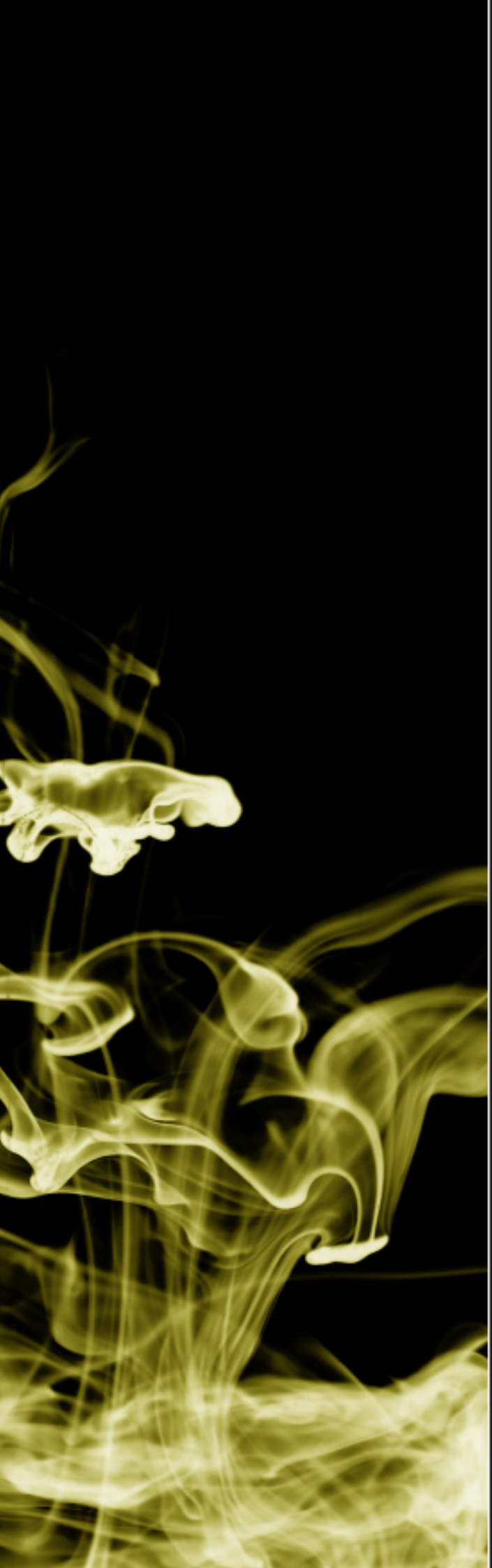


GAU Radioanalytical Laboratories

2009 Services Brochure

GAU Radioanalytical Laboratories

Brochure Overview

00

Business Overview

GAU-Radioanalytical (GAU) is an industry and government-agency focused organisation that specialises in radioanalytical and other analytical services. Project delivery is backed up by an active R&D culture, a team of dedicated and highly skilled scientists, ISO17025 accreditation for radionuclide analysis and competitive pricing.

01

GAU-Radioanalytical Services

We have twenty years practical consultancy and radioanalytical laboratory experience. We offer expert services ranging from all types of radiation spectrometry, X-ray fluorescence analysis, elemental mass spectrometry, pilot-scale studies and on-site field sampling to consultancy advice.

02

Industry Sectors

Our range of specialist services is sought by the Nuclear, Petroleum, Geological, Geotechnical, Pharmaceutical and Cement Industries as well as Defence and Local Government sectors. We play a significant role in support of UK nuclear decommissioning projects through low level waste characterisation, radionuclide fingerprinting and contaminated land and building surveys. Our expertise also covers NORM analysis, XRF analysis, X-radiography, and laboratory-scale investigations (e.g. soil washing, electrokinetic soil treatment and decontamination of radionuclides).

03

Training with GAU

GAU deliver courses for industry, research organisations and academia. Training is targeted at the specific needs of the customer and can cover radioanalytical techniques, X-ray spectrometry, liquid scintillation spectrometry, radiation safety and project management.

04

Environmental Monitoring Studies

GAU has a 20 year history of radionuclide environmental monitoring. It has also been commissioned to investigate radionuclide distributions and dispersion in the marine, freshwater and terrestrial environments as well as studying the impact of radionuclide releases from nuclear and non-nuclear establishments.

05

Research & Development by GAU

Innovation and problem solving are central skills for the staff of the GAU and these attributes assist in the delivery of contracts for customers. As well as undertaking commercial R & D programmes, GAU-Radioanalytical is committed to ongoing research in radioanalytical chemistry, waste remediation and environmental process studies.

06

Facilities & Equipment

We have well-equipped, dedicated laboratories for sample preparation, radioanalytical chemistry, radionuclide detection and quantification, micro- and macro-X-ray analysis and ready access to ultra-modern mass spectrometric and clean-lab facilities.

Business Overview

GAU-Radioanalytical Laboratories (also known as the Geosciences Advisory Unit) is a financially independent research and consultancy Unit that operates within the National Oceanography Centre in Southampton (part of the University of Southampton). First established in 1988, the Unit quickly became internationally recognised as a centre of expertise in environmental radioactivity, environmental geochemistry, radioanalytical chemistry and X-ray analysis. The combination of ISO17025 accreditation for radionuclide analysis, competitive pricing and a team of dedicated and highly skilled staff have ensured significant success in winning a wide range of competitive contracts in the nuclear and industrial sectors.

GAU-Radioanalytical plays a significant role in support of UK nuclear decommissioning projects through low level waste characterisation, radionuclide fingerprinting and contaminated land and building surveys. It also provides radioanalytical and non-radioanalytical services to a diverse range of non-nuclear organisations including the petroleum and pharmaceutical industries, MoD, government agencies and local authorities.

GAU-Radioanalytical's proven capability in commercial project delivery and training is underpinned by active R&D projects. Many of these projects are conceived and supervised by GAU staff (and partner organisations) and carried out as industrially-funded PhD projects or as contract-funded research. Publication of the research in the international literature is an important aim of GAU-Radioanalytical.

Accreditation

GAU-Radioanalytical is accredited to ISO/IEC 17025:2005 through the United Kingdom Accreditation Service (UKAS). For more details of the schedule of accreditation, please visit our web site at www.gau.org.uk which links through to the official UKAS website.

UKAS TESTING 2758

Clients and Customer Service

GAU-Radioanalytical has a long-standing track record in providing radioanalytical services and consultancy to a wide range of both nuclear and non-nuclear organisations. Organisations routinely using the services of GAU-Radioanalytical include AWE plc, Nuvia Ltd, Magnox Electric plc, UKAEA and Esso Petroleum Co Ltd.

GAU is committed to providing a high level of customer service and continually strives to improve and tailor services to specific customer requirements.

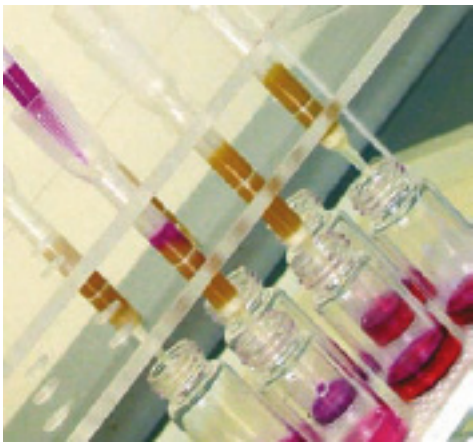
"A first class service, delivered to time and with professionalism little seen in this sector. A joy to work with"

"It doesn't get better than this! First class and friendly/professional"

"I appreciate the technical input and flexibility of the whole team. Thanks for the good service"

Summary of GAU Services

- Radiochemical support for nuclear decommissioning
- Research on many aspects of low-medium level radioactivity
- Environmental radioactivity surveys and monitoring
- Natural radionuclide characterisation
- Sediment dating for industry and academia
- Radiochemical training for industry and academia



GAU Radioanalytical Services

Materials Analysed by GAU	Waste Characterisation	Environmental Monitoring	Petroleum Industry	Manufacturing Industry
Water	•	•		
Aqueous solutions	•			
Oil			•	
Petroleum condensates			•	
Scales			•	
Concrete	•			
Brick	•			
Ceramic tiles	•			
Insulation	•			
Asbestos	•			
Steel	•			
Aluminium	•			
Cadmium metal	•			
Sodium metal	•			
Graphite	•			
Paint	•			
Filters	•			
Smears	•			
Textiles	•			
Plastics	•			
Glass	•			
Soil	•	•		
Sediment	•	•		
Ores				•
Phosphate				•
Clays				•
Sludge	•			
Vegetation	•	•		
Wood	•	•		
Meat		•		
Fish		•		
Shellfish		•		
Eggs		•		
Milk		•		
Urine		•		
Sewage		•		

Standard Radioanalytical Techniques	Gamma Spectrometry	Alpha Spectrometry	Liquid Scinitillation Counting	Gas Flow Proportional Counting	Mass Spectrometry
High resolution Gamma Spectrometry	•				
Gross alpha/beta				•	
Tritium			•		
Carbon-14			•		
Chlorine-36			•		
Calcium-41, 45			•		
Iron-55, 59			•		
Nickel-63			•		
Selenium-79			•		
Strontium-89, 90			•		
Zirconium-93			•		
Technetium-99			•		
Cadmium-109, 113m			•		
Iodine-125, 129	•		•		•
Promethium-147			•		
Samarium-151			•		
Lead-210	•				
Polonium-210		•			
Radon-222			•		
Radium-226			•		•
Thorium-230, 232		•			•
Uranium-235, 236, 238		•			•
Neptunium-237					•
Plutonium-238, 239+240, 241		•	•		•
Americium-241, 243	•	•			
Curium-242, 243		•			
Sediment Dating					
Pb-210 dating	•	•			
Cs-137 dating	•				
Field Based Services					
Field gamma surveys	•				
Sampling					
Autosampling					

X-ray Analytical and Imaging Techniques	X-ray fluorescence spectrometry	X-radiography
Major elements (e.g. Si, Al, Mg, Ca, Fe, Mn, Na, K, Ti, P, S)	•	
Trace elements (e.g. Cr, V, Ni, Cu, Rb, Sr, Zr, Nb, Y, Th, U)	•	
X-radiography of cores and slabs		•
Non-destructive combined elemental and radiographic analysis of cores	•	•
Mineral identification (XRD & SEM)		

Further GAU Services:

- Sample Preparation
- Systematic Research Studies
- Radiochemical Training
- Method Development

Intercomparison Exercises

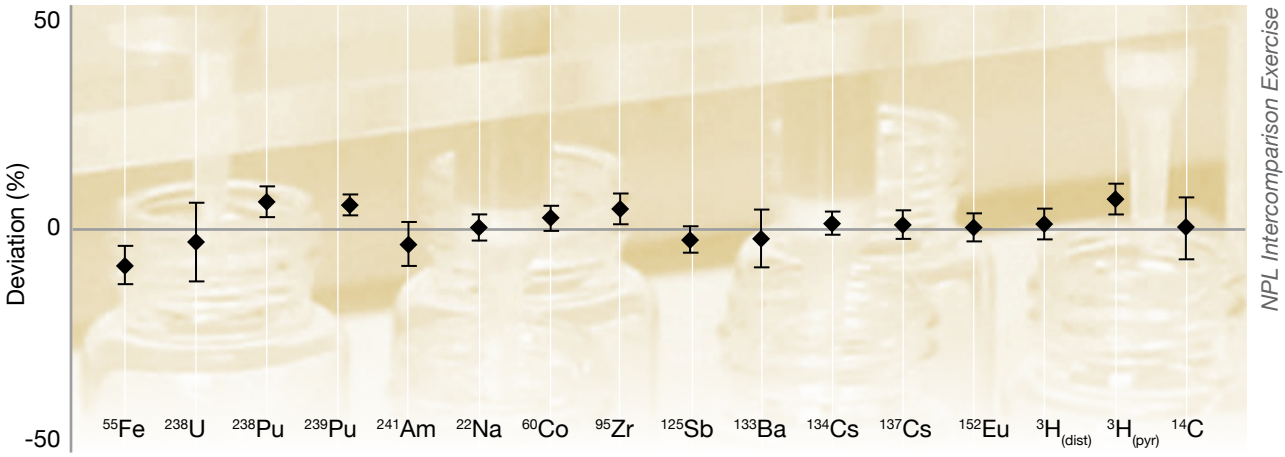
GAU-Radioanalytical regularly participates in National and International intercomparison exercises including those organised by:

- National Physical Laboratory (NPL)
- International Atomic Energy Agency (IAEA)
- National Institute of Standards and Technology (NIST)

Results for these intercomparison exercises are reviewed and used to assess the continuing accuracy of our analytical procedures.

Environment Agency Authorisations

GAU-Radioanalytical works within the National Oceanography Centre's authorisations for holdings, usage and disposal of radioactive materials. Under these authorisations, GAU-Radioanalytical can handle significant quantities of alpha, beta and gamma emitting radionuclides enabling the group to offer a wide ranging service to its customers.



Annual Analytical Throughput	2004	2005	2006	2007
Gross α/β	271	311	187	459
γ	794	992	926	1244
^{3}H	860	686	1453	1024
^{14}C	565	153	507	148
^{55}Fe	20	123	185	68
^{63}Ni	20	131	122	42
^{90}Sr	21	49	34	76
^{99}Tc	70	28	22	20
^{129}I	14	61	108	34
^{210}Pb	1	8	0	20
^{226}Ra	7	11	15	0
Th(α)	21	63	16	6
U(α)	36	100	44	23
Pu(α)	293	191	114	103
^{241}Pu	27	61	11	38
Am(α)	72	79	105	77
Actinides (mass spec)	18	39	8	13
XRF major	103	129	19	54
XRF trace	56	72	55	56
Other	76	36	183	68
Total Number of Samples	3314	3334	4136	3603

Specialist Services

- Novel sample preparation techniques (e.g. sectioning of concrete cores whilst retaining the volatile ^{3}H inventory)
- Pure beta and electron capture radionuclides in wastes (^{36}Cl, ^{41}Ca, ^{45}Ca, ^{55}Fe, ^{63}Ni, ^{113m}Cd)
- High precision isotopic ratio measurements for source apportionment studies
- Low level measurements of radionuclides (e.g. U, Th and K in particle physics detector components)
- Rapid radiochemical separation techniques to facilitate high throughput analysis (e.g. Pu and U in soils)
- Techniques for characterisation of unusual or hazardous materials (e.g. ^{3}H and ^{14}C in Na metal and asbestos, gross alpha/beta and ^{3}H in saturated $ZnBr_2$)
- Development of non-radioanalytical techniques for radioactive waste characterisation (e.g. EDTA, citrate and NH_4^+ in ion exchange resins)

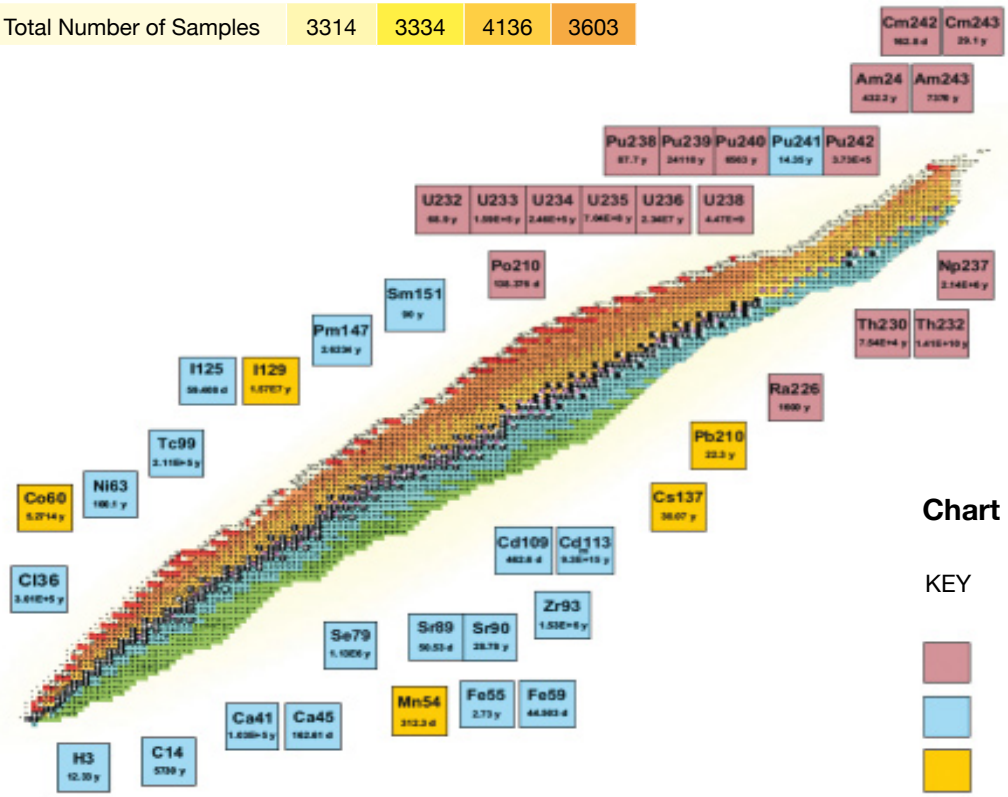


Chart of the Nuclides

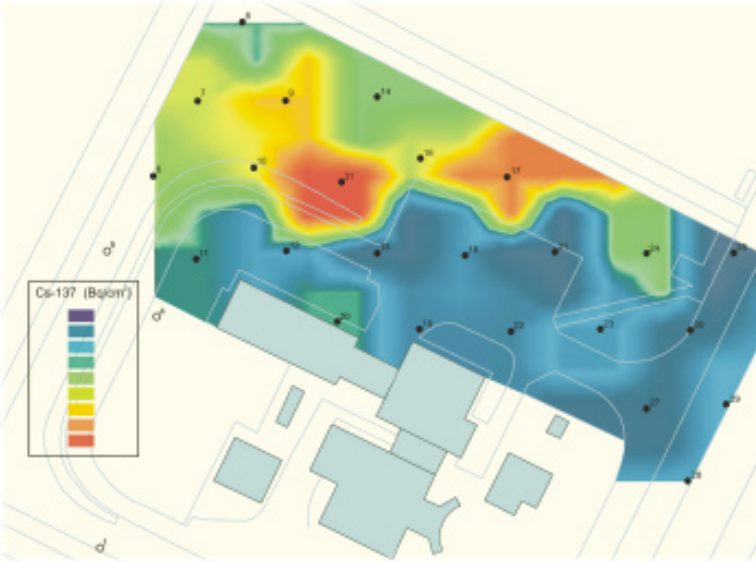
KEY — Radionuclides routinely analysed by GAU

- by alpha spectrometry
- by liquid scintillation counting
- by gamma spectrometry

In-situ Gamma Spectrometry

GAU-Radioanalytical performs ground gamma surveys involving *in-situ* HPGe gamma spectrometry. Anthropogenic radionuclides (^{137}Cs, ^{60}Co) are contoured to highlight zones of elevated activity and used in conjunction with field observations to identify potential sources of contamination.

Soil core sub-samples are also collected at appropriate depth intervals. These are measured in the laboratory by high resolution gamma spectrometry and the results used to validate the *in-situ* gamma data.



Sampling and Advisory Services

GAU-Radioanalytical has considerable experience of sampling in a wide range of environments and can provide both on-site sampling services and consultancy advice on available techniques.

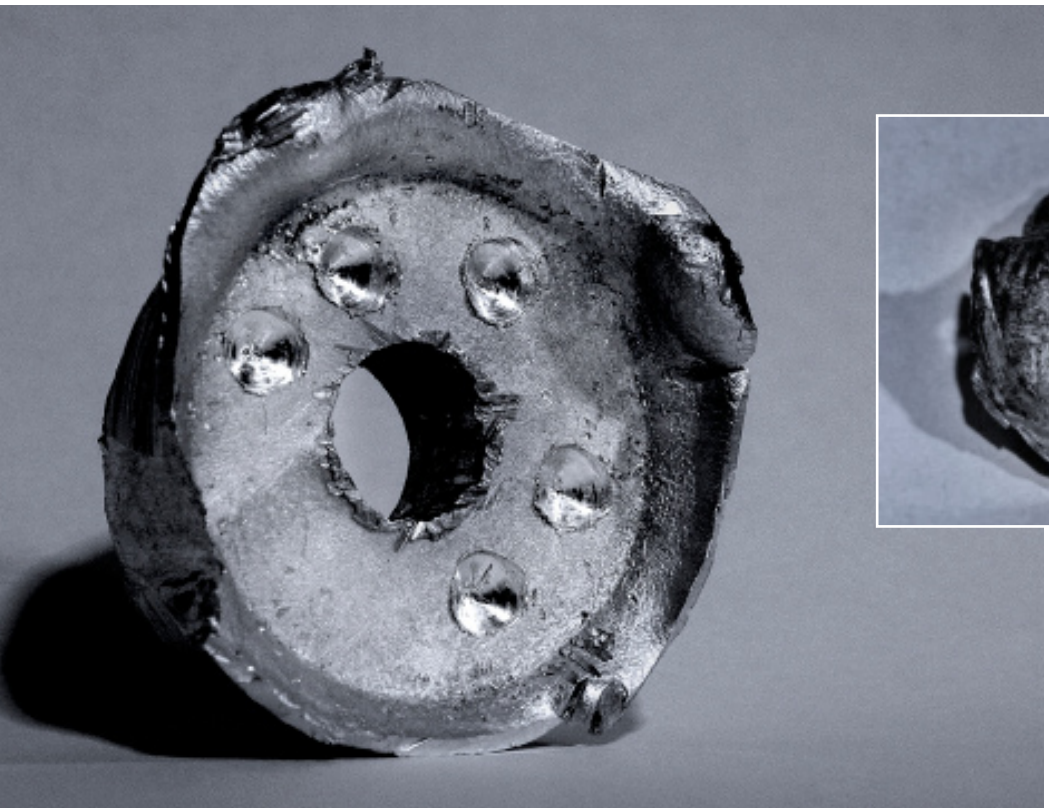
- Soil sampling (grab and coring)
- Vegetation sampling
- Riverine, intertidal and subtidal marine sediment coring
- Borehole, river and marine water sampling
- Air sampling using bubbler-based systems and low / high volume air filtering samplers
- *In-situ* monitoring (including high resolution gamma spectrometry, gamma dose rate, *in-situ* radon in air and water monitoring)
- Advice on sample packaging, storage and transport to ensure that sample integrity is maintained
- Quality assurance and quality control associated with sampling procedures

Crushing, grinding & homogenisation

Concrete core splitting

Sample Preparation

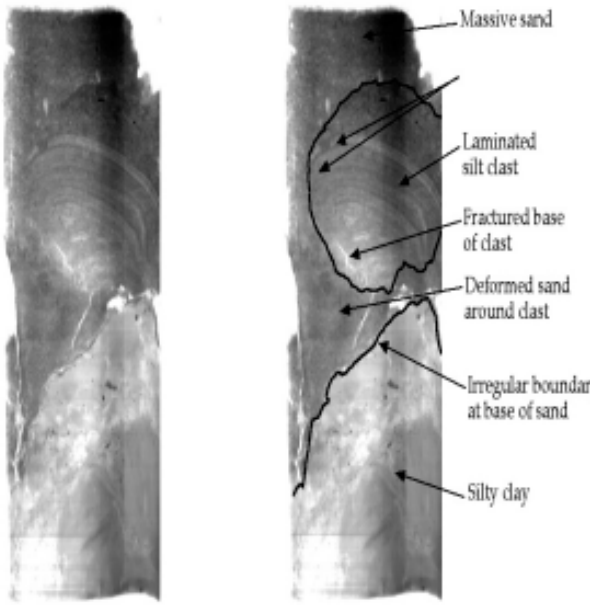
- Crushing, grinding & homogenisation
  Equipment includes flypresses, jaw crushers, TEMAs and planetary mills.
- Concrete core splitting
  Special core cutter for splitting and slabbing active concrete cores for analytical profiling.
- Metal samples
  Representative sampling of metals such as aluminium, steel & cadmium by drilling and filing.
- Paint removal
  Removal of thin coatings of paint from surfaces such as metal drums and luminous dials for separate analysis.
- Borate fusion
  A method developed by GAU for the rapid digestion of samples prior to radiochemical analysis.



Metal samples

X-ray Core Imaging

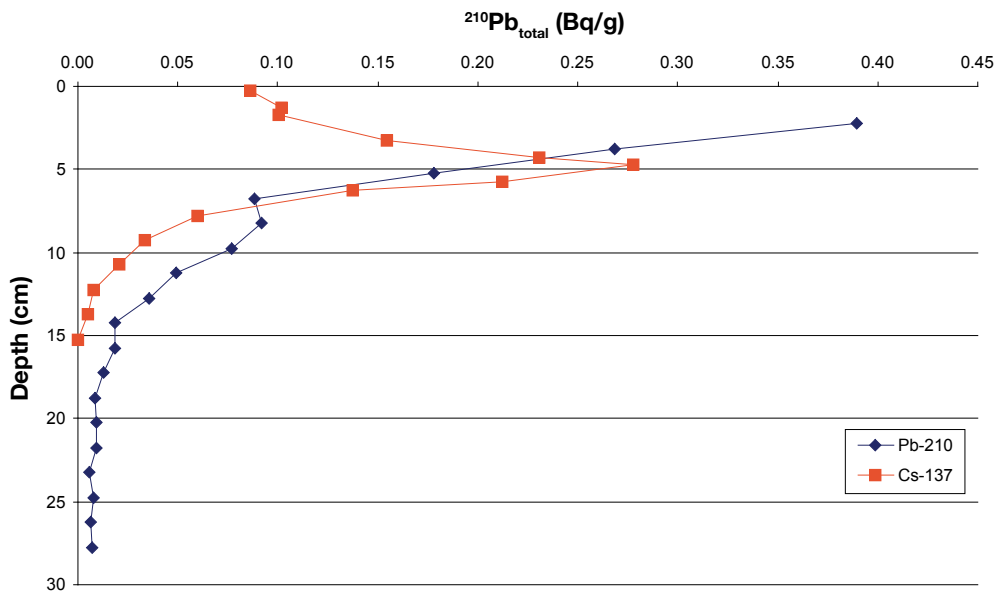
- Identification of invisible internal structures in rock, soil, sediment and concrete cores, etc.
- Radiographic images of full cores, half cores or thin-slabs.
- Identification of hidden sediment fabrics and discontinuities to identify potential features such as gravity-flow deposits (which have significance for major sub-marine engineering projects).
- Images are acquired using medical scanners or Laboratory systems (ItraX or Hewlett Packard Faxitron digital radiographic system).
- CT imagery available on request.



Radiograph of sediment core (Caspian Sea) showing evidence of a gravity flow feature

Sediment Dating

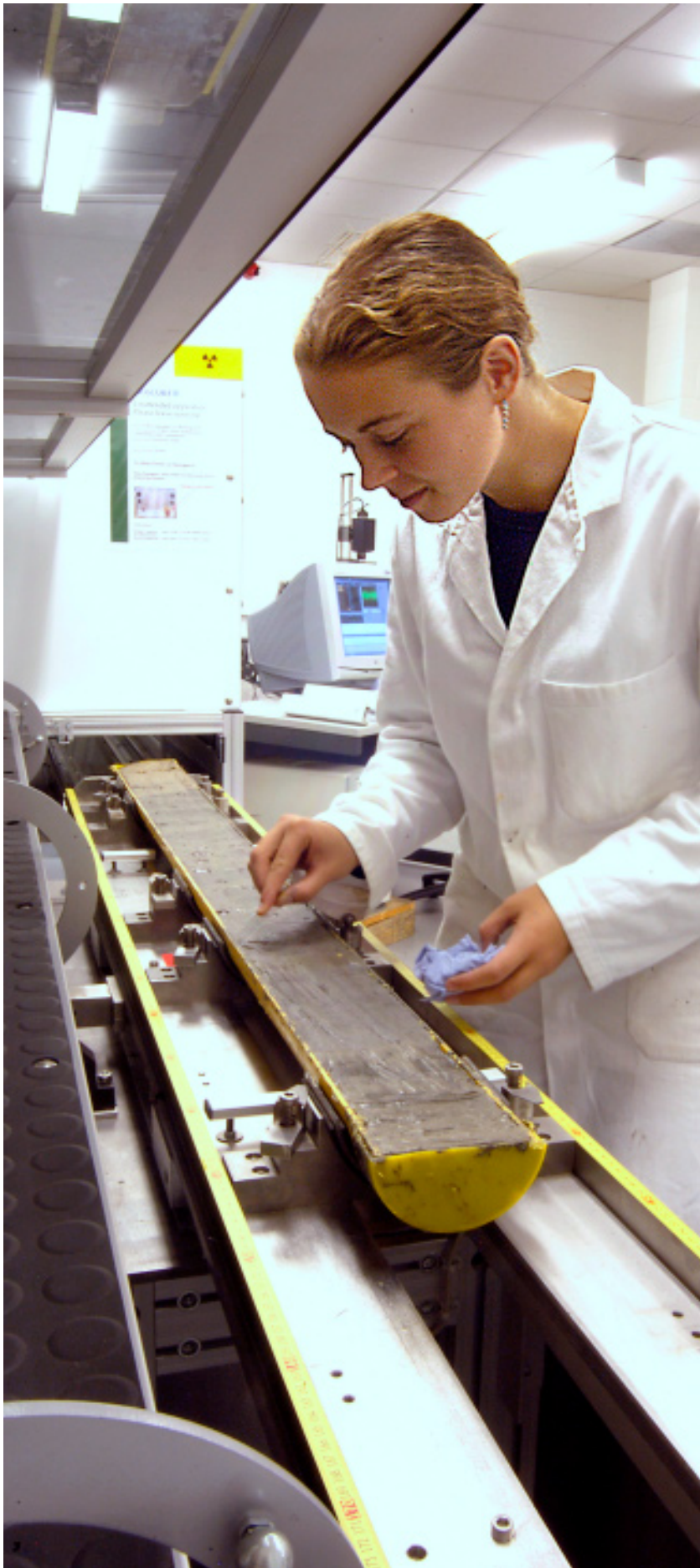
- Use of the impulse dating methods (^{137}Cs, ^{241}Am) and the natural ^{210}Pb method to determine accumulation rates.
- Alternative radiometric methods are also available where appropriate (e.g. tritium & ^{60}Co).
- Application to sediment from diverse environments (coastal, estuarine, marine and lacustrine) for applied research and geotechnical applications.
- Clients include scientists from Environmental Protection Agencies, Academia and Geotechnical companies.
- Links with other specialist groups can include microfossil and ^{14}C dating.

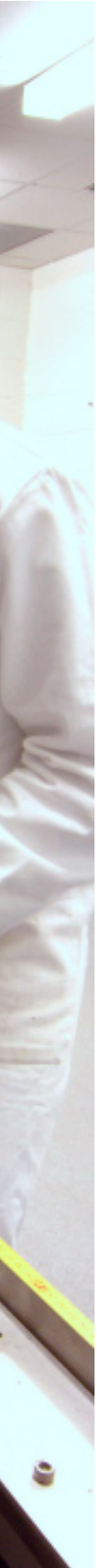


Data from lake at Baulavallavattn, Iceland

Combined Elemental and Radiographic Core Scanner

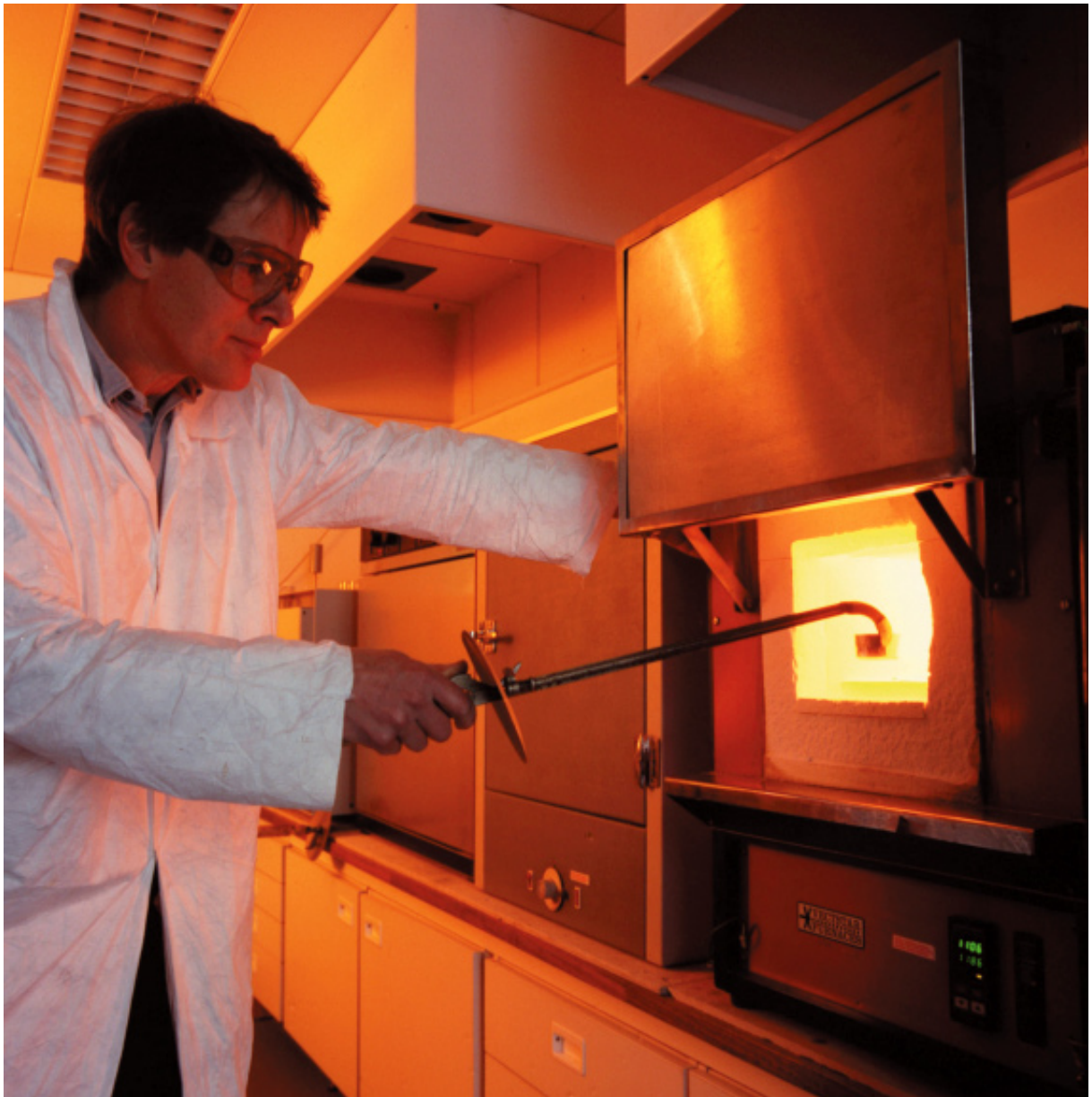
- Non-destructive investigation of cores using the ItraX µXRF.
- High spatial resolution imaging and elemental profiling.
- Rapid geochemical analysis of sediment cores.
- Diverse application areas (past climate and environmental change, pollution, sedimentology).
- Conceived at the National Oceanography Centre by GAU scientist.





Elemental and Isotopic Analysis

- Routine major and trace element analysis of sediments, rocks, soils, ores, and oils using WD-XRF spectrometry.
- High precision, qualitative and quantitative elemental analysis.
- Simple preparation with samples normally analysed as fused glass discs, pressed powders, thin-films or liquids.
- Measurement of major and trace element concentrations and isotopic ratios using ICPOES and ICPMS through close affiliations with other expert groups within the University of Southampton.
- High precision isotopic analysis (e.g. U and Pu isotopes).



Borate fusion of soils

Nuclear & Non-Nuclear Waste Characterisation

GAU-Radioanalytical has a proven track record in the characterisation of a diverse range of radionuclides in varied sample types. The laboratory routinely handles sample activities ranging from materials being screened against free release criteria to LLW and certain forms of ILW. GAU specialises in developing radionuclide fingerprints for wastes relative to key indicator radionuclides and in the characterisation of wastes for radionuclide, trace metal and complexant concentrations. It also routinely performs analyses in support of land remediation and post decommissioning assurance monitoring. In all cases, GAU will provide comprehensive advice on sampling, sample storage and analytical strategies ensuring the delivery of a cost effective and robust analytical programme.

- Extensive track record in the characterisation of a diverse range of radionuclides in a wide range of complex matrices.
- Well equipped, modern laboratories and highly trained, experienced staff providing a cost effective and efficient radioanalytical service to agreed timescales.
- Advice, support and feedback provided throughout the lifetime of the project.

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Examples of projects

- Profiling of ^{3}H concentrations in metal samples prior to and after shotblasting
- Radionuclide profiles (including ^{3}H, ^{41}Ca, ^{55}Fe & ^{63}Ni) through concrete bioshield cores
- Radionuclide screening of saturated $ZnBr_2$ solutions
- Characterisation of radionuclide and trace elements in Na metal
- Assessment of ^{3}H contamination in a range of construction materials at Borehamwood
- Assessment of ^{226}Ra contamination levels on former MoD sites
- Screening of ^{3}H in asbestos lagging from Magnox reactor boilers
- Characterisation of radionuclide and complexant concentrations in ion exchange resins
- Comprehensive radionuclide fingerprinting of IONSIV samples
- *In-situ* gamma surveys and associated soil profiling

Asbestos holding tube for tritium analysis

Sodium in oil

Materials analysed:

- water
- soil
- sediment
- vegetation
- sludge
- oils
- aluminium
- steel
- cadmium
- sodium
- plastics
- brick
- concrete
- asbestos
- graphite
- paint

Waste Remediation Research

- Development of waste remediation techniques
- Clean up of uranium-rich aqueous wastes
- Decontamination studies of soils
- Collaborative research projects with clients

© Magnox Electric Ltd

Removal of Pu contamination from soils

AWE plc funded a pilot study to investigate high-field magnetic separation of paramagnetic minerals. Particle size separation was also used for the removal of plutonium from soils to reduce the Pu content to below 0.4 Bq/g. The study achieved successful clean-up and proposed an engineering concept for the establishment of a 'soil's clinic' at AWE which could cost-effectively decontaminate 90% or more of the soils. A pilot-scale plant was envisaged that could process up to 1 tonne per hour of soil.

Removal of U and other contaminants from clay-rich soils

A laboratory-scale evaluation of a low-energy electrokinetic remediation technique for the removal of Pu, U and other anthropogenic contaminants from nuclear site soils was commissioned. GAU-Radioanalytical worked in collaboration with the patent holders, the University of Brighton, to investigate the system.

Study of soil washing for tritium remediation

Consultancy and analytical support has been provided to Nukem Ltd (now Nuvia Ltd) as part of a scoping study to evaluate the effectiveness of soil washing and size partitioning to remediate tritium contaminated soils.

Decontamination of aqueous solutions using bone-char

This study was undertaken on behalf of Brimac Environmental Services Ltd to investigate the application of bone-char for the removal of contaminants from aqueous waste streams. Initial results have demonstrated that a wide range of elemental species can be adsorbed / incorporated into bone-char, including actinides, Cs and Tc. The relative ease of producing these compounds and their stability indicates that there is considerable potential for the application of this sorbent material in the isolation of radionuclides from aqueous nuclear waste streams and the stabilisation of these wastes during storage and disposal. A range of possible long-term storage options are packaging of the dried phosphatic powders, grouting with cement, or incorporation into phosphatic or borosilicate glass.

Photograph by Paul Carter

Petroleum Sector

- Chemical and radiochemical analysis of petroleum products.
- Non-destructive imaging and chemical profiling techniques for cores etc.
- Over 10 years of experience in serving the petroleum industry.

NORM Analysis

The analysis of naturally occurring radioactive materials (e.g. ^{226}Ra, ^{210}Pb and ^{210}Po) is carried out for pipeline condensates and production waters for a number of clients in the petroleum sector.

Analysis of catalyst residues from marine fuel oils

Refractory element residues can occur in fuel oils which when combusted can lead to significant wear of engine parts (piston liners etc). GAU has carried out analysis of heavy fuel oils for silicon and aluminium using X-ray fluorescence analysis which is the technique of choice owing to its extreme rapidity and sensitivity.

Core logging and interpretation (X-radiography, non-destructive XRF analysis)

The examination of drill core and sediment core can be carried out using a variety of non-destructive methods to provide insights into some geochemical properties, heterogeneity, down-core chemical composition variations etc. GAU has undertaken support work for major geotechnical companies to investigate evidence for historical slope instability (e.g. existence of turbidites).

ItraX combined radiography and XRF core logger

This instrument was conceived at NOCS and co-developed with Cox Analytical of Sweden. It can analyse sediment cores and other samples non-destructively producing high resolution digital X-radiograph and multi-elemental profiles. The instrument has been used to characterise many hundreds of rock and sediment cores but it can also be adapted to investigate other samples.

Training with GAU

Training Areas

- Radioanalytical method-specific training
- Instrument specific training (Pyrolyser and Quantulus)
- Radioanalytical training at nuclear laboratories
- Radiochemistry for the End-user
- Nuclear site investigations handbook
- Masters and PhD programmes of research in environmental radioactivity

Training expertise

GAU-Radioanalytical deliver and develop courses for industry and academia. These are targeted at the specific needs of the customer and cover radioanalytical techniques, X-ray spectrometry, liquid scintillation spectrometry, radiation safety and project management of analytical programmes both for analysts and end users. Tailored courses to address specific training needs can also be provided that range from one day seminars to extended research-based training programmes.

Senior GAU-Radioanalytical staff are actively involved in training at undergraduate, Masters and PhD level within the University of Southampton.

Radiochemistry End-Users Course

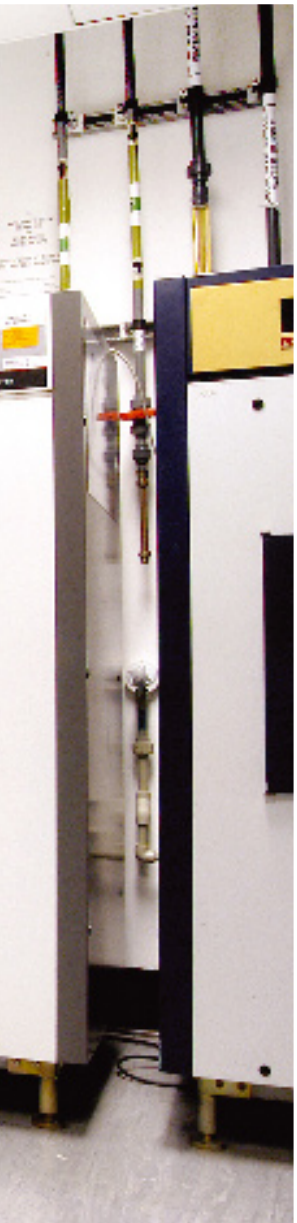
A course to enable project managers to:

- Liaise more effectively with analytical laboratories
- Select appropriate analyses for their requirements and ensure that suitable samples are submitted
- Understand the limitations and assess the quality of data

Topics covered include:

- Sources of radioactivity
- Legislation and analytical requirements
- Sampling protocols
- Radioanalytical techniques and *in-situ* analysis

The course has been run at numerous sites including
UKAEA Winfrith, Harwell, Risley, HPA & Golders Associates, Nottingham



Method Specific Training

GAU offer training on specific methods that have been developed in-house including use of the Pyrolyser furnace for tritium and ^{14}C measurements as well as in depth training on the use of liquid scintillation counters.

Customers who have benefited from GAU method training include

- Health Protection Agency (Chilton)
- Magnox Electric Ltd (Chapelcross, Dungeness)
- VT Nuclear Services (Westlakes)
- Society for Radiation Protection
- DSTL (Alverstoke)
- Babcocks BES (Rosyth)
- Atomic Weapons Establishment
- Korea Atomic Energy Research Institute (KAERI)
- Korea Institiute of Nuclear Safety (KINS)

Southampton students at the AWE North Ponds Complex

International Scientific Links

Korean Atomic Energy Research Institute (KAERI)

GAU-Radioanalytical scientists were invited to KAERI, South Korea to formally sign an MOU for medium-term scientific co-operation with its Nuclear Environment Safety Research Centre based in Daejeon. GAU has provided radioanalytical training and been involved in instrumental developments. During one visit the GAU team presented three technical talks at a specially convened KAERI workshop concerned with 'Nuclear decommissioning and radioactive waste characterisation'. Annual scientific collaboration visits have taken place since 2006.

Korean Institute of Nuclear Safety (KINS)

In 2008 GAU-Radioanalytical scientists were invited to the Radiation Assessment Division of KINS to present a 5-day series of talks on Radioanalytical Methods for Waste Characterisation. KINS is the expert technical organisation that supports the Korean Regulator.

State Ocean Administration Laboratories, China

Chinese oceanographers (SOA) are showing strong interest in the ItraX scanner. The ItraX is currently located in thirteen leading institutions worldwide; soon to be fifteen following a recent commitment from two leading Oceanography Institutes in China.

The original concept for this new generation X-ray core scanner was first made by GAU-Radioanalytical and BOSCORF scientists (Croudace and Rothwell) at the National Oceanography Centre, NOC. Both scientists worked with Cox Analytical of Sweden to develop the prototype ItraX core scanner. The ItraX represents a significant innovation in rapid and non-destructive analysis of sediment and rock cores since it combines micro-XRF analysis and microradiography.

MOU signing ceremony, KAERI

Sediment core repository, Qingdao

NDA Site Investigations Handbook

The National Nuclear Laboratory (formerly Nexia Solutions Ltd) and GAU-Radioanalytical have produced an electronic handbook of concise, up-to-date information detailing currently available methods for the characterisation of nuclear licensed sites. The handbook was developed with funding from the Nuclear Decommissioning Authority (NDA).

The ***Site Investigation Handbook*** is freely downloadable* and is designed to be a user-friendly and searchable tool for the contaminated land practitioner. It provides clear information and enables users to rapidly identify the costs, advantages and disadvantages of any investigative or analytical technique used for the identification and quantification of both chemotoxic and radioactive contaminants in soil and water. The tool provides a fundamental description of all the techniques considered and enables users to decide if a proposed technique is likely to provide the information required in any given instance.

* http://www.nnl.co.uk/news/site-investigations-handbook-update.html

PhD programmes of research supervised by GAU

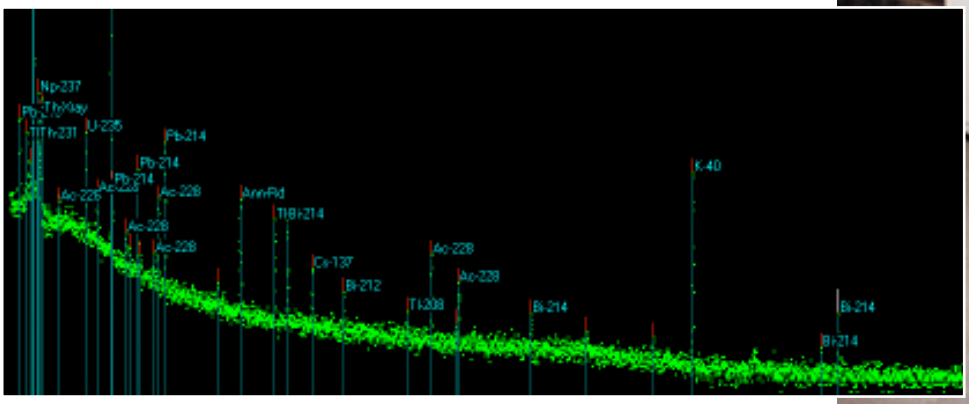
Environmental geochemistry

- The use of foraminifera as indicators of marine pollution
- Evolution of the Jiangfenling granite complex, China
- Migration of elements in saltmarshes; diagenesis and pollution
- High resolution geochemical studies of eastern Mediterranean sapropels
- Influence of rising sea level on ecosystem dynamics of salt marshes
- Analytical enhancement and validation of the high-resolution ItraX µXRF core scanner

Environmental radioactivity

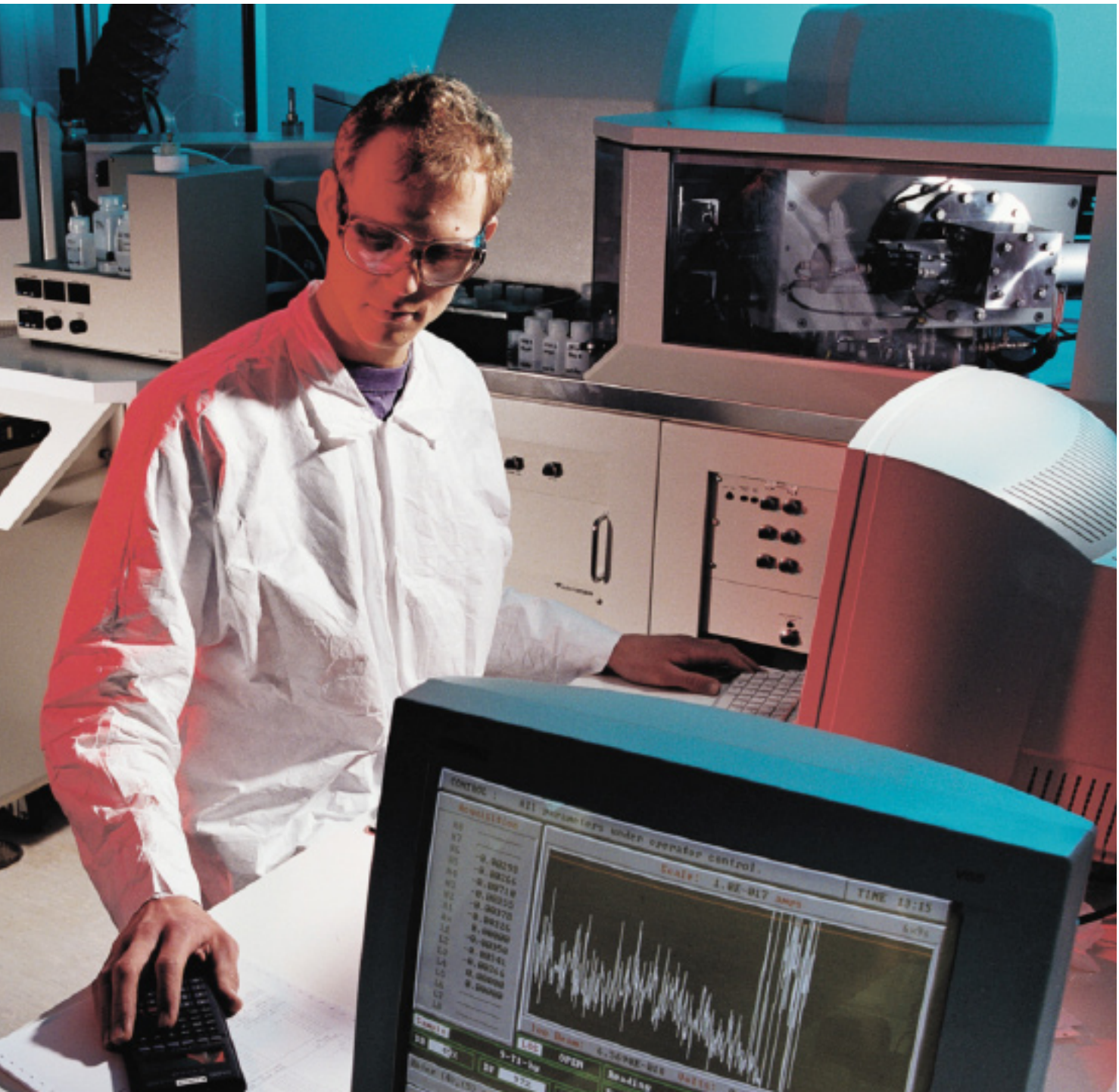
- Radionuclide and geochemical studies of recent sediments from the Solent estuarine system
- Pure beta emitters in the estuarine environment
- Accumulation & migration of radionuclides in the Ravenglass salt marsh
- Biodegradation of liquid scintillation cocktails
- Mechanisms for accumulation and migration of ^{99}Tc in estuarine systems
- Source apportionment of U and Pu contamination in the environment using multi-collector mass spectrometry
- Neptunium distribution, mobility and bioavailability in soils and sediments
- Spatial and temporal distribution of plutonium radioisotopes in Bristol Channel sediment
- Attachment and remediation of radionuclides in drinking water biofilms
- Mechanisms of accumulation of organically-bound tritium in the estuarine environment
- Understanding the contribution of naturally occurring radionuclides to the measured radioactivity in environmental samples

MC-ICPMS of Pu isotopes



Radioanalytical chemistry and decommissioning

- Fundamental studies of methods for tritium analysis in environmental and construction materials
- Production of high capacity iron sulphides to decontaminate radioactive or chemical pollutants
- Development of novel methods for tritium determination in decommissioning samples



Environmental Studies

- Investigation of radionuclide distribution and dispersion in the marine, freshwater and terrestrial environments
- Studies of the impact of radionuclide releases from nuclear and non-nuclear establishments
- Public reassurance monitoring programmes
- High precision isotopic ratio measurements for source apportionment studies
- Sediment accumulation rate measurements

Severn Estuary Environmental Study

Two Severn Estuary research projects, commissioned by the Food Standards Agency and by Amersham GE-Healthcare, were carried out from 1998-2003. The studies were concerned with understanding the role of sediment in trapping tritiated organic compounds (discharged from the Amersham radiopharmaceutical plant in Cardiff). The complementary studies showed that local saltmarsh and sub-tidal sediments retain a well-preserved record of the organically-bound ^{3}H discharges.

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Greenham Common Study

The Greenham Common Study was commissioned by Newbury DC and Basingstoke & Deane BC to establish whether a nuclear accident had occurred at the Greenham Common Airbase in early 1958. This high profile study sparked intense public and media interest. A detailed isotopic study, using a specially developed high precision mass spectrometric method, found no evidence to support the allegation of damage to a nuclear weapon. Three reports and five scientific papers in leading journals were published.

Croudace I.W., Warwick P.E., Taylor R.N. and Cundy A.B. (2000). Investigation of an alleged nuclear incident at Greenham Common airbase using TI-mass spectrometric measurements of uranium isotopes. Environmental Science and Technology, 34, 4496-4503.

Greenham Common Airbase ca. 1996

AWE Independent Environmental Study

AWE awarded a research contact to the GAU to carry out a detailed 3-year isotopic study of uranium and plutonium in the environment of west Berkshire. This study followed longstanding public concern regarding the potential for radioactive contamination from the two AWE sites and alleged links with leukaemia clusters in the area. The study found only negligible contamination around the sites. Three reports and three scientific papers were published.

Croudace, I.W., Warwick, P.E., Taylor, R.N., Bradshaw K and Warneke T. (1999). Assessment of radioactive contamination around the AWE sites in Berkshire. Report 1 to AWE Hunting-BRAE, 80pp.

Croudace, I.W., Warwick, P.E., Cundy A.B., Warneke T. and Taylor, R.N (2000). Assessment of radioactive contamination around the AWE sites in Berkshire. Report 2 to AWE Hunting-BRAE, 65pp.

Croudace, I.W., Warwick, P.E., Warneke T., Cundy A.B. and Taylor, R.N (2002). Assessment of radioactive contamination around the AWE sites in Berkshire. Report 3 to AWE Hunting-BRAE, 90pp.

Public Sector Radiation Monitoring

- Regional monitoring in S. England and N. Ireland since 1980
- Design and implementation of regional sampling programs
- Routine analysis of widely ranging environmental samples
- Maintain capability for rapid response to incidents

GAU-Radioanalytical Laboratories manage and provide a radiation monitoring capability for two local authority consortia in Southern England and Northern Ireland. It has provided this service for 20 years and 10 years respectively (www.sermg.org.uk and www.nirmg.org.uk). The programmes arose as a result of local authorities choosing to have an independent monitoring capability.

Southern England Radiation Monitoring Group

The Southern England Radiation Monitoring Group (SERMG) was formed in 1988 and comprised a consortium of 55 Local Authorities. It represents an independent radiological capability that monitors radionuclide variations in environmental samples (marine and terrestrial) throughout southern England. Its inception was initially stimulated by the 1986 Chernobyl accident but continued thereafter to maintain the capability for any future events. Approximately 1000 samples per year are investigated for a variety of alpha, beta and gamma radionuclides. Reports are published annually and are available as downloads from www.sermg.org.uk.

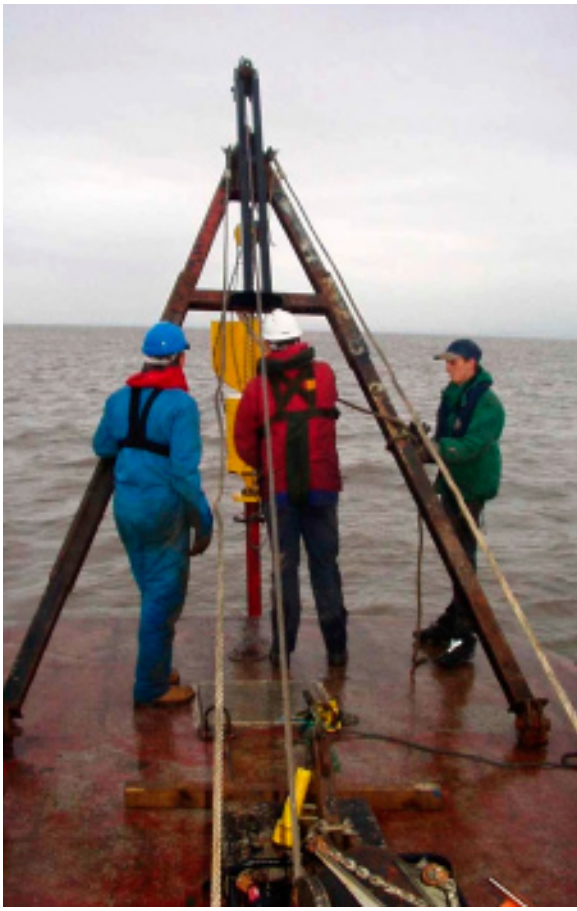
Cundy A. B., Croudace I. W., Warwick P. E. & Bains M. E. (1999). Decline of Radionuclides in the Nearshore Environment Following Nuclear Reactor Closure: A UK Case Study. Environmental Science & Technology, 33, 2841-2849.

Northern Ireland Radiation Monitoring Group

A consortium of 26 Local Authorities in Northern Ireland commissioned the GAU to act as the radiological laboratory for the NIRMG programme. The work involves measuring a range of gamma, alpha and beta emitters. The interests of the group originated from concerns about the impact of releases from Chernobyl and also from the Sellafield site. The monitoring shows that Chernobyl produced only a small impact in Northern Ireland and confirmed that discharges from Sellafield have declined markedly and persistently over the life of the scheme. Reports are published every three years (www.nirmg.org.uk).

Orkney Radiation Monitoring

The Orkney monitoring program is contracted to GAU on a three year cycle (since 1997) to monitor samples for alpha and gamma emitting radionuclides in marine biota from sites across the Orkney Islands. This project is concerned with identifying any possible contamination of the marine environment arising from discharges from UK nuclear sites.



Research & Development by GAU

Research

- Research projects commissioned by the nuclear industry
- Method development tailored to customer needs
- Strong links with academia

Research Areas

- Development of novel procedures for the measurement of α and pure β emitting nuclides
- High precision isotopic ratio measurements for U and Pu source apportionment studies
- Biodegradation of liquid scintillation cocktails
- Distribution of ^{99}Tc in marine sediments
- Distribution of alpha emitting radionuclides in intertidal sediments
- Mechanisms for the deposition of short lived naturally occurring radionuclides and their impact on nuclear site environmental monitoring programmes
- Development of *in-situ* automated sampling equipment
- Use of radionuclides in environmental process studies
- Development of rapid and automated analytical techniques

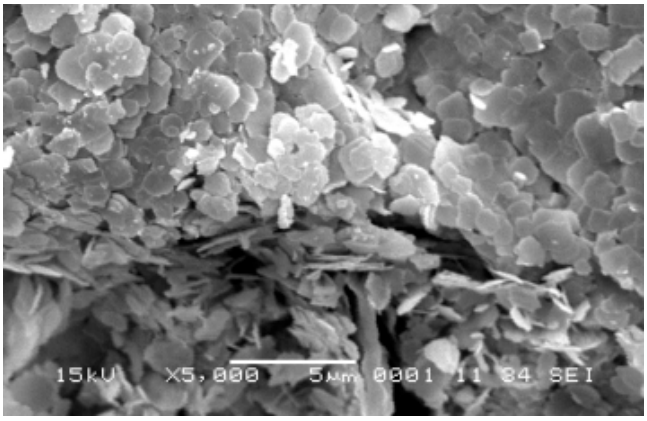
GAU-Radioanalytical actively participates and supports research and development and sees it underpinning the group's commercial operations. As well as undertaking commercial R & D programmes, GAU-Radioanalytical is committed to an ongoing programme of R & D in the fields of radioanalytical chemistry, waste remediation and environmental process studies.

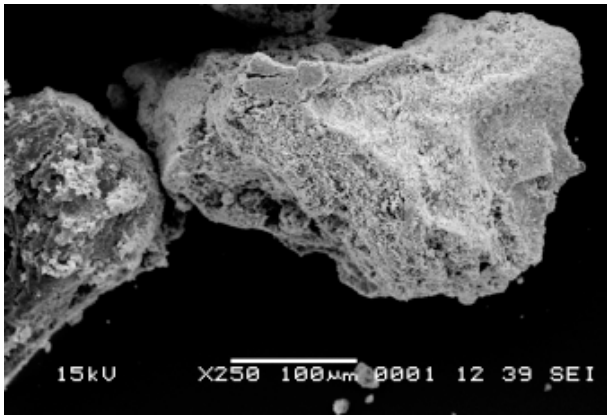
The group sponsors and supervises postgraduate research and maintains facilities and equipment in support of these research programmes. Whenever practical, the findings of these research programmes are published in peer reviewed international scientific journals ensuring the widespread dissemination of information.

Investigating bone char as an effective long-term absorbent for radionuclides

A study undertaken on behalf of BRIMAC Environmental Services Ltd involving reactions of uranyl ions with bone char under a range of controlled conditions. The reactions led to a variety of products that were found to be effective in incorporating and retaining radionuclides. The products are highly insoluble and are compositionally analogous to natural uranium-bearing minerals found in the supergene geological environment.

Warwick P.E., Croudace I.W., Holland N.G., Watson J.W.P. & Foss Smith P. (2006). Effective media for immobilising and isolating radionuclides from aqueous nuclear wastes: reaction products of bone char and uranyl ions. Paper presented at WM'06 Tucson.





Uranium oxy-hydroxides on bone char

Radioactive degradation rates in sands under simulated marine conditions

Degradation rates for two types of nuclear fuel particle (DFR and MTR) found in the marine and coastal environments of NE Scotland were studied using tank experiments to simulate sub-bottom marine conditions. After emplacement for 1 month and 5 months the tanks were freeze cored, the sediment sampled at 5cm intervals and the fuel fragments recovered before finally determining diffusion profiles for various fission products and U. The MTR particles showed the development of clear diffusion profiles for several radionuclides with time whereas the DFR particles showed microfragmentation with virtually no diffusion. Selective leaching of fission products rather than dissolution of the particle matrix was found to be the dominant mechanism for the MTR particles. The experiment is now being repeated using smaller particles to study the effect of particle size on leach rate.

Croudace I.W., Warwick P.E. & Toole J. (2007). Mineralogical and particle size controls on ^{137}Cs abundances in offshore and foreshore sands from Dounreay, N Scotland. In Warwick P (Ed) Environmental Radiochemical Analysis II, Special Publication, Royal Society of Chemistry.

Low-energy Electrokinetic Remediation of Solis

A novel low-energy electrokinetic remediation technique is being evaluated by GAU to clean up contaminated soil. This project is co-funded by AWE under a Knowledge Transfer Partnership to the University of Brighton. A pilot study has been completed that investigated two experimental cells, one using site soil mixed with a high ionic strength electrolyte, the other pre-conditioned with citric acid, using a current of ~35mA. Comparison of post-treatment soil chemistry with control and pre-treatment soils indicates that a range of stable elements and radionuclides were mobilised in both treatment cells.

Cundy A.B., Hopkinson L., Croudace I.W., Warwick P.E. (2006). A pilot study to investigate Electrokinetic Remediation (FIRS) for decontamination of Pu-labelled soil and sediment from the AWE Aldermaston site. Report to AWE Plc.

FSA & GE Healthcare OBT Research Project (1999 - 2002)

This project investigated the mechanisms of accumulation of organically-bound tritium in the Severn Estuary. The interest arose over concerns about discharges from the radiopharmaceutical company Amersham International (now Amersham GE Healthcare).

Warwick P.E., Croudace I.W., Morris J.E., Howard A.G. and Cundy A.B. (2002). Organically-bound tritium (OBT) dispersion and accumulation in Severn Estuary sediments. Final report to the Food Standards Agency.

Warwick P.E. and Croudace I.W. (2004). Tritium accumulation and persistence in sub-tidal sediments within the Severn Estuary. Final Report to Amersham GE Healthcare.

Croudace I.W. and Warwick P.E. (2005). Organically-bound tritium (OBT) dispersion and accumulation in Severn Estuary sediments; Extension to Study. Report to the Food Standards Agency.

Warwick P.E., Croudace I.W., Howard A.G., Cundy A.B. & Morris J. (2003). Spatial and temporal variation of tritium activities in coastal marine sediments of the Severn Estuary (UK), in Warwick P. (Ed) Environmental Radiochemical Analysis II, Special Publication 291, 417pp, Royal Society of Chemistry 2003.

Paramagnetic Separation of Plutonium

A study undertaken for AWE (in collaboration with Terra Verde Services Ltd.) to consider a means of removing Pu from AWE soils to reduce levels to below 0.4 Bq/g. The study focused primarily on paramagnetic separation but also considered the effects of size partitioning, leaching, vibratory disaggregation and thermal treatment of the soils. Three soil types were investigated containing up to 1.9 Bq/g of plutonium. The study found that:

- Pu is concentrated in the sub-75 µm fraction; over 75% of the soil is >75 µm and contains <0.4 Bq/g Pu.
- Pu can be paramagnetically separated to some degree.
- Citric acid and nitric acid leaches can remove up to 70% and 85% of Pu respectively.

An engineering concept was proposed for the establishment of a 'soil's clinic' at AWE which could cost-effectively and rapidly decontaminate 90% or more of the soils. A pilot-scale plant would enable up to 1 tonne per hour of soils to be treated and decontaminated.

Amos S., Croudace I.W. and Voss J. (2005). Remediation of Plutonium-Contaminated Soils, Paper presented at WM'05 Tucson.

Amos S., Croudace I.W. and Voss J. (2005). Remediation of Plutonium-Contaminated Soils, Nuclear Futures, 1, 141-144.

Greenham Common District Study (1996 - 1997)

A high-profile project that stimulated intense local and national media interest in the summer of 1996 following the disclosure of a previously confidential scientific report produced in 1961. The study was concerned with investigating the alleged nuclear accident at the former USAF Airbase at Greenham Common using newly-developed, high precision mass spectrometric measurements of uranium measured in over 600 samples of soil.

Croudace I.W., Sanderson D.C.W., Warwick P.E. & Allyson J.D. (1997). A regional study of the radiation environment of Greenham, Newbury district and surrounding areas. Open Published Report for Newbury District Council and Basingstoke & Deane Borough Council, 84pp.

Croudace I.W., Warwick P.E., Taylor R.N. & Dee S.J. (1997). Radioactive contamination at Greenham Common, Newbury District and surrounding areas. Open Report for Newbury District Council and Basingstoke & Deane Borough Council, 120pp.

Croudace I.W., Warwick P.E., Taylor R.N. & Dee S.J. (1997). Greenham Common: a Cold War tale. NERC COGER (Co-ordinating Group on Environmental Radioactivity) Annual Conference, Liverpool. Sep 1997.

Croudace I.W, Warwick P.E. & Dee S.J. (1997). Greening the Common. Chemistry in Britain, 26-29.

Croudace I.W., Warwick P.E. & Taylor R.N. (1997). Borate fusion followed by ion-exchange/extraction chromatography for the rapid determination of plutonium and uranium in environmental materials. NPL Teddington, October, 1997. Published in Conference Proceedings 'Rapid radioanalytical methods for emergencies'.

Croudace I.W., Warwick P.E, Taylor R.N. & Dee S.J. (1998). Rapid procedure for Pu and U determination in soils using a borate fusion and extraction chromatography. Anal. Chim. Acta, 371, 217-225.

Taylor, R.N., Croudace, I.W., Warwick, P.E. & Dee, S.J. (1998). Precise and rapid determination of $^{238}U/^{235}U$ and uranium concentration in soil samples using thermal ionisation mass spectrometry. Chemical Geology, 144, 73-80.

Croudace I.W., Warwick P.E., Taylor R.N. & Cundy A.B. (2000). Investigation of an alleged nuclear incident at Greenham Common airbase using TI-mass spectrometric measurements of uranium isotopes. Environmental Science and Technology, 34, 4496-4503.

AWE Independent Environmental Study (1998 - 2001)

This project investigated contamination of U and Pu in the environment around the AWE sites in Berkshire. The research involved developing a new method of plutonium analysis using plasma-source mass spectrometry. A significant innovation included the measurement of Pu isotope ratios at very low concentrations using mass spectrometry.

Croudace I.W., Warwick P.E., Warneke T., Cundy A.B. & Taylor R.N. (2001). Assessment of radioactive contamination around the AWE sites in Berkshire. Open Report 3 (FINAL) to AWE plc, 90pp.

Taylor R.N., Warneke T., Milton J.A., Croudace I.W., Warwick P.E. & Nesbitt R.W. (2001). Plutonium isotope ratio analysis at femtogram to nanogram levels by multicollector ICP-MS. J. Anal. At. Spectrom., 16, 279-284.

Croudace I.W. (2002). High precision mass spectrometric measurements of $^{240}Pu/^{239}Pu$ in environmental samples. Royal Society Chemistry International Radiochemical Methods Group.

Warneke T., Croudace I.W., Warwick P.E. & Taylor R.N. (2002). First ground-level fallout record of uranium and plutonium isotopes for northern temperate latitudes. Earth Planet Sci. Lett., 203, 1047-1057.

Croudace I.W., Warneke T., Warwick P.E., Taylor R.N. & Milton J.A. (2003). High precision Pu isotope ratio measurements using MC-ICPMS, in Warwick P (Ed) Environmental Radiochemical Analysis II, Special Publication 291, 417pp, Royal Society of Chemistry 2003.

Taylor R.N., Warneke T., Milton J.A., Croudace I.W., Warwick P.E. & Nesbitt R.W. (2003). Multiple ion counting determination of plutonium isotope ratios using multi-collector ICPMS. J. Anal. Atom. Spectrom., 18, 480-484.

Instrument & Software Development

- Laboratory equipment for enhanced sample throughput and improved analytical precision
- Software for data processing, laboratory information management and regulatory compliance
- Automated *in-situ* sampling equipment

Pyrolyser Furnaces

The Pyrolyser has been specifically designed for high throughput extraction of ^{3}H and ^{14}C from a range of matrices. Samples are introduced into a sample zone and heated using a predefined ramping program. The resulting combustion products are passed over a heated Pt-alumina catalyst to ensure that all species are completely oxidised to water and CO_2. The water and CO_2 are subsequently trapped in bubblers prior to quantification by liquid scintillation counting. The Pyrolyser incorporates an innovative multi-tube design permitting the simultaneous extraction of up to 6 samples. The Pyrolyser is now installed in numerous laboratories throughout the UK for the routine determination of ^{3}H and ^{14}C in environmental and waste samples.

In-situ Autosamplers

A stand alone autosampler has been developed in collaboration with AWE plc for the sampling of Pu and U in river waters. The ruggidised sampler is powered by 12V batteries which are charged via solar panels. The sampler is programmable and samples known volumes of water at regular intervals throughout a monthly sampling period. An efficient extraction resin has been incorporated which concentrates the Pu and U from the water. The sampler incorporates data logging to record the volume of water sampled and time of sampling. GAU-Radioanalytical have also developed an *in-situ* gamma-in-water monitor based on a NaI detection system capable of measuring ^{137}Cs down to 1 Bq/L. The system incorporates computer controlled sampling and measurement hardware and software for system control, spectrum processing and data logging.

Automated Radiochemistry

GAU-Radioanalytical is currently developing automated analytical separation instrumentation to improve throughputs, turnaround times and analytical precision for actinide analysis. Based on the laboratory's experience in rapid radioanalytical techniques, the autoanalyser uses multiple column sequential separation approaches to isolate a range of actinides from a single sample. The fully programmable instrument will be capable of analysing multiple samples with enhanced flow rates considerably reducing analysis times.

Software

GAU-Radioanalytical has partnered with JF-Computing to develop a range of computer software packages to comprehensively support its QA and QC systems as well as for efficient processing of laboratory data derived from its instruments.

LIMS

The GAU-LIMS system is a highly integrated, web-based, laboratory information and management system produced as a bespoke system for the GAU. It is used for job control, quality assurance, performance monitoring, quality control and financial management.

ISOINVENTORY

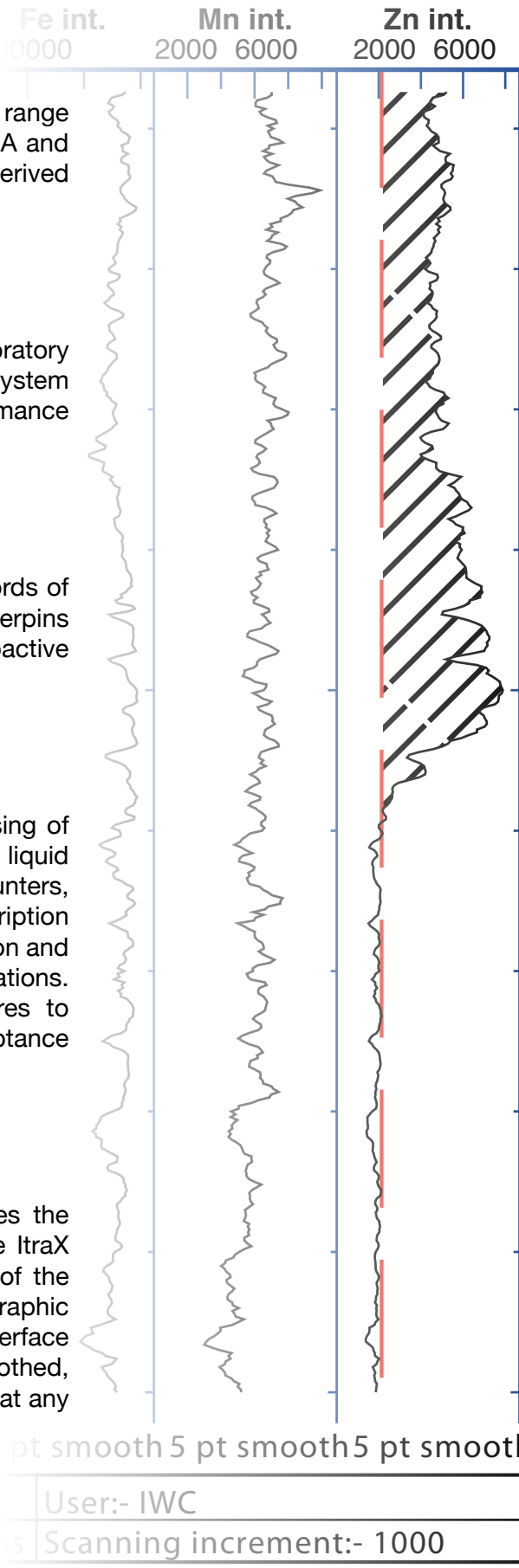
Isoinventory is a radionuclide inventory database maintaining records of radioactive material holdings, usage and disposal and which underpins the group's protocols for ensuring compliance with the Radioactive Substances Act, 1993.

LSC+

LSC+ has been developed to enable rapid and accurate processing of liquid scintillation data. The software extracts information from liquid scintillation data output files from both Packard and Wallac counters, dramatically reducing data processing times and eliminating transcription errors. Raw count rate data are combined with instrument calibration and supporting analytical data to determine sample activity concentrations. The software incorporates statistical and quality control features to enable the integrated assessment of data against predefined acceptance criteria.

ItraX-PLOT

ItraX-PLOT is a data visualisation software package that enables the efficient display of elemental data and images acquired from the ItraX sediment core scanner. Rapid visualisation is an important part of the evaluation process for downcore textural, elemental and radiographic profiles. ItraX data files are easily opened and an intuitive user-interface readily allows graphical images and data to be manipulated, smoothed, adjusted, highlighted and formatted. No original data are modified at any stage.



ItraX-Plot image from Newport Deep Core

Facilities and Equipment at GAU-Radioanalytical Laboratories

- Seven dedicated laboratories
- Extensive range of radiometric counting equipment
- Use of affiliated mass spectrometric facilities
- Well equipped sample preparation facility

ItraX µXRF Scanner

Gamma and Alpha Spectrometry

- 3 well-type HPGe detectors
- 4 standard HPGe detectors
- 2 portable HPGe detectors
- 1 NaI(Tl) portable detector
- 2 Octete alpha spectrometer systems (16 detectors)
- 8 Quad alpha spectrometer systems (32 detectors)

Gas Flow Proportional Counters

- 1 Tennelec XL5B
- 1 Tennelec LB-4100

Liquid Scintillation Counters

- 3 Wallac 1440 Quantulus ultra low-level LSC
- 1 Wallac 1400 LSC

Pyrolyser Furnaces

- 4 systems

RAD-7 Radon System

Philips MagiX-Pro WD-X-ray fluorescence spectrometer

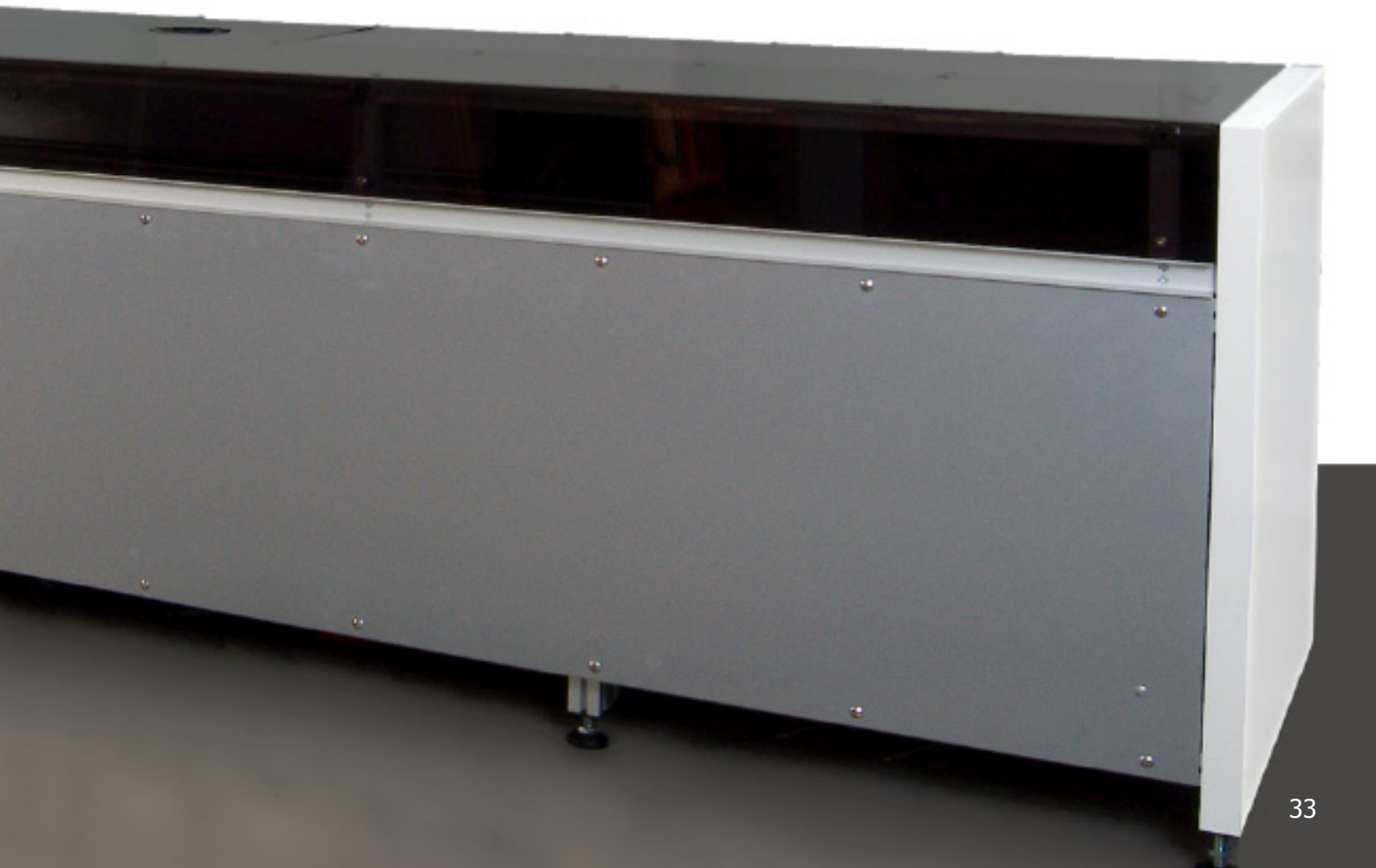
ItraX µXRF Logger

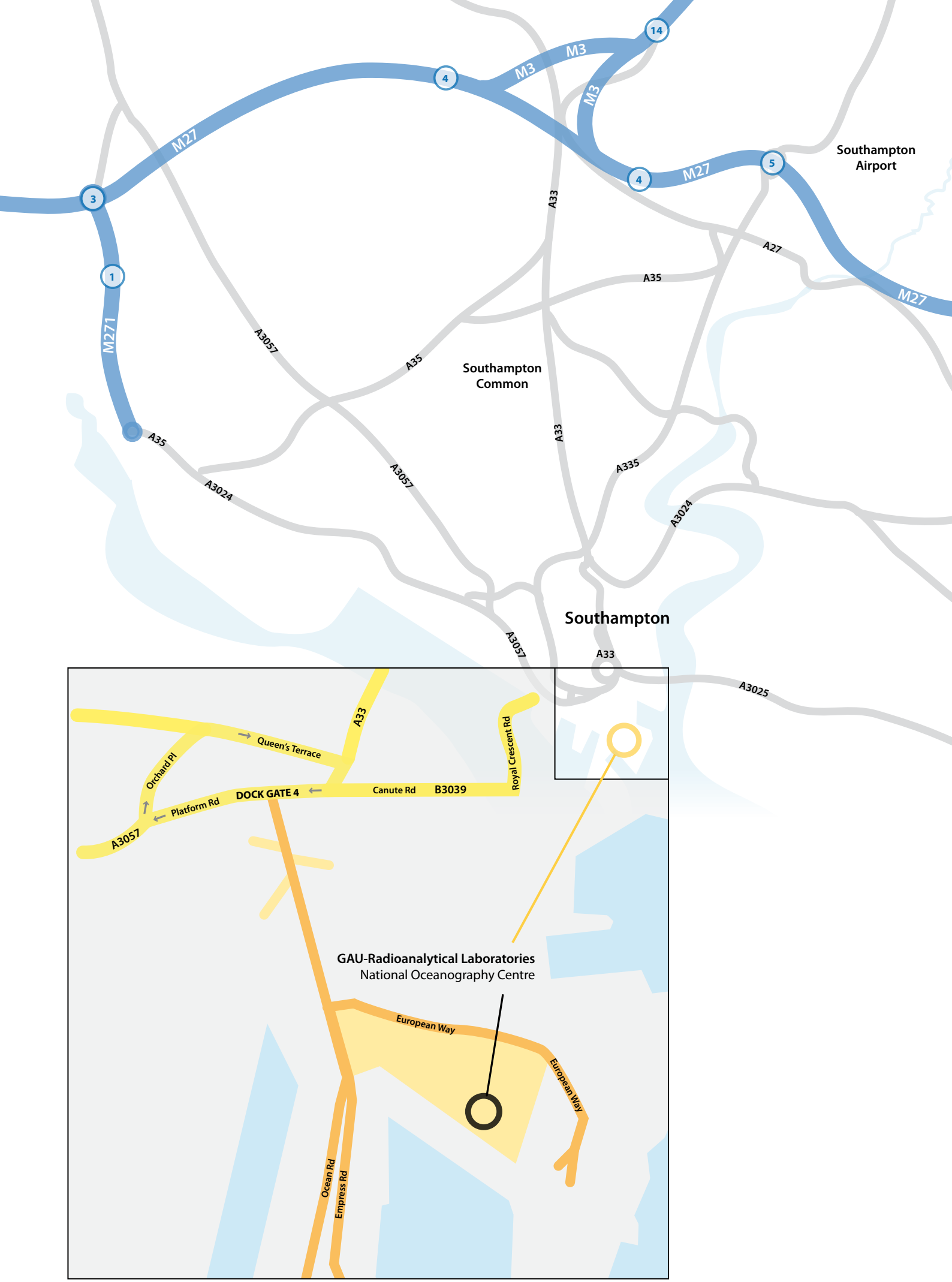
EDAX Eagle III Varifocus µXRF spectrometer

Mass spectrometers (ICPMS and MC-ICPMS)

GAU-Radioanalytical work closely with a number of other UKAS accredited laboratories to provide a comprehensive analytical service covering a wide range of inorganic and organic contaminants and asbestos characterisation in non-radioactive materials. On-site characterisation of radioactive asbestos can be arranged.

GAU collaborates with other groups within the National Oceanography Centre to provide additional state of the art analytical facilities.

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Southampton Common
Southampton
Queen's Terrace
Orchard Pl
Platform Rd
DOCK GATE 4
Canute Rd
B3039
Royal Crescent Rd
GAU-Radioanalytical Laboratories
National Oceanography Centre
European Way
Ocean Rd
Empress Rd

GAU-Radioanalytical Laboratories are based at the National Oceanography Centre, Southampton

By Train - Fast services from London, Bournemouth / Weymouth, Portsmouth and Bristol / South Wales stop at Southampton Central Station. There are usually plenty of taxis at the Station to take you to the NOCS, or there is a free bus to Town Quay, from which the NOCS is about a 10 minute walk, or you can pick up the Uni-link service U1C adjacent to platform 4 (the U1A service to the Highfield campus also departs from the same bus-stop).

By Road - If using the M3 (from London, the North and the Midlands) leave at Junction 14 and onto the A33 into Southampton; from the West leave the M27 at Junction 3, onto the M271 and the A35/33 into Southampton; from the East leave the M27 at Junction 5 and onto the A335/A33 into Southampton. On all routes follow signs for the Waterfront and Dock Gate 4. Once through Dock Gate 4, take the second turning on the left into European Way and the NOCS entrance is 100 yards further along on the right hand side.

GAU Radioanalytical Laboratories

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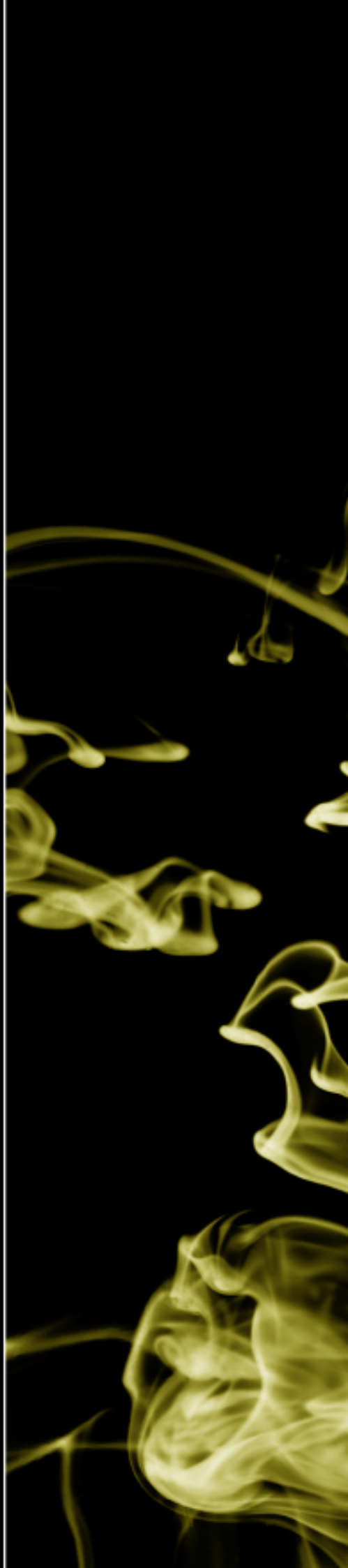
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