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

SERVICE	FUNDING	AGREEMENT	ESTABLISHED as S&F	TERM
IMF	Contract	R8/H10/51	1987	5yrs

TYPE OF SERVICE PROVIDED:

The **Ion Microprobe Facility (IMF)** (see http://www.geos.ed.ac.uk/facilities/ionprobe/) is the only UK facility enabling **SIMS** (**secondary ion mass spectrometry)** analysis of a wide range of natural and synthetic materials. It allows in-situ, high spatial resolution (5–20 μm) analysis of elements and isotopes across the whole Periodic Table, and is ideal for studies of fine-grained and zoned Environmental and Earth Sciences materials. The IMF has a very strong international reputation and has pioneered the development and application of SIMS isotope and trace element analysis in the Earth Sciences.

Two ion microprobes (Cameca ims-1270 and Cameca ims-4f) provide the analysis of a wide range of **stable isotope ratios** (H, Li, B, C, N, O, S, Si), **trace elements** (e.g. rare-earth elements, large ion lithophile elements, high field strength elements) and **light elements** (H, Li, Be, B, C, N). The high transmission of the ims-1270 permits U-Th-Pb isotopic **geochronology** of zircon and other U- and Th-bearing minerals. In general most heavy (>C) stable isotope work is done on the ims-1270 since its analytical precisions are some four to five times higher and analysis times (with multi-collector) significantly shorter than on the ims-4f. The ims-4f is mainly used for multi-element and light element isotope analysis. The in-house developed multi-sample airlock of the ims-4f offers significant advantages for the analysis of volatile elements. A number of projects have combined access to both instruments.

The IMF is located in the Grant Institute of Earth Science, School of GeoSciences, University of Edinburgh, where the ion microprobe (SIMS) instruments form the centre-piece of a unique and complementary suite of micro-beam instruments. The IMF also provides access to the Cameca SX100 electron microprobe and analytical SEM facilities (including detectors for Energy Dispersive Analysis, Backscattered Electron Imaging, Cathodoluminescence and Electron Backscatter Diffraction); these may be used for full characterisation of samples on site. A range of state-of-the-art transmitted and reflective microscopes (with digital cameras) are available for on-site material characterisation. Sample preparation is critical to the success of this surface analysis technique. Help on sample preparation is available to users (both on the website and by staff members) and includes, if necessary, access to a sample preparation equipment and specialist support.

Tephrochronology, involving high precision microanalysis of glasses to permit correlation of tephra layers for relative age dating, forms an integral part of the service (see http://www.geos.ed.ac.uk/facilities/tephra/).

ANNUAL TARGETS AND PROGRESS TOWARDS THEM

The total number of S&F instrument user hours of 3718 was slightly up on the average of the previous 4 years. This usage was equivalent to 65% of the total 5961 hours provided on both instruments, again slightly higher than the 4 year average. All users received time within deadlines set.

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

CAPACITY of HOST ENTITY FUNDED by S&F	Staff & Status	Next Review (March)	Contract Ends (31 March)
60%	Dr N. Cayzer (13%), Dr J. Craven (62%), Dr C. Hayward (35%), Dr R. Hinton (62%), Dr C-J De Hoog (36%), and PI's Prof S. Harley (5%) and Prof C. Graham (5%)	2012	2013

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			
253	0.125 per hour	0.25 per session				475

FINANCIAL COMMITMENT (by year until end of current agreement) £k				
2010-11 331.5	2011-12 348.1	2012-13 365.5	2013-2014	2014-2015

STEERING COMMITTEE	Independent Members	Meetings per annum	Other S&F Overseen
	6	2	1

APPLICATIONS: DISTRIBUTION OF GRADES (current FY — 2010/11)								
	α5	α4	α3	α2	α1	β	R*/Pilot	Reject
NERC Grant projects*		5					2	1
Other academic		7	1					
Students	2	3	4	1			4	2
Pilot								
TOTAL	2	15	5	1			6	3
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*	2	6.33	.67				.33	.33
Other Academic	.67	4.67	2	.33		.33	2	1.67
Students		4.33	3.67	.67			2.67	.67
Pilot								
TOTAL	2.67	15.33	6.33	1		.33	5	2.67

PROJECTS COMPLETED (current FY – 2010/11)							
	α5	α4	α3	α2	α1	β	R*/Pilot
NERC Grant projects*	2	3					
Other Academic		3					
Students	1	6	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
31	5	12	6		8					
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
36.34	8.67	8.33	4.67	.67	14					

User type(current FY – 2010/11) (include each person named on application form)				
Academic	NERC Centre/Survey	NERC Fellows	PhD Students	Commercial
13			18	
User type (per annum average previous 3 financial years - 2007/2008, 2008/2009 & 2009/2010)				
Academic	NERC Centre/Survey	NERC Fellows	PhD Students	Commercial
20.33	.33	1.67	13.33	

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
	41	3		1			45	21	22	2
Distribution of Projects (by science areas) (FY 2010/11)										
Grand Total	SBA	ES	MS	AS	TFS	EO	Polar			
31		28	3							
OUTPUT & PERFORMANCE MEASURES(per annum average previous 3 years)										
Publications (by science area & type) (Calendar years 2007, 2008 &2009)										
SBA	ES	MS	AS	TFS	EO	Polar	Grand Total	Refereed	Non-Ref/ Conf Proc	PhD Theses
	45	6					51	26.33	21	3.67
Distribution of Projects (by science areas) (FY 2007/2008, 2008/2009 & 2009/2010)										
Grand Total	SBA	ES	MS	AS	TFS	EO	Polar			
34		26.3	7		.67					

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
31	3		20		7		1

**Combined Responsive Mode and Directed Programme grants*

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

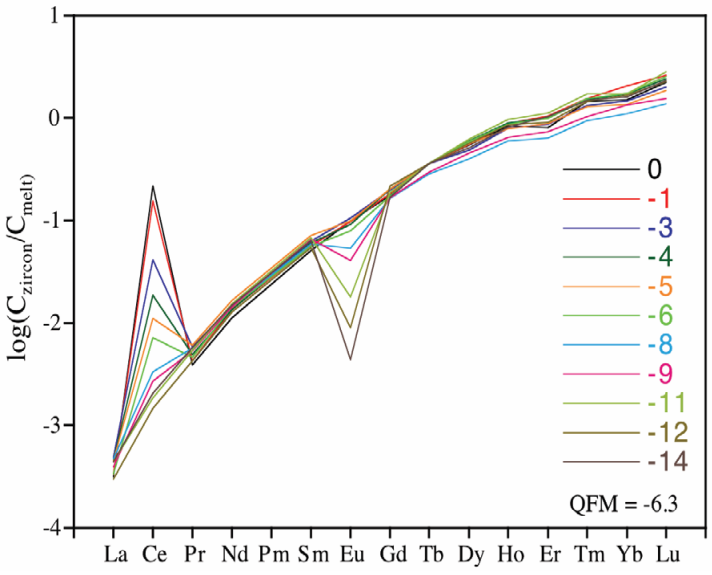
OVERVIEW & ACTIVITIES IN FINANCIAL YEAR (2010/11)

Each year the Facility requests that all users provide a short scientific report of the results from their IMF work. Thirty-one reports from IMF users are included in this year's Annual Science Report and all are available on the Facility web site. Despite its age the ims-4f continues to operate reliably. Some time was lost on the ims-1270 in November 2010 due to weather-related delays in delivery of spare parts. However, disrupted work was successfully rescheduled and finished. The combined use of both instruments has been essential for the completion of a number of projects. Although usage normally involves isotopes measurements on the ims-1270 and trace elements on the ims-4f, strategies have included trace element determinations using both instruments. $\delta^{18}O$ measurement of melt inclusions has been successfully developed and used in a project on Icelandic volcanoes. Time was given to analyse samples from the Eyjafjall volcano whose eruption disrupted air traffic over Europe earlier in the year (one day access and partly funded under a NERC Emergency Grant). Three days instrument time was used as part of a Schools Outreach programme and one day as part of the University's Open Day

SCIENCE HIGHLIGHTS

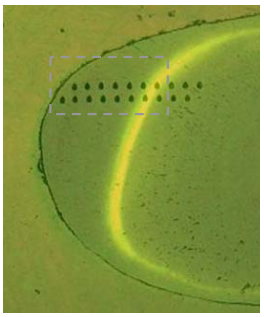
The widespread social and economic impact of the 2010 **eruption of the Eyjafjall volcano** (left) brought into sharp focus the need to understand magma plumbing and the dynamics of magma mixing and volatile interactions in Icelandic volcanic systems **(Thordarson et al)**. Trace element and volatile content (CO_2, H_2O) measurements of glasses from the 2010 flank and summit eruption products, carried out on the ims-4f, have shown a clear link between the two eruptions and suggest that volatiles for the explosive summit eruption were sourced from basaltic melt injected into more silicic magma stored at a higher level in this volcano. Trace element and oxygen isotopic studies of glasses from historical eruption events have demonstrated that spatially-related volcanic rocks have different sources and chemical evolutions – controlled by crystal fractionation in one case and by mixing with an evolved (rhyolitic) magma in a shallow magma chamber in another. These results imply that lateral flow from disrupted shallow magma chambers does not provide an explanation for contemporaneous or spatially-associated eruptions in the Icelandic setting.

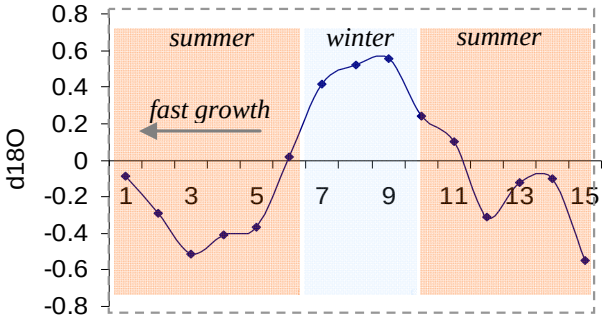
The utility of zircon as a mineral recorder (Burnham and Berry) of ages of events and sensor of melt chemistry, temperatures of geological systems and earth evolution through its trace element and isotopic chemistry is well known. It potentially has key information on redox conditions locked in Rare Earth Elements abundance patterns, especially given the anomalies for the multi-valence elements Ce and Eu often recorded in those patterns. SIMS analyses demonstrated clear effects of oxygen fugacity on the partitioning of Ce and Eu relative to their neighbouring REE, with positive Ce and negative Eu anomalies co-existing over a 3 log unit range in oxygen fugacity at the 1 bar experimental conditions (figure on left). The combination of experiments and high-precision SIMS microanalysis also showed changes in U-Th behaviour with oxygen fugacity which imply that U exists in three oxidation states in the silicate melts.



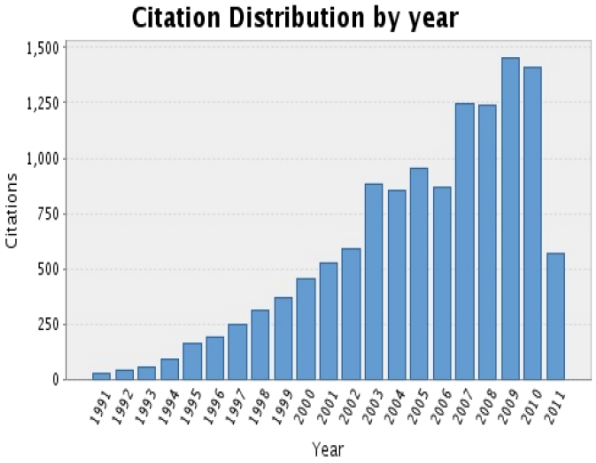
Characterisation of the coupled ocean-atmosphere climate system (Sadekov et al) and its impact on past marine conditions is a long-term goal of many climate change and environmental projects that utilise the high spatial resolutions afforded by SIMS. Recent research has sought to characterise vital and seasonal effects so that longer-term ocean changes can be discriminated. Typically, measurements are made at resolutions of 10-20 µm, but this is not adequate for some organisms that otherwise are of great potential for climate work. We have developed low-intensity beam methods on the ims-4f that enable Mg/Ca trace element measurements across the shell walls of individual forams at 1-2 µm spatial resolution, an order-of-magnitude improvement that also allows for analysis free from contamination from the outer and inner shell surfaces. Application of this approach to forams collected during and after a cyclone demonstrate that the organisms retain original trace element chemical signatures, thus accurately recording changes in sea temperature.

Otolith chemistry (Lewis et al), i.e the variations in minor/trace metal concentrations and $\delta^{18}O$ of fish ear bones, is of considerable potential as a proxy for the environmental history of individual fish. To realise this potential it is necessary, however, to validate the patterns experimentally and account for the effects of physiology. In a ground-breaking study, both aquarium-grown and wild plaice have been analysed for $\delta^{18}O$ and trace element variations. Otolith Sr contents agree with previous laser-icpms analyses, and show systematic fluctuations related to fish age that are resolved to a superior spatial resolution on the ims-4f. $\delta^{18}O$ profiles of wild plaice have been compared with experimental plaice for a female plaice maintained in an aquarium under controlled conditions for 12 months. The photograph below shows the otolith analysis pits and the yellow mark indicates the experiment start point. The graph shows $\delta^{18}O$ values for the experimental period. Clear temperature-dependent seasonal fluctuations in otolith $\delta^{18}O$ values allow a basic timeline to be devised in the wild fish through wiggle matching with the experimental $\delta^{18}O$ values. Considerable slowing of otolith growth during the winter spawning season has been demonstrated by this work, a result that is unlikely to have been identified based on visual banding.





PUBLICATIONS



ISI Web of Knowledge
EIMF Citation Metrics

Total articles: **400**
Articles with citation data: **370**
Sum of times cited: **12,574**
Avg. citations per article: **34.0**
h-index: **690**

last updated: 12 April 2011

The impact of publications which include data collected at the EIMF has been assessed using the Web of Science. Papers which include EIMF data are now cited over 1400 times per year. The facility maintains an extensive website which is continuously updated. The website not only gives details of access, publications, Annual Reports and approved projects but also information about the analytical techniques and sample preparation. There were over 4000 downloads of documents from the website in February 2011.

Paper highlights include:

Allison N., Finch A.A. and EIMF (2010) $\delta^{11}B$, Sr, Mg and B in a modern Porites coral: the relationship between calcification site pH and skeletal chemistry. Geochimica et Cosmochimica Acta **74**, 1790-1800.

Blundy, J., Cashman, K., Rust, A. and Witham, F. (2010) A case for CO_2-rich arc magmas. Earth and Planetary Science Letters **290**, 289-301.

Dohmen, R., Kasemann, S.A., Coogan, L., Chakraborty, S. (2010) Diffusion of Li in olivine. Part I: Experimental observations and a multi species diffusion model. Geochimica et Cosmochimica Acta **74**, 274-292.

FUTURE DEVELOPMENTS/STRATEGIC FORWARD LOOK

Expanding analytical capabilities

Dr. Cees-Jan De Hoog has completed his first full year at the EIMF and his expertise in ICPMS analytical techniques and procedures has provided a new perspective to the ion microprobe analytical procedures for trace elements. The laboratory will continue to expand the number of phases available for each isotopic system (e.g. B, Li) as well expand into new isotopic systems (S, Fe). The main challenge is the development of well-characterised standards for a broad range of major-element compositions.