer temperatures in the region cooled by at least 8°C between 14.07 ± 0.05 Ma and 13.85 ± 0.03 Ma. These results provide novel constraints for the timing and amplitude of middle-Miocene cooling in Antarctica and reveal the ecological legacy of this global climate transition.

LLOYD, N.S., CHENERY, S.R. & PARRISH, R.R., 2009.

The distribution of depleted uranium contamination in Colonie.

Science of the Total Environment, 408(2): 397-407.

http://nora.nerc.ac.uk/8892/

Uranium oxide particles were dispersed into the environment from a factory in Colonie (NY, USA) by prevailing winds during the 1960's and '70's. Uranium concentrations and isotope ratios from bulk soil samples have been accurately measured using inductively coupled plasma quadrupole mass spectrometry (ICP-QMS) without the need for analyte separation chemistry. The natural range of uranium concentrations in the Colonie soils has been estimated as 0.7 – 2.1 μg g-1, with a weighted geometric mean of 1.05 ± 0.06 μg g 1; the contaminated soil samples comprise uranium up to 500 ± 40 μg g-1. A plot of $^{236}U/^{238}U$ against $^{235}U/^{238}U$ isotopes ratios describes a mixing line between natural uranium and depleted uranium (DU) in bulk soil samples; scatter from this line can be accounted for by heterogeneity in the DU particulate. The end-member of DU compositions aggregated in these bulk samples comprises (2.05 ± 0.06) x10-3 $^{235}U/^{238}U$, (3.2 ± 0.1) x10-5 $^{236}U/^{238}U$, and (7.1 ± 0.3) x10-6 $^{234}U/^{238}U$. The analytical method is sensitive to as little as 50 ng g-1 DU mixed with the natural uranium occurring in these soils. The contamination footprint has been mapped northward from site, and at least one third of the uranium in a soil sample from the surface 5 cm, collected 5.1 km NNW of the site, is DU. The distribution of contamination within the surface soil horizon follows a trend of exponential decrease with depth, which can be approximated by a simple diffusion model. Bioturbation by earthworms can account for dispersal of contaminant from the soil surface, in the form of primary uranium oxide particulates, and uranyl species that are adsorbed to organic matter. Considering this distribution, the total mass of uranium contamination emitted from the factory is estimated to be c. 4.8 tonnes.

LLOYD, N.S., MOSSELMANS, J.F.W., PARRISH, R.R., CHENERY, S.R.N., HAINSWORTH, S.V. & KEMP, S.J., 2009.

The morphologies and compositions of depleted uranium particles from an environmental case-study.

Mineralogical Magazine, 73: 495-510.

http://nora.nerc.ac.uk/8910/

Uraniferous particles from contaminated environmental samples were analysed by scanning electron microscopy with energy dispersive X-ray analysis (SEM-EDXA), and microfocus extended X-ray absorption fine-structure (μEXAFS) spectroscopy. The particles of interest are uranium oxides, which were released into the environment by the combustion of scrap depleted uranium (DU) metal at a factory in Colonie, NY, USA. Most of the identified particles appear to have primary, 'as emitted' morphologies; some have evidence of minor dissolution, including corrosion pitting. Polycrystalline and often hollow microscopic spheres were identified, which are similar to particles produced by DU munitions impacting armoured targets. They are attributed to the autothermic oxidation of melt droplets. The compositions of the analysed spheres are dominated by UO2+x with variable amounts of U3O8, two of the least soluble and bioaccessible phases of uranium. These particles, collected from dusts and soils, have survived more than 25 years in the terrestrial environment. This study further supports the case for using Colonie as an analogue for battlefield DU contamination.

LLOYD, N.S., PARRISH, R.R., HORSTWOOD, M.S.A. & CHENERY, S.R.N., 2009.

Precise and accurate isotopic analysis of microscopic uranium-oxide grains using LA-MC-ICP-MS.

Journal of Analytical Atom Spectrometry, 24(6): 752-758.

http://nora.nerc.ac.uk/7990/

Uranium isotope (^{235}U, ^{236}U, ^{238}U) ratios were determined for microscopic uranium-oxide grains using laser-ablation multi-collector inductively-coupled-plasma mass-spectrometry (LA-MC-ICP-MS). The grains were retrieved from contaminated

soil and dust samples. The analytical technique utilised is rapid, requires minimal sample preparation, and is well suited for nuclear forensic applications. Precision and accuracy were assessed by replicate analyses of natural uraninite grains: relative uncertainty for $^{235}U/^{238}U$ is 0.2 % (2σ), and the mean is in agreement with the natural ratio. A total of 115 uranium-oxide grains were analysed from environmental samples (soils and dusts); all of these were depleted uranium (DU) from a factory that produced uranium articles. Knowledge of the range of isotope ratios from particles of this controversial contaminant has proven useful when interpreting isotope ratios from bulk samples. Variation of the measured isotope signatures reveals details of the history of uranium processing and emissions.

LOVE, G.D., GROSJEAN, E., STALVIES, C., FIKE, D.A., GROTZINGER, J.P., BRADLEY, A.S., KELLY, A.E., BHATIA, M., MEREDITH, W., SNAPE, C.E., BOWRING, S.A., CONDON, D.J. & SUMMONS, R.E., 2009.

Fossil steroids record the appearance of Demospongiae during the Cryogenian period.

Nature, 457(7230): 718-U5.

http://nora.nerc.ac.uk/9117/

The Neoproterozoic era (1,000–542 Myr ago) was an era of climatic extremes and biological evolutionary developments culminating in the emergence of animals (Metazoa) and new ecosystems1. Here we show that abundant sedimentary 24-isopropylcholestanes, the hydrocarbon remains of C30 sterols produced by marine demosponges, record the presence of Metazoa in the geological record before the end of the Marinoan glaciation (c. 635 Myr ago). These sterane biomarkers are abundant in all formations of the Huqf Supergroup, South Oman Salt Basin, and, based on a new high-precision geochronology, constitute a continuous 100-Myr-long chemical fossil record of demosponges through the terminal Neoproterozoic and into the Early Cambrian epoch. The demosponge steranes occur in strata that underlie the Marinoan cap carbonate (>635 Myr ago). They currently represent the oldest evidence for animals in the fossil record, and are evidence for animals pre-dating the termination of the Marinoan glaciation. This suggests that shallow shelf waters in some late Cryogenian ocean basins (>635 Myr ago) contained dissolved oxygen in concentrations sufficient to support basal metazoan life at least 100 Myr before the rapid diversification of bilaterians during the Cambrian explosion. Biomarker analysis has yet to reveal any convincing evidence for ancient sponges pre-dating the first globally extensive Neoproterozoic glacial episode (the Sturtian, approx713 Myr ago in Oman).

MARSHALL, M.H., LAMB, H.F., DAVIES, S.J., LENG, M.J., KUBSA, Z. & UMER, M., 2009.

Climatic change in northern Ethiopia during the past 17,000 years: a diatom and stable isotope record from Lake Ashenge

Palaeogeography, Palaeoclimatology, Palaeoecology, 279: 114-127.

http://nora.nerc.ac.uk/7703/

Lake Ashenge, a closed-basin lake near the northernmost penetration of summer monsoon rains, is well placed to provide a continental record of past changes in the strength of the African monsoon system. Diatom and oxygen isotope analyses of the lake sediments confirm that the overall trend of climate change during the past 17,000 years was driven by precessional forcing, punctuated by abrupt shifts that may be linked to changes in Atlantic surface temperatures. The lake level was low from at least 17.2 to 16.2 cal kyr BP, and then rose between 16.2 and 15.2 cal kyr BP, which may represent a temporary reactivation of the monsoonal circulation system following its reduced activity during the Last Glacial Maximum. The lake was significantly low between 13.6 and ~ 11.8 cal kyr BP coinciding approximately with the Younger Dryas, but beginning 900 years before its recognised onset in the Greenland ice-core record. A major sedimentary hiatus, covering the interval ~ 11.8 to 7.6 cal kyr BP, was probably caused by an early Holocene lowstand, the precise timing of which cannot be determined because pre-lowstand sediments were eroded from the core site. The lake filled to its overflow from 7.6 cal kyr BP until 5.6 cal kyr BP, when the sediments record an abrupt lake response to the regional transition to arid conditions that mark the end of African Humid Period. Evidence is also presented for climate changes which may have been associated with the rise and fall of Aksum, Ethiopia's first great civilisation.

MCCONNELL, B., RIGGS, N. & CROWLEY, Q.G., 2009.

Detrital zircon provenance and Ordovician terrane amalgamation, western Ireland.

Journal of the Geological Society, London, 166: 473-484.

http://nora.nerc.ac.uk/7311/

Detrital zircon analysis of sandstones interbedded with c. 464 Ma ignimbrites in the lower Mweelrea Formation of the South Mayo Trough, western Ireland, suggests Ordovician source-rock provenance that corresponds to two distinct volcanic-arc phases on the Laurentian margin. East-derived sandstones contain a suite of zircons with a mean age of c. 487 Ma that suggests derivation from the Cambrian to early Ordovician Baie Verte Oceanic Tract arc–ophiolite complex, locally represented by the Lough Nafooey arc rocks and the Clew Bay Complex. Zircons from south-derived sandstones within the Bunnacunneen conglomerate fan have average ages of c. 467–474 Ma, and correspond to the Notre Dame arc and locally the Connemara metagabbro and orthogneiss suite. Granite clasts in the Bunnacunneen conglomerate are similar to the Connemara orthogneiss suite, in terms of both their geochemistry and their age (c. 471 Ma). The southerly derived sedimentary strata also include Archaean and Proterozoic zircon age spectra consistent with a Dalradian source. A southern

provenance from the Notre Dame arc and Dalradian rocks suggests that the Connemara terrane lay to the south of the South Mayo Trough during middle Llanvirn times, from at least 464 Ma.

NEHLICH, O., MONTGOMERY, J., EVANS, J.A., SCHADE-LINDIG, S., PICHLER, S.L., RICHARDS, M.P. & ALT, K.W., 2009.

Mobility or migration: a case study from the Neolithic settlement of Nieder-Morlen (Hessen, Germany).

Journal of Archaeological Science, 36(8): 1791-1799.

http://nora.nerc.ac.uk/8328/

A combination of stable carbon and nitrogen isotope analysis of collagen and radiogenic strontium isotope analysis of tooth enamel was used to investigate diet and mobility at the early Neolithic settlement of Nieder-Mo¨ rlen in Germany. The carbon and nitrogen ratios suggest a mixed terrestrial based diet that is consistent with data previously published for early Neolithic sites in Europe. The strontium isotope data indicate a high degree of human mobility with only one individual having an isotope ratio consistent with locally derived strontium. Unusually, a group of non-local juveniles with isotope ratios typical of upland regions is also present at the settlement but there are no adult burials with such values. Whilst transhumance is considered as an explanation, it would not explain why these non-local juveniles lived foreshortened lives and other possible mechanisms are therefore discussed.

NEILSON, J.C., KOKELAAR, B.P. & CROWLEY, Q.G., 2009.

Timing, relations and cause of plutonic and volcanic activity of the Siluro-Devonian post-collision magmatic episode in the Grampian Terrane, Scotland.

Journal of the Geological Society, London, 166: 545-561.

http://nora.nerc.ac.uk/7377/

Calc-alkaline magmatism in the Grampian Terrane started at c. 430 Ma, after subduction of the edge of continental Avalonia beneath Laurentia, and it then persisted for at least 22 Ma. Isotope dilution thermal ionization mass spectrometry U–Pb zircon dating yields 425.0 ± 0.7 Ma for the Lorn Lava Pile, 422.5 ± 0.5 Ma for Rannoch Moor Pluton, 419.6 ± 5.4 Ma for a fault-intrusion at Glencoe volcano, 417.9 ± 0.9 Ma for Clach Leathad Pluton in Glencoe, and, in the Etive Pluton, 414.9 ± 0.7 Ma for the Cruachan Intrusion and 408.0 ± 0.5 Ma for the Inner Starav Intrusion. The Etive Dyke Swarm was mostly emplaced during 418–414 Ma, forming part of the plumbing of a large volcano (2000 km3) that became intruded by the Etive Pluton and was subsequently removed by erosion. During the magmatism large volumes (thousands of km3) of high Ba–Sr andesite and dacite were erupted repeatedly, but were mostly removed by contemporaneous uplift and erosion. This volcanic counterpart to the 'Newer Granite' plutons has not previously been fully recognized. The intermediate magmas forming both plutons and volcanoes originated mainly by partial melting of heterogeneous mafic to intermediate lowermost crust that had high Ba–Sr derived from previous melting of large ion lithophile element (LILE)-enriched mantle, possibly at c. 1.8 Ga. This crustal recycling was induced by heat and volatiles from underplated small-degree melts of LILE- and light REE-enriched lithospheric mantle (appinite–lamprophyre magmas). The post-collision magmatism and uplift resulted from breakoff of subducted oceanic lithosphere and consequent rise of asthenosphere.

NOWELL, G.M. & HORSTWOOD, M.S.A., 2009.

Comments on Richards et al. Journal of Archaeological Science 35, 2008 "Strontium isotope evidence of Neanderthal mobility at the site of Lakonis, Greece using laser-ablation PIMMS".

Journal of Archaeological Science, 36(7): 1334-1341.

http://nora.nerc.ac.uk/5889/

We present an evaluation of the laser ablation Sr isotope data reported by Richards et al. (2008) for a Neanderthal tooth recovered from a site in Greece. Based on an alternative and analytically more robust method of correcting for isobaric interferences present during the analysis the tooth appears to be isotopically homogenous and within uncertainty of the value for modern seawater. If this is the case then contrary to the migration model proposed by Richards et al. (2008) the Neanderthal individual may have actually been a coastal dweller and lived within the vicinity of the find site.

NUNN, E.V., PRICE, G.D., HART, M.B., PAGE, K.N. & LENG, M.J., 2009.

Isotopic signals from Callovian-Kimmeridgian (Middle-Upper Jurassic) belemnites and bulk organic carbon, Staffin Bay, Isle of Skye, Scotland.

Journal of the Geological Society, London, 166: 633-641.

http://nora.nerc.ac.uk/7702/

The stable isotope data presented here significantly extend and expand upon previous isotopic investigations of the Middle to Late Jurassic interval. The belemnite samples collected from the Staffin Bay and Staffin Shale formations from the Isle of Skye, Scotland, yielded oxygen isotope values consistent with Callovian–Kimmeridgian palaeotemperatures of 6.7–20.6 8C. The carbon isotope data comprise one of the first moderately high-resolution investigations of the relationship between terrestrial 13Corg (predominantly fossil wood debris) and marine 13Ccarb (belemnites) as derived from a geologically

coeval record. The Staffin Bay data reveal a broad Early to Mid-Oxfordian positive carbon isotope excursion. The excursion maximum occurs in the cordatum Zone (British Boreal ammonite zonation), although high values persist into the tenuiserratum Zone. The correspondence between the marine and terrestrial records indicates a strong coupling of the ocean–atmosphere system and suggests that the total exchangeable carbon reservoir would have been affected at this time. The Mid-Oxfordian negative carbon isotope excursions identified in published Tethyan records and commonly attributed to methane release are not recorded in the Staffin Bay data, which may suggest that the Tethyan excursions do not represent fluctuations in the global carbon reservoir and that the fidelity of the methane hypothesis should be re-evaluated.

RILEY, T.R., CURTIS, M.L., LEAT, P.T. & MILLAR, I.L., 2009.

The geochemistry of Middle Jurassic dykes associated with the Straumsvola – Tvora alkaline plutons, Dronning Maud Land, Antarctica and their association with the Karoo large igneous province.

Mineralogical Magazine, 73(2): 223-244.

http://nora.nerc.ac.uk/8099/

Jurassic dykes of western Dronning Maud Land (Antarctica) form a minor component of the Karoo large igneous province. An extensive local dyke swarm intrudes Neoproterozoic gneisses and Jurassic syenite plutons on the margins of the Jutulstraumen palaeo rift in the Svedrupfjella region. The dykes were intruded in three distinct episodes (~204, ~176 and ~170 Ma). The 204 Ma dykes are overwhelmingly low-Ti, olivine tholeiites including some primitive (picritic) compositions (MgO >12 wt.%; Fe2O3 >12 wt.%; Cr >1000 ppm; Ni >600 ppm). This 204 Ma event precedes the main Karoo volcanic event by ~25 Ma, so any correlations to the wider province are difficult to make. However, it may record the earliest phase of rift activity along the Jutulstraumen. The 176 Ma dyke event is more intimately associated with the two syenite plutons. The dykes are alkaline (basanite/tephrite) and were small-degree melts from an enriched, locally derived source and underwent at least some degree of interaction with a syenitic contaminant. This ~176 Ma dyke event is widespread elsewhere in the Karoo (southern Africa and Dronning Maud Land). Later-stage (170 Ma) felsic (phonolite-comendite) dykes intrude the 176 Ma basanite-tephrite suite and represent the last phase of magmatic activity in the region.

SCHROEDER, H., O'CONNELL, T.C., EVANS, J.A., SHULER, K.A. & HEDGES, R.E.M., 2009.

Trans-Atlantic Slavery: Isotopic Evidence for Forced Migration to Barbados.

American Journal of Physical Anthropology, 139(4): 547-557.

http://nora.nerc.ac.uk/8079/

The question of the ultimate origin of African slaves is one of the most perplexing in the history of trans-Atlantic slavery. Here we present the results of a small, preliminary isotopic study that was conducted in order to determine the geographical origin of 25 enslaved Africans who were buried at the Newton plantation, Barbados, sometime between the late 17th and early 19th century. In order to gain a more nuanced understanding of the slaves' origin, we used a combination of carbon, nitrogen, oxygen, and strontium isotope analyses. Carbon and nitrogen isotope ratios were determined in bone and dentinal collagen; oxygen and strontium isotopes were measured in tooth enamel. Results suggest that the majority of individuals were born on the island, if not the estate itself. Seven individuals, however, yielded enamel oxygen and strontium ratios that are inconsistent with a Barbadian origin, which strongly suggests that we are dealing with first-generation captives who were brought to the island with the slave trade. This idea is also supported by the fact that their carbon and nitrogen stable isotope values differ markedly between their teeth and bones. These intra-skeletal shifts reflect major dietary changes that probably coincided with their enslavement and forced migration to Barbados. While it is impossible to determine their exact origins, the results clearly demonstrate that the slaves did not all grow up in the same part of Africa. Instead, the data seem to suggest that they originated from at least three different areas, possibly including the Gold Coast and the Senegambia.

SELBY, D., MUTTERLOSE, J. & CONDON, D.J., 2009.

U-Pb and Re-Os geochronology of the Aptian/Albian and Cenomanian/Turonian stage boundaries: Implications for timescale calibration, osmium isotope seawater composition and Re-Os systematics in organic-rich sediments.

Chemical Geology, 265(3-4): 394-409.

http://nora.nerc.ac.uk/7741/

Presented is the first absolute age for the basal Albian from the Schwicheldt Ton Member, Gault Formation, Vöhrum, Germany. A $^{206}Pb/^{238}U$ age of 113.1 ± 0.3 Ma is determined for chemically abraded zircon from a tuff horizon 65 cm above the Aptian/Albian boundary. The new U–Pb age, although within uncertainty of the GTS 2008 determination (112 ± 1 Ma), is nominally older. The younger GTS 2008 basal Albian age is obtained from cyclostratigraphy using an $^{40}Ar–^{39}Ar$ age from the base Cenomanian. The nominal difference between the GTS 2008 age and new basal Albian age is consistent with the documented ca. 0.65% bias between U–Pb and $^{40}Ar/^{39}Ar$ geochronology. The new $^{206}Pb/^{238}U$ age calls into question a recently published age for the basal Albian (106.9 ± 0.4 Ma) determined from K–Ar glauconite analysis, as well as the K–Ar age for the GL-O international standard. Rhenium–osmium isotope analysis of the basal Albian grey clay of the Schwicheldt

Ton Member, Gault Formation and basal Turonian grey shale of the Schwarz–Weisse–Wechselfolge, Hesseltal Formation (recording Oceanic Anoxic Event 2) yields low and similar $^{187}Re/^{188}Os$ values (49–167) that are positively correlated with 187Os/188Os values. For both sections imprecise Re–Os ages (6–9%, 2σ) that overlap the stratigraphic boundary ages are determined (Aptian/Albian = 108.9 ± 6.2 Ma; Cenomanian/Turonian = 91.5 ± 8.6 Ma). Although the Re–Os data suggest that organic-rich sediments other than black shales are potentially amenable for Re–Os geochronology, the large uncertainties contrast with that from previous Re–Os organic-rich sediment studies. The latter show sample sets with a significant spread in $^{187}Re/^{188}Os$ ratios (several hundred units). The imprecise Re–Os geochronology presented here relates to the limited spread in the $^{187}Re/^{188}Os$ values. The redox conditions of deposition are suggested to control the $^{187}Re/^{188}Os$ ratio of an organic-rich sediment. However, trace element and Re–Os data for samples from NW Germany and previous Re–Os geochronology studies show no direct relationship between $^{187}Re/^{188}Os$ values and the redox condition of the water column. These results suggest that the fractionation of Re and Os in organic-rich sediments is not controlled by water column redox conditions. Instead, Re–Os fractionation in organic-rich sediments may be controlled by sedimentation rate, recharge of Re and Os to the water column and/or post-deposition mobility of Re and Os within the sediment. The initial Os isotope composition of an organic-rich sediment is inferred to reflect the seawater composition at the time of deposition. For the Cenomanian/Turonian boundary grey shale a seawater Os composition of 0.33 ± 0.02 is determined. This Os isotope composition contrasts with that of the stratotype section at Pueblo, Colorado (0.15) and for those obtained from Furlo, Italy and ODP Site 1260B (~ 0.5). This data may suggest that the Cenomanian/Turonian ocean was not homogeneous with respect to Os suggesting either alternate oceanic circulation or basin dynamics.

SHEPHERD, T.J., CHENERY, S.R.N., PASHLEY, V., LORD, R.A., ANDER, L.E., BREWARD, N., HOBBS, S.F., HORSTWOOD, M.S.A., KLINCK, B.A. & WORRALL, F., 2009.

Regional lead isotope study of a polluted river catchment: River Wear, Northern England, UK.

Science of the Total Environment 407(17): 4882-4893.

http://nora.nerc.ac.uk/8232/

High precision, lead isotope analyses of archived stream sediments from the River Wear catchment, northeast England (1986–88), provide evidence for three main sources of anthropogenic lead pollution; lead mining, industrial lead emissions and leaded petrol. In the upper catchment, pollution is totally controlled and dominated by large lead discharges from historic mining centres in the North Pennine Orefield ($^{208}Pb/^{206}Pb$, $^{207}Pb/^{206}Pb$ ratios range from 2.0744–2.0954 and 0.8413–0.8554 respectively). In the lower catchment, co-extensive with the Durham Coalfield and areas of high population density, pollution levels are lower and regionally more uniform. Isotope ratios are systematically higher than in the upper catchment ($^{208}Pb/^{206}Pb$, $^{207}Pb/^{206}Pb$ ratios range from 2.0856–2.1397 and 0.8554–0.8896 respectively) and far exceed values determined for the geogenic regional background. Here, the pollution is characterised by the atmospheric deposition of industrial lead and petrol lead. Lead derived from the combustion of coal, although present, is masked by the other two sources. Recent sediments from the main channel of the River Wear are isotopically indistinguishable from older, low order stream sediments of the North Pennine Orefield, indicating that contamination of the river by lead mining waste (up to several 1000 mg/kg Pb at some locations) continues to pose an environmental problem; a pattern that can be traced all the way to the tidal reach. Using within-catchment isotope variation and sediment lead concentrations, estimates can be made of the discharges from discrete mines or groups of mines to the overall level of lead pollution in the River Wear. As well as providing information pertinent to source apportionment and on-going catchment remediation measures, the database is a valuable resource for epidemiologists concerned with the health risks posed by environmental lead.

SMITH, D.J., PETTERSON, M.G., SAUNDERS, A.D., MILLAR, I.L., JENKIN, G.R.T., TOBA, T., NADEN, J. & COOK, J.M., 2009.

The petrogenesis of sodic arc magmas at Savo volcano, Solomon Islands.

Contributions to Mineralogy and Petrology, 158(6): 785-801.

http://nora.nerc.ac.uk/8446/

Savo, Solomon Islands, is a historically active volcano dominated by sodic, alkaline lavas, and pyroclastic rocks with up to 7.5 wt% Na_2O, and high Sr, arc-like trace element chemistry. The suite is dominated by mugearites (plagioclase–clinopyroxene–magnetite ± amphibole ± olivine) and trachytes (plagioclase–amphibole–magnetite ± biotite). The presence of hydrous minerals (amphibole, biotite) indicates relatively wet magmas. In such melts, plagioclase is relatively unstable relative to iron oxides and ferromagnesian silicates; it is the latter minerals (particularly hornblende) that dominate cumulate nodules at Savo and drive the chemical differentiation of the suite, with a limited role for plagioclase. This is potentially occurring in a crustal “hot zone”, with major chemical differentiation occurring at depth. Batches of magma ascend periodically, where they are subject to decompression, water saturation and further cooling, resulting in closed-system crystallisation of plagioclase, and ultimately the production of sodic, crystal and feldspar-rich, high-Sr rocks. The sodic and hydrous nature of the parental magmas is interpreted to be the result of partial melting of metasomatised mantle, but radiogenic isotope data (Pb, Sr, Nd) cannot uniquely identify the source of the metasomatic agent.

STREULE, M.J., PHILLIPS, R.J., SEARLE, M.P., WATERS, D.J. & HORSTWOOD, M.S.A., 2009.

Evolution and chronology of the Pangong Metamorphic Complex adjacent to the Karakoram Fault, Ladakh: constraints from thermobarometry, metamorphic modelling and U-Pb geochronology.

Journal of the Geological Society, 166(5): 919-932.

http://nora.nerc.ac.uk/8429/

Sillimanite- and staurolite-grade metamorphic rocks exhumed along the Pangong fault, the NE branch of the right-lateral Karakoram strike-slip fault in northern Ladakh, NW India, show multiple episodes of metamorphism and fabric development. Debate has centred on whether these metamorphic rocks were formed as a result of shear heating during strike-slip faulting, or whether they are exhumed earlier metamorphic rocks unrelated to movement on the Karakoram fault. Here we constrain the burial and exhumation history of the Pangong Metamorphic Complex combining the pressure–temperature evolution with accessory phase geochronology. Sillimanite-grade metamorphism in graphitic pelites was superseded by the preserved P–T conditions of a Bt + Ms + St + Grt + Qtz + Fsp assemblage at 585–605 °C and 6.05–7.25 kbar, equivalent to c. 20–25 km of burial. Laser ablation monazite U–Pb geochronology reveals that sillimanite-grade metamorphism occurred at 108.0 ± 0.6 Ma in rocks immediately adjacent to the Pangong strand of the Karakoram fault, implying that most metamorphic rocks along the Karakoram fault were not formed by shear heating during Miocene strike-slip faulting. This age correlates closely with the ages of the Hunza granite–granodiorite batholith, and the K2 orthogneiss in northern Pakistan, and confirms that some high-grade metamorphism occurred before collision and accretion of the Kohistan arc and the Indian plate to Asia; protracted high-grade metamorphism, and accompanying crustal thickening lasted at least 100 Ma along the South Asian plate margin. Our P–T and geochronology results also demonstrate the continuity of Cretaceous metamorphism across the Karakoram fault.

SWANN, G.E.A. & LENG, M.J., 2009.

A review of diatom $\delta^{18}O$ in palaeoceanography.

Quaternary Science Reviews, 28: 384-398.

http://nora.nerc.ac.uk/6837/

Measurements of diatom oxygen isotopes ($\delta^{18}O_{diatom}$) hold the potential to provide an important additional source of palaeoceanographic information in regions depleted in carbonates. However, despite analyses of $\delta^{18}O_{diatom}$ being carried out since the 1970s and the increasingly widespread use of $\delta^{18}O_{diatom}$ in palaeolimnology since the 1990s, to date only a handful of studies have applied $\delta^{18}O_{diatom}$ in marine reconstructions. Here the historical development and current state of affairs concerning the usage of δ18Odiatom in palaeoceanography is reviewed. This includes a summary of: 1. sample purification and analytical techniques for $\delta^{18}O_{diatom}$; 2. existing palaeoceanographic reconstructions with an emphasis on sites at which both diatoms and foraminifera have been analysed for $\delta^{18}O$; 3. uncertainties associated with $\delta^{18}O_{diatom}$ including the presence of isotope vital effects and secondary isotope exchanges; 4. a review of the current and future developments required to improve the reliability of $\delta^{18}O_{diatom}$ based reconstructions in palaeoceanography.

THOMAS, E.R., WOLFF, E.W., MULVANEY, R., JOHNSEN, S.J., STEFFENSEN, J.P. & ARROWSMITH, C., 2009.

Anatomy of a Dansgaard-Oeschger warming transition: High-resolution analysis of the North Greenland Ice Core Project ice core.

Journal of Geophysical Research, 114(D08102): 1-9.

http://nora.nerc.ac.uk/8243/

Large and abrupt temperature oscillations during the last glacial period, known as Dansgaard-Oeschger (DO) events, are clearly observed in the Greenland ice core record. Here we present a new high-resolution chemical (2 mm) and stable isotope (20 mm) record from the North Greenland Ice Core Project (NGRIP) ice core at the onset of one of the most prominent DO events of the last glacial, DO-8, observed ~38,000 years ago. The unique, subannual-resolution NGRIP record provides a true sequence of change during a DO warming with detailed annual layer counting of very high depth resolution geochemical measurements used to determine the exact duration of the transition. The continental ions, indicative of long-range atmospheric loading and dustiness from East Asia, are the first to change, followed by the snow accumulation, the moisture source conditions, and finally the atmospheric temperature in Greenland. The sequence of events shows that atmospheric and oceanic source and circulation changes preceded the DO warming by several years.

THOMAS, R.J., DE WAELE, B., SCHOFIELD, D.I., GOODENOUGH, K.M., HORSTWOOD, M.S.A., TUCKER, R., BAUER, W., ANNELLS, R., HOWARD, K., WALSH, G., RABARIMANANA, M., RAFAHATELO, J.M., RALISON, A.V. & RANDRIAMANANJARA, T., 2009.

Geological evolution of the Neoproterozoic Bemarivo Belt, northern Madagascar.

Precambrian Research, 172(3-4): 279-300.

http://nora.nerc.ac.uk/7336/

The broadly east-west trending, Late Neoproterozoic Bemarivo Belt in northern Madagascar has been re-surveyed at 1: 100 000 scale as part of a large multi-disciplinary World Bank-sponsored project. The work included acquisition of fourteen U-Pb zircon dates and whole-rock major and trace element geochemical data of representative rocks. The belt has previously been modelled as a juvenile Neoproterozoic arc and our findings broadly support that model. The integrated datasets indicate that the Bemarivo Belt is separated by a major ductile shear zone into northern and southern "terranes", each with different lithostratigraphy and ages. However, both formed as Neoproterozoic arc/marginal basin assemblages that were translated southwards over the north-south trending domains of "cratonic" Madagascar, during the main collisional phase of the East African Orogeny at ca. 540 Ma. The older, southern terrane consists of a sequence of high-grade paragneisses (Sahantaha Group), which were derived from a Palaeoproterozoic source and formed a marginal sequence to the Archaean cratons to the south. These rocks are intruded by an extensive suite of arc-generated metamorphosed plutonic rocks, known as the Antsirabe Nord Suite. Four samples from this suite yielded U-Pb SHRIMP ages at ca. 750 Ma. The northern terrane consists of three groups of metamorphosed supracrustal rocks, including a possible Archaean sequence (Betsiaka Group: maximum depositional age approximately 2477 Ma) and two volcano-sedimentary sequences (high grade Milanoa Group: maximum depositional age approximately 750 Ma; low grade Daraina Group: extrusive age = 720 to 740 Ma). These supracrustal rocks are intruded by another suite of arc-generated metamorphosed plutonic rocks, known as the Manambato Suite, 4 samples of which gave U-Pb SHRIMP ages between 705 to 718 Ma. Whole-rock geochemical data confirm the calc-alkaline, arc-related nature of the plutonic rocks. The volcanic rocks of the Daraina and Milanoa groups also show characteristics of arc-related magmatism, but include both calc-alkaline and tholeiitic compositions. It is not certain when the two Bemarivo terranes were juxtaposed, but ages from metamorphic rims on zircon suggest that both the northern and southern terranes were accreted to the northern cratonic margin of Madagascar at about 540 to 530 Ma. Terrane accretion included the assembly of the Archaean Antongil and Antananarivo cratons and the high-grade Neoproterozoic Anaboriana Belt. Late- to post tectonic granitoids of the Maevarano Suite, the youngest plutons of which gave ca. 520 Ma ages, intrude all terranes in northern Madagascar showing that terrane accretion was completed by this time.

TROFIMOVS, J., FISHER, J.K., MACDONALD, H.A., TALLING, P.J., SPARKS, R.S.J., HART, M.B., SMART, C.W., BOUDON, G., DEPLIS, C., KOMOROWSKI, J.-C., LE FRIANT, A., MORTON, S.G. & LENG, M.J., 2009.

Evidence for carbonate platform failure during rapid sea-level rise; ca 14 000 year old bioclastic flow deposits in the Lesser Antilles.

Sedimentology: 1-25.

http://nora.nerc.ac.uk/9546/

Bioclastic flow deposits offshore from the Soufrière Hills volcano on Montserrat in the Lesser Antilles were deposited by the largest volume sediment flows near this active volcano in the last 26 kyr. The volume of these deposits exceeds that of the largest historic volcanic dome collapse in the world, which occurred on Montserrat in 2003. These flows were most probably generated by a large submarine slope failure of the carbonate shelf comprising the south-west flank of Antigua or the east flank of Redonda; adjacent islands that are not volcanically active. The bioclastic flow deposits are relatively coarse-grained and either ungraded or poorly graded, and were deposited by non-cohesive debris flow and high density turbidity currents. The bioclastic deposit often comprises multiple sub-units that cannot be correlated between core sites; some located just 2 km apart. Multiple sub-units in the bioclastic deposit result from either flow reflection, stacking of multiple debris flow lobes, and/or multi-stage collapse of the initial landslide. This study provides unusually precise constraints on the age of this mass flow event that occurred at ca 14 ka. Few large submarine landslides have been well dated, but the slope failures that have been dated are commonly associated with periods of rapid sea-level change.

TUCKER, M.E., GALLAGHER, J. & LENG, M.J., 2009.

Are beds in shelf carbonates millennial-scale cycles? An example from the mid-Carboniferous of northern England.

Sedimentary Geology, 214: 19-34.

http://nora.nerc.ac.uk/6458/

The mid-Carboniferous strata of northern England are characterised by mixed clastic-carbonate cycles (Yoredale cycles), attributed here to the short eccentricity Milankovitch rhythm. In a typical cycle, transgressive normal-marine shelf carbonates are succeeded by marine shales, then highstand prodelta mudstones and delta front-delta top sandstones with local coals. A detailed study of one cycle, the Great Limestone Cyclothem of the northern Pennines (Alston Block), reveals that within the transgressive carbonates, the beds, averaging 75 cm in thickness and defined by mm-shale partings or cm-

mudrock layers, form two thinning-upward to thickening-upward bed-sets. Individual beds and the bed-sets are regionally correlatable. Oxygen isotope and strontium trace element data also reveal patterns of increasing and decreasing values through the limestone, which broadly correspond to the bed-thickness cycles. The beds are interpreted as millennial-scale cycles, the result of high-frequency, arid-humid climatic fluctuations. The bed-sets are interpreted as the response to a longer term arid-humid climate and sea-level cycle, driven by the precession rhythm. It is postulated that millennial-scale climatic changes, which are a well-known feature of the Quaternary, and are here inferred for the Carboniferous, were responsible for the deposition of the beds that are a characteristic feature of many marine sedimentary successions in the geological record. The most likely over-riding control is fluctuations in solar output.

VERSCHUREN, D., SINNINGHE DAMSTÉ, J.S., MOERNAUT, J., KRISTEN, I., BLAAUW, M., FAGOT, M., HAUG, G.H., VAN GEEL, B., DE BATIST, M., BARKER, P., VUILLE, M., CONLEY, D., OLAGO, D.O., MILNE, I., PLESSEN, B., EGGERMONT, H., WOLFF, C., HURRELL, E., OSSEBAAR, J., LYARUU, A., VAN DER PLICHT, J., CUMMING, B.F., BRAUER, A., RUCINA, S.M., RUSSELL, J.M., KEPPENS, E., HUS, J., BRADLEY, R.S., LENG, M., MINGRAM, J. & NOWACZYK, N.R., 2009.

Half-precessional dynamics of monsoon rainfall near the East African Equator.

Nature, 462: 637-641.

http://nora.nerc.ac.uk/8696/

Extensive records exist with which to assess the relationship between external climate forcings — such as changes in insolation — and climate variability for middle and high latitudes, but records from equatorial regions are relatively few, especially from regions experiencing the passage of the Intertropical Convergence Zone. A continuous and well-resolved climate-proxy record of hydrological variability during the past 25,000 years from equatorial East Africa is now presented and analysed.

WEEKS, L., KEALL, E., PASHLEY, V., EVANS, J.A. & STOCK, S., 2009.

Lead isotope analyses of Bronze Age copper-base artefacts from the site of al-Midamman, Yemen: Towards the identification of an indigenous south-west Arabian metal production and exchange system.

Archaeometry, 51(4): 576-597.

http://nora.nerc.ac.uk/8054/

The results of the lead isotope analysis (LIA) of 15 copper-base artefacts from the Bronze Age site of al-Midamman, Yemen, are reported. The LIA data suggest the existence of an indigenous Bronze Age metal production and exchange system centred on the southern Red Sea region, distinct from those in neighbouring regions of Arabia and the Levant. These preliminary results are highly significant for the archaeology of the region, suggesting that local prehistoric copper extraction sites have thus far gone unrecorded, and highlighting the need for systematic archaeometallurgical fieldwork programmes in the countries surrounding the southern Red Sea.

WILL, T.M., ZEH, A., GERDES, A., FRIMMEL, A.E., MILLAR, I.L. & SCHMÄDICKE, E., 2009.

Palaeoproterozoic to Palaeozoic Magmatic and Metamorphic Events in the Shackleton Range, East Antarctica: Constraints from Zircon and Monazite Dating, and Implications for the Amalgamation of Gondwana.

Precambrian Research, 172(1-2): 25-45.

http://nora.nerc.ac.uk/9123/

A comprehensive set of new geochronological data from different parts of the Shackleton Range in East Antarctica, comprising U–Pb single zircon and Th–U–Pb single and multi-grain monazite data, combined with published results, reveal a complex tectono-thermal history of the Shackleton Range. Three distinct, spatially separated terranes or units with different magmatic and metamorphic history are now recognised: (i) the Southern Terrane (Unit I) contains detrital components as old as 2850 Ma, experienced magmatism between 1850Ma and 1810Ma and underwent amedium- to high-grade metamorphic event at 1710–1680Ma and, locally, again at 510 Ma; (ii) the Eastern Terrane (Unit II) occurs in the easternmost part of the Shackleton Range and contains c. 1060Ma old Grenvillian granitoids, which experienced metamorphism at c. 600 Ma; and (iii) the Northern Terrane (Unit III) is characterised by 530Ma old granites and diorites, which are hosted within paragneisses as well as mafic and ultramafic rocks. All rocks of Unit III experienced upper amphibolite- to granulite-facies and, locally, eclogite-facies metamorphism at 510–500 Ma. The geologic features of Palaeoproterozoic tectonism in the Southern Terrane are very similar to those of the Australo-AntarcticMawson Continent. Thismay indicate that theMawson Continent extends across the East Antarctic Shield into the Shackleton Range. The 1060Ma and 600Ma events in the Eastern Terrane have not been documented for any part of the Shackleton Range before and are correlated with Grenvillian and Pan-African tectonism in Dronning Maud Land. By implication, this suggests that the Pan- African Mozambique/Maud Belt continues into the Shackleton Range. The associated suture is located in the easternmost Shackleton Range and is related to the amalgamation of the Indo-Antarctic plate with West Gondwana. This was followed by further collision of the combined Indo-Antarctic/West Gondwanan block with East Gondwana at approximately 510Ma in theNorthern Terrane. A suture related to this latter collision can be traced in the Northern Shackleton Range and may continue northwards to the Sør Rondane Mountains and the Lützow Holm Bay area. Our data

support the model that East Antarctica finally assembled during the Pan-African orogeny, rather than during earlier Mesoproterozoic events.

WILLIAMS, M., HAYWOOD, A.M., HARPER, E.M., JOHNSON, A.L.A., KNOWLES, T., LENG, M.J., LUNT, D.J., OKAMURA, B., TAYLOR, P.D. & ZALASIEWICZ, J., 2009.

Pliocene climate and seasonality in North Atlantic shelf seas.

Philosophical Transactions of the Royal Society, 367(1886): 85-108.

http://nora.nerc.ac.uk/4887/

This paper reviews North Atlantic shelf seas palaeoclimate during the interval 4–3Ma, prior to and incorporating the 'Mid-Pliocene warm period' (ca 3.29–2.97Ma). Fossil assemblages and stable isotope data demonstrate northwards extension of subtropical faunas along the coast of the Carolinas–Virginia (Yorktown and Duplin Formations) relative to the present day, suggesting a more vigorous Florida Current, with reduced seasonality and warm water extending north of Cape Hatteras (reconstructed annual range for Virginia 12–30°C). This interpretation supports conceptual models of increased meridional heat transport for the Pliocene. Sea temperatures for Florida (Lower Pinecrest Beds) were similar to or slightly cooler than (summers 25–27°C) today, and were probably influenced by seasonal upwelling of cold deep water. Reduced seasonality is also apparent in the Coralline Crag Formation of the southern North Sea, with ostracods suggesting winter sea temperatures of 10°C (modern 4°C). However, estimates from Pliocene bivalves (3.6–16.6°C) are similar to or cooler than the present day. This 'mixed' signal is problematic given warmer seas in the Carolinas–Virginia, and climate model and oceanographic data that show warmer seas in the 'Mid-Pliocene' eastern North Atlantic. This may be because the Coralline Crag Formation was deposited prior to peak Mid-Pliocene warmth.