SERVICES & FACILITIES ANNUAL REPORT - FY April 2015 to March 2016

SERVICE	FUNDING	AGREEMENT	ESTABLISHED as S&F	TERM
NERC Radiocarbon Facility (NRCF)	Block	EK: PR130030 Ox:	EK: 1975 Ox: 1991 Joint NRCF nodes: 2007	5 years

TYPE OF SERVICE PROVIDED:

Radiocarbon dating is the most versatile technique for archaeologists, palaeoclimatologists, palaeoenvironmentalists and earth scientists seeking to precisely date the timing of events and rates of processes in the history of humans and earth systems over the last 50,000 years. Natural abundance and 'bomb' radiocarbon also have wide applications in quantifying the movement of carbon in the environment. The NERC Radiocarbon Facility (NRCF http://www.c14.org.uk/) is internationally recognised and supports, participates in and initiates globally competitive science at its two nodes **NRCF-Oxford (NRCF-O)**, within the Oxford Radiocarbon Accelerator Unit (ORAU), University of Oxford and **NRCF-East Kilbride (NRCF-E)**, hosted by the Scottish Universities Environmental Research Centre (SUERC), East Kilbride. The joint facility simplifies access to NERC-supported radiocarbon analyses, increases flexibility in operation and enhances collaborative opportunities to the benefit of the user community. The two nodes have complementary expertise and work closely together and with the wider international radiocarbon community to provide a comprehensive service for the NERC research community, including Universities and NERC Centres BGS, CEH, BAS, NOC:

- Expertise across a wide spectrum of radiocarbon techniques & applications
- Specialist advice at all stages of projects from project inception, applications and grant proposals, field sampling, sample storage and preparation, to data interpretation and publication
- Technical developments, often developed collaboratively, to provide leading edge and unique research opportunities
- Access to state-of-the art equipment, including three accelerator mass spectrometers (AMS)
- Training of students and visiting researchers, including project-customised practical laboratory experience, residential radiocarbon courses, and the unique opportunity to experience the diverse yet recent technologies of the AMS used by NRCF

The remits of the nodes are determined by science area and technique, project requirements and capacity at the two nodes. Archaeological Science applications are largely supported by NRCF-O, while those relating to Earth and Environmental Science are supported by NRCF-E. Collaborative approved projects, using the expertise of both nodes, are encouraged. NRCF-E expertise includes Terrestrial, Marine and Freshwater Science (including palaeoclimate, carbon dynamics, greenhouse gases, land use, polar research). NRCF-O expertise is focused on Science-based Archaeology (including human evolution, dispersals and paleao-anthropology), but also provides an important contribution to Earth Science (past climates, evolution of life) and Terrestrial Science (human management and response to the environment, climate change) and unique expertise in the calibration and statistical modelling of radiocarbon and other chronological data. NRCF supported science includes Earth, Marine, Terrestrial and Freshwater, Atmospheric and Polar Science and Science-based Archaeology.

ANNUAL TARGETS AND PROGRESS TOWARDS THEM

Approved projects are allocated analyses on a per sample basis, but capacity is calculated as analytical units, taking into account resources required to process samples and standards and project-related development. Facility management and administration (including steering committee related) and science contribution to publications, grants etc is not separately accounted so is included in the overall unit cost. **NRCF-E:** 2007 units were processed in 2015-16, c.50% more than funded capacity of 1300 units. Average turnaround 5.6 months due to high sample volume (ranging from 2.5-10 months, related to complexity of sample preparation). **NRCF-O:** Funded capacity for NRCF-SC approved work = 500 AMS analytical units. In 2015-16 679.5 units were processed which is well above capacity. Despite this average turnaround time dropped to 3.9 months.

SCORES AT LAST REVIEW (each out of 5)			Date of Last Review:	March 2012
Need	**Uniqueness**	**Quality of Service**	**Quality of Science & Training**	**Average**
5.0	**4.5**	**5.0**	**5.0**	**4.9**

CAPACITY of HOST ENTITY FUNDED by S&F	Staff & Status	Next Review (March)	Contract Ends (31 March)
NRCF-E: 100% **NRCF-O: ~30%**	**NRCF-E Scientific:** Head NERC Band 4 (0.6 FTE); Glasgow University-Deputy Head Grade 8 (1 FTE), Grade 7 (2.5 FTE); Technical: Grade 6 (4FTE); Administrative: Grade 6 (1FTE); **NRCF-O:** Head Grade 10 (0.4FTE); Deputy Head Grade 10 (0.6); 2 PDRAs Grade 7 and 8 (0.4,0.4); Technical Grades 4 and 5 (5 x 0.3). Administrative: Grades 6-8 (0.4,0.3, 0.1, 0.05)	**TBC**	**2018**

FINANCIAL DETAILS: CURRENT FY

Total Resource Allocation £k	Unit Cost £k			Capital Expend £k	Income £k	Full Cash Cost £k
	Unit 1 Total Res Alloc/Units provided	Unit 2 FCC/Units provided	Unit 3			
NRCF-E: 874.40	0.44	0.50		18.0	60.30	992.15
NRCF-O: 325.00	0.48	0.60		-	-	406.32
2016-17 £k	NRCF-E: 820.00	NRCF-O: 311.00				

STEERING COMMITTEE	Independent Members	Meetings per annum	Other S&F Overseen
	Joint Chair + O: 6 E:9	2	

APPLICATIONS: DISTRIBUTION OF GRADES (current FY — 2015/16)													
	10	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**	**R***	**Pilot**
NERC Grant projects*	0	5	5	3	1	1	0	0	1	0	1	2	0
Other academic	0	1	6	12	4	4	1	1	1	0	1	10	0
Students	0	4	8	8	10	0	1	2	1	1	0	5	0
TOTAL	0	10	19	23	15	5	2	3	3	1	2	17	0

APPLICATIONS: DISTRIBUTION OF GRADES (per annum average previous 3 financial years —2012/2013, 2013/2014 & 2014/2015)													
	10	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**	**R***	**Pilot**
NERC Grant projects*	2.67	3.00	8.00	7.33	0.33	0.33	0.33	0.33	0	0	0	2.00	0
Other academic	0.33	2.67	7.00	7.00	1.33	1.67	1.67	0.67	0.33	0	1.00	4.33	0
Students	0.33	2.67	6.33	10.67	13.67	0.67	0.33	1.67	0.67	0	0.33	6.67	0
TOTAL	3.33	8.34	21.33	25.00	15.33	2.67	2.33	2.67	1.00	0	1.33	13.00	

PROJECTS COMPLETED (current FY 2015/16)												
	10 (α5)	**9**	**8 (α4)**	**7**	**6 (α3)**	**5 (α2)**	**4**	**3 (α1)**	**2**	**1 (β)**	**0 (Reject)**	**Pilot**
NERC Grant projects*	1	3	4	7	0	0	0	0	0	0	0	0
Other Academic	0	3	7	9	3	0	0	0	0	0	0	0
Students	1	4	6	12	13	0	0	0	0	0	0	0

Project Funding Type (current FY – 2015/16) (select one category for each project)										
Grand Total	**Infrastructure**					**PAYG**				
	Supplement to NERC Grant *	**PhD Students NERC**	**PhD Students Other**	**NERC Centre**	**Other**	**NERC Grant***	**PhD Students NERC**	**PhD Students Other**	**NERC Centre**	**Other**
105	36	15	30	1	23	0	0	0	0	0

Project Funding Type (per annum average previous 3 financial years - 2012/2013, 2013/2014 & 2014/2015)										
Grand Total	**Infrastructure**					**PAYG**				
	Supplement to NERC Grant *	**PhD Students NERC**	**PhD Students Other**	**NERC Centre**	**Other**	**NERC Grant***	**PhD Student NERC**	**PhD Student Other**	**NERC Centre**	**Other**
95.66	28.00	11.67	26.00	0.33	24.33	0.00	0.33	0.33	0.67	4.00

User type (current FY – 2015/16) (include each person named on application form)				
Academic	**NERC Centre**	**NERC Fellows**	**PhD Students**	**Commercial**
263	**21**	**4**	**51**	**1**

User type (per annum average previous 3 financial years - 2012/2013, 2013/2014 & 2014/2015)				
Academic	**NERC Centre**	**NERC Fellows**	**PhD Students**	**Commercial**
243.33	**14.67**	**3.33**	**42.66**	**3.67**

OUTPUT & PERFORMANCE MEASURES (current year)

Publications (by science area & type) (calendar year 2015)										
SBA	**ES**	**MS**	**AS**	**TFS**	**EO**	**Polar**	**Grand Total**	**Refereed**	**Non-Ref/ Conf Proc**	**PhD Theses**
21.5	**9.5**	**11.0**	**2.5**	**18.5**	**0**	**5.0**	**68**	**56**	**6**	**6**

Distribution of Projects (by science areas) (FY 2015/16)							
Grand Total	**SBA**	**ES**	**MS**	**AS**	**TFS**	**EO**	**Polar**
105	**26.7**	**34.3**	**8.0**	**1.0**	**32.0**	**1.0**	**2.0**

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

Publications (by science area & type) (Calendar years 2012, 2013 & 2014)										
SBA	**ES**	**MS**	**AS**	**TFS**	**EO**	**Polar**	**Grand Total**	**Refereed**	**Non-Ref/ Conf Proc**	**PhD Theses**
34.2	10.23	12.33	0.67	25.23	0	4.17	**86.83**	65.00	9.33	12.5

Distribution of Projects (by science areas) (FY 2012/2013, 2013/2014 & 2014/2015)							
Grand Total	**SBA**	**ES**	**MS**	**AS**	**TFS**	**EO**	**Polar**
95.66	26.47	29.43	10.33	2.23	22.70	0.67	3.83

Distribution of Projects by NERC strategic priority (current FY 2015/16)							
Grand Total	**Climate System**	**Biodiversity**	**Earth System Science**	**Sustainable Use of Natural Resources**	**Natural Hazards**	**Environment, Pollution & Human Health**	**Technologies**
105	**26.67**	**29.18**	**19.90**	**12.00**	**5.25**	**12.00**	**0.0**

**Either Discovery Science (Responsive Mode) or Strategic Science (Directed Programme) grants*

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

OVERVIEW & ACTIVITIES IN FINANCIAL YEAR (2015/16):

NERC grant projects

25 approved projects at NRCF-E were in support of NERC grants. Of these the largest allocations were for the following:

- NERC Arctic Research Programme: Permafrost methane emissions (PI I Hartley, Univ Exeter), part of CYCLOPS Carbon Cycling Linkages to Permafrost Systems, to elucidate the impact of Arctic warming and release of greenhouse gases relative to increased vegetation growth; Permafrost catchments in transition: hydrological controls on carbon cycling and greenhouse gas budgets (PI P Wookey, Heriot-Watt Univ);
- NERC Macronutrient Cycles Programme: Analysis and simulation of the Long-Term/Large-Scale interactions of C, N and P in UK land, freshwater and atmosphere (PI E Tipping, CEH Lancaster)
- NERC-funded consortium: BRITICE-CHRONO aiming to constrain the timing and rate of British Irish Ice Sheet collapse to provide a benchmark against which predictive ice sheet models can be improved (PI C Clarke, Univ Sheffield)
- NERC Standard grants: Understanding how drought affects the risk of increased mortality in tropical rain forests (PI P Meir, Univ Edinburgh); Ecological 'Tipping Points'? - How invasion of a potential canopy dominant affects landscape-scale ecosystem patterns (PI B Huntley, Univ Durham) Peatlands and the global carbon cycle during the past millennium (PI D Charman, Univ Exeter); Inner-shelf reef growth and future trajectories of reef geomorphic change (PI C Perry, Univ Exeter); The role of natural and artificial pools in northern peatland carbon cycling (PI M Billett, Univ Stirling);

NRCF-O has been involved in radiocarbon dating samples for several NERC projects. These include NE/J009342/1, Seeing Genes in Space and Time, a project exploring mammoth genetics, NE/E015905/1, the RESET project, which involves dating samples associated with volcanic ash events dating over the last 50,000 years in continental Europe, and NE/H004491/1, a NERC grant which is attempting to develop methods of using amino acids for AMS dating of bone proteins. In addition, NRCF-O has also been involved in dating support for AHRC supported grants: AH/K0060291/1, which focuses on cultural resilience and climate change in the recent Alaskan prehistoric period, AH/L006979/1; tracing the early dispersal of chickens in Europe, AH/J006068/1, dating the Anglo-Saxon royal centre at Lyminge, Kent, and AH/I021841/1; examining the movement of the earliest Neolithic in the peripheral island of the British Isles.

Training: The now annual NRCF joint training course on radiocarbon dating and Bayesian Chronological analysis was hosted at Oxford again this year. There were 27 participants ranging from doctoral students to experienced academics. Participants came from UK & European Universities, several participants from N America (US and Canada) and one from Japan. The course included background on radiocarbon dating with a visit to NRCF-O and instruction on Bayesian analysis for radiocarbon and other dating techniques.NRCF-O has undertaken in-lab training for several students linked with NRCF projects and NERC grants. This has included training in radiocarbon sample pretreatment chemistry, the interpretation of results and identification of samples for dating. Students working at NRCF-O this year have included:

- Gwydion Jones (student on Prof. Siwan Davies project NF/2015/1/36) working on dating peat samples and abrupt climate change during the last glacial-interglacial transition at Llyn Llech Owain (SW Wales);
- Emma Loftus (Oxford) (project led by Prof. Lee-Thorp: NF/2015/1/10) working on new chronometric dating of two key sites in South Africa in terms of climate changes in the Holocene and Late Glacial (see Loftus et al. 2016, Radiocarbon);
- Benjamin Ball (University of Manchester), working on dating a high-resolution peat sequence from Morocco, N. Africa (NF/2014/2/32);
- Francisca Santana Sagredo (Oxford) (NF/2015/1/7) working on the radiocarbon preparation and dating of samples from the Chilean Atacama desert, integrating the results with dietary reservoir offsets and marine food consumption amongst humans dating to the Late Intermediate period of the Andes.

At NRCF-E eleven PhD students had individual training visits of 2-3 days, to discuss their projects and samples and receive project-specific hands-on laboratory training in sample pre-treatment and vacuum rig sample processing. Positive responses to these visits were received directly and in the annual user survey.

Technique Development and Capital Funding:

NRCF-E

A prototype **automated sample processing system** has been built (£18k capital funding) and is being tested with radiocarbon standards. Routine use is planned for 2016/17 to reduce operator time during CO_2 recovery part of sample processing.

Enhanced zeolite molecular sieve sampling system Unique to NRCF-E and used extensively in NRCF-SC projects and NERC grants, the system has been further developed, with numerous advantages over the previous system eg a 90% reduction in cost due to a newly available CO_2 monitor; sampling kits are simpler and quicker to use; can be loaned to UK researchers for field sampling for reliable sampling of suitable sample sizes to improve results; reduction of Facility time. Further improvements to the sieve cartridges aim to address problems with long storage times (eg when transporting from remote sites) and small samples.

Field collection methods for ^{14}C in dissolved methane- Responding to user community need, sampling techniques are being developed for methane radiocarbon analysis in groundwater and river samples. Build on previous training at NRCF-E for an approved project, Dr J Dean (form. Univ Stirling) was funded by SUERC to progress development of aquatic methane field sampling. The sources and fate of methane released due to changes in Arctic soils are of global interest and radiocarbon and the methods developed at NRCF make an important contribution to the international research effort towards this.

Hydropyrolysis System-In collaboration with Dr P Ascough at the SUERC AMS Facility, jointly funded by SUERC and S&F capital this was commissioned in 2015 and successfully tested with radiocarbon standard. Further testing and a pilot application of the method are underway, using dissolved organic carbon from UK streamwaters (NERC Macronutrient Programme project PI E Tipping, CEH). The method will enable pyrolysis of samples using high hydrogen pressures to reductively separate carbon compounds on the basis of chemical resistance, applicable in dating and carbon cycle research.

Compound specific radiocarbon analysis (CSRA) -There is a strong demand from the user community for using CSRA in carbon cycle studies and for dating purposes in the absence of other materials commonly used for ^{14}C dating (pollen, macrofossils, charcoal) because it offers the opportunity to target compounds of known provenance. Knowing the radiocarbon signature of identified compounds can provide more specific information for carbon cycle studies eg of carbon sources/fates and turnover, compared with operationally defined carbon fractions (e.g. alkali-soluble humic substances). The work is demanding of resource and expertise, involving working close to analytical limits of sample size and using complex extraction procedures. Techniques and new standard materials have been successfully tested at NRC-E for the analysis of n-alkanes from plant leaf waxes, in collaboration with colleagues from Newcastle University and Rothamsted Research and isolating compounds by preparative capillary gas chromatography at NRCF-E. *Cisneros-Dozal LM, Xu X, Bryant C, Pearson EJ, Dungait JAJ. (2016). Grass material as a modern process standard for ^{14}C analysis of n-alkanes. Radiocarbon/FirstView Article / March 2016 1 – 14. DOI: 10.1017/RDC.2016.24*

NRCF-O Our recent method development work is focusing on two new and exciting methods of purification; the dating of single amino acids using HPLC methods, and super-critical fluid extraction (SFE) and chromatography (SFC). The aim is to move rapidly towards compound specific analysis of carbon samples for dating. The advantages are significant; we hope to be able to eliminate contaminants and date only compounds that are specific to the material being analysed. An example is the AMS dating of the amino acid hydroxyproline (HYP). This is essentially a biomarker for mammalian collagen, since it is very rarely if ever found elsewhere in nature. Extracting and dating HYP therefore provides a contaminant-free compound for dating. SFE and SFC will hopefully enable us to purify or extract molecules of interest with super-critical CO_2. In the case of organic molecules targets might include residues from pottery fragments, proteins from archaeological bones and extracted fractions of from charcoal, sediments and wood cellulose. Using SFE we anticipate that it might we possible to effectively improve and speed up the removal of contaminating and exogenous carbon from samples for AMS dating.

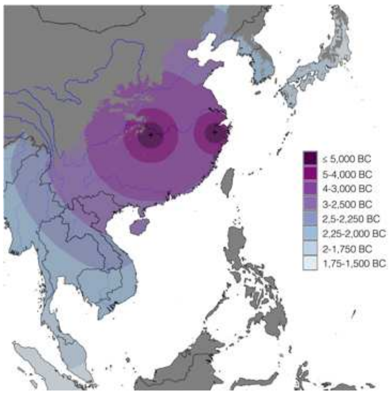
Facility demand and user community feedback: High demand for analytical support at NRCF continued this year and efforts were focused on managing large numbers of samples and projects and minimising turnaround times. NRCF-E analytical units were 1.5 times higher than funded capacity and following the very high demand in 2014/15 (1.7 times funded capacity) this has had an adverse effect on turn-around times which have increased to 5.6 months. Sample complexity and the need for approved project related development or additional quality control tests also contribute additional turnaround time. Improving the turnaround time is a high priority of the Facility and measures being implemented to achieve this currently include managing the Facility demand via NRCF-Steering Committee (although a very high volume of work was via NERC grants), in-house procedural changes and transferring projects with suitable sample types to NRCF-O. NRCF-O analytical units were 1.36 times capacity this year but despite this we managed to reduce turnaround time to under 4 months. We achieved this through prioritising NRCF work through the Oxford unit and through very high performance by all of the associated laboratory staff. The annual on-line survey was sent to164 researchers who had either applied for, or received NRCF support during the previous calendar year. 32 responses were received and feedback was mostly positive but with some concerns about higher turnaround times and high demand at NRCF-E which is being addressed.

SCIENCE HIGHLIGHTS. ***To focus on economic and societal impacts and benefits where possible*:**

NRCF-OXFORD

SPATIAL MODELLING OF THE GEOGRAPHICAL ORIGIN OF RICE CULTIVATION

Rice is a key global crop, feeding the majority of the world's population. Much research has been undertaken to understand the origin and dispersal of rice from its place of domestication in Asia, throughout the rest of the wider region, including southeast Asia and India. Many researchers now agree that the domestication process was protracted and that several thousand years elapsed during which people collected wild rice. Rice was domesticated some time in the middle Holocene. Silva and colleagues (2015) have used a modelling approach and multiple radiocarbon determinations to consider the most probably areas for origins of cultivated rice and its spread. A simple least-cost distance was used to fit to known occurrences of rice in time and space. Different models were built and tested against one another. The model that best fitted the data was a dual origin model, which posited two independent developments of rice in the Yangtze basin (see right). The authors suggest that the most likely scenario involves multiple domestication episodes rather than one or two. *Silva, F. et al. (2015). Modelling the geographical origin of rice cultivation in Asia using the Rice Archaeological Database. PLOS One, 10(1).*
Supported by NERC grant "The impact of evolving rice systems from China to Southeast Asia" (NE/G005540/1).



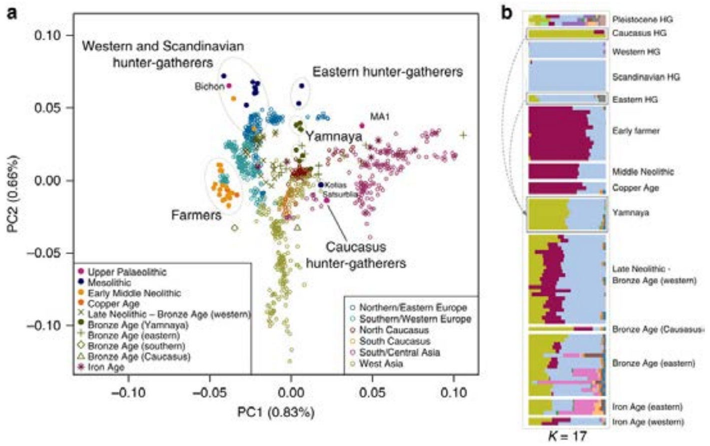
THE ROMAN AND ISLAMIC SPICE TRADE: NEW EVIDENCE

Tropical spices are of key importance in early trade and exchange networks. During the Roman and later Islamic periods the site of Quseir al-Qadim (on the Red Sea in modern Egypt) was active as a transport hub during both periods (ca. AD 1–250, known as Myos Hormos, and again during ca. AD 1050–1500, known as Kusayr). At least 7 tropical spices were recovered from excavations here directed by Marijke van der Veen of Leicester University and her colleagues. These included black pepper, ginger, cardamom, turmeric, fagara, myrobalan and betelnut. The only spice employed in cuisine was pepper, the rest were all used in ritual, perfumery and medicine. Radiocarbon of individual identified seeds was undertaken by NRCF-Oxford to provide the chronology for the study. In both periods, spices were accessible only to the elite. This fuelled greater demand for spices from a wider

section of society and gave rise to the early modern expansion of the spice trade. In pursuit of this gorwing trade new relationships were forged, political power struggles occurred and people became entangled in a complex mesh of new relationships. One can see the origins of modern globalisation in this ancient rush to open new trade markets for spices. *Van der Veen, M., & Morales, J. (2015). The Roman and Islamic spice trade: new archaeological evidence. Journal of Ethnopharmacology, 167, 54-63.*
Supported by NERC grant NER/A/S/2003/00336.

UPPER PALAEOLITHIC GENOMES REVEAL DEEP ROOTS OF MODERN EURASIANS

New genetic sequencing of a 13,300 years old and 9,700 years old males from western Georgia has revealed that Caucasus hunter-gatherers (CHG) belong to a distinct ancient clade that split from western hunter-gatherers ~45 kya, shortly after the expansion of anatomically modern humans into Europe. The CHG genomes significantly contributed to the Yamnaya steppe herders DNA who migrated into Europe ~3,000 BC. This data supports a formative Caucasus influence on this important Early Bronze age culture. The Caucasus has left a strong genetic imprint on modern populations from this region and also in central and south Asian populations too. This might well mark the arrival of Indo-Aryan languages. CHG genes represent a fourth ancestral component of the European gene pool (see right) and underscores again the importance of dense geographical sampling for human palaeogenomes.



Jones, E. P. et al. (2015). Upper Palaeolithic genomes reveal deep roots of modern Eurasians. Nature Communications, 6.

NRCF-EAST KILBRIDE *(NRCF staff co-authors underlined)*

LOCKING AWAY ARCTIC SOIL CARBON

Almost twice as much carbon is stored in Arctic soil, as frozen plant remains, as in the atmosphere. If the soils warm, this carbon can be released as greenhouse gases (carbon dioxide, CO_2, and methane) to the atmosphere, and contribute to warming of Earth's climate. However, some of the soil organic carbon can be eroded and transferred to rivers. If it is not converted to CO_2 during river transport it can eventually reach the sea and become buried in marine sediments. In this case, the carbon can be locked away for millions of years. Knowing the extent to which this happens is important as it is part of the global carbon cycle, and for predicting the possible effects of northern soil warming on climate. Radiocarbon and stable carbon and nitrogen isotopes were measured in sediment samples from one of the largest rivers in the Arctic, the Mackenzie River of Canada to work out that most of the eroded organic carbon ranged from recent to about 8,000 years old, with smaller amounts from very old carbon from rocks. The amount of carbon eroded from soils and transported by the Mackenzie River was calculated to be 2.2 million tonnes of carbon per year. Sediments collected from a core offshore indicated that the terrestrial carbon is rapidly buried in the sediments of the Arctic Ocean. This process will contribute to stabilising the Earth's CO_2 levels over thousands of years, but is not enough to counter CO_2 from burning fossil fuels. It is also about 10-20 times too slow to offset the predicted release of CO_2 if the frozen soils thaw over the next 100 years.The international collaboration was supported by NERC, WHOI Arctic Research Initiative, an Early Career Research Grant by the British Society for Geomorphology, a Royal Society University Fellowship, and a grant from the US National Science Foundation.


Photo: R Hilton

Hilton, R. G., Galy, V., Gaillardet, J., Dellinger, M., Bryant, C., O'Regan, M., Gröcke, D. R., Coxall, H., Bouchez, J. and Calmels, D. (2015). Erosion of organic carbon in the Arctic as a geological carbon dioxide sink. Nature 524(7563): 84-87.

1000 YEARS OF GREAT EARTHQUAKES IN SOUTH CENTRAL CHILE

Earthquakes and tsunamis caused by the release of stress in subduction zones, where a tectonic plate is thrust beneath another plate, pose significant risks to human populations. The potential for great earthquakes in Chile is well known and the 1960 Valdivia, Chile earthquake remains the largest seismically recorded earthquake (magnitude of 9.5) and caused local and trans-Pacific tsunamis. Although historical records provide some understanding of mechanisms and frequency of geohazards in subduction zones, a geological approach to understanding the timing and characteristics of past earthquakes over a longer timescale is essential for assessing future hazards related to subduction zones. Understanding how well the geological records can record past earthquakes and tsunamis is key to this and the Chilean subduction zone is an important area to examine palaeoseismic modelling. A 1000 year sediment record of megathrust earthquakes and tsunamis from the coast at Chucalén south central Chile was compared with historical records. By examining changes in sediment/soil and which types of diatoms occurred (comparing them with those found in modern environments) in coastal


Photo: C. Taylor-Garrett

marshes, evidence of uplift or subsidence, tsunamis and relative sea-levels were modelled. The results showed net relative sea-level rise over the last millennium. Radiocarbon dates of plant remains were used to determine the timing of changes in the record. Although the geological record from Chucalén did not show as many great earthquakes (magnitude ≥8.0) as the historical record this is consistent with hypothesised spatial variability in earthquake rupture zones. The results demonstrated the potential and possible future refinements of using palaeoseismic modelling in this area. *Garrett, E., Shennan, I., Woodroffe, S. A., Cisternas, M., Hocking, E. P. and Gulliver, P. (2015). Reconstructing paleoseismic deformation, 2: 1000 years of great earthquakes at Chucalén, south central Chile. Quaternary Science Reviews 113: 112-122.*

6,000 YEAR RECORD OF THE NORTH AMERICAN MONSOON

The North American Monsoon (NAM) provides up to 60% of annual precipitation within its core region of Mexico and the southwest USA and is vital to sustaining agriculture, industry and biodiversity. Climate change projections for the NAM region suggest that both increased temperatures and reduced precipitation are likely in the coming century. Understanding past NAM variability and how it is controlled are essential for predicting future changes. In regions affected by the NAM records of lake sediment components which can be linked with precipitation change can be used to identify both the long term evolution of the NAM and its variability under different climatic conditions. Sedimentary titanium concentrations compared with observational, instrumental and historical records through the last 2000 years indicate inwash of sediment to Laguna de Juanacatlan, Mexico are controlled by rainfall amount, mainly due to summer rainfall in the lake's catchment, and so titanium concentrations could be used to reconstruct past NAM rainfall variability. A high resolution timescale was provided combining very fine scale measurements of titanium and using radiocarbon and radiocaesium dating of the lake sediment. The lake records indicated a shift to predominantly Pacific climatic influence of the NAM between 4,000 and 3,000 years ago, giving rise to the present day climatic controls in this region. *Jones, M. D., Metcalfe, S. E., Davies, S. J. and Noren, A. (2015) Late Holocene climate reorganisation and the North American Monsoon. Quaternary Science Reviews 124: 290-295.*

GRASS ROOTS MAGNIFY SOIL CO_2 RELEASE

Soils are the largest store of the world's terrestrial carbon, containing about four times as much carbon as in the atmosphere. Knowing whether higher atmospheric carbon dioxide (CO_2) concentrations increase soil carbon by stimulating plant productivity or decrease soil carbon due to temperature-driven increases in soil organic carbon decomposition rates, is crucial to predictions of future climate. Many studies have investigated microbial mineralisation of soil organic carbon to CO_2 but most of these have been on soil without growing plants, because interpreting results with added CO_2 fluxes from below ground respiration root systems of growing plants is complicated. The NRCF-E designed zeolite molecular sieve field system was used at the Bangor University Henfaes Experimental Station to collect respired CO_2 from plots with growing plants (grass swards) and those with no plants. The effect of a 3^oC increase in temperature on respiration from soils was examined. Radiocarbon results from sampling intervals over a year helped to estimate the carbon sources and changes in proportion of recent carbon and older soil organic carbon. The presence of plants in grass swards more than doubled the effect of warming on the rate of mineralisation of soil organic carbon, with an estimated mean carbon age of ca. 8 years or older relative to incubated soils without recent plant inputs. These results not only illustrate the complexity of mechanisms controlling carbon fluxes in soils but also suggest that the dual biological and physical effects of CO2 on primary productivity and global temperature have the potential to synergistically increase the mineralisation of existing soil carbon.
Hill, P. W., Garnett, M. H., Farrar, J., Iqbal, Z., Khalid, M., Soleman, N. and Jones, D. L. (2015). Living roots magnify the response of soil organic carbon decomposition to temperature in temperate grassland. Global Change Biology 21: 1368-1375.

FUTURE DEVELOPMENTS/STRATEGIC FORWARD LOOK

NRCF developments will provide innovative, internationally competitive techniques and unique opportunities for the UK scientific community. NRCF is responsive to community needs and developments, as well as to changes in NERC's Strategic Priorities and will work closely with the NRCF-Steering Committee and BGS to optimise management of NRCF, to further strengthen the Facility. Given current tight financial constraints, prioritising some areas of work over others will be necessary which will require the support of NRCF-SC, BGS and careful management of financial implications by NRCF. A major focus over the last year has been on planning how services might develop through the next commissioning cycle. This has generated a lot of ideas for integration of elements across the different services. In particular on training we are already starting to work towards training relevant across the geo-chronological disciplines, but there is scope to take this further with courses that give people transferable skills across techniques. Another area where we hope to make the facilities more convenient for users is with the ability to apply to several different services with one application, with a single online submission process. There is also considerable scope for integration of other aspects such as logging of outputs from Facility support.
At NRCF-O plans are now getting more advanced for a replacement AMS facility, with space allocated and elements of funding being secured. This is a major priority for improved efficiency, precision, sensitivity and reduced unit costs. Good progress is also been made on methods for compound-specific dating on bone in conjunction with the ERC Palaeochron project led by Tom Higham. New innovative statistical methods are also under development in conjunction with a NERC DTP studentship with potential applicability for environmental records using a whole range of dating methods. This is in conjunction with further developments in the widely used OxCal package. Both OxCal and NRCF-O's online databases are being developed in conjunction with these new statistical methods to make use of Open Linked Data models for the easy sharing of diverse datasets. NRCF-E will focus on reducing turn-around times and radiocarbon methods for global carbon cycle research, to quantify sources and rates of carbon transport. These will include techniques for greenhouse gases, compound specific methods eg n-alkane analysis and the hydropyrolysis system. Both NRCF nodes will be supporting the SUERC AMS Laboratory to commission the positive ion source towards a novel and more efficient method of radiocarbon analysis.