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

SERVICE	FUNDING	AGREEMENT	ESTABLISHED as S&F	TERM
NERC Argon Isotope Facility (AIF)	Block	R8/H10/43	1994	2010-2014

TYPE OF SERVICE PROVIDED:

The age of geological materials and the rates of Earth system processes are fundamental to geoscience research. The ^{40}K-^{40}Ar clock is one of the most widely used radio-isotopic dating methods, and is capable of determining the age of rocks that were erupted in historical times to meteorites that are older than the Earth (>4.5 Ga). The NERC Argon Isotope Facility (AIF) offers the capability to determine high-quality $^{40}Ar/^{39}Ar$ ages.

The AIF was established in response to community demand and provides access for UK geoscientists to a comprehensive suite of analytical equipment dedicated to argon isotope determinations in both rocks and minerals. The Scottish Universities Environmental Research Centre (SUERC), East Kilbride, hosts the Facility and benefits from complementary technical and academic expertise provided by in-house technical and academic staff, in particular those from noble gas, stable and radiogenic isotope laboratories. The AIF has the most extensive range of gas extraction techniques and analytical tools in the UK, and aims for flexibility and versatility of service. The techniques allow high-precision age determinations of rocks/minerals, and high spatial resolution *in situ* dating. Earth Science problems across the entire NERC remit are tackled by the AIF, in particular Climate Systems and Natural Hazard.

The AIF head is Dr. Finlay Stuart, scientific support is provided by Dr. Darren Mark and Dr. Dan Barfod, technical support by James Imlach. Facility science quality is maintained by NIGFSC (α3H and above for postgraduate student projects and α4 for other research). The AIF is committed to training project leaders, post-doctoral and doctoral researchers in $^{40}Ar/^{39}Ar$ geochronology. AIF personnel provide input into project design. Training is concentrated during intensive laboratory visits, data redaction, and thesis/manuscript preparation. Output is measured by peer-reviewed publications, PhD theses, conference presentations and production of chronology-literate research scientists**.**

ANNUAL TARGETS AND PROGRESS TOWARDS THEM

Within the past year the AIF received 11 applications, 6 new users. Six applications, from different institutions, were funded. Projects cover all aspects of the NERC Scientific Remit.

Mass spectrometer blanks for all systems remain at an all time low and the Facility capacity remains at an all time high. The time taken from sample receipt to data return to PI remains on average 6 months (which includes a 3 month irradiation period). There is now no significant sample backlog.

A new extraction line for the HELIX-SFT (Spring 2011 delivery) has been constructed. The extraction line is fully automated and a dual-inlet system with two independent manifolds was designed for flexibility. Full pumping bypass systems linking laser extraction chambers allows for independent baking and maximise sample throughput. During the past year AIF has constructed a new CO_2 laser system to facilitate extraction of Ar from large samples of basaltic groundmass. This was completed in October 2010, underwent full testing and was integrated with AIF automation control software. The system was specifically designed for the dating of young (Quaternary-Holocene) volcanic rock and has been successfully deployed for analysis of basalts from Tristan da Cunha (IP-1152-1109) with unprecedented precision (see science highlights). Dr. Barfod is presenting a paper at the European Geophysical Union (EGU) conference (Vienna) discussing the laser system and its application to young volcanic rocks.

The AIF have continued to diversify its research portfolio. Work with the Oxford University Toba project (IP-1184-0510) and international Out of Africa project (IP-1186-0510) (see science highlights) are due to Facility staff actively seeking out projects within new fields. The AIF continues to lead the UK Ar/Ar effort to improve timescale calibration working with both the NSF- and EU-funded EarthTime initiative and the Marie Curie GTSnext training network. Dr Mark is presenting a paper at EGU discussing recent revisions to the Ar/Ar system (standard ages and decay constants) and intercalibration of the Ar/Ar and U-Pb timescales.

SCORES AT LAST REVIEW (each out of 5)		Date of Last Review:		
Need	Uniqueness	Quality of Service	Quality of Science & Training	Average
5	4.5	4.5	4.5	4.63

CAPACITY of HOST ENTITY FUNDED by S&F	Staff & Status	Next Review (March)	Contract Ends (31 March)
	Dr. D.F. Mark (Grade 8, PDRA, R1A, 100% FTC)		
	Dr. D.N. Barfod (Grade 7, PDRA, R1A, 100% FTC)		
%	Mr. J.G. Imlach (Grade 6, Technician, 100% FTC)	2013	2014

FINANCIAL DETAILS: CURRENT FY						
Total Resource Allocation £k	Unit Cost £k			Capital Expend £k	Income £k	Full Cash Cost £k
	Unit 1	Unit 2	Unit 3			
284	400			10		294

FINANCIAL COMMITMENT (by year until end of current agreement) £k				
2010-11 283.65	2011-12 299.41	2012-13 315 (approx)	2013-2014 -	2014-2015 -

STEERING COMMITTEE	Independent Members	Meetings per annum	Other S&F Overseen
NIGFSC	8	**2**	**NIGL, ICSF, OUUSF**

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

	α5	α4	α3	α2	α1	β	R*/Pilot	Reject
NERC Grant projects*								
Other academic		**3**						
Students		**1**	**2**					
Pilot								
TOTAL		**4**	**2**	**0**	**0**	**0**	**0**	**0**

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

	α5	α4	α3	α2	α1	β	R*/Pilot	Reject
NERC Grant projects*		0.333						0.333
Other Academic		2.667	1.000		0.333	1.333		2.667
Students		1.333	0.667				0.333	1.333
Pilot								
TOTAL		4.333	1.667		0.333	1.667	0.333	4.333

PROJECTS COMPLETED (current FY – 2010/11)

	α5	α4	α3	α2	α1	β	R*/Pilot
NERC Grant projects*		1					
Other Academic		5	1				
Students		1	3				
Pilot							

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

Grand Total	Infrastructure					PAYG				
	Supplement to NERC Grant *	PhD Students NERC	PhD Students Other	NERC C/S	Other	NERC Grant*	PhD Students NERC	PhD Students Other	NERC C/S	Other
22	2	3	3		14					

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

Grand Total	Infrastructure					PAYG				
	Supplement to NERC Grant *	PhD Students NERC	PhD Students Other	NERC C/S	Other	NERC Grant*	PhD Student NERC	PhD Student Other	NERC C/S	Other
16	1.7	6.0	1.0		9.5					

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

Academic	NERC Centre/Survey	NERC Fellows	PhD Students	Commercial
20	**1**			

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

Academic	NERC Centre/Survey	NERC Fellows	PhD Students	Commercial
15.7	**0.5**	**0**	**0**	**0**

OUTPUT & PERFORMANCE MEASURES (current year)

Publications (by science area & type) (calendar year 2010)

SBA	ES	MS	AS	TFS	EO	Polar	Grand Total	Refereed	Non-Ref/ Conf Proc	PhD Theses
	13						13	13	0	

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

Grand Total	SBA	ES	MS	AS	TFS	EO	Polar
	22						

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

Publications (by science area & type) (Calendar years 2007, 2008 &2009)

SBA	ES	MS	AS	TFS	EO	Polar	Grand Total	Refereed	Non-Ref/ Conf Proc	PhD Theses
	7						7	6	1	

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

Grand Total	SBA	ES	MS	AS	TFS	EO	Polar
	16						

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

Grand Total	Climate System	Biodiversity	Earth System Science	Sustainable Use of Natural Resources	Natural Hazards	Environment, Pollution & Human Health	Technologies
22	9	2	4	2	5		

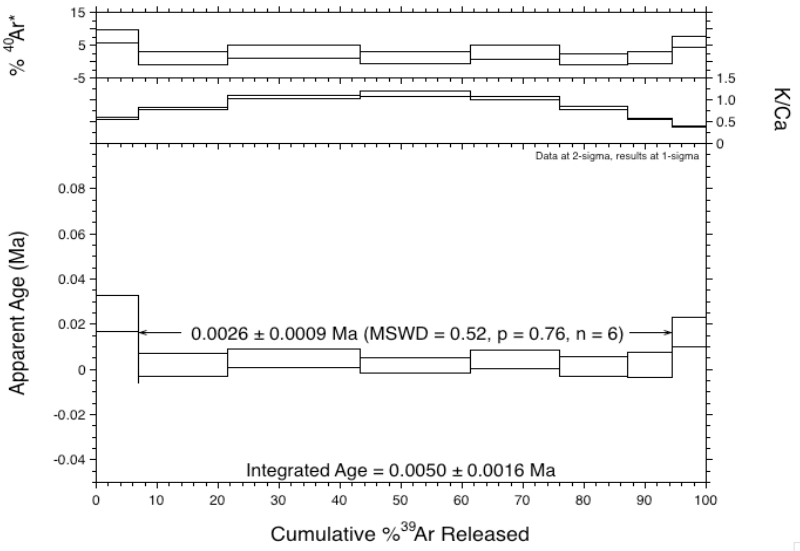
**Combined Responsive Mode and Directed Programme grants*

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

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

Project throughput:
Within the past year the AIF has worked on 14 different projects, involving 13 PIs from 13 different institutions that included training and supervision of 3 PhD students. 7 projects have been completed of which 5 were finished within 6 months of sample receipt. Facility capacity remains unchanged and project throughput is at an all time high. In total, 7420 sample runs, blanks, calibrations and fluence monitors were performed in comparison to 7100 the previous year. A total of 9 applications have been submitted to the April 2011 NIGFSC round.

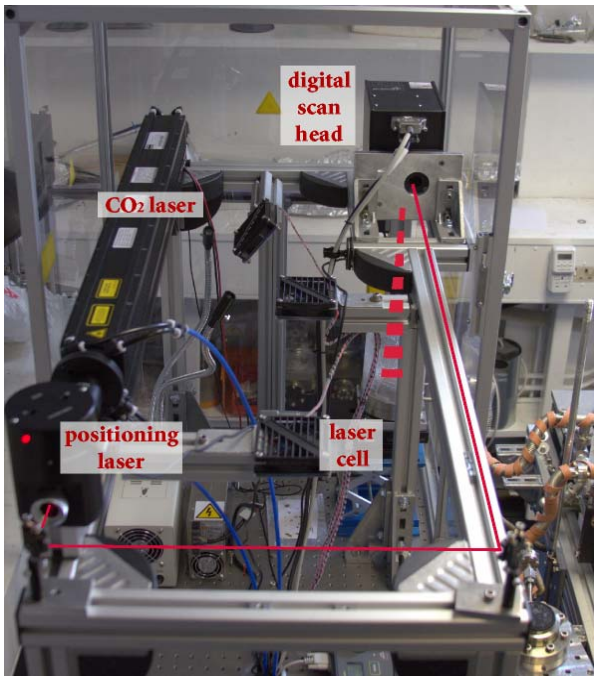
Output:
6 papers involving AIF personnel were published in international journals and 3 are currently in press. Additionally, 5 manuscripts submitted during this time are sub judice. AIF personnel have contributed to a total of 19 conference papers and presented and attended several international and national conferences, e.g., Thermo2010, EGU, Goldschmidt, VMSG.



Age spectrum for coastal strip basalt from Tristan da Cunha (IP1152-1109). This is the youngest basalt ever dated by Ar/Ar.

Laboratory management & improvements:

- Continual monitoring of blanks and backgrounds show that they remain at an all time low.
- AIF have completed the construction of a new CO_2 laser equipped with a digital scanhead (see photo below). The digital scanhead allows for accurate rastering over large wells of basaltic groundmass (and other geological material) providing homogenous heating with a normal Gaussian profile. The ability to heat large samples homogenously coupled with the subsequent improvements in blanks has allowed us to readily date Pleistocene and Holocene low-K basalts. This has included the youngest basalt ever measured by Ar/Ar: 2.6 ± 0.9 ka (1σ) (see figure above).
- Having spent many years perfecting extraction line design for the ARGUS and MAP 215-50 mass spectrometers and reducing backgrounds and blanks we have used our accrued knowledge to build a small volume low-blank extraction line for the new HELIX-SFT. The design has centred on flexibility and versatility. A double-manifold design allows for analysis of samples using both CO_2 and UV lasers whilst maximum sample throughput is retained.
- *In situ* laser ablation dating will now be performed using the UP-213nm UV laser and new HELIX-SFT.
- The MAP 215-50 system was equippedwith a second double-pumped ZnS laser cell to reduce machine downtime.



Indicators of esteem:

- Dr. Mark and Dr. Stuart were members of the scientific panel and co-conveners for the 12th International conference on Thermochronology (Thermo2010) that was held in Glasgow, August, 2010.
- AIF staff continues to review both manuscripts in top peer-reviewed journals (e.g., EPSL and Geology etc.) and grant proposals for NERC, Leverhulme, NSF and EPSRC.

Other business:

- AIF was awarded a NERC capital boost of £10,000 to purchase pneumatic computer controlled valves for the automation of the HELIX-SFT extraction line.
- Dr. Stuart & Dr. Mark awarded £580,000 STFC grant to investigate the timing and duration of fluid-rock interaction on the martian surface using the nakhlites.
- Dr. Leah Morgan (VU) has been awarded a 2 year Marie Curie Fellowship to develop a primary calibration of the K-Ar system at SUERC in collaboration with Dr Mark. Leah starts on Sept. 1st 2011.

SCIENCE HIGHLIGHTS:

1. Temporal calibration of palaeoclimate archives (DFM personal research, Quaternary Science Reviews, in review): Numerous visible and non-visible volcanic ash layers form unique age markers within the SG06 core. The ash layers are too fine and crystal-poor to be directly dated using the Ar/Ar technique so the tephras were correlated to proximal volcanic deposits using glass shard compositions. A high-precision sanidine Ar/Ar age of 10.0 ± 0.3 ka (1σ) was obtained for the SG06-1288 (U-Oki) proximal tephra (Ulleungdo U4). Radiocarbon dates determined immediately above and below the tephra (10232 to 10255 years) confirm the accuracy of the Ar/Ar age. The study shows that within the Holocene and Pleistocene Ar/Ar can be used to inter-calibrate climate records.

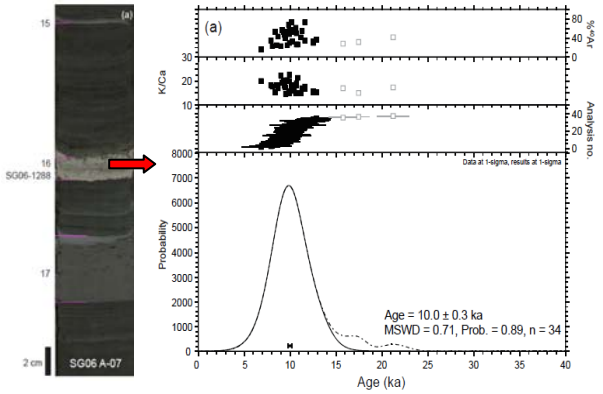
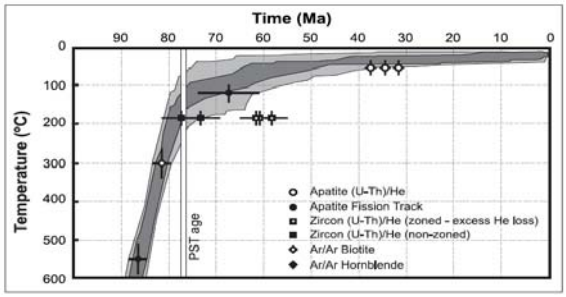


Photo of SG06-1288 tephra & Ar/Ar data

2. Tristan da Cuhna – Working to keep Britain's remotest community safe: IP/1152/1109, PI Barclay (UEA): Tristan da Cunha (South Atlantic) has a poorly defined eruptive record. The population currently have little effective monitoring capability and information for hazard assessment. The purpose of this project was to determine the timing and frequency of volcanic activity on the island. The regular distribution of these ages between c 0.118 to 0.002 Ma implies that eruptions have been episodic since its emergence. Contrary to previous models it appears that Tristan grew in sectors, with the southern sector pre-dating the north. Data also suggest that the steep summit cone pre-dated shield building phases, rather than the reverse. The confirmation that the summit and flanks were active during and after construction of the young coastal strips is critical for hazard assessment. The Ar/Ar ages and our assessment have been communicated to the Tristan Island Council. The Council have incorporated the results into their disaster management plan and have presented features in the local press.



Thermal evolution of the pseudotachylyte host rock.

Fundamental 'local' controls on earthquake magnitude: IP/1110/0509,PI Shipton.(Glasgow): The stress drop during an earthquake is a fundamental macroscopic rupture parameter, expressing both the energy released during an earthquake and the absolute strength of the Earth's crust. We quantified the spatial variation of stress drop for a single palaeo-earthquake. Ar/Ar dates of pseudotachylytes (76.6 ± 0.3 Ma, 2σ) formed coseismically in 5 to 10 m long discontinuous patches along faults in the Sierra Nevada, California. Thermochronology shows that the rupture occurred at depths between 2.75 to 6.5 km (depending on the geothermal gradient). Calculations of pseudotachylyte shear resistance and failure stress at the initiation of slip reveals that stress drop for the pseudotachylyte-bearing patches was 34-80 MPa.

Can the structure of an explosive caldera (Los Humerous, Mexico) affect eruptive behaviour? IP-1095-0509, PI Branney (Leicester). Explosive caldera volcanoes cause catastrophic events at the Earth's surface, yet we know little about how their internal structures evolve with time, and whether this can affect both differentiation and eruptive behaviour. The present study tests whether the Los Humerous caldera, Mexico may become more intensely fractured with time as a result of successive distinct caldera-collapse eruptions ("multi-cyclic calderas"). It has been proposed that this scenario could lead to an increase in eruption frequency, with smaller eruptions over time. Magma leakage through the increasingly fractured volcano might also lead to less evolved compositions with time due to shorter residence times. Detailed structural mapping, optical and SEM petrography, XRF major and trace element geochemistry and new single-crystal plagioclase $^{40}Ar/^{39}Ar$ and radiocarbon dating of the pyroclastic stratigraphy have revealed new insights into the structural and eruptive history.

FUTURE DEVELOPMENTS/STRATEGIC FORWARD LOOK

- Install HELIX-SFT and quantify improvements in analytical accuracy owing to the resolution of isobaric interferences at mass 36. AIF currently houses the most precise noble gas mass spectrometer (ARGUS V) but with respect to calibration of the geological timescale the accuracy of measurements and hence the accuracy of Ar/Ar ages is a major concern. Efforts by the recent EARTHTIME Initiatives have identified isobaric interferences at mass 36 ($H^{35}Cl$ and $^{12}C_3$) may resulting in the over-correction of $^{40}Ar_{total}$ for $^{40}Ar_{atmospheric}$ and hence yielding inaccurate ages. The AIF is leading efforts to fully resolve isobaric interferences at mass 36 and will have access to the first noble gas mass spectrometer capable of achieving this. One of the first objectives following installation is to quantify the effect of isobaric interferences.
- Quantify attainable precision by using the HELIX-SFT in dual- and single-collection mode. The new mass spectrometer is equipped with a switchable $10^{12}/10^{13}$ ohm resistor Faraday and Balzers SEV-217 ion counting multiplier. We will assess the precision of isotope ratios and Ar/Ar ages acquired in both configurations.
- Quantify how young the HELIX-SFT will allow us to go with improvements in accuracy and precision. The improved sensitivity of the HELIX-SFT and enhanced resolution relative to previously available technology will allow AIF to date younger and younger samples using the Ar/Ar technique. We will target a series of volcanic eruptions recorded during the past two thousand years to quantify accuracy and precision and the exact capabilities we can offer the user community.

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

The AIF continues to run a summer internship scheme (SUERC funded) that allows talented final year undergraduates to do 10 week placements in the and Dr. Barfod continues to do public outreach in Primary Schools looking at the rock cycle.