SERVICES & FACILITIES ANNUAL REPORT - FY April 2014 to March 2015

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 also 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. **NRCF-E:** Annual capacity=1300 analytical units (2,184 units processed 2014-15, excluding repayment work). Average turnaround time = 4.7 months; range 1.3-8.9 months. **NRCF-O:** Funded capacity for NRCF-SC approved work = 500 AMS analytical units (373.5 units processed 2014-15. This is lower than previous years when the facility ran over capacity). Average turnaround time = 4.7 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 5 (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 Scientific:** Head Grade 10 (0.45FTE); Deputy Head Grade 10 (0.5); 3 PDRAs Grade 7 and 8 (0.4,0.4,0.4); **Technical** Grades 4 and 5 (4x0.3). **Administrative:** Grade 6 (0.4).	**2017**	**2018**

FINANCIAL DETAILS: CURRENT FY						
Total Resource Allocation £k	**Unit Cost £k**			**Capital Expend £k**	**Income £k**	**Full Cash Cost £k**
	Analytical Unit (using allocation)	**Unit 2**	**Unit 3**			
NRCF-E: 872.44	0.40			17.8	18.21	991.89
NRCF-O: 327.14	0.65			-	-	611.57

FINANCIAL COMMITMENT (by year until end of current agreement) £k				
2014-15 **E:**872.44 **O:**327.14	**2015-16** **E:** 836.94 O:			

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

APPLICATIONS: DISTRIBUTION OF GRADES (current FY — 2014/15)													
	10	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**	**R***	**Pilot**
NERC Grant projects*	1	1	5	10	0	1	1	1	0	0	0	1	1
Other academic	0	2	11	9	2	1	2	1	0	0	2	3	0
Students	1	1	6	10	14	0	1	2	0	0	0	6	0
TOTAL	2	4	22	29	16	2	4	4	0	0	2	10	1

APPLICATIONS: DISTRIBUTION OF GRADES (per annum average previous 3 financial years —2011/2012, 2012/2013 & 2013/2014)													
	10	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**	**R***	**Pilot**
NERC Grant projects*	2.33	3.67	6.67	4.34	0.33	0	0	0	0	0	0.33	2	0.33
Other academic	0.33	3.33	5.33	7	1.33	2.34	1.33	0.66	0.67	0	0.33	4.67	0.33
Students	0	3	5.66	11.33	12	1	0.33	1.33	1.33	0	0.33	7	0
TOTAL	2.66	10	17.66	22.67	13.66	3.33	1.66	2	2	0	1	13.67	0.67

PROJECTS COMPLETED (current FY – 2014/15)											
	10 (α5)	**9**	**8 (α4)**	**7**	**6 (α3)**	**5 (α2)**	**4**	**3 (α1)**	**2**	**1 (β)**	**0 (Reject)**	**Pilot**
NERC Grant projects*	0	4	7	7	0	0	0	0	0	0	0	0
Other Academic	0	2	5	6	2	0	0	0	0	0	0	0
Students	0	3	6	11	12	0	0	0	0	0	0	0

Project Funding Type (current FY – 2014/15) (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**
109	**38 incl 3 AHRC**	**17**	**25**	**0**	**23**	**0**	**1**	**0**	**1**	**4**

Project Funding Type (per annum average previous 3 financial years - 2011/2012, 2012/2013 & 2013/2014)										
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**
92.50	**19 incl 4.33 AHRC**	**10.33**	**24.33**	**1**	**25.33**	**2**	**0**	**2**	**2**	**6.5**

User type (current FY – 2014/15) (include each person named on application form)				
Academic	**NERC Centre**	**NERC Fellows**	**PhD Students**	**Commercial**
267	**12**	**2**	**47**	**3**

User type (per annum average previous 3 financial years - 2011/2012, 2012/2013 & 2013/2014)				
Academic	**NERC Centre**	**NERC Fellows**	**PhD Students**	**Commercial**
186	**12.67**	**4**	**39.33**	**2.67**

OUTPUT & PERFORMANCE MEASURES (current year)

Publications (by science area & type) (calendar year 2014)										
SBA	**ES**	**MS**	**AS**	**TFS**	**EO**	**Polar**	**Grand Total**	**Refereed**	**Non-Ref/ Conf Proc**	**PhD Theses**
24.6	6.8	6.5	0	19.5	0	4.5	62	46	4	12

Distribution of Projects (by science areas) (FY 2014/15)							
Grand Total	**SBA**	**ES**	**MS**	**AS**	**TFS**	**EO**	**Polar**
109.0	22.3	40.2	9.0	2.5	28.0	1.0	6.0

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

Publications (by science area & type) (Calendar years 2011, 2012 & 2013)										
SBA	**ES**	**MS**	**AS**	**TFS**	**EO**	**Polar**	**Grand Total**	**Refereed**	**Non-Ref/ Conf Proc**	**PhD Theses**
32.73	9.00	18.17	0.73	28.87	0	4.00	93.60	70	9.6	14

Distribution of Projects (by science areas) (FY 2011/2012, 2012/2013 & 2013/2014)							
Grand Total	**SBA**	**ES**	**MS**	**AS**	**TFS**	**EO**	**Polar**
92.50	27.00	26.00	11.10	1.70	23.90	0.50	2.30

Distribution of Projects by NERC strategic priority (current FY 2014/15)							
Grand Total	**Climate System**	**Biodiversity**	**Earth System Science**	**Sustainable Use of Natural Resources**	**Natural Hazards**	**Environment, Pollution & Human Health**	**Technologies**
109	36.2	20.8	23.4	12.3	6.4	9.9	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 (2014/15):

NERC grant projects supported by large NRCF allocations included: 1) 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 with BGS, HEIs and UK research institutes), part of the NERC Macronutrient Cycles Programme. 2) BRITICE-CHRONO, a NERC-funded consortium (PI C Clarke, University of Sheffield) 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. 3) Permafrost methane emissions (PI I Hartley, University of Exeter), part of the NERC Arctic Research Programme project Carbon Cycling Linkages to Permafrost Systems, aiming to elucidate the impact of Arctic warming and release of greenhouse gases relative to increased vegetation growth. 4) Peatlands and the global carbon cycle during the past millennium (PI D Charman, University of Exeter) 5) Seeing genes in space and time: the evolution of neutral and functional genetic diversity using woolly mammoth (PI Michi Hofreiter, formerly University of York. 5) Earthquakes without frontiers: a partnership for increasing resilience to seismic hazard in the continents (PI Richard Walker, Earth Sciences, University of Oxford. 6) Towards a Decadally-Resolved Radiocarbon Calibration for the Last Glacial Period (30,000-11,700 years ago) Using New Zealand Kauri (Agathis australis) (PI Christopher Ramsey, Univ. of Oxford). 7) Seeing Landscapes (PI Stephen P. Hicks, University of Liverpool).

Training: As part of NERC DTP at Oxford the NRCF-O ran a 3 day short course in Radiocarbon Dating and Bayesian Chronological Analysis, open to any students and members of the public and involving teaching by staff from both NRCF nodes and practical hands-on tutorials for using OxCal software for simulations, calibration and statistical analysis. As in previous years strong positive feedback was received from the 25 students that participated. NRCF-O also had 3 students in the laboratory for training and observation in radiocarbon methods, linked with NRCF projects. Ten PhD students visited NRCF-E, to discuss projects and samples, of which seven students and a further three post-doctoral researchers received hands-on laboratory training. Enthusiastic and positive responses to these visits were received directly and in the annual user survey.

Technique Development and Capital Funding: Development work, in support of approved projects and to improve infrastructure and scientific opportunities offered, was reduced due to the high workload for approved projects, but included:

- The new high performance liquid chromatography system at NRCF-O, which was supported via NERC capital funding, has been successfully installed and is now running. It is being used in addition for Super-critical Fluid Extraction (SFE), which holds great promise for speeding up the pretreatment chemistry and cleaning of organic samples for AMS dating.
- A proposal to the NERC Strategic Environmental Science Capital for 'A plasma source positive-ion mass spectrometer for next generation radiocarbon and beyond' was awarded to SUERC (£475k). The entirely novel form of radiocarbon measurement was pioneered by the SUERC AMS Laboratory (a NERC Recognised Facility), leading the project. The new measurement technique aims to provide a 100-fold reduction in sample size and greater throughput, with reduced labour requirements and operating costs. It will be developed in partnership with NRCF-E and with collaborative support from NRCF-O, including loan of gas handing equipment and technical support.
- In collaboration with P Ascough at the SUERC AMS Facility and jointly funded by SUERC and Services and Facilities capital, the hydropyrolysis system has been installed and initial commissioning carried out. This will enable pyrolysis of samples using high hydrogen pressures to reductively separate carbon compounds on the basis of chemical resistance.
- Radiocarbon techniques to isolate methane at low concentrations from groundwater are under development with BGS.
- Automation of the molecular sieve system has reduced staff time required by a half and further efficiencies have been achieved on other lab processes, through on-going improvements to data recording and process automation.
- Standards and background materials for compound specific radiocarbon (n-alkane isolation) have been developed and tested. Careful characterisation of background contamination in very small samples and collaboration with the Keck Carbon Cycle AMS Laboratory, University California Irvine, has enabled successful analysis of sample sizes as low as 25µg carbon. This has meant that approved project samples which would previously have been too small (eg pollen) were analysed.

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 1.7 times higher than capacity but the turnaround time was less than one month longer than in 2013/14 when units were 1.16 times higher than capacity. This was achieved by prioritisation of work and transfer of 53 approved samples to NRCF-O. Strong capabilities of NRCF, including staff expertise and host institution support have ensured that effective, high quality support was provided for NRCF's community. Analytical units take into account resource requirements for processing and reporting samples (including failed samples), associated quality control standard materials for approved projects, analytical equipment and student training; the units do not include staff time for publications relating to approved projects, new methods, providing feedback on steering committee application drafts and enquiries and NERC/BGS administrative tasks (eg steering committee secretaries). The high proportion of NERC grants supported, many of which are collaborative with NRCF staff, is evidence of Facility alignment to NERC's strategic priorities and many of these projects rely on unique capabilities at NRCF. The annual on-line survey was sent to147 researchers who had either applied for, or received NRCF support during the previous calendar year. 84% of respondents rated the overall quality of NRCF service as excellent and the majority indicated that they had received useful feedback on applications and advice following reporting of results.

SCIENCE HIGHLIGHTS. ***To focus on economic and societal impacts and benefits where possible*:**
Facility staff co-authors are underlined

NRCF-OXFORD
SPATIO-TEMPORAL MODELLING OF NEANDERTHAL DISAPPEARANCE

Neanderthals and modern humans were both living in Europe for between 2,600 and 5,400 years. This is the key conclusion of a large NERC-funded study published this past year in the journal *Nature*. For the first time, a robust chronology for when the last Neanderthals died out. Significantly, the data suggest that Neanderthals disappeared at different times across Europe rather than being rapidly replaced by modern humans all at once.
The Oxford team, led by Professor Tom Higham, obtained fresh radiocarbon dates from over 400 samples of bone, charcoal and marine shell from 40 key European Palaeolithic archaeological sites. The sites, ranging from Russia in the east to Spain in the west, were either associated with the Neanderthal tool-making industry, known as Mousterian, or were 'transitional' sites containing stone tools also associated with early modern humans. The chronology was pieced together by building mathematical models that combine the new radiocarbon dates with established archaeological evidence. The results showed a 95% probability that both groups were contemporaneously living in Europe for a significant period, giving ample time for interaction and interbreeding. The data suggest some complexity in the ages of the earliest modern human industry known in Europe (the Uluzzian, found in Italy) and the final industries associated with Neanderthals that are found archaeologically suggesting that between 45-40 ka BP there was a mosaic of human populations across Europe.
Higham and 49 others. 2014. The timing and spatiotemporal patterning of Neanderthal disappearance. Nature 512(7513): 306-9.

THE OPENING AND CLOSING OF THE BERING STRAIT AND PLEISTOCENE MIGRATION TO THE NEW WORLD
Human colonization of the New World is generally believed to have entailed migrations from Siberia across the Bering isthmus. However, the limited archaeological record of these migrations means that details of the timing, cause and rate remain cryptic. Work funded by the NRCF based on a combination of ancient DNA, ^{14}C dating, hydrogen and oxygen isotopes, and collagen sequencing has been used to explore the colonization history of one of the few other large mammals to have successfully migrated into the Americas at this time: the North American elk, also known as wapiti. Meiri et al. (2014) identified a long-term occupation of northeast Siberia, far beyond the species's current Old World distribution. Migration into North America occurred at the end of the last glaciation, while the northeast Siberian source population became extinct only within the last 500 years. This finding is congruent with a similar proposed delay in human colonization, inferred from modern human mitochondrial DNA, and suggestions that the Bering isthmus was not traversable during parts of the Late Pleistocene. These new data imply a fundamental constraint in crossing Beringia, placing limits on the age and mode of human settlement in the Americas, and further establish the utility of ancient DNA in palaeontological investigations of species histories. A total of 32 samples were funded by NRCF and these provide an anchor for the DNA Bayesian skyline models and analysis published the paper below.
Meiri, M. & others. (2014). Faunal record identifies Bering isthmus conditions as constraint to end-Pleistocene migration to the New World. Proceedings of the Royal Society B: Biological Sciences, 281(1776), 20132167.

THE ARCHAEOLOGICAL SEQUENCE OF NIGERIA, FROM 1500 BP
The NRCF has funded several applications for support to work in the archaeology of Nigeria, a region of key importance for African archaeology, but one that has suffered from a dearth of effective archaeological science, post-excavation work and in particular chronology building. Anne Haour and her collaborators have been working to change this, in an area of northern Nigeria that is, in a sense *terra incognita* for this type of work. There are no radiocarbon labs in Nigeria and much excavated material is never properly analysed in post-excavation. This is a great pity because Nigeria boasts a particularly rich archaeological heritage and there is much that needs to be done to place it within its wider political and social framework, particularly over the recent millennia. Trade and exchange across large tracts of western Africa was widely practised since the Iron Age but little definitive is known about it or has been published. A few new radiocarbon dated sites make a huge difference in a region where there are few, if any, reliable chronometric dates. The support of the NRCF for researchers working in Nigeria is a significant help to understanding the prehistoric sequence there.
Sule Sani, A & Haour, A (2014). The archaeology of northern Nigeria: trade, people and polities, 1500 BP onwards. Azania 50, 1-24.

NRCF-EAST KILBRIDE

DOES PEATLAND DRAINAGE CAUSE CARBON LOSS?
Human impact on peatlands, including drainage, burning, land conversion for agriculture, timber, and biofuel production, cause loss of peat-forming vegetation. Carbon sequestration and storage in peatlands requires high water tables and associated anaerobic conditions leading to slow decomposition. Peatland disturbance can expose previously anaerobic peat to much faster aerobic decomposition, which can shift peatlands from net CO_2 sinks to large CO_2 sources, releasing carbon held for millennia. Peatlands also

export significant quantities of carbon via fluvial pathways, mainly as dissolved organic carbon (DOC). In undisturbed peatlands this is largely from recently photosynthesised carbon. Radiocarbon levels in DOC in drainage water from multiple peatlands in Europe and Southeast Asia were used to infer differences in the age of carbon lost from intact and drained systems. In most cases, drainage led to increased release of older carbon from the peat profile but with marked differences related to peat type and a gradient of peatland sensitivity to drainage, with tropical peat>fen>raised bog>blanket bog. Runoff from drained tropical peatlands indicated loss of very old (centuries to millennia) stored peat carbon whereas high-latitude peatlands (eg upland UK blanket bogs) appeared more resilient to drainage. Higher peat surface temperatures, burning of surface peat, loss of natural vegetation cover, and other drainage-related disturbances also appeared to exacerbate carbon loss. The results emphasize the general susceptibility of peatlands to drainage and other anthropogenic degradation, but also highlight the apparently greater vulnerability of tropical peatlands. Active drainage of northern peatlands is generally decreasing, and in some areas is now being reversed through rewetting and restoration, whereas tropical peatlands remain under severe and ongoing pressure, particularly in Southeast Asia, as demands to drain and clear forest land for agriculture and large-scale plantations intensify. *Evans, C. D., Page, S. E., Jones, T., Moore, S., Gauci, V., Laiho, R., Hruška, J., Allott, T. E. H., Billett, M. F., Tipping, E., Freeman, C. and Garnett, M. H. (2014). Contrasting vulnerability of drained tropical and high-latitude peatlands to fluvial loss of stored carbon. Global Biogeochemical Cycles 28(11), 1215-1234.*

SEA LEVEL CHANGE OVER THE PAST 2000 YEARS

Understanding how sea level has varied in the last few thousand years is important for several reasons, including 1. Sea-level variability records the net effect of changes in polar ice sheets, mountain glaciers and ocean-atmospheric processes. 2. Long-term trends in sea level provide insights into past climate variability. 3. Past sea-level records can be used to test and develop models of ice-sheet response to climate change and models of glacial isostatic adjustment (rebound of landmasses after glaciations, following depression by ice sheets). There are few precisely dated, continuous records of sea-level change covering the last 2000 years, but those from low energy salt-marsh deposits that fringe mid latitude coastlines are especially useful. Establishing the significance of forcing factors affecting sea level requires additional records from the North Atlantic and beyond. Radiocarbon data from salt marsh deposits in north west Scotland, UK and the eastern North Atlantic provided a timescale for the first continuous 2000 year long records of relative sea level change in these areas. Sea level was reconstructed by comparing the foraminifera and diatoms found at different levels in the salt marsh deposits and assigning these to conditions in which the same organisms are found today. The records showed that relative sea level has been stable (±0.4 m) during the last two millennia**.** The most recent change in the organisms found in the records indicated a regional tendency to marine conditions and that 20th century sea-level acceleration in north west Scotland may have exceeded the rate of background relative sea level fall (0.4 mm yr^{-1}), but the signal was muted and later than in the western North Atlantic**.** These regional differences between sea-level histories on both sides of the North Atlantic provide important clues to identify underlying driving mechanisms. *Barlow, N. L. M., Long, A. J., Saher, M. H., Gehrels, W. R., Garnett, M. H. and Scaife, R. G. (2014). Salt-marsh reconstructions of relative sea-level change in the North Atlantic during the last 2000 years. Quaternary Science Reviews 9, 1-16.*

WESTERN ANTARCTIC ICE SHEET CHANGES

Fully understanding controls on recent ice sheet changes and predicting their future responses requires an assessment of the duration, timing and forcing of past ice sheet retreat. Such assessment is particularly needed for the Amundsen Sea sector of the West Antarctic Ice Sheet (WAIS), where glaciers have thinned and retreated dramatically over the past 20 years and now account for >35% of its total discharge. There are concerns that large-scale glacier collapse is possible on human timescales. Complete collapse of the glaciers in this region would raise global sea level by ~1.5 m and although this remains a possibility, recent estimates suggest that melting of the region's Pine Island Glacier alone would contribute 3.5–10 mm over the next 20 years. Using marine geological data and an extensive new radiocarbon dataset from the eastern Amundsen Sea Embayment this study characterised the retreat of the WAIS since the Last Glacial Maximum and assessed the significance of these changes. Deglaciation of the outer shelf was underway before 20,600 calibrated years before present (cal yr BP), reaching the mid-shelf by 13,575 cal yr BP and the inner shelf to within ca. 150 km of the present grounding line by 10,615 cal yr BP. The timing of retreat is broadly consistent with previous studies in the eastern and western Amundsen Sea Embayment and provides new constraints for ice sheet models. Despite revealing these broad scale trends, the current dataset does not capture detailed changes in ice flow, such as stillstands and possible readvances as depicted in the geomorphological record and highlights the need for additional marine geological data from the area in order to improve ice sheet models and investigate the mechanisms responsible for forcing ice sheet retreat. *Smith, J. A., C.-D. Hillenbrand, Kuhn, G, Klages, JP, Graham, AGC, Larter, R D, Ehrmann, W, Moreton, S G, Wiers, S, Frederichs, T (2014). New constraints on the timing of West*

Antarctic Ice Sheet retreat in the eastern Amundsen Sea since the Last Glacial Maximum. Global and Planetary Change 122 224-237

WATER TREATMENT OF DISSOLVED ORGANIC MATTER

Pressure on water resources has led to the need to utilise water with higher organic matter concentrations. Increased dissolved organic carbon concentrations have been observed in rivers draining peatlands. Evidence from numerous rivers shows riverine DOC as relatively 'young' in radiocarbon age and rivers acting as organic carbon processors, with microbial decomposition of previously unavailable soil carbon. Water treatment involves physico-chemical processes to remove organic matter, which help to minimise the formation of potentially carcinogenic disinfection by-products and microbial regrowth. The energy consumption of treating water (including waste water) has increased significantly in the last 30 years, globally emitting an estimated annual 1.21 Pg CO_2e yr^{-1}, equivalent to approximately 3.6% of annual anthropogenic carbon emissions. Understanding how organic matter is changed through the treatment processes can provide insight into the treatment efficiency. For the first time stable carbon isotopes and radiocarbon measurements of dissolved organic carbon were used to characterise dissolved organic matter through a water treatment works. This showed that new sources of organic carbon were added during the treatment processes, and that treated water is isotopically lighter and typically younger in radiocarbon DOC age than untreated water. *Bridgeman, J., Gulliver, P., Roe, J. and Baker, A. (2014). Carbon isotopic characterisation of dissolved organic matter during water treatment. Water Research 48(0): 119-125. Carbon isotopes in dissolved organic matter during water treatment are measured for the first time, reveal carbon addition during drinking water treatment, implications for energy use.*

MOUNTAINS AS SOURCES OR SINKS OF CARBON

A major source of carbon dioxide (CO_2) to the atmosphere occurs when oxygen reacts with ancient, organic carbon within rocks and may counter sequestration through burial of new organic carbon in sediments. Previous work has suggested the CO_2 release will be significant in mountain belts where erosion exposes rocks rapidly but this 'mountain respiration' has never before been quantified. CO_2 release across the mountain belt of Taiwan was quantified using the element rhenium as a proxy to track organic carbon oxidation from rocks and radiocarbon measurements were used to quantify oxidation of rock-derived organic carbon in soils. Erosion rate sets the pace of CO_2 emissions by mountain respiration but overall Taiwan acts as a CO_2 sink through erosion of organic carbon from the terrestrial biosphere, its fluvial transport and marine burial off-shore. Mountain building in Taiwan presently acts as an organic carbon sink, sequestering atmospheric CO_2 during weathering and erosion. *Hilton, R. G., J. Gaillardet, et al. (2014). Geological respiration of a mountain belt revealed by the trace element rhenium. Earth and Planetary Science Letters 403, 27-36.*

FUTURE DEVELOPMENTS/STRATEGIC FORWARD LOOK

NRCF developments will provide innovative 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. Priorities over the next 2-3 years will include supporting the large sample demand (many existing NERC grant commitments extend over this period); managing commitments to minimise turnaround; succession planning and training for anticipated retirements, existing staffing levels need to be maintained to meet current demand; improvements in technical efficiency, eg further automation of lab processes and record keeping. NRCF contributes to the general advance of radiocarbon science by knowledge exchange with other radiocarbon laboratories.

Development work will focus on exciting new techniques and application of these to approved research projects and collaborations:

- Further development of the internationally used OxCal programme and related statistical tools for optimising environmental chronologies.
- Compound specific methods (such as single-amino-acid dating of bone, and the development of n-alkane dating)
- Continued development of methods to quantify sources and rates of greenhouse gas emissions (CO_2 and methane sampling from landfill sites, ground-water and other aquatic systems), making full use of radiocarbon as a tool to understand the global carbon cycle as well as the key chronometer for the last 50,000 years.
- Hydropyrolysis system

Infrastructure development will include:

- Capital expenditure priorities at NRCF-O focussed on updating of AMS facilities with the aim of having a system well suited to student training, collaborative research projects and efficient delivery of service.
- Supporting the SUERC AMS Laboratory to commission the positive ion source and to develop interfaces for introducing samples to the new equipment, including automated techniques.
- In light of the NRCF-E building lease expiry in 2017, funding is being sought for a new building, purpose-built for current scientific and staffing needs and adaptable to future requirements.