



British
Geological Survey

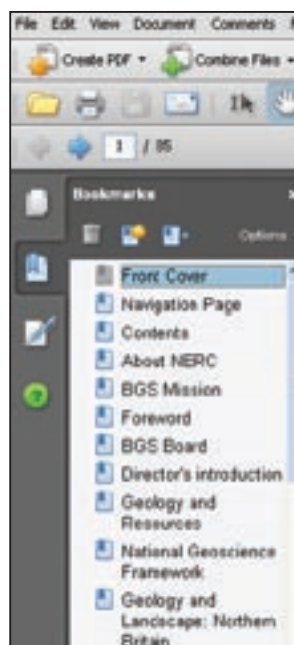
NATURAL ENVIRONMENT RESEARCH COUNCIL

2007–08
Annual Report

HOW TO NAVIGATE THIS DOCUMENT

Bookmarks

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The Annual Report is contents page driven.



Where there is a double-page article, click on the banner headline to go to the second page.



In addition, the Annual Report contains links from each page number back to the navigation page.

Cover: Part of an 8 km long tunnel for Scottish and Southern Energy's Glendoe hydroelectric scheme, near Fort Augustus. The tunnel created an unrivalled opportunity for BGS geologists to examine the geological structure of a key area in the Grampian Highlands. Driven perpendicular to the regional trends, the smooth-bored tunnel revealed extraordinary examples of folding and shearing, including a transect through the regionally important Eilrig Shear Zone. Detailed observations have already provided important new insights into Grampian Highland terrane rocks. Access of the tunnel was only possible thanks to the enthusiastic collaboration of Scottish and Southern Energy, their consultants Jacobs, and contractors Hochtief Glendoe JV, who enabled access, and provided essential logistical support.

BGS © NERC (Photographer: Fergus MacTaggart, P700856).

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NATURAL ENVIRONMENT RESEARCH COUNCIL

British Geological Survey

Annual Report 2007–08

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BGS geology data viewed in ArcGIS Explorer
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About the British Geological Survey

The British Geological Survey is a part of the Natural Environment Research Council and is its principal supplier of national capability in geoscience.

It advances understanding of the structure, properties and processes of the solid Earth system through interdisciplinary surveys, monitoring, modelling and research for the benefit of society.

It is the UK's premier provider of objective and authoritative geoscientific data, information and knowledge for wealth creation, sustainable use of natural resources, reducing risk and living with the impacts of environmental change.

Our vision

To be a world-leading centre for applied geoscience.

Next Generation Science for Planet Earth

The Natural Environment Research Council (NERC) funds independent environmental research in the United Kingdom. The priorities we develop with our researchers and stakeholders provide a focus for the marine, polar, atmospheric, earth, terrestrial and freshwater science communities.

The research is often multidisciplinary and in collaboration with other national and international partners. NERC runs a fleet of research ships and scientific aircraft. We have bases in some of the world's most hostile environments and invest in satellite technology to monitor environmental change on a global scale.

NERC's research and collaborative centres maintain and develop UK national capability across the disciplines that make up environmental science. We fund centres and universities to carry out research and to train and support a world-class community of environmental scientists.

NERC is one of the seven UK research councils.

NERC's strategic goal

To deliver world-leading environmental research at the frontiers of knowledge:

- enabling society to respond urgently to global climate change and the increasing pressures on natural resources;
- contributing to UK leadership in predicting the regional and local impacts of environmental change over timescales from days to decades; and
- creating and supporting vibrant, integrated research communities.

Visit www.nerc.ac.uk for more details.



Foreword

Mr Derek Davis — Chairman of the BGS Board

The process of change described in last year's Annual Report has been gathering pace with reorganisation at the top-level, appointments within the new structure and new committees driving science, information and commercial strategy.

Care is being given to evolving the new science strategy collectively, to thinking through styles of collaboration and how best to combine strengths across the geoscientific research and wider communities. We have been asking ourselves searching questions about how we work. The exercise is generating promising new approaches and the makings of a vibrant new in-house consensus.

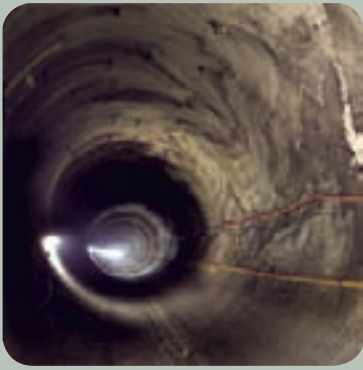
We have also taken the opportunity to review, after ten years, the BGS Board's terms of reference and ways of working. The emphasis has been on enhancing the added value non-executive Board members bring to governance. One new feature is that non-executives are participating in the subject strategy committees, contributing the same

wider perspective and experience and deepening Board engagement in meeting the strategic challenges of the next few years. These include new arrangements for science funding, development of the information market and making the most of geoscientific business opportunity for BGS, other suppliers and customers.

This Annual Report describes the continuing achievements of 2007–08 alongside these changes and preparations. As an example, I will single out the Tellus Conference held in Belfast in October. This was the culmination of long and patient work on the aerial survey of Northern Ireland and parts of the Republic of Ireland. It was also a model of knowledge transfer from leading edge survey technique into exploitation. The occasion generated real

excitement and follow-up and the publicity it attracted was a tribute to the skilled work of Marie Cowan and her press office team.

The Survey holds unrivalled data, deploys internationally prized capability and has a hugely dedicated staff. It is a privilege working with them, with the Board, John Ludden, Denis Peach as Chief Scientist, Ian Jackson as Chief of Operations, the Senior Leadership Team and the NERC, to make the most we can of these assets for science and the quality of everyday life. We shall sorely miss Mick Lee who retired during the year and Martin Culshaw who has moved to academia. We owe them both an enormous debt of gratitude for their long and distinguished contributions to making the Survey what it is today.



The BGS Board 2007–08

The BGS Board was established to support the management and strategic direction of the Survey. Board members are appointed by the Executive Director and are ratified by the NERC. Membership comprises up to ten non-executive members from a broad cross-section of the BGS user community, and the BGS Senior Leadership Team.

Board members: non-executive

Mr D Davis	Chairman (formerly of the DTI)
Mr P Bide	Department for Communities and Local Government (Observer)
Mrs R Johnson-Sabine	Vice President of Exploration, Tethys Petroleum
Mr J Smith	Managing Director, Wardell Armstrong
Professor S Sparks	Department of Earth Sciences, University of Bristol
Professor P Styles	School of Earth Sciences & Geography, Keele University
Professor L Warren	Zoologist and Emeritus Professor of Environmental Law at the University of Wales
Dr S Wilson	Director Science and Innovation, NERC

BGS Senior Leadership Team

Professor J Ludden	Executive Director
Professor D Peach	Chief Scientist
Mr I Jackson	Chief of Operations
Dr A Howard	Director of Science Programmes
Dr R Hughes	Director of Information & Knowledge Exchange
Mr J Murray	Director of Finance & Administration
Mr D Ovidia	Director of Business Development and Strategy
Professor M Petterson	Director of Science Resources

The Secretariat is provided by the BGS's Senior Leadership Team Support Unit.



From top:
Andy Howard, Richard Hughes and John Murray joined the Board this year.



Director's introduction

John N Ludden — Executive Director

In my introduction to last year's Annual Report I stated that the BGS was in the process of reviewing its governance and organisational structure to address the evolving needs of our stakeholders. This year has largely been dedicated to bringing about these changes. Despite this, we have maintained an excellent performance across a spectrum of scientific and information- and knowledge-related activities.

The BGS is a research centre within the Natural Environment Research Council (NERC) and the Council provides a little over 50% of our funding, in addition to maintaining our estate and capital. The NERC too is undergoing significant change, with the introduction of a new funding model which will better identify the role of its research centres and allow for more flexible and reactive funding and also ensure the new NERC strategy Next Generation Science for Planet Earth is delivered. Some of these changes will result in more risk for our funding profile, but they also provide opportunities.

Each of the NERC research centres has a different mix of scientific and knowledge transfer activities. The BGS is the largest of the NERC's centres with 780 employees, and, although we have a strong environmental research and survey component, we also have an important advisory role to government, industry and the public. The NERC recognises the latter and is helping us create a Government Advisory Panel which will guide our activities. We have started the process of enhancing relationships with other NERC research centres and the academic sector.

Our strengths lie in our staff's expertise which is applied to a programme of

monitoring and geological and environmental data acquisition, data management and modelling. The programme is essential for understanding long-term trends and processes in the natural environment. The information is deployed through leading-edge knowledge exchange activities.

The BGS hosts and supports the NERC Isotope Geosciences Laboratory (NIGL). We also manage the UK's involvement in the Integrated Ocean Drilling Programme (IODP) and act as the European science operator for drilling operations. We house the National Geoscience Data Centre and collaborate with the NERC Centre for Ecology and Hydrology (CEH) to run the National Water Archive. These activities contribute to NERC National Capability (NC) which underpins key environmental sciences research projects (RP). In 2007/08 of our total budget of £53.4 million about 80% was dedicated to NC and 20% to RP.

Our new structure is shown on the opposite page. An important change has been to fuse the two areas of Geology and Environment into a single science directorate. This has allowed us to be more flexible in moving funds between key geoscience sectors; in 2008, as part of our 2009 planning,

significant funding transfers were made to the energy and the climate vulnerability science sectors. This reflects a more strategic approach to geological survey which will correspond generally to the new NERC strategy and government drivers.

Another significant change has been the creation of a Team Leader role underpinning the Heads of Science and Information. This role will allow the development of science leaders in BGS. Team Leaders have the responsibility of co-ordinating and delivering projects, permitting the Heads of Science and Information a more outward-looking role for the BGS and NERC on the UK, European and world stage.

The change was difficult for some but was helped by the introduction of a change management process. I thank the BGS staff for their help in bringing about the change. The good results in 2007/08 are a reflection of the quality, reach and flexibility of all our staff. The changes we have made seek to make more of these qualities in many ways, from wider publication in various media to novel commercial and licensing opportunities and to move to a BGS business model capable of adapting to new ways to tackle our science.

BGS Executive Director

Chief Scientist

Chief of Operations

Director of Science Resources

Director of Science Programmes

Director of Information & Knowledge Exchange

Director of Business Development

Director of Administration and Finance

- Geology
- Geophysics
- Geochemistry, Mineralogy
- Information Systems
- Laboratory Operations
- Publications
- IT Infrastructure
- Training
- NERC Isotope Geoscience Laboratory

- Geology & Landscape
 - England
 - Scotland
 - Wales
 - Northern Ireland*
- Marine Geoscience
- Environmental Geoscience Baselines
- Climate Change
- Energy
- Minerals
- Groundwater Resources
- Land Use and Development
- Earth Hazards & Systems
- Environment & Health
- Spatial Geoscience Technologies

* Geological Survey of Northern Ireland (GSNI)

- Information Management
- Information Products
- Information Delivery

- UK Business Development
- International Business Development
- Policy in Europe, & Grantsmanship

- Finance
- Personnel
- Facilities
- Operations Support

- Senior Leadership Team
- Science and information matrix
- Heads of business development, policy and administration

Senior Leadership Team (SLT) defines organisational strategy and directs programmes in science and information. Sub-components of the SLT have a particular focus on science, information, knowledge transfer, resources, laboratories services and facilities, and marketing and business development.

The contact details for all of the key managers indicated above, and the team leaders, are listed on page 76.



New science horizons for BGS

Denis Peach — Chief Scientist

BGS is poised to develop its National Capability and Research Programme role to underpin and help provide the science to solve some of the most significant threats facing the social and economic fabric of the United Kingdom: serious environmental change impacts and insecurity of energy and water supply.

John Ludden recognised the need for a new BGS at an early stage and as a part of the development of a new Senior Leadership Team, created the role of BGS Chief Scientist to help him achieve a greater visibility and flexibility in our science. The Senior Leadership Team is tasked with shaping the BGS to underpin the recently-published NERC science strategy (Next Generation Science for Planet Earth), improve the science and profile of the BGS and continue to provide the excellent 'national good' services and science advice for the benefit of the nation.

By the end of what has been very much a transitional year for our structure and science, most of the Team Leaders were

appointed. They have the challenge of delivering new BGS science to an even higher standard. The BGS will be directly competing for an increasing portion of the research part of its Science Budget funding from 2009 to 2014 and much rests on our new Teams to develop the skills necessary for success as a part of Next Generation NERC.

In the light of the NERC Science Strategy and national need, we are in the process of developing a new programme of climate change research, an increased focus on energy, especially carbon sequestration, and recognition of the role of technology in BGS science. We also feel that a positive move towards more quantification and prediction in our geoscience is required.



© Corbis

Undoubtedly, the new direction of NERC science requires much more integration of environmental science across traditional disciplinary boundaries. This means that our staff will be working ever closer with the academic community, decision/policy makers and practitioners. A start has been made in developing the new contacts and consortia that will be necessary. Heads of Science and Information have been heavily engaged with NERC Science Themes Leaders, who will be preparing Theme Action Plans (TAP) in draft towards the end of the year. It is crucial for us to be prepared for these research programmes as they come on stream in autumn 2008.

We are now set to develop our new science strategy, as a part of the NERC science strategy, to help move the UK forward in world-leading geoscience survey, monitoring, modelling and research. I believe our new thematic approach will enable us to focus on the science required to find solutions to the major issues facing the world today, such as security of supply for energy, food and water, and living with environmental change.





Operating in a digital era

Ian Jackson — Chief of Operations

The Chief of Operations is a new role within the senior team of the BGS and is responsible for ensuring that the organisation operates effectively and efficiently and that our procedures and governance are sound. Basically my job is to monitor our performance against our overall science and business goals and ensure we achieve them.

Despite an especially challenging year, the BGS achieved its major objectives in 2007/08. We exceeded our financial targets and for the eighth year running there was record demand for our information services. We continue to place a high priority on developing new and innovative digital geoscience solutions — in modelling, visualisation and web delivery. These developments are increasingly important and especially as traditionally strong markets for our information in the conveyancing sector experience difficult times.

Within the UK relationships were refreshed with several key stakeholders including the Environment Agency, Scottish Government, Welsh Assembly and several UK Government Departments. Internationally, our work in Afghanistan and Madagascar came to a conclusion and new opportunities overseas were explored. The 81-nation OneGeology initiative which the BGS co-ordinates continues to grow in extent and profile and will launch its web map portal at the 33rd International Geological Congress in

Oslo. We continue to proactively contribute to the implementation of the EC INSPIRE Directive on environmental spatial data and its transposition into UK law.

Like other UK Research Councils, the NERC, and thus the BGS, is moving components of its administration to a Shared Service Centre operation (SSC). This is proving a very difficult transition which has affected staff at all levels and which we are attempting to manage as effectively as possible. We hope that the significant contribution the BGS is making now to the development of the SSC protocols will improve the quality of the service available in the new operation.

More positively, during the year the face of the Keyworth site changed dramatically as the construction of the new William Smith Building progressed. The expectation is that this welcome major regeneration of the BGS estate will be ready to house about 200 staff in April 2009. We hope that this will represent merely the first phase in bringing the BGS estate into the twenty-first century, to match the leading edge applied science the BGS is renowned for.





Science Programmes

The BGS Science Programme is organised into 14 themes which, collectively, provide up-to-date knowledge on the three-dimensional geology, environmental characteristics and natural resources of the UK landmass and continental shelf, and model and predict the environmental and human impacts of natural hazards, land and resource exploitation and climate change. In collaboration with our research partners, clients and sponsors, our science programme combines the national geoscientific 'evidence base' with high-impact research to support policy and decision-making on sustainable use of energy and natural resources, and living with environmental change.

During the year, we continued to accelerate the implementation of new technologies for geological mapping and modelling, and digital field data recording systems were deployed on all our geological mapping projects. Regional 3D geological models were completed for the Central Belt of Scotland, Lancashire and the Weald. The Environment Agency increasingly uses our 3D models in developing and implementing groundwater management policies and we now have a framework agreement with them to deploy and develop modelling methodologies. New, national 1:625 000 scale geological maps and accompanying explanatory booklets were published, and the maps were also released as freely downloadable digital data from our website. The maps were accompanied, for the first time, by two wallcharts summarising the lithostratigraphy of the UK to formation level, produced in collaboration with the Geological Society of London Stratigraphy Commission. These products are not only of considerable educational value but also provide a consistent national framework for our higher resolution maps, models and data.

An understanding of climate-driven processes and events in the recent geological record can help predict impacts of future change. Integrated analysis of onshore digital terrain models with high-resolution seabed bathymetry derived from fishing boat sonar data has enabled us to model the collapse of the Scottish ice sheet at the end of the last ice age. This model will inform wider NERC-funded polar research on the potential collapse of the West Antarctic and Greenland ice caps and the associated impacts on terrestrial and marine environments.



Our new 1:625 000 geological maps of the UK are accompanied by explanatory books aimed at educational users. Digital versions of the maps can be freely downloaded from the BGS website. www.bgs.ac.uk/downloads

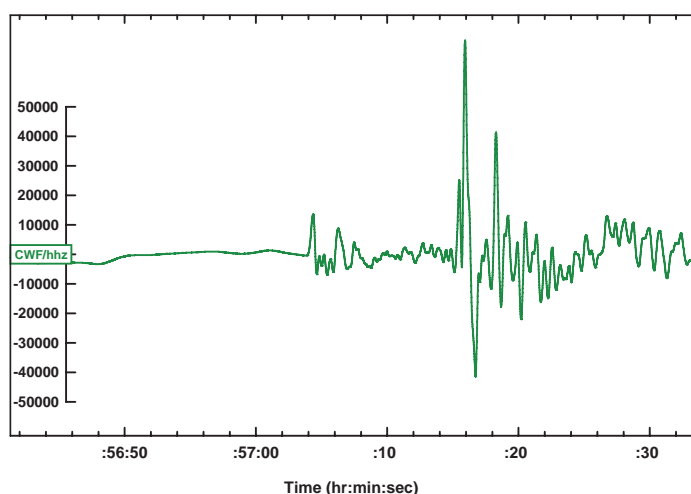
Carbon Capture and Storage is a new technology that can help to reduce emissions of carbon dioxide into the atmosphere from the burning of fossil fuels, until alternative energy sources can be developed to meet our national needs. Collaborative research funded by the EU and the International Energy Agency has led to publication of a best practice manual for assessing CO₂ storage capacity in deep saline aquifers. Meanwhile, collaboration with our partners in the newly established CO₂GeoNet Association is simulating the potential impact of CO₂ leakage on terrestrial ecosystems. Inventories of storage capacity and environmental impact assessments will be essential policy development and implementation tools if Carbon Capture and Storage is to provide a viable contribution to future CO₂ emissions reduction.

Information and decision-support to help resolve conflicting pressures on land use and environmental degradation continue to provide a major focus for our applied science, in partnership with diverse

collaborators, clients and funding bodies. Publications and geographical information systems completed during the year will help to inform policy on minerals security for English regions, underground storage of resources in man-made cavities and pore space, and management of the risks to groundwater posed by leaching of chemical pollutants from soils. A two-day conference, held in Belfast in October 2007, demonstrated the societal impact and future research potential of the high-resolution environmental geochemistry and airborne geophysical datasets delivered by the DETI-funded Tellus project. Tellus has so far generated over £16 million inward investment in new mineral exploration and gas storage licences in Northern Ireland.

Our vulnerability to natural hazards in the UK was highlighted by the summer 2007 floods and the Kent and Market Rasen earthquakes in April 2007 and February 2008 respectively. Our digital Geological Indicators of Flooding maps were updated by new aerial photographic data taken from specially chartered flights over flooded areas. These maps will play a substantial role in implementing the recommendations of the government's Pitt Review: Lessons learned from the 2007 Floods, specifically on the improved delineation of flood prone areas. In comparison to major seismic events elsewhere in the world, such as the devastating earthquake in the Sichuan province in China in May 2008, the two UK earthquakes were minor events and only caused local, superficial damage to property. Public alarm and media interest in both events was considerable, and threw into focus the continued need for national monitoring and analysis of the risks to critical national infrastructure, both onshore and offshore, from seismic events.

A magnitude 5.2 ML earthquake near Market Rasen, Lincolnshire, was widely felt across the Britain in the early hours of 27 February 2008. We were inundated with calls from the public, media and emergency services throughout England.



Geology and Landscape



Steeply-dipping Carboniferous Limestone crags at Crook Peak, southern Mendips

The UK's physical landscape preserves a rich heritage of the interaction of natural processes, human development and the properties and structure of the underlying rocks and soils. With increasing pressures on land and resources, and the need to predict and adapt to environmental change, demands for comprehensive and authoritative knowledge of the nation's geology continue to grow and diversify.

Our surveys provide baseline knowledge on the geology of the UK at a range of resolutions, delivered as printed or digital maps and, increasingly, 3D digital models of the subsurface. This information underpins applied geoscientific research carried out by all BGS programmes and our research partners, and the advice and client services we provide to support policy and decision-making by government, regulators, private enterprise and the public.

We also produce a range of published products, including maps, guides and reports, to add to the amenity and educational value of the nation's geological heritage.

Resource modelling in Mesozoic and Tertiary Basins

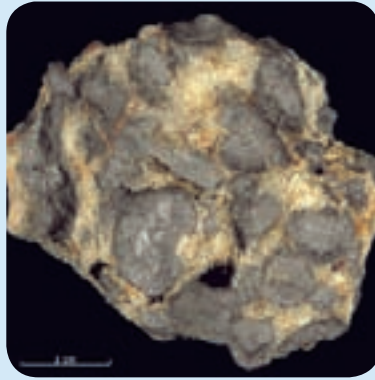
The Isle of Wight, with its extensive coastal exposures of Cretaceous and Tertiary rocks and its unique fold structure is one of the classical areas of British geology.



Isle of Wight resurvey. Several inaccessible cliff sections in the Cretaceous and Tertiary rocks were recorded with the help of the RNLI using their lifeboats to land BGS geologists.

Cool graphite

Graphite deposits from Borrowdale, the only economic concentration of graphite known to be hosted by volcanic rocks, have been shown to be the first reported example of highly crystalline graphite precipitated from fluids containing carbon dioxide and methane at temperatures as low as 500°C. A collaborative study with the Complutense University, Madrid has important implications for the production of synthetic highly crystalline graphite for industrial uses. This process currently requires temperatures greater than 2000°C. Borrowdale graphite was worked extensively from the late sixteenth until the late nineteenth century, mainly for



Natural graphite deposits from Borrowdale, Cumbria; the first record of low-temperature genesis of this mineral.

the casting of cannonballs, and as the basis for the renowned Keswick pencil industry.

A detailed multidisciplinary resurvey of the island is in progress together with seismic interpretation of the deeper structure. New structural and sedimentological interpretations will inform resource management and environmental issues on the island.

Increasing pressure on the environment and resources in Greater London stimulated the development of a 3D geological model covering 2400 square kilometres and extending down to the base of the Chalk Group at depths of up to 500 metres. The model, created using interactive GSI-3D software developed by the BGS, helps to explain the geological evolution of the area. It enables synthetic cross-sections and borehole prognoses to be generated across the capital to inform land-use planners and the water industry on subsurface conditions. Similar 3D models have been commissioned by the Environment Agency to investigate resource implications for nationally important aquifers in England, such as the Cretaceous Chalk in the south-east, the Triassic Sherwood Sandstone in the Midlands and the Permian 'Magnesian Limestone'.

Understanding the big picture — the UK Geoscience Framework

Our understanding of the 3D geoscience framework of parts of the UK, at the regional scale, was extended through delivery of a number of computer-viewable models. These show the subsurface distribution

and structure of key geological horizons for the Weald, the Kent Coalfield and the Midland Valley of Scotland. Based on exhaustive interpretations of boreholes, seismic and other geophysical data, they include all significant faults and summarise the 3D geology, at a regional scale, to a depth of between five and ten kilometres. These regional-scale models complement shallower resource-specific studies and provide an overview for the assessment of regional resources.

An additional highlight was the production of the *BGS Stratigraphical Chart of the United Kingdom*, published jointly

with the Geological Society. The wallcharts complement the new 1:625 000 scale geological maps of the UK. They summarise and correlate, for the first time, the bedrock geological succession and lithofacies for onshore and offshore regions throughout the UK. We intend to develop this concept in the future as an interactive web-based interface leading the user to further geological datasets and information.

Available from www.geologyshop.com

Appreciating geodiversity and landscape

As part of the BGS's contribution to science outreach, geodiversity and biodiversity, two colourful 'walkers' guides covering the geology and landscapes of the Mendip Hills were launched. The guides, aimed at non-specialists, include the world-famous caves and landscape features cut into the Carboniferous Limestone, such as Wookey Hole and Cheddar Gorge.

Reconstructed Ediacaran fossil assemblages

Ediacaran (late Precambrian age, about 600–550 million years old) fossils are the oldest multicellular organisms and are critical to our understanding of the subsequent evolutionary radiation of more complex animals. Casts of Charnian fossils from the type locality in Leicestershire have enabled BGS palaeontologists, in collaboration with Natural England and the fossil replica company GeoEd, to reconstruct fossils that have recently been destroyed by illegal collecting. Study of the new casts has revealed several new taxa and



Cliffs of steeply dipping Chalk Group strata, picked out by dark grey flint bands. View across Freshwater Bay towards Tennyson Down, Isle of Wight.

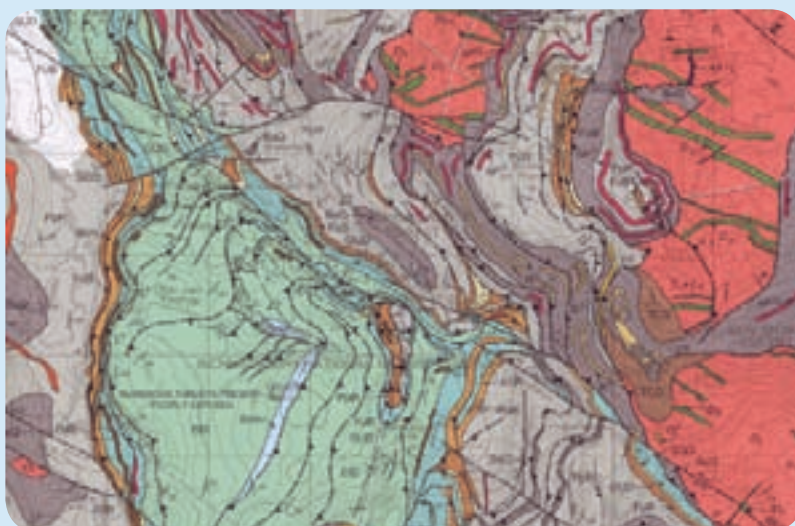
Highlands and Islands

The revised edition of the classic Assynt Special Sheet was published and includes a series of modern cross-sections, and a thorough revision of the unique ultra-potassic igneous rocks of the district. Its release coincided with the Continental Tectonics and Mountain Building Conference organised by BGS staff in collaboration with researchers from Leeds, Portsmouth and Virginia Tech (USA) universities and under the auspices of the Geological Societies of London and America. Over 120 participants came from the USA, Canada, Italy and Korea to discuss the natural tectonic laboratory of Assynt, Laxford and Eriboll.

A major new advance in Highland geology came with the reinterpretation

of part of the Neoproterozoic Moine Supergroup as being of fluvial origin. This reinforces a link to the thick Torridon sequence west of the Moine Thrust and advocates that these strata were formed in a vast foreland basin to the one billion year old Grenville Mountain Belt in Canada.

A tunnel excavated for the Glendoe hydroelectric scheme provided a unique opportunity for access to new rock sections crossing major tectonic structures (*see front cover photograph*). Our geologists recorded superb continuous exposures through the north-west part of the Grampian Highlands, adjacent to the Great Glen Fault and intersecting a major shear zone defining the Grampian Orogenic Front.



OS topography © Crown Copyright

Extract from the new 1:50 000 scale Assynt Special Sheet.

has improved our understanding of the biota, including discovery of a new genus and the recognition of a 'life assemblage' with many juvenile forms. The diversity of this newly catalogued assemblage is comparable with the best in the world.

High-resolution geophysical surveys

Hi-RES geophysical surveys in the Ayr area were interpreted to assess and map contaminated land, groundwater quality and high compressibility peaty soils. The data were distributed to planners and regulators for the first time in Scotland, and feedback is being used to refine survey and data representation methods for future UK HiRES surveys.

Quaternary palaeoenvironments

In south-east England, collaboration with Royal Holloway University of London and the University of Sheffield has demonstrated that geological processes have evolved over the course of the past 2.5 million years in response to climate change. Rivers have become progressively more powerful elements within the landscape, sea-level has risen and fallen, and glaciers have periodically eroded and redistributed geological materials throughout lowland Britain and the adjacent continental shelves. One example from the Breckland area of central East Anglia shows several phases of sand dune activation and stabilisation which influenced the impact and land-use practices

of humans since the last ice age, 11 000 years ago.

Clyde regeneration

The Clyde Corridor, a key Scottish government regeneration priority, received a boost with Glasgow's successful bid for the 2014 Commonwealth Games. The BGS continued to work closely with Glasgow City Council and other partners to provide a range of 3D geoscientific information on the soils, rocks and related geotechnical properties, and on the groundwater and associated contamination. The work was carried out by a multidisciplinary group, assembled jointly with our Urban Development team (see Land Use and Development page 32–33). The construction of new 3D models, based on borehole, mine plan and other data, was accelerated to assist in planning, regulation and redevelopment for the Commonwealth Games sites and East End regeneration. This work addresses the NERC natural resources and environment pollution and health themes, through ongoing work on past coal mining and associated hazards, groundwater resources, regional pollutant linkages and surface threats to contamination of shallow groundwater. New opportunities are being explored to develop collaborative research with centres in Scotland and further afield.

New dates for the evolution of Wales

Collaborative studies with the NERC Isotope Geoscience Laboratory and the National Museum of Wales are providing new information on the evolution of the continental crust beneath Wales. The age at which igneous bodies originally crystallised can be determined by analysing zircon grains using high-precision mass spectrometry techniques. Subsequent metamorphic events may be dated from other analyses. The results provide a basis for calibrating crustal processes and for correlation with other igneous and sedimentary rock successions both within Wales and internationally. This new information underpins a new and radical interpretation of the early Palaeozoic Welsh Basin.

The fault-bounded Stanner Hanter Inlier in eastern Powys includes the oldest rocks so far recorded in Wales, providing a uranium–lead age of 712 ± 0.7 million years. In north Wales, emplacement of the Twt Hill granite near Caernafon is shown by uranium–lead dating to have occurred 615.2 ± 1.3 million

years ago. But a younger rubidium–strontium age (491 ± 12 million years) records the effects on this body of a subsequent — previously unknown — late Cambrian period of crustal accretion and metamorphism. These new dates suggest that, though parts of the platform of older rocks on which the thick Ordovician to Silurian Welsh Basin succession accumulated were in place by the late Precambrian, its northern margin was still under construction during late Cambrian and early Ordovician times.

Pipeline reveals new geological relationships

In summer 2007 a major gas pipeline trench excavated across the Llandovery area of mid Wales afforded our geologists a unique opportunity to examine some of the otherwise poorly exposed yet critical geological contacts of this region. The trench provided an almost unbroken section through a rock sequence ranging in age from latest Ordovician (446 million years) to latest Silurian (418 million years) deposited along the margin of the deep-water, early Palaeozoic Welsh Basin; and including a traverse through the global type section for the early Silurian Llandovery Series. The new exposures provided an early opportunity to test and refine a new BGS

New inliers and wind farms in Palaeozoic Wales

During our survey of the Llanidloes and Dinas Maddwy districts in mid Wales, previously unrecognised sequences of Ordovician and early Silurian rocks have been discovered. Burrow-mottled mudstones which record the onset of the late Ordovician glaciation in Wales have been identified in the Hengwm Valley and on the eastern flanks of Plynlimon. Within a narrow up-faulted belt to the north of the village of Carno, the distinctive, burrow-mottled sandy mudstones of the late Ordovician Dolhir Formation record this same event beneath a newly dated graptolite-bearing succession of early Silurian turbidite mudstones and sandstones. These discoveries illustrate the complex folding and faulting which affect the deep-marine Ordovician and Silurian succession in mid Wales. Our new, high-quality bedrock maps of this region, which also provide detailed information on glacial deposits and landforms, flood-prone ground and on the distribution of upland peat, underpin the area's importance as a



Wind turbines sited on the hills of mid Wales.

major source of renewable energy by providing essential data on ground conditions for use during wind turbine construction. Additionally, they are providing data to allow the contribution of upland peat deposits in Wales to be assessed in the context of carbon capture and storage.



A BGS geologist observes rocks exposed in the gas pipeline trench excavated near Llandovery, mid Wales.

model for this internationally important sequence. A contact previously interpreted as a tectonic fault was revealed as the base of mid Silurian submarine landslides measuring in excess of ten kilometres across and a kilometre in thickness. Together with older marine landslides recognised during our recent survey of the area, this newly identified example confirms that major slope failures were a feature of this portion of the basin margin during the late Ordovician and early to mid Silurian.

These discoveries contribute to the geodiversity of the region and underpin its inclusion within the Fforest Fawr Geopark. An initiative where BGS is collaborating with the Brecon Beacons National Park Authority and Cardiff University to raise public awareness and understanding of the earth sciences in south and mid Wales. A grant from the Welsh Assembly Government-administered Aggregate Levy Sustainability Fund for Wales is supporting the production of a series of popular publications and a new geological map of the Geopark area.

Science Programmes

Marine Geoscience

A new terrain model for the Loch Lomond area, following a multibeam survey of the loch

NEXMap Britain elevation data from Intermap Technologies

The strategic importance of our marine resources is reflected in increased activity across many sectors, including marine renewables, marine aggregates, oil and gas, new cables and pipelines, and further research into marine biodiversity and definition of Marine Protected Areas. We continue to work closely with industry and government to provide the underpinning geological knowledge to support marine spatial planning for the future.

Marine geoscience

The BGS contribution to the Mapping European Seabed Habitats (MESH) Interreg project was completed following a survey of one of the canyons on the South West Approaches continental margin. Multibeam, video and deep-tow boomer data provided the main techniques for understanding the geology and its relationship to marine habitats.

Our new 15-metre rock drill was tested successfully in a series of boreholes around the Summer Isles to investigate

the glacial deposits, and to the west of the Isle of Lewis and in the Nun Rock area to investigate the basement rocks. They were sited using new multibeam data provided by the Maritime and Coastguard Agency, and have revealed new outcrops of Lewisian and two new granites. A multibeam and vibracoring programme was completed in several sea lochs, and cores were also taken through the debris apron of a cold water coral reef near Mingulay. Analysis of results is now under way, including a Ph.D. project with the Scottish Association for

Marine Science to study the corals. A new dating project for the basement cores is in progress.

The use of seabed imagery, including multibeam and Olex data (a composite



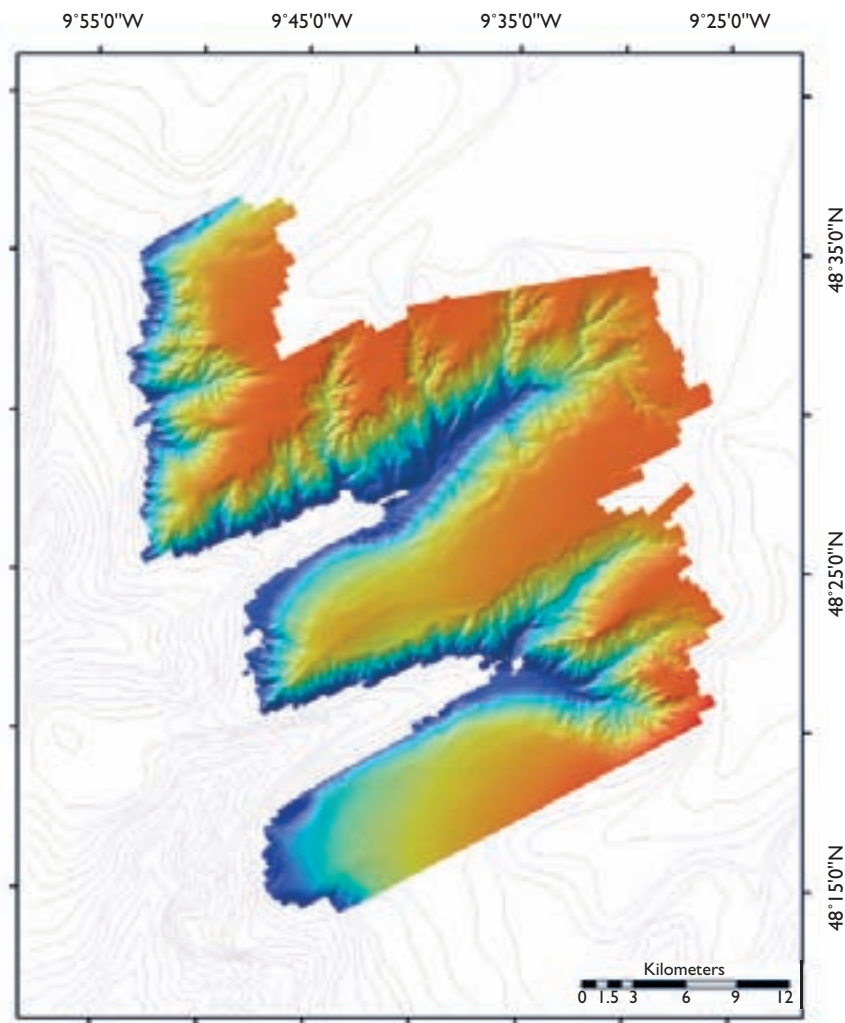
The BGS 15 m rock drill in use off the Scottish coast.

seabed image generated from primarily single beam data from fishing boats), combined with onshore terrain models has provided a tremendous database for developing models of the last glaciation and research is focusing on understanding the role of ice streams and the rate of deglaciation.

We took delivery of an EM3002 multibeam system in 2007 and the first survey was undertaken on Loch Lomond in collaboration with the National Park authority, who provided the platform and crew. This survey marks the first bathymetric survey of the Loch since the nineteenth century and the first lake mapping programme conducted by the BGS. Loch Lomond National Park will publish a new chart of the Loch, and we will follow up with a high-resolution seismic survey and a study of the bedrock, glacial history and lacustrine sediments. Collaborative work to study the biodiversity and habitats of the loch may follow.

We have participated in the Healthy and Biologically Diverse Seas Evidence Group (HBDSEG) and are leading a working group looking to develop a model for a National Seabed Survey based on multibeam data that makes maximum use of existing data.

A detailed picture of the sea floor in parts of the outer Clyde Estuary was obtained by a new full multibeam survey. A close grid of seismic lines was also completed and



Bathymetric map of a submarine canyon on the UK's South West Approaches.



Marine geoscience. Cores obtained from offshore north-west Scotland: part of a quartzite boulder (left). A medium- to fine-grained quartz-mica schistose metamorphic rock, possibly a metadiorite (right).

core samples collected to investigate the presence and mobility of contaminants.

Continental margins

The text for both the new Faroe–Shetland offshore regional report and the Rockall regional report were completed and, following external review by sponsors from the oil industry, BERR and Jarðfeingi (Faroese Geological Survey), these will move to publication. Support from the oil industry for a new Faroe–Shetland consortium to study a series of questions developed from the regional report work has resulted in a new three-year strategic research programme in the area.

Regional hydrocarbon prospectivity

We have continued to work closely with the UK Department for Business, Enterprise and Regulatory Reform (BERR), contributing to numerous ongoing studies of ‘yet-to-find’ reserves, and helping promote future UK exploration. We also continued to provide

expert palaeontological and micropalynological services to oil companies worldwide.

We continued to provide licensing and exploration advice to the Falkland Islands Government (FIG) and to liaise with operating oil companies on FIG's behalf to ensure the safe, expeditious and thorough exploration of the region. We oversaw the wrapping-up of gold exploration operations on the Islands. Significant scientific results have been published by the BGS on the timing of dyke swarm intrusions across the Falklands, and also on potential field modelling of the Falkland Plateau Basin's crustal structure.

A joint petroleum exploration and economic modelling contract was completed for the National Petroleum Agency of Sao Tome and Principe, identifying several geological play concepts in a working hydrocarbon system that has been greatly under-explored. The results of the prospectivity study were fed into an economic model for the region that was constructed by our project partners AUPEC.

Science Programmes

Environmental Geoscience Baselines

*Collecting panned concentrate
samples during the G-BASE 2007
summer field campaign*

The Environmental Geoscience Baselines programme provides a knowledge base on the physical and chemical properties of the surface and subsurface environment. Data are collected by both remote airborne and field-based techniques; a national capability that is also applied on commissioned projects worldwide. The information generated underpins environmental research and decision making for healthy and sustainable environments. The need for baseline data continues to be of fundamental importance in the exploration of mineral resources and for environmental assessments in response to legislative and socio-economic drivers.

Interpretation of radiometric data

Spectral analysis of high-resolution airborne radiometric data was completed using survey data from Northern Ireland and Ayrshire, Scotland. Images of the artificial nuclide caesium-137 were prepared that showed unprecedented detail. A significant portion of the pattern of high values is

thought to be due to sequences of rainfall intercepting the passage of the Chernobyl release plume of 1986. Radar measurements (at the time of the release) showed narrow bands of rain moving across the UK and this would have resulted in sequential wet radionuclide deposition across the plume intersection points.

Geochemical Baseline Survey of the Environment

The Geochemical Baseline Survey of the Environment (G-BASE) continued sampling to the north-west of London at a high sampling density (about one drainage and soil site every two square kilometres). With the completion of the geochemical mapping component of the Tellus Project in Northern Ireland in 2007, only southern England (some 18% of the UK land area) remains to be mapped. Urban geochemical mapping has become an increasingly important activity as sustainable and healthy environments in the most densely populated areas are linked to many socio-economic and legislative drivers. The G-BASE project team delivered two presentations to the international urban geochemistry and health conference in New Orleans (July 2007) including an invited keynote address on 'Urban geochemical mapping studies: how and why we do them'.

Europe-wide geochemical mapping of agricultural soils

BGS geochemists are active members of the EuroGeosurveys' Geochemistry

Working Group. This group has initiated a Europe-wide project (geochemical mapping of agricultural soils and grazing land of Europe, or GEMAS) backed by the European metals industry, to sample and analyse the chemistry of soils used for food production.

EC Water Framework Directive

The Metal Baseline Reference Concentrations (MBRC) project co-funded by the Environment Agency was concluded with the production of a final report. This applied G-BASE stream water data in support of the UK response to the European Water Framework Directive, and provided information on the natural concentration range of nine metal elements in stream waters, in relation to the proposed legislative standards. There are many instances where high natural concentrations will result in failure of water-quality standards and the MBRC project has proposed a compliance procedure that takes this into account.

Airborne geophysical baselines for Kosovo

The Geophysical Baselines Team, whose principal activity is airborne mapping as part of the Joint Airborne Capability (JAC)

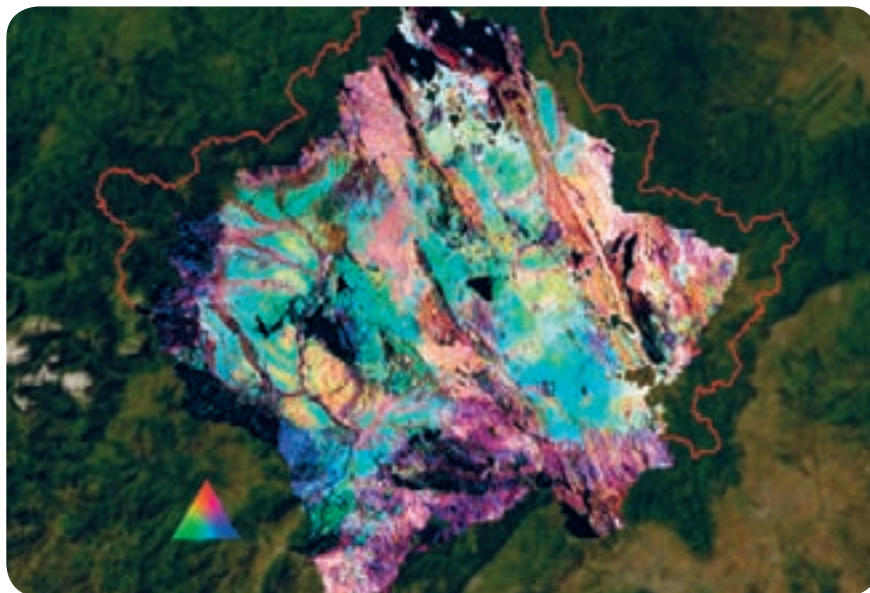


Image courtesy of ICMVM

Gamma ray spectroscopy (radiometric) data for Kosovo displayed as a three-colour ternary plot (red = K, blue = eU, green = eTh). The data reflect the natural radionuclide distribution within the near-surface.

consortium, completed a two-year programme of mapping in Kosovo. The project delivered a total of 45 500 line-kilometres of geophysical magnetic, radiometric and electromagnetic data using a line separation of 200 metres.

The new high-resolution data together with existing geological and mineralogical

data were used in a neural network classification of the metalliferous prospectivity of Kosovo. The analysis together with associated data, reports and maps were delivered to the Independent Commission for Mines and Minerals in Pristina.

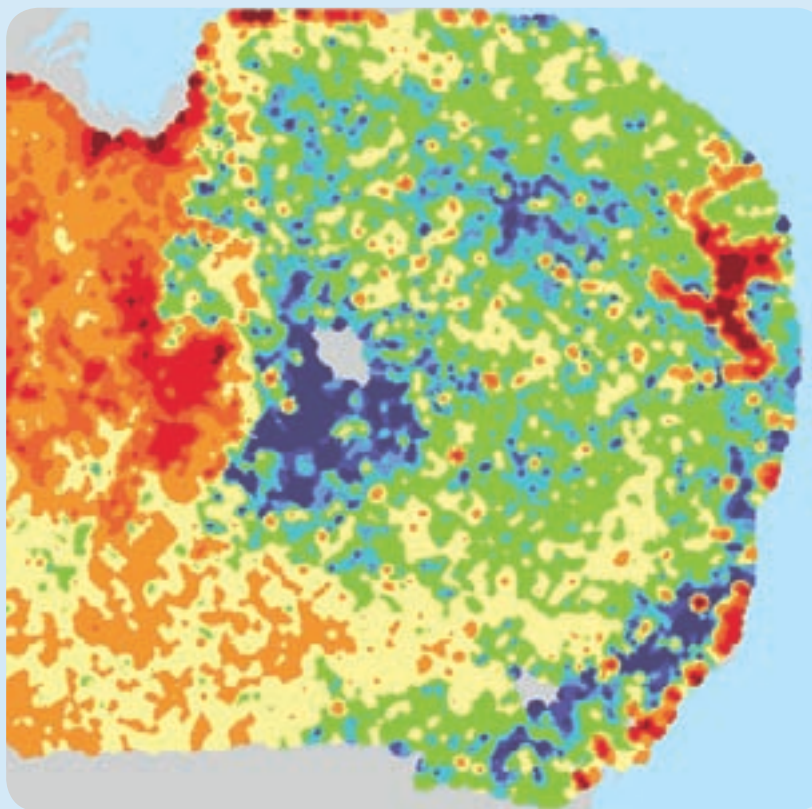
Geochemical baseline data underpins research

Baseline geochemical mapping underpins many of our research areas, particularly for sustainable soils, medical geology and contaminated land. The G-BASE project now routinely reports baseline chemical data for more than 50 elements including many trace elements important to human and animal health such as iodine and selenium. G-BASE data is also available for university undergraduate and post-graduate projects, for example an M.Sc. project incorporated G-BASE results into a GIS study in Scotland of the distribution of equine grass sickness in horses.

Iodine (mg/kg)

48–120	99th	2.2–2.7	25th
27–47	95th	1.9–2.1	15th
17–26	90th	1.5–1.8	10th
6.9–16	75th	<1.4	5th
4.2–6.8	50th	No data	
2.8–4.1			

Key to map (right).



Iodine in the topsoils of East Anglia.

Science Programmes

Geological Survey of Northern Ireland

Tellus airborne magnetic map overlaid with areas licensed for mineral and hydrocarbon exploration: Over 70% of Northern Ireland is under licence

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The Geological Survey of Northern Ireland (GSNI) is part of the Department of Enterprise, Trade and Investment (DETI). It is staffed by BGS scientists under contract to the DETI, which also allows the GSNI to call upon expertise from within other parts of the BGS. GSNI also works for other Northern Ireland government departments and liaises closely with the Geological Survey of Ireland (GSI).

Sir Keith O’Nions, (Director General, Science and Innovation at the Department of Innovation, Universities and Skills) was the after-dinner speaker. Both Nigel Dodds OBE, MP, MLA (Minister for Enterprise,

Collaboration

A Geoscience Strategy for Northern Ireland and the Republic of Ireland has been developed and the BGS has signed an agreement which formalises scientific co-operation between the GSI and GSNI. This agreement will allow the three surveys to align geoscientific priorities and to develop collaborative ventures. Initial projects include an educational wallchart showing climate change throughout geological time and a map showing the building stones of Ireland.

Tellus Project

The Tellus project has completed data acquisition and moved on to the interpretation and delivery phases. The initial results of the project were presented at a well attended conference in W5, Northern Ireland’s science and discovery centre. The conference was opened by the BBC’s geoscience presenter, Iain Stewart, and included presentations from several BGS scientists currently using the Tellus data in a range of studies, including soils, radon and natural resource exploration.



Iain Stewart with a sample of gold from the Sperrin Mountains.



Ministers Eamon Ryan (DCENR, back left) and Nigel Dodds OBE, MP, MLA (DETI, back right) look on while the Scientific Cooperation document is signed by (left to right) Peadar McArdle, Director GSI, Garth Earls, Director GSNI and John Ludden, Executive Director BGS.

Trade and Investment) and Arlene Foster (Environment Minister) attended the conference.

We continue to work with the private sector and the Tellus data has been licensed to the majority of natural resource companies exploring in Northern Ireland. There are currently some 20 collaborative university research projects under way using the new information in a wide range of areas.

The success of the Tellus outreach programme continued to be recognised, with the project being highly commended in the UK-wide PRIDE awards of the Chartered Institute of Public Relations. Media coverage of the Tellus Conference alone reached an audience of 50 million.

Energy and Minerals

The availability of the Tellus data has allowed us to promote Northern Ireland as an exciting place to explore for natural resources. In excess of 70% of the country is under licence for mineral and hydrocarbon exploration and this has resulted in record expenditure commitments. The Cavanacaw gold mine is in production and the nearby Curraghinalt deposit has increased its resource base to 600 000 ounces of gold.

Interpretation of onshore and offshore geology in Northern Ireland and the west

Irish Sea was completed to identify salt beds sufficiently thick and deep to construct gas storage caverns and the GSNI's advice has led to the issue of licences for two areas.

The BGS and GSNI, in collaboration with a range of bodies in the Republic of Ireland, contributed to a major report on carbon capture and storage (CCS) potential on the island of Ireland. This document will focus future research towards areas where CCS is geologically appropriate.

Geology and Landscape

An increasing number of learned international organisations visited Northern Ireland during the year, including the International Ocean Drilling Program, Geological Society of London, Society for Geology Applied to Mineral Deposits and the Edinburgh Geological Society. GSNI staff facilitated many of these visits and published a new field guide describing the classic geology of the North of Ireland.

We continued to act as an advisor to UNESCO on geoparks and also completed two World Heritage Site accreditation visits.

Environment and Hazards

The GSNI continued to fulfil its service level agreements with the Department of the Environment's Planning Service

and Environment and Heritage Service and provided advice on a wide range of issues ranging from the Water Framework Directive to Environmental Impact Assessments relating to wind farm development. Information enquiries reached an all time high and there are plans to deliver more of this service through digital means.

The GSNI chairs the Abandoned Mines Committee and in association with the DETI Minerals Branch has been working to ensure that the necessary land is acquired to ensure the safe closure of the Carrickfergus-International salt mine.

Outreach

We provided considerable scientific advice and input to the flagship BBC Northern Ireland television, radio and web production 'Blueprint'. This highly acclaimed three-part series explained the relationships between the geology, flora, fauna and human settlement of Northern Ireland.

In association with the Quarry Products Association, we developed a permanent exhibit in W5, the Northern Ireland science and discovery centre. The exhibit seeks to illustrate the distribution and commercial use of various rocks in Northern Ireland. Other outreach events include a schools event in which students debated the practicalities and environmental issues associated with gold mining.

The GSNI and GSI worked together to facilitate a workshop on geoparks in Ireland. This forum drew a large audience and highlighted the opportunities and benefits to areas that achieve European Geopark status.



GSNI exhibit at W5, the Northern Ireland science and discovery centre.

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Climate Change



The edge of the George VI Sound Ice Shelf

Predicting the impacts of climate change, and developing strategies for mitigation and adaptation, are among the greatest challenges of our time. Our research in climate change is planned to grow significantly over the next few years, and will focus on understanding the climate change drivers and feedbacks at the interfaces of the land, ocean, and atmospheric systems. This will be coupled with analysis of climate change and associated events preserved in the geological record to model and predict the impacts of current and future climate change.

British ice sheet reconstruction

Our Quaternary specialists are investigating environmental change and its landscape legacy over the past two to three million years. A new, highly detailed reconstruction has revealed for the first time how the highly dynamic British ice sheet responded to millennial-scale oscillations. New 'Olex' bathymetry data from fishing boat sonar systems has enabled integrated

onshore–offshore evaluation of landscapes exhumed following ice sheet collapse, including megagrooves and streamlined bedrock indicating ice stream movement. Detailed work on clast orientations and microscopic signatures of groundwater movement has enabled precise modelling of glacier advance and pro-glacial meltwater flow. The reconstruction has, critically, highlighted key thresholds in the finely

balanced ice sheet–ocean system, and is of major relevance to policy makers concerned with the outcomes of future, polar ice sheet retreat and collapse. The work has led to several high-impact scientific publications and invited presentations at conferences such as the International Quaternary Association meeting in Cairns, Australia, and at the Quaternary Research Association in London. In addition, BGS scientists were invited on a scientific cruise with the British Antarctic Survey to the George VI Ice Shelf, West Antarctica. Events in present-day Antarctica show remarkable parallels with events from the geological record.

Biodiversity in a greenhouse world

Late Jurassic to Early Cretaceous ostracod assemblages show that migration of southern species into the North Sea was associated with global climatic oscillations at a time generally considered to be a 'greenhouse' world. Latitudinally arranged bioprovinces were established, although compared to the nine seen today these were greatly reduced; probably as few as three during the Early Cretaceous, indicating

Coastal geochemistry

Sea-level rise is widely considered one of the most important impacts of climate change by virtue of the potential impacts on coastal populations and ecosystems. Geologically based rates of sea-level rise provide a benchmark against which historical and present-day rates can be compared and future predications made. Most Holocene relative sea-level reconstructions are microfossil based, however the utility of this proxy is limited by preservation. Our geochemists in collaboration with coastal researchers at the University of Pennsylvania are developing an organic geochemical and stable carbon isotope approach to detect changes in organic matter source which can be related to salinity and altitude in contemporary salt marshes of the eastern USA. The application of multiple proxy indicators to palaeoclimate and sea-level reconstructions will provide a powerful research approach to climate change studies filling data gaps, reducing uncertainty and thereby improving our projections of sea level change in the future.



Spartina alterniflora-dominated marshes of the Delmarva Peninsula Virginia, USA provide a means of calibrating down-core changes in geochemistry.

Image © NERC based on DLEX AS bathymetric data and NEXMap Britain elevation data from Intermap Technologies



Echo-sounder data of the seabed around the northern UK. Over 700 geomorphological features relating to the last British Ice Sheet have been mapped on the continental shelf preserving a footprint of ice sheet collapse at the end of the last glaciation. Discoveries include intricate moraine morphologies north-west of Orkney and north-east of Shetland; and vast subglacial meltwater channels in the Moray Firth and northern North Sea.

possible greenhouse world impacts on biodiversity. Preliminary results were presented at an international conference in Frankfurt in September 2007.

Climate change and plant evolution

Onshore mapping and modelling projects in Upper Palaeozoic basins have initiated some exciting scientific advances. Novel analyses of carbon isotopes (carried out in collaboration with the NERC Isotope Geosciences Laboratory) determined on bulk organic matter extracted from mudstones within the cyclical Namurian (Serpukhovian, Carboniferous) succession in northern England show that full marine salinity was only established intermittently as a result of glacioeustatic marine transgressions. Palynological studies on these same rocks indicate that plant groups such as ferns were affected by changing sea level, and a connection between sediment cyclicality and the first appearance of walchiacean conifer-like monosaccate pollen is considered possible. The long-term increasing values in carbon isotopes may reflect the onset of major glaciation in Gondwana about 326 million years ago.

Energy



Energy has been a hot science topic this year with concerns about security of supply for Britain becoming as strong as worries over climate and environmental change. Our Energy science area contributes important strategic and 'blue-sky' research to support Britain's drive to reduce carbon emissions, develop renewable energy sources and ensure security of energy supply.

Carbon capture and storage

Research into the large-scale application of carbon capture and storage (CCS) may increase the use of Britain's coal — a home-grown resource — in electricity generation, as well as allowing removal of carbon dioxide from other point sources like steelworks and refineries. The CCS Team has been very active in European research, co-ordinating the European Network of Excellence (CO₂GeoNet) and playing a leading role in the Integrated Project CO₂ReMoVe; the latter aiming at improving methodologies for storage site performance assessment

and monitoring. One of our current research topics is the detection and measurement of carbon dioxide leakage. We are currently developing an atmospheric analysis system that integrates readings from a stationary gas flux-tower with measurements from a portable infrared laser. Trials of vehicle-mounted laser analysers for carbon dioxide were carried out successfully on natural carbon dioxide vents in central Italy and in southern Germany. Both known and previously undetected vents were located using the equipment mounted on a quad bike. Another focus of our current research

is to assess the dynamic storage capacity of saline aquifers via generic numerical flow simulations, to calculate the induced pressure effects of large-scale injection.

Developing a suitable regulatory framework for carbon dioxide storage is a high priority, and the BGS has a key technical advisory role, both in the UK and overseas. This is also the case with the UK competition to build the first UK 'carbon capture' power plant, where we are acting as technical advisors to the Department for Business, Enterprise & Regulatory Reform in the bid evaluation process.

The BGS is a partner alongside the universities of Cambridge, Leeds and Manchester in the exciting new NERC-funded CRIUS (CO₂ Reactions In Underground Storage) project which involves fundamental research into the geochemical aspects of carbon dioxide storage, with particular focus on the rates and mechanisms of CO₂-water-rock reactions through laboratory experimentation, theoretical modelling and the study of natural carbon dioxide-rich systems. The CCS team is active in China, in the COACH and NZEC projects, working with Chinese and European partners to



Trials of vehicle-mounted laser analysers for carbon dioxide were carried out successfully on natural carbon dioxide vents in central Italy and in southern Germany using the equipment mounted on a quad bike.

identify opportunities and evaluate potential for geological storage of carbon dioxide in selected regions of north-east China. The BGS co-leads the geological storage work-package for NZEC alongside the China University of Petroleum (Beijing).

A notable milestone in 2008 was the publication of the *Best Practice Manual for the Storage of CO₂ in Saline Aquifers*. This multipartner volume, published by the BGS, distils the findings of a number of recent European projects to summarise the latest understanding of storage site characterisation and operation.

Edinburgh Anisotropy Project

Within our world-leading Edinburgh Anisotropy Project, advanced techniques for processing seismic data in complex areas have been developed. Analysis techniques and software to image structures in oil reservoirs under difficult conditions (such as beneath gas clouds) using P–S converted waves have been successfully implemented and have attracted increased support from oil companies. New analyses of seismic waves at different frequencies are providing information on gas saturation and allowing refined discrimination of the oil–water interface in productive oilfields. The Edinburgh Anisotropy Project has been designated as an International Key Laboratory by the China National Petroleum Corporation and is training their seismologists. Prof Xiang-Yang Li was awarded the highly prestigious International Scientific and Technological Co-operation Award of China for long-term collaboration on seismic anisotropy.

Britain's geothermal potential

The development of geothermal and 'clean coal' technology will allow

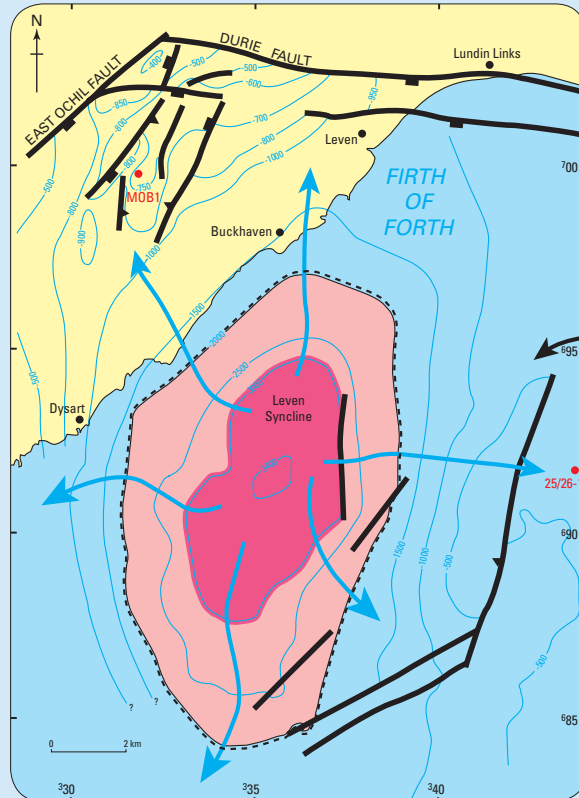
low emission electricity generation from Britain's home-grown resources. As part of our strategic role in geothermal research, subsurface temperature data was re-examined in order to assess temperatures in the 100- to 500-metre depth range. This allows the direct use of geothermal resource to be assessed and identifies regions where advection of groundwater generates positive thermal anomalies. Work started on loading and verifying new data, particularly from water boreholes. The chalk

aquifer, which underlies much of southern and eastern Britain, is both a source and a sink for heat. The dual-porosity nature of the chalk has several potential, but as yet unquantified, impacts on the effectiveness of the aquifer to manage energy. In particular the thermal properties of the unsaturated zone are poorly understood. Initial work has focused on numerical thermal modelling and it is intended that these models will be tested with field experiments.

Oil routes

Knowledge of the structural evolution and hydrocarbon prospectivity in the Midland Valley of Scotland has been advanced through an integrated study, including 3D modelling of stratigraphical surfaces, carried out in collaboration with the University of Edinburgh. Structural control on basin development and major synsedimentary growth folds during Carboniferous times is inferred from the interpretation of seismic, borehole, outcrop and coal mine plan datasets. The burial history

of the Midlothian-Leven Syncline that underlies the Firth of Forth indicates that the hydrocarbon source rock 'kitchen area' is inferred to have been sufficiently mature for oil generation during Carboniferous times and, although terminated by Variscan uplift, resumed with up-dip hydrocarbon migration during the Mesozoic and Cenozoic. The results imply that untested petroleum resources may exist in analogous fold structures beneath Permian and younger strata off the eastern coast of Scotland.



Model of the Leven Syncline (deeper parts shown in red), offshore Firth of Forth, and hydrocarbon migration paths both onshore and offshore (shown in blue).

Based on Underhill, Monaghan and Browne (2008), Marine and Petroleum Geology.

Science Programmes

Minerals



BGS geologist carrying out moisture testing at a sand and gravel quarry in south-east England

The BGS MineralsUK: Centre for Sustainable Development of Mineral Resources collaborates with academia, government and industry on a research portfolio that includes metallogenesis, resource security and policy issues. This is underpinned by our internationally-respected mineral statistics database and our position as the major UK provider of national spatial and statistical minerals information.

authorities and other bodies for planning purposes, while the ease of access via the Internet means that the information is available to all interested parties.

Aggregate supply

We have published two new reports dealing with different aspects of the supply and demand for primary aggregate minerals. This research was sponsored by the DEFRA Aggregates Levy Sustainability Fund administered by the Mineral Industry Research

A new look at minerals in the Central Belt of Scotland

Much of Scotland's population lives within the eighteen local authority areas of the Central Belt. We have produced a major review of the mineral resources of this area in collaboration with the Scottish government's Aggregates Levy Fund. Data on nationally-important minerals such as coal, silica sand and aggregates have been compiled into a geographical information system (GIS) which, in turn, has been used to produce four 1:100 000 scale maps and a web GIS. These are of value to local



Minerals in the Central Belt of Scotland: Cruicks aggregate quarry in Fife.

Gold in the Sperrin Mountains

Possible areas of mesothermal vein-hosted gold mineralisation in the Sperrin Mountains of Northern Ireland have been assessed for the Department of Enterprise, Trade and Investment. Data on geology, known mineralisation and previous commercial mineral exploration were combined with geochemical and geophysical data obtained from the recent Tellus project carried out by the Geological Survey of Northern Ireland. All the primary datasets including geology, geochemistry, geophysics, mineral occurrences, prospecting licences, topography and infrastructure, plus the images and lineaments derived from them, were integrated into a GIS. New locations where gold might exist in significant quantities were identified using Arc-SDM® prospectivity analysis linked to the GIS. The same methodology could be applied to pinpoint other types of mineral deposits elsewhere in the



Mineral potential in Northern Ireland: vein gold mineralisation at Omagh Mine, County Tyrone.

province, such as magmatic sulphide-hosted nickel and platinum group elements.

Organisation, and will form part of a wider review into aggregate supply in England.

Along with our research partners at the Centre for Economics and Business Research, we have produced a report called *The need for indigenous aggregates production in England*. This highlights the contribution that the extraction of primary aggregates makes to the English economy and sets this against estimates of the environmental costs of this production. It also examines the case for significantly increasing imports of primary aggregates from outside England.

Supplying primary aggregate from designated areas such as National Parks and other areas of outstanding natural beauty (AONBs) can be controversial. A second report entitled *Aggregate resource alternatives: Options for future aggregate minerals supply in England* looks at the amount of aggregate currently taken from designated areas. It then examines the options available to maintain an adequate supply of aggregates in the future if additional resources located within these designations become unavailable. New 1:250 000 maps of the English regions have been published, showing the extent of aggregate resources located outside National Parks, AONBs and other selected national and international designations. Research partners

on this project were Green Balance Planning and Environment Consultants.

Big feet? Reducing carbon footprints

Minerals are essential in maintaining our economy and lifestyle, but their extraction, processing and handling are responsible for about 7% of total global energy consumption.



European security of supply: Okarusu fluorspar mine in Namibia is an important raw material supplier to the European chemicals industry.

Around 40% of this amount is used in transporting primary minerals around the world. Reducing this significant carbon footprint is therefore a major challenge facing the mining industry and its regulators. In September 2007, we started a three-year research project with the Centre for Spatial Policy Analysis at the University of Leeds to develop mechanisms for evaluating options for the sustainable supply of aggregate minerals for major infrastructure projects. The ultimate aim of this research is to provide regulators with a tool to enable them to predict the carbon footprint of different policies for aggregate mineral supply and transport.

Security of mineral supply in Europe

Europe is a major trading region and its economy depends on the availability of many essential minerals, some of which may be vulnerable to disruption of supply. Substantial quantities of mineral raw materials are currently imported from rapidly emerging economies where export may become increasingly constrained as domestic consumption rises. The latest European Mineral Statistics trade and production data for 32 European countries, published by the BGS, is an important source of trend information related to this topic.

With increased concern about rising raw materials costs and security of supply, we have a key role in providing information and advice to the European Commission's Directorate for Enterprise and Industry as it formulates future non-energy raw materials policy for the EU.

Groundwater Resources



Oxford in flood 2007: location for ongoing investigation into the significance of groundwater flooding

The programme carries out surveys of groundwater quantity and quality and investigates groundwater processes, as well as developing and applying innovative monitoring and modelling techniques to improve understanding of groundwater issues. An understanding of groundwater extreme events is increasingly important in relation to environmental change studies. Integration of research funded by the Natural Environment Research Council and by commercial organisations ensures our science is relevant to users, both in the UK and internationally.

Hydrogeology of the South Wales Coalfield

Hydrogeological conditions in parts of Wales are not widely understood and there are a number of issues yet to be resolved. Throughout the Principality, as elsewhere, the industrial and mining heritage coupled with modern-day activities has created pollution that will take many years to flush

through the groundwater system. Another issue is the prospect of *in situ* gasification of coal reserves remaining in the deep western part of the South Wales coalfield and the risks this may pose to the shallow aqueous environment. Work is progressing with the collation of available knowledge and data on the hydrogeology of Wales focusing particularly on the South Wales coalfield.

The topographical and structural influences on the groundwater flow system in the South Wales coalfield have been used to assess the groundwater flow pattern. Groundwater in the Coal Measures has long been considered a threat both underground during mining and more recently because of acid mine water discharges to the surface. Evaluation of groundwater flow has been carried out piecemeal in the past and there was a need to view the subregional picture. However, this view was inhibited by the scarcity of modern-day potentiometric data for the area.

A 3D model of the coalfield was developed at a scale of 1:50 000 which enables the topographical and structural controls in the coalfield to be seen graphically and to be interrogated. The model incorporates the present-day potentiometric data for the region and the more abundant historical data collected when the mining industry was still active in the 1970s and 1980s. These data have enabled a new subregional conceptual groundwater flow model to be developed which highlights catchment scale flow draining to valley bottoms with virtually no

subregional flow towards the coast. The aquifer divides into a series of catchment-scale ponds which reflect a predominantly shallow flow system. The work offers a foundation for more detailed studies that may assist further development of the coalfield and the ongoing development of the region.

LOCAR

BGS staff designed and built the LOCAR website, which describes the NERC's now completed Lowland Catchment Research (LOCAR) Thematic Research Programme. It is the NERC's first detailed themed science website, and provides information for policy makers, industry and business, the general public, and researchers. It describes the issues addressed by the programme as well as giving more detailed descriptions of the LOCAR projects and their application. It also includes resources, such as details of over 150 peer-reviewed publications, reports and conference abstracts that were produced by researchers working in the LOCAR programme, and access to LOCAR data. The site can be visited at: <http://catchments.nerc.ac.uk/>.

The BGS also retains responsibility for the future of the LOCAR hydrogeological infrastructure. This involves providing information to support:

- decommissioning sites for which access agreements can not be renewed or for

Summer 2007 flooding and groundwater flood risk

In response to a request from the Environment Agency, research was completed in collaboration with the Centre for Ecology and Hydrology to estimate the probability of groundwater flooding in the winter of 2007/08, given the rapid rises in groundwater levels that resulted from the June and July 2007 summer floods. The study was updated in the autumn to incorporate new data, and led to recommendations in the Pitt Review to avoid or remediate possible groundwater floods and their consequences.



Groundwater flooding in Berkshire, caused by exceptional winter rainfall.

which there was no further research demand;

- transferring responsibility for sites to agencies and research groups where they have continuing interests; and
- maintaining a number of selected sites for future research opportunities.

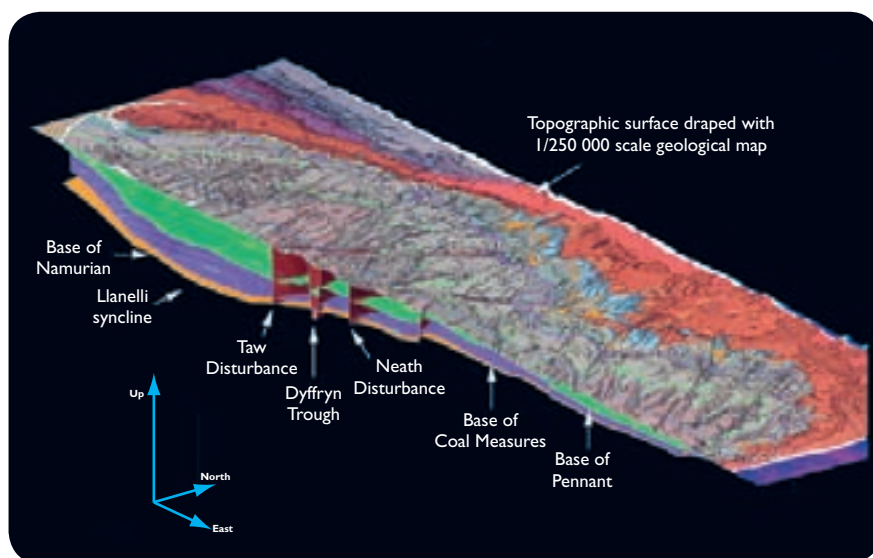
The LOCAR legacy of hydrogeological research infrastructure will be publicised on the LOCAR website.

UK Groundwater Forum meeting on climate change

Climate predictions indicate that as the concentrations of greenhouse gases

increase in the atmosphere, in general, winters in the UK will get wetter, summers will get hotter, and extreme events will become more common. This will have a direct impact on the recharge to our groundwater resources as well as indirect impacts on the resource due to factors such as changing demand and land use. What does this mean for the water supplies that our groundwater resources provide and the ecosystems that they support, and how prepared are we if there is a greater frequency or intensity of droughts and floods?

The UK Groundwater Forum (www.groundwateruk.org) is a grouping of stakeholders from the groundwater community. It is run by a secretariat based within the BGS at Wallingford and by a steering committee, chaired by the BGS. On 23 May 2007, the Forum held a one-day meeting (one of an annual series) at the Royal Geographical Society in London to discuss climate change and the implications for the management of the UK's groundwater resources. This meeting was attended by over 100 representatives of government, the environment regulators, the water industry, environmental consultancies and academia. Speakers at the meeting presented the results of latest research into the impacts of climate change on our groundwater resources, the lessons learnt from recent extreme events, the government's policies for adaptation and risk management and the long-term water resource plans of the environment regulators and the water industry.



Vulcan™ 3D model of the South Wales coalfield. An oblique west–east cross-section along National Grid line 200 000 N, looking towards the north-west. The structure is generalised and not all faults are shown. Structure contours are at 200 m intervals, National Grid at 10 km spacing at -3000 m elevation, vertical exaggeration x 2.

Science Programmes

Land Use and Development



Emergency survey of an active landslide threatening public safety at Lyme Regis

Land Use and Development comprises four thematic research teams — Shallow Geohazards, Geo-engineering Properties and Processes, Urban Development, and Sustainable Soils. These teams carry out an integrated programme of mapping, sampling, testing, monitoring and modelling to describe the physical properties of the UK landmass and provide the underlying information and expertise that supports decision making in fields such as government policy, extreme event response, sustainable development of cities and food supply.

Leaking sewers and aquifer vulnerability

Collaboration with the Environment Agency has fed into a new groundwater management strategy in the Knowsley area. A model was built of the urban subsurface beneath an industrial park that combined 3D characteristics of the underlying till and the Sherwood Sandstone aquifer with a location model of sewers in the area. The

model provided important information about the risks posed to the aquifer from potential sewer leaks. The most vulnerable parts of the aquifer were identified, improving pipeline risk management.

Human impacts on the landscape

We are researching the impacts of anthropogenic (human) processes on the evolution of urban landscapes. Just like

natural processes, human activities result in erosion, transport and deposition of materials. In urban areas, more than anywhere else, these have had an enormous impact upon the ground, leaving planners and developers with a complex pattern of contaminated land, variable ground conditions and disrupted drainage patterns. Future developments must not only cope with this legacy, but be environmentally sensitive and sustainable.

Research in the Lower Mersey Corridor development zone and other urban areas in London and Glasgow has revealed how the landscape has evolved in response to excavation of quarries, canals and pits (human erosion) and the consequent tipping (deposition), for instance along the floodplain of the River Mersey. These 3D models provide an easy-to-understand view of cities that locate problems caused by past human activities.

New robot reveals microscopic rock structures

Understanding the microscale structure in a rock mass is vital when looking at relationships between different properties, especially when assessing the fluid or gas pathways. To help advance the understanding

of microscale structure our Engineering and Geophysical Laboratories have developed a new methodology that uses a robot to assess the microscale structure of rock. The robot enables the acquisition of very closely spaced measurements of electrical resistivity from within a sample. These high resolution measurements can be viewed as a resistivity image that highlights fine-scale sedimentary structures across the area of the core face. This detailed information can then be used to ensure that fluid or gas pathways are correctly modelled in fluid flow or reservoir production assessments.

New model for damage potential in London

Shrink–swell problems give rise to insurance claims worth about £400 million each year, with a high incidence in the south of England. Our scientists have created a new 3D model of the London Clay Formation, using information from the BGS National Geotechnical Database. The voxcel model uses information from 10 000 boreholes to depict the volume-change capacity of clays from surface to depths of up to 50 metres. The new, high-resolution model represents a huge step forward, not only in our understanding of ground shrinkage across London, but also improves our knowledge of the depositional history of the London Clay.

Soil texture and geochemistry

Soil texture — the proportions of clay, silt and sand-sized particles — is a very useful measure of a soil's properties. Texture influences the functions that soil can fulfil and provides a useful indicator in determining practically all other soil properties. However, these characteristics can vary considerably

Inland landslide observatory

We have established the first BGS inland landslide observatory at the active Hollin Hill Landslide in North Yorkshire, to complement the coastal sites already in operation. Movement of the active landslide has been monitored over the past eighteen months using a combination of airborne laser scanning (LiDAR), terrestrial LiDAR and differential GPS. The research is aimed at providing a comparison between airborne and terrestrial LiDAR techniques and developing improved processing algorithms for automatic landslide detection.

The steep topography of the site poses a number of challenges for the landslide team. A Land-Rover has been specially modified for use as a stable surveying base. The work is carried out



The BGS Terrestrial LiDAR system mounted on the modified Land Rover platform.

in parallel with the BGS geophysical tomography and Vale of York mapping teams, who are exploring the electrical signature and the detailed geology of an active slide (see page 38).

even over short distances, and it can be difficult for the agricultural industry or statutory bodies to measure and monitor soil over large areas. The Sustainable Soils Team, in collaboration with colleagues at Nottingham University have developed techniques that use soil geochemistry information to predict the spatial distribution of soil texture with excellent accuracy. The research has also demonstrated the relationship between the parent material (underlying bedrock) and the physical texture of surface soils.

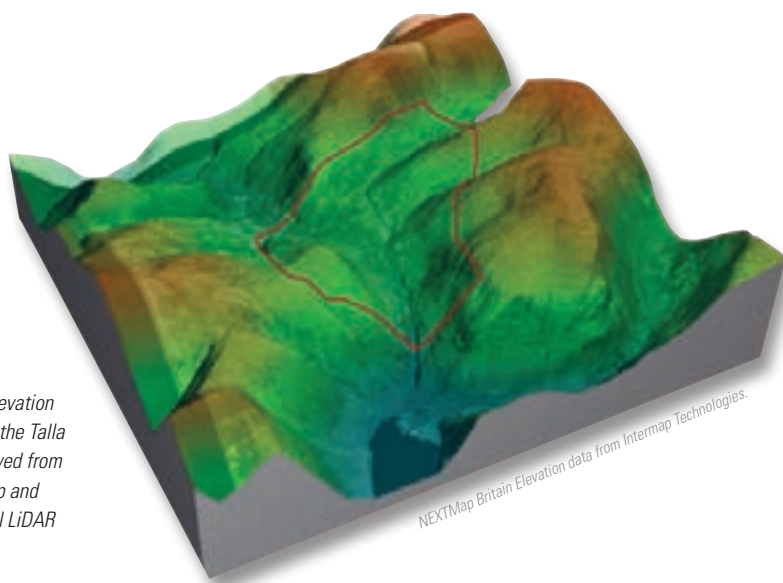
The Talla Earth Observatory

The Talla Earth Observatory in the Scottish Borders allows us to investigate processes in

a typical glaciated upland soil geoscape and choose the most useful analysis methods and tools. Traditional geological survey and soil survey techniques have been combined with terrestrial LiDAR, remote sensing, soil analysis, geophysics, geotechnical testing, groundwater monitoring and modelling, radiocarbon dating, cosmogenic dating, tephrochronology and palynology. Results so far have shown how geophysical techniques can be used to predict the thickness of peat deposits and have begun to reveal the detailed pattern of peat deposition related to the shape of the surrounding catchment and its underlying geology. The project has also developed external links with the Centre for Ecology and Hydrology, the National Soil Resources Institute, and Exeter University School of Geography, Archaeology and Earth Resources.

Response to summer floods

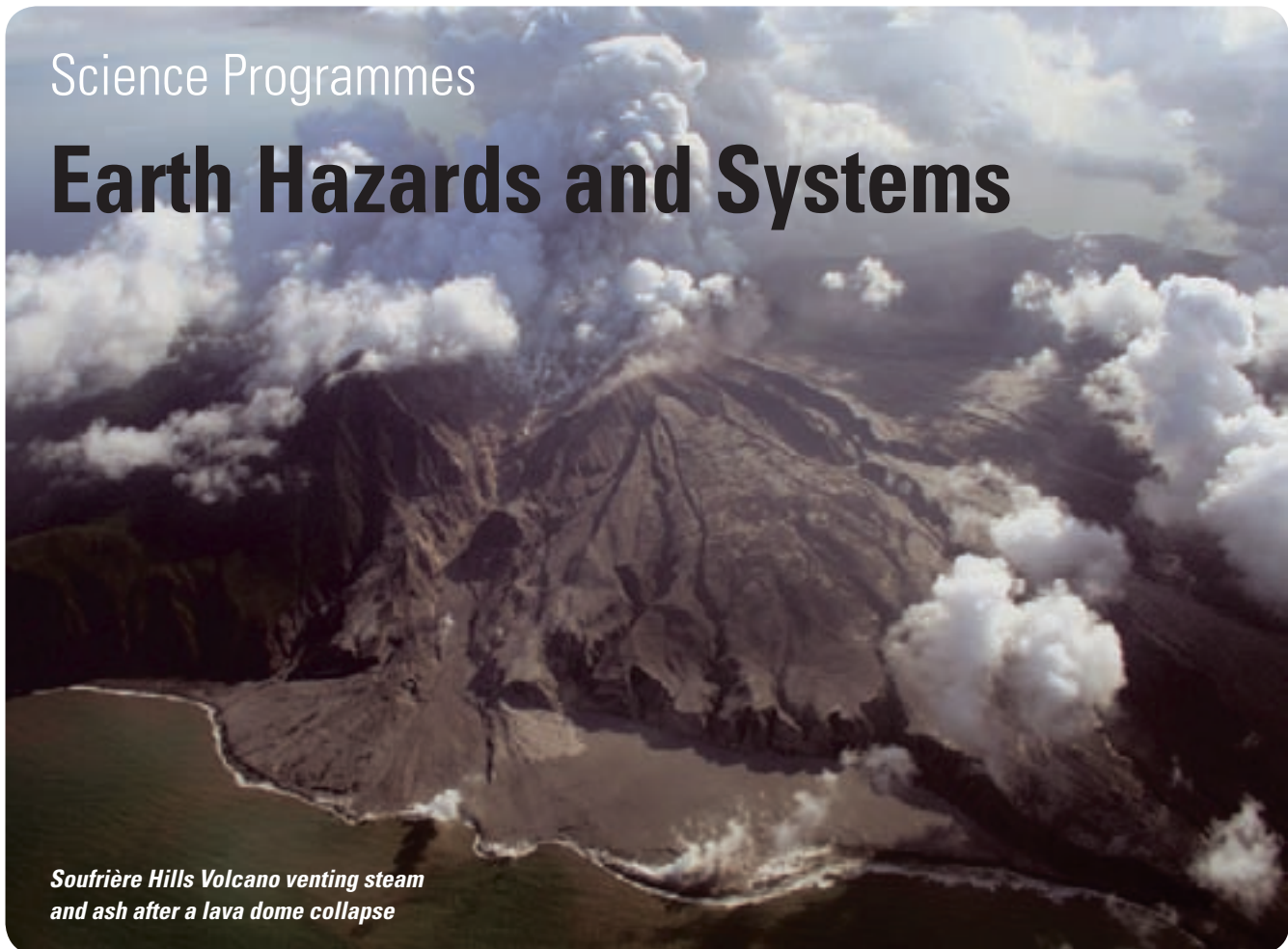
The BGS geohazards team responded to the widespread flooding during the summer of 2007 by chartering flights over flooded areas, and preparing reports and press releases to update key stakeholders and the public. Information was provided to the Environment Agency and to the Cabinet Office's Pitt Review. Aerial photos of flooded areas were used to update our historical flood maps and geographical information systems. There was wide take-up of information and briefings by BGS experts via various media outlets.



Digital elevation model of the Talla site, derived from NEXTMap and terrestrial LiDAR survey.

NEXTMap Britain Elevation data from Intermap Technologies.

Earth Hazards and Systems



Soufrière Hills Volcano venting steam and ash after a lava dome collapse

This image is a product of the programme of work carried out in Montserrat by the BGS under contract to the GOM

The BGS monitors seismic and geomagnetic activity, and carries out research on major Earth system processes and hazards. This understanding is applied to forecast the impacts of earthquakes and volcanic eruptions, and other hazards including tsunamis. Knowledge is turned into information for authorities and the public, and into risk analyses to help decision-makers develop mitigation and adaptation strategies to minimise harm.

Market Rasen earthquake

The largest UK earthquake in over 25 years struck just before 01:00 GMT on 27 February 2008, 4 km north of Market Rasen. The magnitude 5.2 ML earthquake was widely felt across the British Isles. Our online survey received over 30 000 responses which were used to determine the distribution of macroseismic intensities. There were reports of widespread damage but an immediate survey showed that this was mainly superficial damage to masonry and chimneys. Modelling of seismograms suggests that the earthquake's

focus was 25–30 km below the surface, consistent with both the macroseismic data and seismic wave travel-times. Analysis of regional data showed that it was caused by slip on a near-vertical fault, striking either east–west or north–south. We deployed four temporary instruments within 48 hours of the earthquake to detect small aftershocks, most of which would not have otherwise been detected.

Revised seismic hazard maps

New seismic hazard maps for the UK have been produced and published, in support

of the UK National Annex to Eurocode 8 building regulations, to give guidance on the peak ground acceleration (PGA) to be expected in different parts of the country. The region with the highest seismic hazard is Snowdonia, due to the regular occurrence there of significant earthquakes throughout the historical record. This is the first such high-level seismic hazard study in the UK, in which a panel of experts from the UK seismic hazard community made all major decisions



Chimney damage, Gainsborough, caused by the Market Rasen earthquake.

about the model. We carried out this work with financial support from the Institution of Civil Engineers Research and Development Enabling Fund, ABS Consulting Ltd, and BSI.

Tsunami warning system

We have established a system capable of detecting and recognising those earthquakes which could pose a tsunami risk to the UK, by adapting earthquake detection software developed at the US National Oceanic and Atmospheric Administration (NOAA) West Coast and Alaska Tsunami Warning Center. By selecting stations from seismic networks in over a dozen countries, a network of more than 100 stations was built up that provides good coverage for the UK and surrounding waters, and most of the North Atlantic. The system has now been operating reliably for over a year. It has detected earthquakes in most of the areas identified where tsunamigenic sources could affect the UK, and response times for alert messages are good. Thus we are confident that the system would fulfil the requirements of a seismic tsunami warning centre for the UK.

Earth's crustal magnetic field

We produce a global model of the Earth's internal magnetic field for a consortium of navigation, survey and drilling interests. Annual revisions of this model benefit from scientific study of the geomagnetic

'Swarm' Satellite Science Data Centre

The European Space Agency commissioned the BGS, the German Research Centre for Geosciences (GFZ), the Danish National Space Institute (DTU Space), and the Department of Earth Observation and Space Systems (DEOS) of the Delft University of Technology (Netherlands) to define the functions of the proposed science data centre for the Swarm satellite mission. Swarm, due for launch in 2011, will comprise three satellites operating in low Earth orbit and will measure Earth's magnetism, gravity and atmosphere. This 'mini-constellation' concept will provide a unique opportunity to improve our understanding of the physics and evolution of deep-Earth magnetic sources. The BGS has a leading role

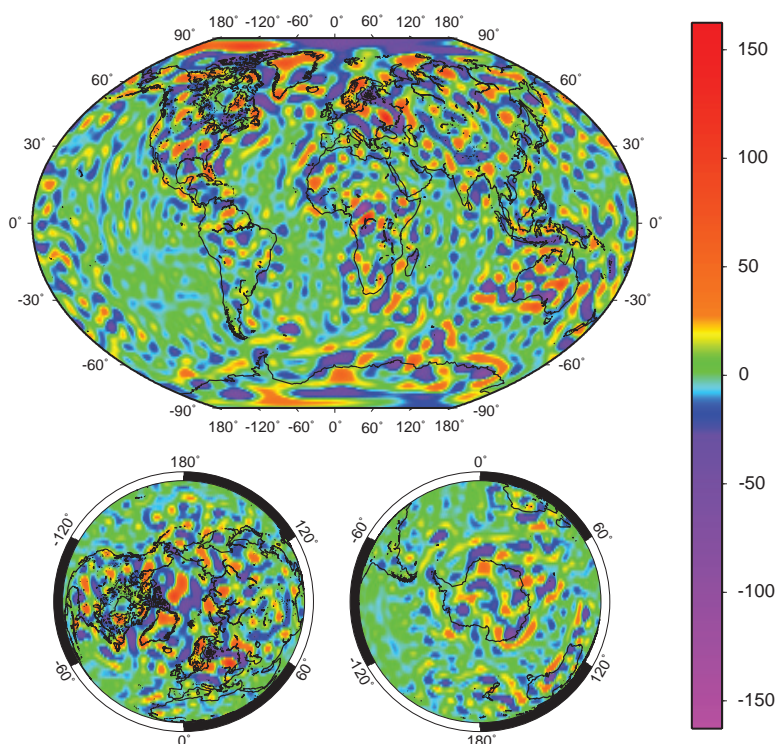
in defining the quality control of the magnetic data. This involves verification by magnetic observatory data available from our World Data Centre for Geomagnetism. We are also responsible for defining a scientific model of the Earth's magnetosphere, to be available from the data centre for scientific use.



Port Stanley Observatory, Falkland Islands: an example of a WDC station.

field, in particular studies supported by the NERC-funded GEOSPACE project. For our new model, we carefully selected magnetic survey data from low Earth orbit satellites and ground magnetic observatories. This process isolates the magnetic fields of the Earth's core and crust. We then implemented a novel data processing scheme to minimise

rapidly-varying residual magnetic signals from the ionosphere and magnetosphere, which can degrade our model accuracy. As a result, the Earth's crustal magnetic field has been imaged to a higher resolution than before. We have also been able to estimate the crustal field at polar latitudes with greater confidence.



Earth's crustal vertical magnetic field at sea level, varying between ± 150 nano-Tesla.

Monitoring Montserrat

We completed a contract with the government of Montserrat to manage the Montserrat Volcano Observatory, monitor the active Soufrière Hills Volcano and provide timely hazard assessments. Research on the extensive datasets collected during the ongoing 12-year eruption includes the changing seismic activity associated with the eruption, seismic analysis of explosive activity, analysis of potential precursors to the onset of lava extrusion, the mechanisms of lava dome growth and collapse, and the study of significant lava dome collapse events. The largest lava dome collapse recorded worldwide took place in Montserrat on 12/13 July 2003 with precursory seismic activity. The second largest lava dome collapse worldwide occurred on 20 May 2006 but with no obvious seismic precursors. We are studying all aspects of this significant collapse which produced the highest gas plume, and the largest emission of sulphur dioxide, of any lava dome collapse at this volcano.

Science Programmes

Environment and Health



The Lasgit experiment in the Äspö Underground Research Laboratory. The steel cap over the deposition hole is held down by rock anchors

The Environment and Health programme investigates and monitors the impacts of contaminated land and groundwater on the environment and human health. Projects address the fate and transport of contaminants within the framework of the source–pathway–receptor model of risk assessment. Our work programme is built around a mix of site investigations and innovative laboratory studies that serve to inform national debates on the remediation of contaminated land and disposal of radioactive waste.

Medical geology

We have continued to provide the chair and secretary of the Bioaccessibility Research Group of Europe. This international working group produced a special publication in the *Journal of Environmental Science and Health Part A* on the measurement of the bioaccessibility of potentially toxic substances in soil: BGS staff co-authored five of the fourteen papers in this volume. We also co-hosted an international

symposium on the use of in vitro bioavailability measurements for regulatory purposes, as part of a conference hosted by the International Society of Exposure Analysis. At the same meeting we joined an international working group on arsenic-contaminated soils along with the US Environmental Protection Agency.

A structured informatics approach to assessing the risk of potentially harmful elements (PHEs) in UK soils has been

developed using our geochemical data for soil, stream sediments and water from the Tamar catchment in Devon. Additional chemical analyses of archived soils were combined with existing data to predict and model the bioaccessibility of arsenic in these soils. This approach combines a number of methods, including sequential extraction of soils, multivariate statistical modelling and geostatistical simulation models, with the aim of understanding and predicting the spatial variability in bioaccessibility of PHEs in UK soils more generally.



Analysis of a contaminated soil sample using a handheld XRF instrument.

Radioactive waste

We continue to undertake a variety of projects relating to the geological disposal of radioactive waste. As well as research commissioned by a number of UK organisations, work is undertaken for the national programmes in France, Sweden, Switzerland and Japan.

As part of the UK government's Managing Radioactive Waste Safely (MRWS) programme, we were represented on DEFRA's Criteria Proposals Group. This group was tasked with defining those geological factors that would make a site unsuitable for the deep geological disposal of radioactive waste. These criteria were an important part of the MRWS public consultation undertaken during 2007, and form an integral part of the government's MRWS White Paper published in June 2008 that initiates the new site selection programme.

The large-scale gas injection test (Lasgit) continues to examine the movement of gases in the Äspö underground research laboratory in Sweden. It has delivered key results and insights to the international radioactive waste management community, aiding development of process models describing gas flow in compact bentonite. The experiment has now completed the initial phase of hydration by injecting water and a subsequent phase of gas injection from which preliminary results will be available in 2008. The next cycle of hydration has now commenced and several cycles of water and gas injection, increasing in complexity as the system evolves, are planned for the remainder of the experiment.



The Lasgit experiment in the Äspö Underground Research Laboratory. Inside the control cabin showing the complex system of remote controlled gas/water injection valves.

Groundwater pollution

Environmental, social and economic regeneration are integral to the government's initiative to build 60% of

Abandoned mines and contaminated land

The widespread occurrence of lead- and zinc-rich tailings and contaminated soils in mid Wales is a legacy of mining over previous centuries. A case study at the Frongoch Mine demonstrated how an integrated approach can be used to characterise a site and assess the environmental impact of an abandoned mine. The intrinsic leaching properties of the waste material and lead bioaccessibility were measured. These provided essential information for modelling the metal emissions produced in response to various disposal or remediation strategies and climate change. A combination of electrical resistivity tomography and ground-penetrating radar revealed the extent of the tailings deposits as well as identifying underlying strata, including peat and glacial till. Petrographical sections have provided new insights into the detailed structure of the mine tailings

at this site. Metal uptake by biofilms in freshwater downstream from the mine site was assessed in collaboration with the University of Aberystwyth. A new joint Ph.D. studentship with Nottingham University will investigate bacterial growth and its influence on trace element geochemistry at abandoned mines.



Tension infiltrometer testing in mine tailings.

new housing on brownfield land. However, before such land can be reused, engineering solutions to clean up soil and groundwater contaminated by decades of industrial activity are required. Geologically complex subsurface environments, particularly multilayered systems, can provide specific challenges to effective remediation. In such situations, low permeability strata ('aquitards') can accumulate contaminants introduced into an adjacent aquifer. When the main aquifer is remediated, the aquitard can act as a secondary, long-term source of contamination. Recent findings indicate that mass transfer kinetics between different geological layers in such systems is poorly understood, even though it is critical for effective site management.

A study of mass transfer mechanisms across a gravel-mudstone interface has been initiated. Examination of cores recovered from a test site in the Midlands has revealed the presence of trichloroethene (TCE), a dense non-aqueous liquid, in the aquifer and at the aquifer-aquitard interface. The depth of penetration of TCE exceeds that predicted by a simple diffusion model typically applied to describe mass transfer in similar geological settings. Preferential pathways for the movement of contaminants such as TCE are

formed by the hydration of anhydrite to form gypsum, which results in significant expansion, disruption and microfracturing of the mudstone fabric. Further laboratory experiments and numerical simulation are planned to understand the processes controlling contaminant migration and storage in the mudstones. Modelling will be used to investigate the likely impact of remediation strategies on the release of contaminant from the mudstone into the aquifer.



Installation of a borehole monitoring network at a contaminated site.

Science Programmes

Spatial Geoscience Technologies

GeoVisionary uses Intermap's NEXTMap Britain elevation data with Infoterra and Getmapping aerial photography to bring UK field areas into the laboratory

Spatial Geoscience Technologies (SGT) is a new BGS science theme that brings satellite, airborne and ground-based observation technologies together with the information systems that enable the extraction of geoscience information from these observations. Our goals are to develop technologies that increase the efficiency of BGS mapping and modelling workflows, improve the information content, quality and consistency of the resulting maps and models, and deliver this information more clearly to stakeholders. All of these technologies are backed up by improved standards and best practice.

Novel applications of telemetry

In terms of observational technologies, a highlight in December 2007 was successful completion of a four-year research contract for the European Commission Framework Programme. This co-funded consortium project was led by the BGS with ten EU partners. The innovative 'ALERT' technology that we designed for the project uses permanent, *in situ* instrumentation to monitor temporal

and spatial changes in subsurface electrical properties regularly and remotely. This technology, installed in the River Andarax in Almeria, Spain to monitor the seawater–freshwater interface in the underlying Quaternary aquifer, is a world first. Data are transmitted automatically to a database by wireless telemetry, which can take advantage of global systems for mobile, radio, satellite or internet communications. Back at the

BGS, these data are processed, inverted and displayed on a dedicated web portal. The entire process from data capture to visualisation on the office computer is seamless and automated. Temporal hydraulic processes can now be observed that could not previously be captured by labour-intensive field sampling.

Following this successful development, another permanent ALERT station has been installed at an active landslide site at Hollin Hill in North Yorkshire (*see also page 33*). This project is designed to determine whether real-time monitoring of geoelectric properties can be used to predict and track gravitational mass movement. The resulting resistivity images clearly show a lobe of mudstone (blue) overriding the sandstone bedrock (red) (*see opposite*). Given the remote locality, a wind turbine and solar panel are used to recharge the ALERT power source. The ALERT technology developed in these projects has been identified as a candidate for commercialisation through a NERC spin-out company (Snowleaf Ltd).

Digital mapping systems

Five years of investment by BGS/NERC in digital mapping technologies culminated

in the completion of our digital mapping workflow. This landmark stage in developing the System for Integrated Geoscience MApping (SIGMA) led to external recognition in the scientific and business community, in terms of Innovation and Best Practice awards from the Association of Geographic Information and ESRI during 2007/08.

Ongoing implementation of this workflow saw increased uptake of these technologies in BGS. As part of this, geologists involved in strategic geological surveying are experiencing the benefits of GeoVisionary, an immersive, virtual 3D environment that has been developed jointly with the visualisation specialists Virtualis, within the Virtual Field Reconnaissance (VFR) project. VFR is providing BGS field staff with the freedom to view and interpret the landscape in the laboratory from any perspective and has been trialled for integrated mapping work in the UK, around both Pateley Bridge and York, and also overseas, on a commissioned project in Tajikistan. Using VFR techniques prior to fieldwork, the mapping team is able to build a picture of the local terrain based on a range of surface and subsurface information, including results from previous research, and so begin to understand how these data relate to the underlying geology.

Fieldwork using other component systems within this digital mapping workflow plays an important role in validating the results obtained in the virtual world and capturing complementary digital field observations. The MIDAS digital field data capture system allows all of the data and work done in the virtual world to be taken into the field. In many cases, geological features that can be

difficult to observe in the field are readily visible using tools like SOCET SET, a digital photogrammetric workstation customised for geological interpretation, both saving time and improving accuracy. In the York area, this has allowed the existing geological interpretation from the 1800s to be visualised in conjunction with the results from recent 3D modelling. This has highlighted deficiencies in the current geological map for the area and is guiding the strategy for ongoing work.

Geological modelling systems are another critical component of this integrated set of spatial technologies. We have continued to implement the modelling workflow and support the systems to enable the production and storage of 3D geological models in south-east England, Merseyside and Glasgow. We have also underpinned applied modelling and curiosity driven science projects in disciplines ranging from geophysical tomography to groundwater modelling and sustainable soils.

The GSI3D software and methodology is currently being extended to cope with all types of bedrock terrain. The software is now in alpha release and one of its early uses has been to model the Greenwich Fault Belt. All code is being developed in-house and software releases are now managed by the BGS. We have developed a strong relationship with groundwater specialists at the regional offices of the Environment Agency. Their increasing acceptance of 3D geological models as a standard tool to aid the management and protection of groundwater is leading to a steady increase in commissioned work in this area. The development of the 3D model viewer has been strongly influenced by external customers and the need to analyse models in their full richness, further increasing the knowledge exchange to customers and the public. The GSI3D methodology has also been published in the academic literature.

Knowledge exchange

Results from several of the SGT teams and BGS projects were presented at the 2007 Geological Society of America conference in Denver. The associated BGS exhibit attracted over 500 people to the stand and helped to raise the BGS's profile in 3D systems development worldwide.

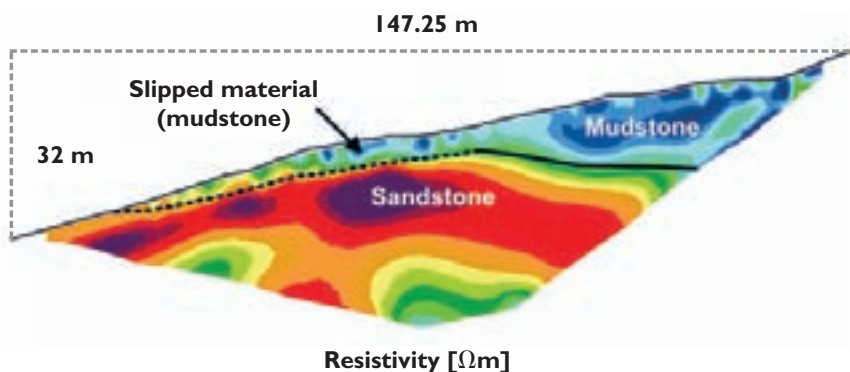
New ultrasonic systems inspired by bats and dolphins

The BIAS (Biologically Inspired Acoustic Systems) project takes its inspiration from the sensory capabilities of bats and dolphins. Echolocation, often called biosonar, has developed in these animals using sound waves at ultrasonic frequencies (above 20 kHz). Based on the frequencies in the emitted pulses, some bats can resolve targets many times smaller than appears theoretically possible. Dolphins are capable of discriminating different materials based on acoustic energy, again significantly out-performing current detection systems. The BIAS project aims to develop new technologies that can resolve and image to a level of accuracy that is not currently possible and to develop significantly greater discrimination capabilities for the physical characterisation of materials, processes and structures.

The BGS are the lead partner in the BIAS consortium that includes the Universities of Edinburgh, Leeds, Leicester, Southampton and Strathclyde, and Fortkey Ltd. The BGS have developed a state-of-the-art ultrasonic laboratory where experimentation can be carried out under accurately calibrated conditions. Novel, complex waveforms are being used to examine the reflected and transmitted characteristics of a variety of materials. Fundamental experimentation is contributing to the development of an enhanced method for measuring distance with ultrasonic sound waves that could lead to a ten fold increase in resolution.



Hollin Hill landslide research site; resistivity image shows slipped mudstone over sandstone.





Modern Glacial Landscapes training course, Iceland

Science Resources

The role of the Science Resources Directorate (SRD) is to ensure that adequate human and physical resources are available to deliver the scientific programme, and to develop scientific capacity in order to ensure that our capabilities remain in line with both our present and future requirements.

Scientific staff are managed and deployed by four Heads of Discipline (HoDs), divided into groupings of: Geology, Geotechnics and Palaeontology; Geophysics, and Marine Geology; Geochemistry, Mineralogy and Hydrogeology; and Information Systems. A separate HoD is responsible for staff in Administration and Finance. SRD also manages the full range of the BGS's scientific infrastructure including laboratories, information technology facilities, and publication services: each of these areas is overseen by a strategic/operational manager. We take staff training and development very seriously and SRD runs an extremely active training section headed by a training manager responsible for meeting the development needs of all staff.

Strategic initiatives

This has been a year of significant change. BGS has developed a new organisational vision, coupled with a new leadership structure involving a large number of appointments. SRD has been at the centre of this activity. A 'change team' comprising some 60 staff stationed across all our sites assisted in a range of activities. They explored specific change issues, drafted new job definitions, and facilitated change roll-out and communication. SRD also works closely with our parent body, the NERC, particularly on issues relating to scientific skills and leadership development.

BGS University Funding Initiative

The BGS University Funding Initiative (BUFI) currently supports over 50 individual



A Derby University student examines glacial till extracted by the BGS Dando drilling rig at Hollington, Staffordshire. Photographer: Matt Howcroft, University of Derby.

scientific collaboration projects. These vary from small grants to students to major international research projects. Our principal aim is to encourage and fund science at the doctoral level. At present we have around 40 Ph.D. students on our books and these early-stage researchers are based at around

25 UK universities. Currently, total BUFI grants are in the region of £400 000 each year.

Our students study a wide range of topics, reflecting the broad scope of our interests. Research subjects include such varied subjects as seismology, ostracod palaeontology, magmatic processes, ice-sheet evolution, and the geological aspects of human health. Research is not restricted to the UK landmass — we support graduate research projects with field areas in the Solomon Islands, Cyprus, Mongolia, the Canaries and the Caribbean. Recently, we have taken steps to encourage greater cross-Research Council collaboration, with projects looking at space weather and the carbon footprint associated with Olympic Games development. In addition to the Ph.D.s, BUFI also supports direct collaboration between BGS staff and established academics; these are mostly small projects. However, we also support large-scale international experiments such as the SEA CALIPSO project to image the magma chamber beneath the Soufrière Hills Volcano on Montserrat.



Students logging boreholes in the BGS Keyworth core store, as part of the Imperial College Petroleum Geoscience M.Sc. course, February 2007.

Science Resources

NERC Isotope Geosciences Laboratory

Svalbard stream

The NERC Isotope Geosciences Laboratory (NIGL) is a comprehensive stable and radiogenic isotope facility that undertakes environmental change, chronology and science-based archaeological research with universities, the BGS (and other NERC institutes), and external clients. A primary focus is the training of NERC Ph.D. students in a collaborative research environment.

previously assimilated by the thin tundra soils, and oxidation of sulfides in beach gravels derived from Tertiary coal deposits add sulfate to the streams. The paper discusses ways in which these processes may be expected to respond to increased depth of the active layer resulting from climate warming. The research was funded through NERC's GANE programme (to the Universities of Nottingham and Sheffield and the NIGL).

■ Tye, A M and Heaton, T H E. 2007.

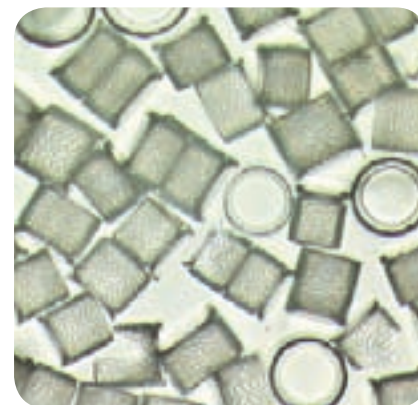
Lake Malawi

A paper on 'Century to millennial scale climatic variability in Lake Malawi revealed by isotope records' has been published in *Earth and Planetary Science Letters*. The paper concerns the use of diatom-based oxygen isotope data from Lake Malawi and shows millennial-scale dry intervals spaced approximately every 2300 years throughout a 25 thousand-year sequence. Dry periods in Malawi correspond to cool episodes in Greenland thereby demonstrating teleconnections between these regions.

■ Barker, P. et al. 2007.

Arctic hydrochemistry

A study of the chemistry and isotopic composition of non-glacial streams draining the Arctic tundra in Svalbard examined processes by which different atmospheric, soil and rock sources of carbon, nitrogen and sulfur are transported to the surrounding sea. Processes are limited to a thin, active layer above the permafrost. The chemistry is dominated by solution of carbonates in a relatively open system in which carbon dioxide is derived equally from atmospheric and soil microbial sources. Nitrate is derived from nitrification of atmospheric nitrogen



A diatom sample from Lake Malawi comprising Aulacoseira nyassensis.

How the Aral Sea is shrinking

The Aral Sea is drying out so rapidly that it has shrunk by two-thirds in less than fifty years, leaving two separate lakes where the world's fourth largest lake once was. But research published in collaboration with the NIGL shows that humans, including Genghis Khan and the White Huns, have affected the lake's fortunes for centuries. The paper published in *Quaternary Research* describes how they deduced changes in the Central Asian lake by investigating changes in the fossils and chemical make-up of the water. The project is part of CLIMAN Holocene climate variability and evolution of human settlement in the Aral Sea Basin (<http://climan.gfz-potsdam.de/>).

- Austin, P, Mackay, A, Palagushkina, O, Leng, M J. 2007.

Ethiopian stalagmites, records of climate?

A paper on actively growing stalagmites from Ethiopia was published in *Geochimica et Cosmochimica Acta*. The research centred on oxygen isotopes and showed that different speleothems provide different aspects of climate information depending on the cave plumbing system.

- Baker, A et al. 2007.



A recent Ethiopian speleothem.

Tectonic evolution of orogen-scale fault systems

A detailed knowledge of the bounding structures of the Greater Himalaya Series is critical to understanding its exhumation and testing channel flow models. Field, petrological, thermobarometric and geochronological data from the Dzaka Chu section of the South Tibetan Detachment System (STDS) suggests this system progressed from ductile- to brittle-deformation without the development of a discrete detachment fault or faults that is common to many STDS sections. It is argued that the Dzaka Chu STDS represents a deeper structural position than is exposed elsewhere in the Himalayas. These findings are an

How the Anglo-Saxons reared their cattle

The isotope patterns in cattle teeth are used to interpret the way in which the animals were reared. Two neighbouring Anglo-Saxon communities raised their cattle in very differently ways because of available land space. A wide variation in isotope signatures between animals from the smaller community

shows that the animals had space to graze freely. In contrast, the isotope patterns from animals of the more urban community were very similar. The results are consistent with the suggestion that these animals had a far more controlled feeding regime because of limited grazing space.

- Evans, J A, and Tatham, S, Chenery, S R, and Chenery, C A. 2007.



Dexter cow — an ancient breed. Photograph courtesy of Peter Hancocks.

important step toward understanding the development of low-angle detachment fault systems active during continental collision.

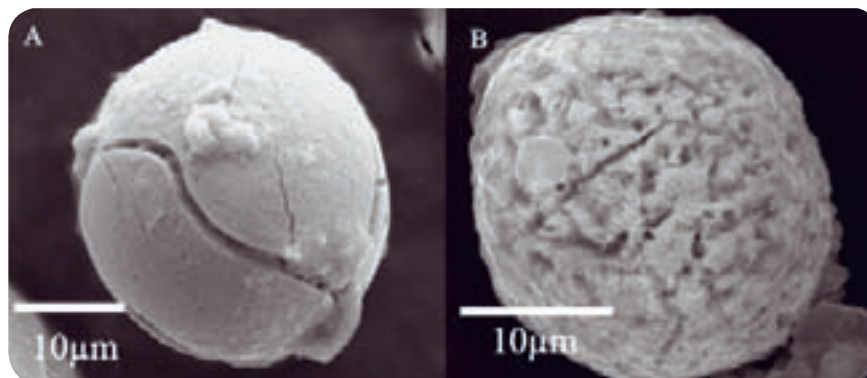
- Cottle, J M, et al. 2007.

Depleted uranium and health

The manufacture and use of depleted uranium (DU) munitions has raised many questions about long-term health implications and the environmental dispersion of DU. A study in the USA near a former munitions plant has shown that DU can be found in

urine, even after 25 years, of individuals who had a significant inhalation exposure. Identification of DU aerosol particles from this factory pollution plume demonstrates that particles exposed to the elements for about 25 years show corrosion and dissolution relative to those preserved in household dust, and that the isotopic composition of single particles proves a considerable variety in the end-member isotopic compositions of DU munition raw materials.

- Parrish, R R et al. 2008.

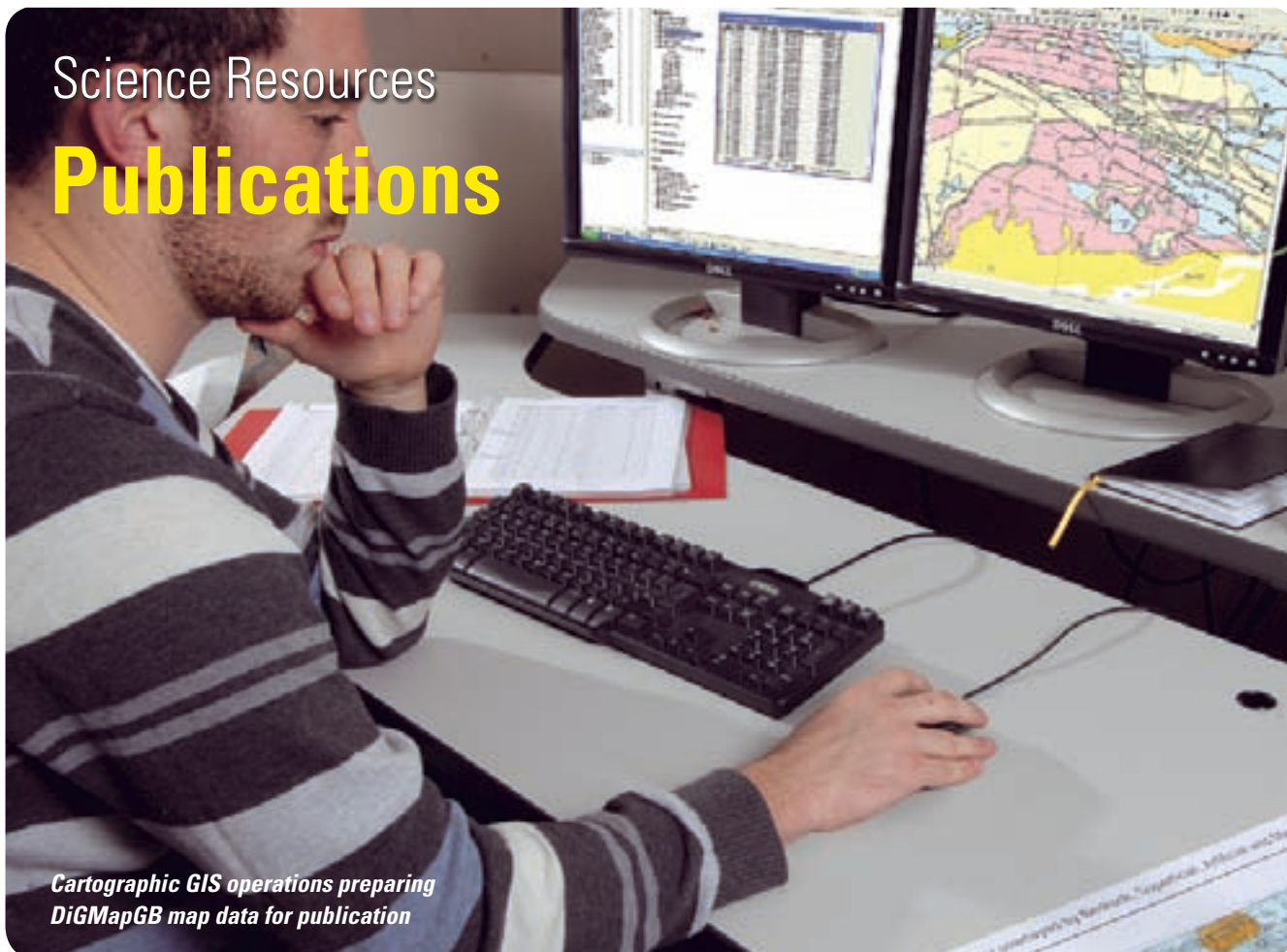


Particle of DU preserved in household dust (left) compared with particle of DU that has been exposed to the elements and has corroded.

See page 67 for full reference list

Science Resources

Publications



Cartographic GIS operations preparing DiGMapGB map data for publication

The Publications programme produces the BGS's formal output of maps, books and reports in hardcopy and digital format. We are a major contributor to digital databases such as the Digital Geological Map of Great Britain (DiGMapGB) and the National Archive of Geological Photographs. We design and produce traditional and digital multimedia output including websites, movies and animations. The 'Exploring the Landscape' series of walkers' guides is proving successful, and we have added maps and guidebooks for Charnwood, East and West Mendips. The Mendips guides are accompanied by a dedicated website.

Cartographic Production

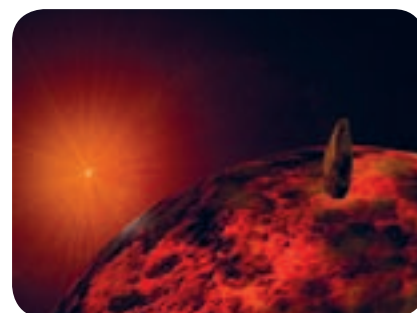
We use geographical information systems (GIS) to capture geoscientific information to build digital map databases (DiGMapGB, *page 51*) and produce cartographically enhanced printed maps. We have increased our digital map database of survey-scale map data (1:10 000 scale), and 14% of the

UK is now covered. Data are submitted to us through the field mapping system (SIGMA Mobile and SIGMA Desktop). These are quality controlled and enhanced to cartographic publication standards using SIGMA-compliant customised cartographic GIS. The data are available for licensing, and, with the addition of generalised vertical

sections to provide the 3D information, print-on-demand maps. Varied thematic maps are produced for a number of environmental products, and collaboration with the British Antarctic Survey has generated some new products, particularly for the OneGeology project (*page 51*).

Graphic Design

Two British Regional Geology guidebooks were published, covering Wales and the Grampian Highlands. These describe the geology and are illustrated with diagrams and photographs. Six Sheet Explanations were published to accompany maps at 1:50 000 scale, providing a concise



Scene from the Geological Time Machine animation.

description of the geology. Multimedia and animated movies remain a strong output, published as websites or DVDs — notably, the BGS University Funding Initiative (BUFI, see page 43) website; contributions to the BGS website and the OneGeology website.

Photographic Services

We were pleased to have won two awards from the British Institute of Professional Photography (Midland Region) Annual Print competition — their 'Scientific' Award, and 'Press and PR' Award. Digitisation of the National Archive of Geological Photographs continued and some 21 000 images were scanned to archive quality, including 4000 important fossil photographs kindly donated from a private collection. Photographic coverage of major geohazards supported scientific studies, and included landslides along the southern coastline of England, Pennan near Fraserburgh, and Arrochar near Loch Lomond. Photographs were also taken of damage caused by the earthquakes at Folkestone and Market Rasen and our images of the severe summer flooding in England and Wales were used by the BBC and national press. We provided comprehensive aerial photographic coverage during the complete scientific remapping of the Isle of Wight, the Jurassic Coast World Heritage Site and the South Downs. Major field photography was shot in the Lake District, Northumberland, Scottish Borders, and Argyll.

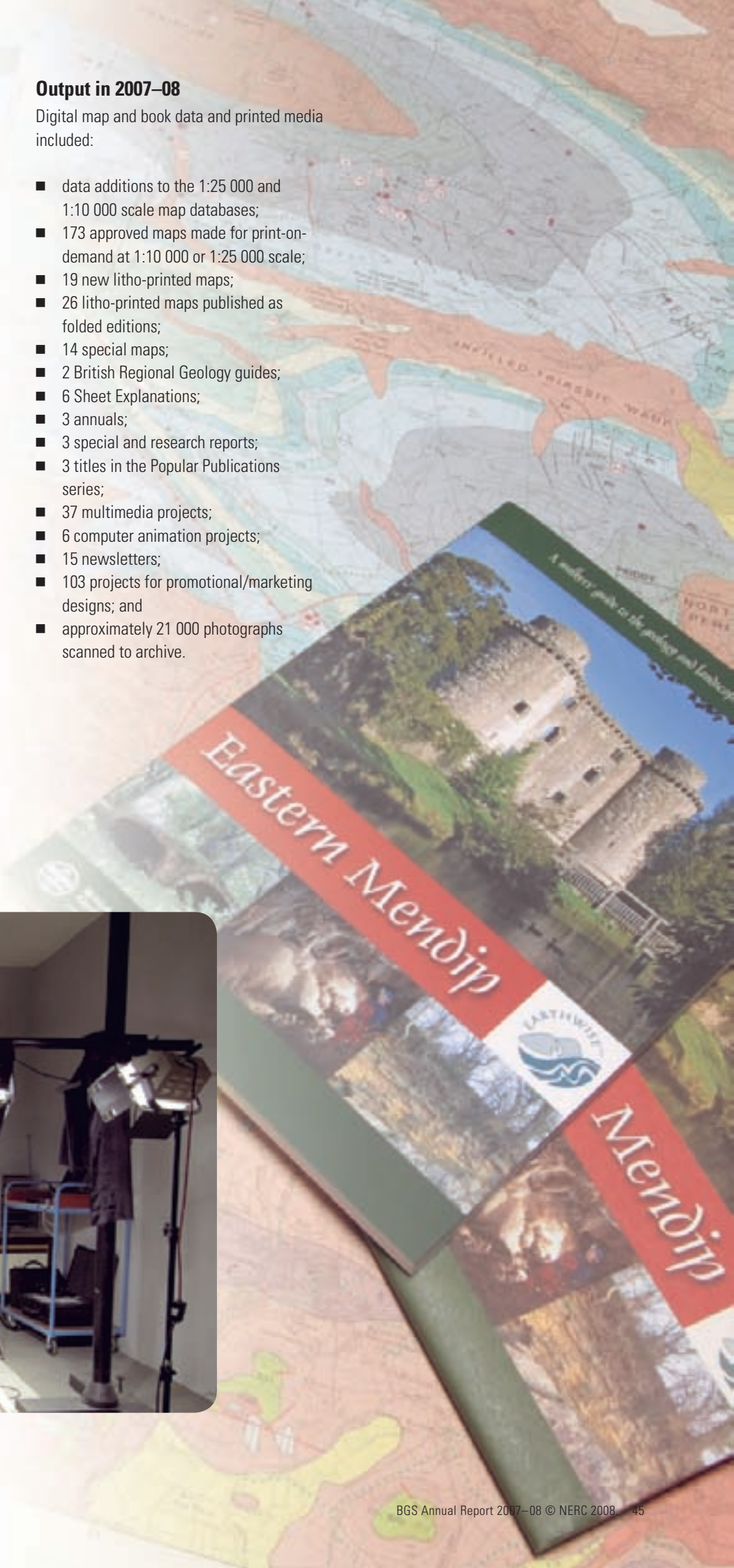
Output in 2007–08

Digital map and book data and printed media included:

- data additions to the 1:25 000 and 1:10 000 scale map databases;
- 173 approved maps made for print-on-demand at 1:10 000 or 1:25 000 scale;
- 19 new litho-printed maps;
- 26 litho-printed maps published as folded editions;
- 14 special maps;
- 2 British Regional Geology guides;
- 6 Sheet Explanations;
- 3 annuals;
- 3 special and research reports;
- 3 titles in the Popular Publications series;
- 37 multimedia projects;
- 6 computer animation projects;
- 15 newsletters;
- 103 projects for promotional/marketing designs; and
- approximately 21 000 photographs scanned to archive.



Photographing cores of glacial till deposits.



Science Resources

Laboratory Operations and Development of Capability

Studying water–rock interactions in the hydrothermal laboratory

Laboratory Operations

The Laboratory Operations programme is responsible for the strategic management of all of the BGS's wide range of laboratory facilities, ensuring that they provide a high quality, cost-effective and scientifically well-aligned input to the BGS core strategic and commissioned programmes.

The range of BGS's laboratories includes: sample preparation and testing, thin sections, analytical geochemistry, mineralogy and petrology, biostratigraphy, groundwater properties, engineering geology and geophysics, radiochemistry and radiometrics, and specialist research facilities.

Gamma core logger

Automatic gamma logging of cores is once again possible within the BGS thanks to a systematic upgrade to the facility. Radionuclides can be analysed in cores for contamination, dating and other studies. The technique is non-destructive and the results can be used to select cores for more

detailed study and help to define efficient subsampling strategies. The cores are moved stepwise past a lead-shielded gamma detector and a full gamma spectrum is collected at each step. The step interval and counting times are preset and the operation is fully automatic and can be monitored and controlled remotely. The data collected are processed in a batch at the end of the run and can be quickly displayed graphically. Calibration is based on commercial sourceless techniques allowing for a range of core diameters and types of material to be analysed.

NERC Environmental Materials Facility

This year the BGS extended its range of high-quality sample preparation services by bringing on stream a large-capacity roller blender in the NERC Environmental Materials Facility (EMF). This equipment was specially designed in collaboration with the BGS workshops and a group of junior technologists from the Loughborough Sixth Form College who subsequently won a national award for their work. This mammoth beast is constructed from polypropylene and

allows us to homogenise up to 600 kg of powdered rock, soil, sediment or vegetation at once. The speed of rotation of the blender is carefully controlled to prevent heating caused by the dynamic movement of such a large volume of powder. The system was developed in response to requests from producers of reference materials whose products underpin many environmental industries. This gives the EMF a key competitive edge in this developing market and we have seen a strong demand for its services.

BGS-sponsored Ph.D. students win prizes

Nick Lloyd (Leicester University) was awarded the Allan Ure Bursary by the Royal Society of Chemistry for his studies of the migration of depleted uranium into the environment from an old metal working factory. Nick, who relies on the ICP-MS facilities in the BGS chemistry laboratories, is producing a map showing the contamination footprint from this highly controversial pollutant, using a novel approach based on the chemistry of individual particles collected from soil profiles.



Nick Lloyd, recipient of the Royal Society of Chemistry's 2008 Allan Ure Bursary.

The Hemphill Prize from the Society for Environmental Geochemistry and Health was awarded to Jenny O'Reilly (Surrey University) for scientific innovation in developing a method to stabilise different forms of arsenic when collecting water samples. She used the method in remote regions of Argentina to trap the arsenic on specific resins. These were then brought back to the BGS where arsenic species with different degrees of toxicity were identified and quantified. The information is being used to assess the impact of high levels of arsenic on human health in the region.

Development of Capability

The Maintenance and Development of Capability programme comprises many small- to medium-scale initiatives covering a diverse range of scientific disciplines.

These initiatives include laboratory operations, remote sensing, geophysical equipment and software maintenance and palaeontological applications. The main objective is to assimilate new scientific ideas and technological developments across a wide range of our present and future activities. The programme maintains our cutting edge capability through introduction of new methodologies, enhancement of existing capabilities and formal accreditation of our scientific services.

Detection of unexploded ordnance

One new area of marine geoscience is the assessment of underwater cultural

heritage sites, particularly with regard to their contamination from shipwrecks. We are currently part of an evolving international consortium preparing to bid for Interreg IV in order to assist in the management of vessels sunk during the Battle of Jutland (First World War). Our primary role will be to explore the potential link between geochemical hot spots in sediments and anthropogenic wreckage. Most high explosives are toxic, and their presence in oceans from naval engagements and exercises can generate plumes that may adversely affect the marine environment.

Our organic geochemistry laboratories have successfully developed a method for the determination of 14 unexploded ordnance (UXO) compounds, including explosives such as TNT and their degradation products. The developed methodology was used to assess the degradation of TNT in microcosms containing marine sediments and seawater spiked with TNT maintained at 6°C (average North Sea bottom temperature) in the laboratory. This work is being used to provide better insight into the degradation of UXO in the marine environment, of which little is currently known.

New method for measuring pH in high pressure systems

The accurate measurement of pH is a fundamental requirement when studying water–rock reactions and for monitoring the underground storage of carbon dioxide. However, most commercially available pH electrodes do not cope with the elevated pressures found deep underground, and those specialist ones that do exist are large and bulky.

Recent work in our hydrothermal laboratory has focused on developing optical methods to measure pH using very small sensors. Not only does this method work at high pressures, but by using optical fibres it also allows the sensitive electronics of the detector to be placed some distance from the actual point of measurement. The technique involves mixing a very small amount of pH-sensitive dye with the solution to be analysed and using a fibre-optic spectrometer at ultraviolet and visible wavelengths to monitor the resulting colour change — akin to a much more sensitive version of litmus paper turning from red in acid to blue in alkali.

This approach has been used to successfully measure the pH of solutions saturated with carbon dioxide at 300 times atmospheric pressure. Such solutions would degas violently if we tried to measure the pH at atmospheric pressure.



A BGS-developed large-capacity roller blender used for homogenising environmental samples.

Science Resources

Staff Development and IT Infrastructure

Sampling glacial lacustrine clays and sands, Vale of York: lowland Quaternary mapping course

Our training and staff development activities are coordinated through the Science Resources Directorate. During 2007–08 we continued to provide training and development opportunities for our staff through a training programme aligned with our corporate strategy and business needs.

Staff development

Training was provided in a number of specialist IT areas, including network administration, geographical information systems (GIS) and Oracle database applications. Additionally, courses in web technologies and in the use of applications software for graphic design were provided to support information delivery activities. Geological modelling and 3D visualisation software was supported through revised and updated GOCAD and GSI3D courses, and in-house training in the corporate software applications used widely by staff continued. Increasing use was made of computer-based learning as a cost-effective

means of delivering appropriately timed IT training.

Scientific training included courses in applied Quaternary geology, modern glacial landscapes, landslide assessment, sequence stratigraphy, geochemical modelling and geophysical interpretation. Laboratory operations were supported with training in the use of a variety of specialist analytical equipment. Field-based courses in sequence stratigraphy and basin analysis, geological feature mapping, mapping deformed terranes and lowland Quaternary geology were run in conjunction with the School of Field Geology and were attended by our own staff and university postgraduate students.

Health and safety training covered a range of standard topics such as fire awareness and first aid as well as more specialist areas including drilling rig operation, mast climbing, quarry safety and sea survival.



Drilling rig operation training.



GIS training in newly-refurbished IT training rooms, Keyworth.

Personal development training covered leadership, management, communication

and other workplace skills and there was special emphasis this year on change

management training. Additionally, coaching groups were established to provide support for senior managers with various aspects of performance management, and language training was provided for staff working overseas.

A new programme of staff exchanges with the Instituto Geológico y Minero de España in Madrid was established, providing a small number of staff with the opportunity to learn new skills, widen horizons and benefit from being exposed to different ways of approaching scientific, technical and institutional challenges.

Career development within the BGS was also supported with a new mentoring scheme to help employees realise their full potential with guidance from more experienced staff. Feedback so far suggests that the scheme has been very rewarding for all involved.

Workplace coaching for new recruits and those undertaking major job changes continued and support was provided for 26 staff working towards further education qualifications.

IT infrastructure

IT infrastructure services are provided by the Systems and Network Support (SNS) team which has IT experts located at both Keyworth and Edinburgh. A recent user survey indicated a high level of satisfaction with IT service provision in the organisation.

SNS has been very focused on green issues and has a 'virtualisation' agenda which will reduce the number of physical computer servers in use. Virtual servers (using VMWARE technology) will be created on a small number of high-performance physical servers. Other significant developments have seen the purchase of a high-performance computing Linux cluster located at Murchison House, a growth in the use of Linux systems and the separation of Oracle production and development systems.

The BGS has given good support to the NERC IT Strategy and has successfully bid to host the NERC corporate email system. This will see us host a high-availability Exchange 2007 service including NERC active directory,

Blackberry and email archive services.

For the future, SNS will be looking to enhance its IT Help Desk services (probably using the Touchpaper help desk software), seek funding to upgrade the

BGS computer room facilities, work more in collaboration with other NERC IT units (the NERC Virtual IT team!) and invest resources in further development of the NERC IT strategy.



High-performance computing, Linux cluster at Murchison House.



New delivery technologies: DiGMapGB geological map data served via Google Earth and through a Web Map Service

Information and Knowledge Exchange

The role of the Information and Knowledge Exchange Directorate is focused on the creation of national digital datasets, and the management and delivery of the BGS's analogue and digital data. The work of the directorate underpins geoscientific and environmental research undertaken within the BGS and the wider community, and the exploitation of our geoscientific data and knowledge for societal benefit. These objectives are achieved through three closely aligned areas of activity, Information Management, Information Products, and Information Delivery.

Significant steps have been taken during the year to raise awareness and increase the availability of our datasets. The digital geological map of Great Britain — DiGMapGB-625 — was made available as a free of charge download from our website for non-commercial purposes. The free availability of this dataset for non-commercial use, mashups and for commercial innovation purposes has been warmly welcomed by the user community. The removal of restrictions on the use of BGS (NERC) copyright materials for non-commercial use has also resulted in a significant increase in their use by the education and research communities.

One of the year's highlights was the release in November 2007 of a new, high-resolution natural radon potential dataset for England and Wales. This dataset is the result of many years of close collaboration with the Health Protection Agency. Natural radon is a major carcinogen and causes a significant number of deaths each year due to lung cancer. Enquirers can now obtain information on natural radon potential levels at specific postal codes or addresses, and

can use it to decide on appropriate courses of action.

The importance and relevance of our national Geographic Information System (GIS) based datasets was further underlined during the extreme summer floods of June and July 2007. During these events the our groundwater flooding and 'geological indicators of flooding' datasets were made available to key organisations to inform their flood predictions and emergency planning responses.

We continue to support the development of GeoSciML, the internet mark-up language that makes geological data interoperable and enables web services. GeoSciML is integral to the global OneGeology project, which continues to gather pace. The OneGeology initiative now has 79 nations as members, and its web map portal will be launched at the opening of the 33rd International Geological Congress at Oslo in August 2008. 'OneGeology-Europe', a 29-partner €3.25 million project that will progress the initiative in Europe, has been approved by the European Commission and is scheduled to begin in September 2008.



Measuring radon: a natural radioactive gas, which enters buildings from the ground and can cause lung cancer.



Tewkesbury Abbey, Gloucestershire, scene of some of the worst flooding in living memory during summer 2007.

Information and Knowledge Exchange

Information Delivery

BGS GeoReports help the construction industry understand site ground conditions

Information Delivery links BGS's science to the wider community through a range of information services including the corporate website and online services, licensing of digital data, media and outreach activities, and sales, enquiry, and library services.

Information Services

The Information Services team operates four services which provide data, information and advice to the user community:

- The Enquiry Service answered more than 21 000 enquiries during the year from members of the public, researchers, businesses and agencies. These included questions of general geological interest, requests for copies of records and requests for advice on site ground conditions in the UK.
- The Sales Service supplies the UK and international geoscience community with BGS publications, including books, maps and other popular publications, through online, mail order and retail routes. Highlights in the year include reproductions of John MacCulloch's 1840 geological map of Scotland, and John Mylne's 1871 geological map of London.
- The Intellectual Property Rights Service advises staff and external parties on the terms and conditions relating to the use of BGS materials. The section dealt with an increasing demand for the licensing and copyright of BGS material this year, including a significant surge of interest from the property insurance sector.
- The Business Solutions Service, which works closely with the BGS UK Business Development section, continued to help customers use licensed BGS digital

maps and other information to the best advantage in their products and services.

Communications and outreach

The year has seen an unprecedented level of exposure for the BGS in the media, with 31 press releases and 2781 online media article citations. Highlights include extensive global media coverage (TV, radio and press) in the immediate aftermaths of the Kent earthquake of April 2007 and the Market Rasen (Lincolnshire) earthquake of February 2008.



Young enthusiasts at the UK School Seismology Project launch event at the Institute of Physics in May 2007.



Staff conducted many media interviews relating to the Market Rasen earthquake in Lincolnshire in February 2008.

The UK Schools Seismology Project was launched officially in London in May 2007. The launch was featured in the Times Education Supplement and the project has received extensive media coverage since. This flagship outreach project has successfully installed low cost seismometers in secondary schools across the UK, and provided specific training for teachers. To date sixty secondary schools and ten universities across the UK have joined the schools seismology network, and significant sponsorship has been received from industry, allowing many of the instruments to be provided free of charge to the school.

Research Knowledge Services

Research Knowledge Services manages the BGS Libraries and online access services to research materials. The collections house almost two centuries of published geoscientific material, the survey's archives, publications, maps and photographs, and a rare books collection. A highlight this year was the launch by NERC's libraries



A key product release for the Sales service is John Mylne's 1871 Geological Map of London.

Web Systems

The Web Systems team builds and maintains all of the BGS websites and online services, and also runs the corporate intranet. Over 1.8 million visits to the main BGS website were made in 2007, a 20% increase on 2006. The amount of material available for free download increased considerably. Major effort has been made in overhauling and re-designing the new corporate website which was launched in May 2008. The goal was to create a website that is attractive and intuitive to use, with improved content and navigability. Web usability experts were consulted throughout the redesign process.

A new GeoRecords online shop has been released that enables customers to order copies of borehole record scans. This customer-facing service is coupled with an accompanying back office application that allows Enquiries staff to manage the incoming orders efficiently. A secure online system (extranet) has been developed that provides regular users of borehole record information with direct access to view the scans. This facility will be rolled out to both commercial and academic stakeholders over the next year.

Development of the DEAL website, which provides information about UK offshore oil and gas, has continued with the introduction of a subscription service and improved functionality.



The new website, launched in May 2008.

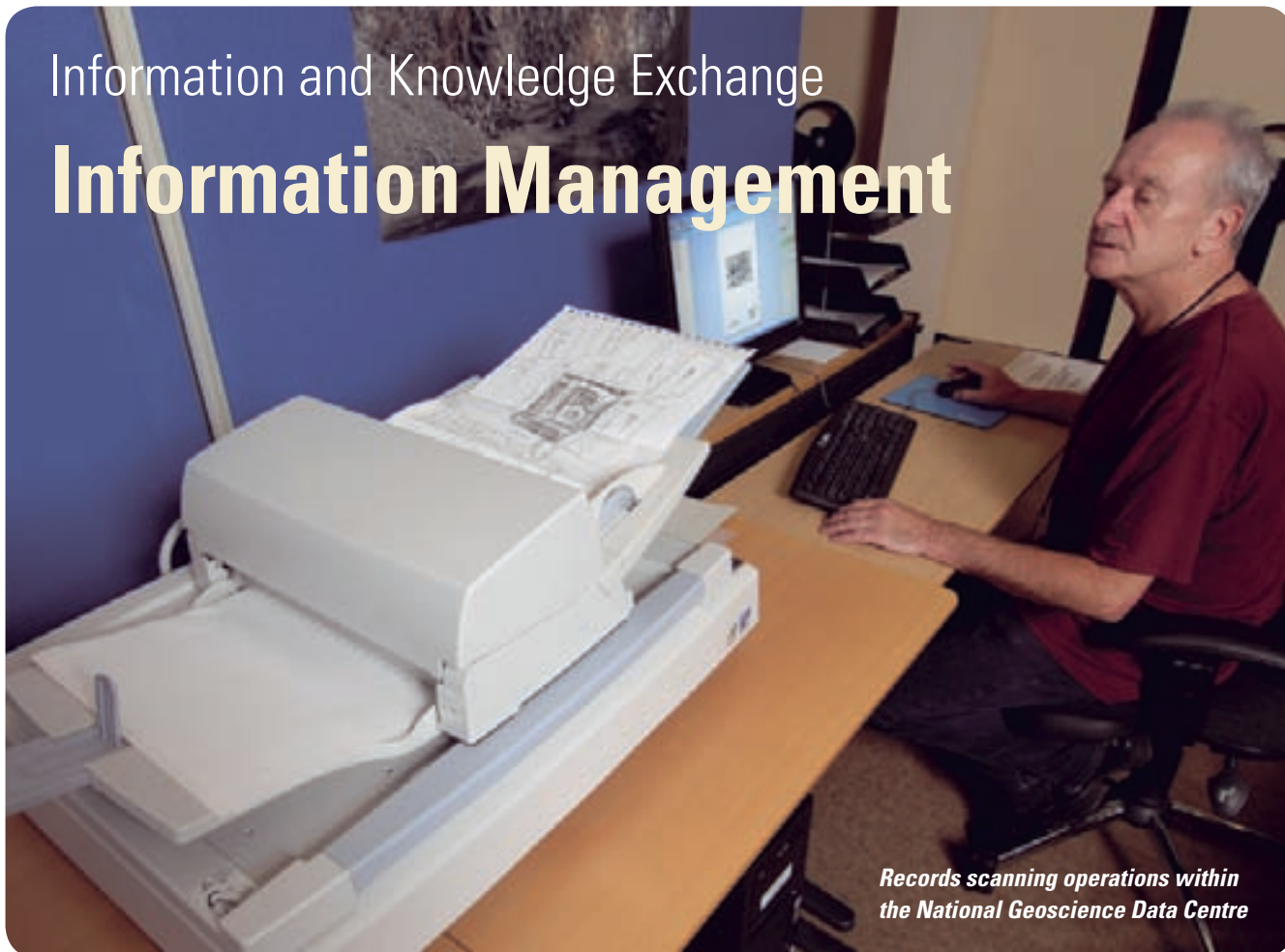
network of the NERC Open Research Archive Repository (NORA). This repository will be

used to provide free and open web access to research papers, reports, posters and conference presentations. NORA can be viewed online at: nora.nerc.ac.uk.

The switch from paper to desktop delivery of information continued with subscriptions to a major collection, GeoScienceWorld. Participation in national activities during the year included involvement in the National Archives Awareness Campaign. This year's theme, 'Women in Geology', explored the history of women in British geology since the early nineteenth century. Murchison House library was involved with the Edinburgh Festival of Libraries, a one-day celebration of the wealth of libraries in Scotland's capital city.

Information and Knowledge Exchange

Information Management



Records scanning operations within the National Geoscience Data Centre

Information Management is responsible for the management of all records, data and other information within the BGS. This includes all digital databases and collections such as paper records, maps and plans, images, archives, rocks, minerals, fossils, and borehole core. The aim is to manage the information in a coherent and integrated manner for the benefit of the citizen, government, industry, academia and the environmental science community.

Geographical information system metadata

Discovery metadata are created and published (www.bgs.ac.uk/discovery/metadata) in a structured way so that potential users can judge whether data assets are of value to them. Within the BGS, metadata are managed in several collections of different types, such as data holdings, 3D models, or maps. Geographical information system (GIS) metadata have been incomplete. To aid the collection of this information a customised metadata editor was developed for ArcGIS that replicates

Corporate software development framework

A wide range of in-house software is developed for a variety of applications, often driven by short-term, project-based goals. Problems supporting some of this legacy software have led to a review of this approach. During 2007–08 significant advances were made towards the implementation of a professional, corporate software development framework. This task involved publishing a new framework for IT/IS developments

built around two key corporate roles, the data and applications architects. A critical element of the solution has been the introduction of team working. The primary aims of this were to facilitate the transfer of technical skills and system/architecture knowledge within the IT development staff pool, and to ensure that the new development standards were promulgated and implemented. The framework was trialled successfully in 2007–08 and will form the basis of future corporate IT/IS development.



Records management within the National Geoscience Data Centre.

Scanning the Kidston photographic plates

The 2006–07 Annual Report noted the addition of more than 7000 samples of the Kidston Collection of fossil plants to PalaeoSaurus, the BGS biostratigraphy collection online database. Dr Robert Kidston (1852–1924) was one of the eminent palaeobotanists of his day, and he worked closely with the Survey, authoring a series of monographs and papers. He was a pioneer of scientific photography, building up a collection of over 4000 glass plate negatives, which he also bequeathed to the Survey. He received several international awards for his photography. During the year, the glass plates have been scanned and added to our image database, together with associated metadata. In due course, the images will be linked to the appropriate PalaeoSaurus entries and made available through our website. They will provide an invaluable resource for future biodiversity and taxonomic work.



Kidston Collection: transverse section of a fossil specimen Sphenophyllum plurifoliatum, a Carboniferous plant from Halifax. Original image is glass quarter plate, Kids 98.

the functionality of the Corporate Metadata Application. This customised metadata editor allows routine recording of ISO19115-compliant metadata for GIS datasets, which are currently stored alongside the datasets to which they refer. The intention is that the ArcGIS metadata editor output will eventually feed directly into the Corporate Metadata System.

BGS digital archive

October 2007 saw the launch of the BGS digital archive. This system is designed



BGS Data Architect discussing database design with a team of software developers.

too meet our obligations under legislation and NERC policies to maintain project information assets. The BGS archive consists of a range of information management policies and procedures that guide the archiving process, and a corporate software application for loading the data and capturing the metadata. The primary role of the digital archive system is to allow project managers to create interim and project closure archives with associated metadata records. The metadata record is crucial to provide the facility to search and find relevant records and the associated archives in the future. The system has also been built to allow for corporate dataset archiving when appropriate.

Records management

Regulations relevant to the field of information management include the Freedom of Information Act and the Environmental Information Regulations. A corporate records manager has been appointed to improve records management and to reduce the risk of legislative non-compliance. We are now in the process of implementing the *Lord Chancellor's Code of Practice on the Management of Records* issued under Section 46 of the Freedom of Information Act. A records policy has been prepared and agreed by senior management. An archivist has also been appointed to manage the extensive archives. These new posts have brought professional records and archives management expertise into the BGS for the first time.

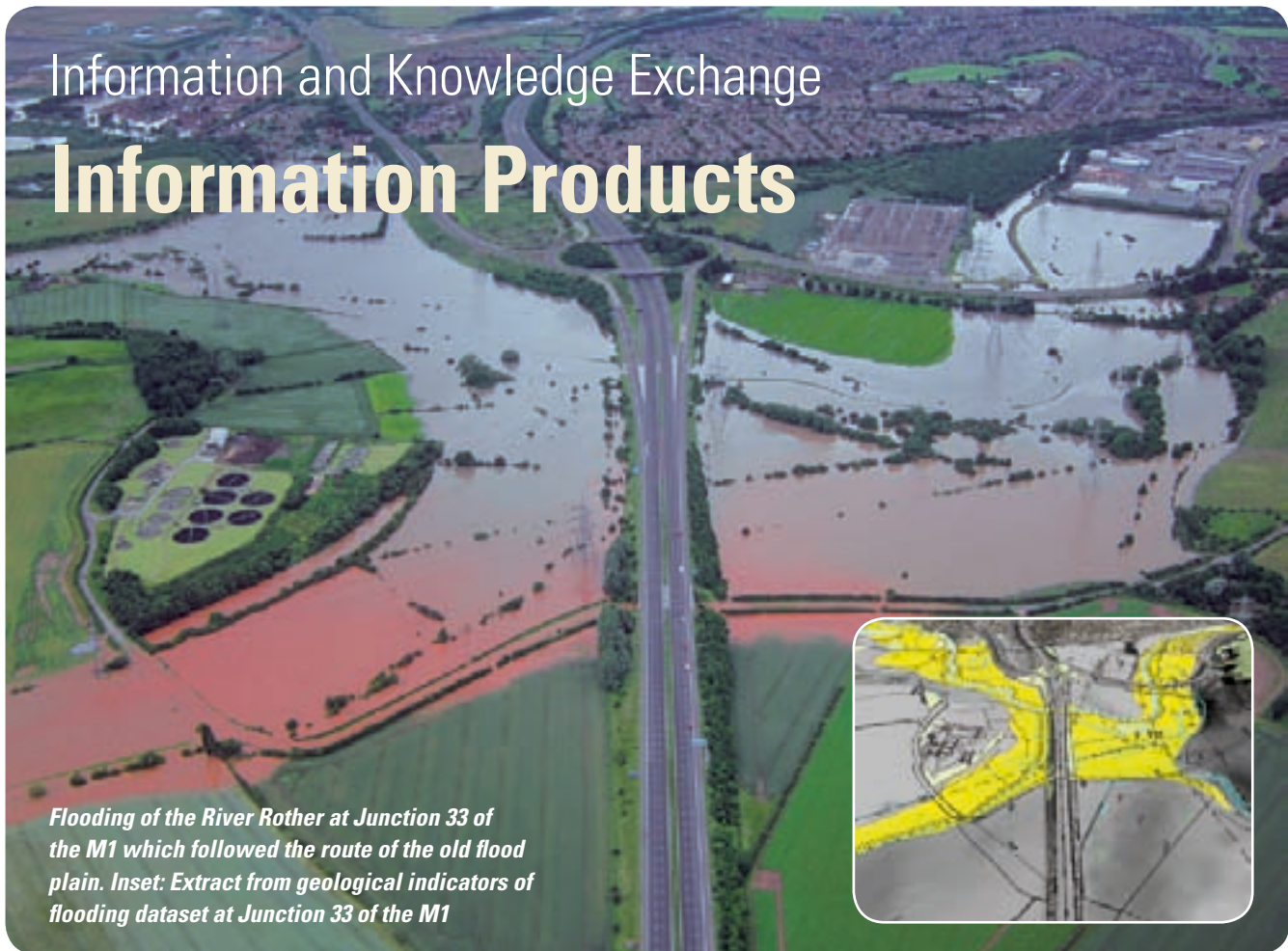
Conserving a rare fossil biota

With the current interest in biodiversity and earth system science, the study of the origin of multicellular animals is becoming increasingly relevant. The Ediacaran (late Precambrian) biota appears to represent the earliest widespread such fauna and it occurs at a number of localities in Charnwood Forest, Leicestershire. To aid the conservation of these fossils, we have been working with a British company that specialises in moulding 'outcrop-scale' features, in a project jointly financed by Natural England. The resulting casts have formed an important addition to our collections, and are already the focus of various collaborative research projects.



Replica cast of Cyclomedusa davidi. It is of uncertain biological affinity, although it was originally considered to be of medusoid (jellyfish) type.

Information and Knowledge Exchange Information Products



Flooding of the River Rother at Junction 33 of the M1 which followed the route of the old flood plain. Inset: Extract from geological indicators of flooding dataset at Junction 33 of the M1

Information Products generates national digital datasets that underpin research and knowledge exchange, and respond to commercial demand. Geographical information system (GIS) datasets are created by exploiting the BGS's own data and knowledge, in collaboration with external organisations and data sources where appropriate. Our information products are used in academia, central, local and devolved government, industry, commerce and by the public.

Baseline products

Baseline products provide the building blocks for more complex derived datasets, and underpin geoscientific research. They include DiGMapGB, models of the superficial deposits, soil parent materials and borehole data that record our diverse geology.

DiGMapGB — the digital geological map of Great Britain — is produced at several scales. Version 4 of the 1:50 000 scale dataset incorporates significant improvements to the geological

interpretations of Wales and Scotland. This national data was generalised to create a new bedrock dataset at 1:625 000 scale. Ongoing capture of 1:10 000 scale maps (carried out externally) will soon provide our highest resolution digital map data for selected priority areas.

The DiGMapGB-50 dataset has been combined with satellite imagery, terrain modelling, geochemical analyses and archive records to create a soils parent material dataset. Early versions have been used to inform the installation of earthing

conductors for electricity substations, and for assessing the preservation potential of archaeological artefacts.

Boreholes provide reference data points that underpin geoscientific interpretation. The national borehole capture project is generating a standardised dataset comprising key boreholes that typify and define our geology across onshore and offshore UK. The geological terms used in borehole records of all ages and sources will be translated into agreed standardised values using a concept-based thesaurus (ontology).

Around 600 000 boreholes were used to create the thickness model for superficial deposits for Great Britain. Cross-sections illustrate the changing stratigraphy of these deposits for the different Quaternary domains (landscape units developed in the last 500 000 years) across Britain. Within the superficial deposits geologists have identified materials that delineate the maximum extents of flooding from rivers, lakes and the sea that have occurred during the last 10 000 years. This information will be used to assist in identifying areas likely to flood in future extreme events.

Derived products

Baseline datasets underpin the development of derived, 'value-added' datasets that include natural ground stability, non-coal mining hazards, natural radon, geochemical hazards, permeability and groundwater flooding datasets.

During the year a new, high-resolution natural radon dataset for England and Wales was released, the product of several years of close collaboration with the Health Protection Agency. Natural radon gas is highly carcinogenic, and detailed knowledge of its distribution will greatly improve decision-making related to property design and to local authority planning.

GeoSure — a natural ground-movement hazard dataset — provides information on the potential for landslides, shrink–swell clays, running sand, soluble rocks, compressible and collapsible deposits. GeoSure is used by insurers, developers, local authorities, engineering consultants and home owners to identify areas prone to natural subsidence. The dataset has been updated to incorporate new information on clay and landslide movements. New research is investigating how climate change might affect future ground stability.

Version 1 of a non-coal mining hazard information system is almost complete and the dataset will be released in 2008. It includes an assessment of all non-coal commodities that have been extracted by underground methods



Richard Straw

In situ remains of an abandoned mid nineteenth century waterwheel that was used for pumping and winding from an underground shaft in a small copper mine (Ystrad Eynon) near Talybont in Mid Wales.

in Great Britain, including metals, chalk, salt, gypsum, buildings stones and various industrial minerals.

Scanning and indexing of non-coal mine plans continues, using both our own and private collections. Agreements have now been reached to capture plans in the hands of several private owners. This is part of a national consortium initiative to scan and index all non-coal mine plans held across

the country. We are working with the Health and Safety Executive, the Coal Authority, the National Archive and Valuation Office Agency to develop an online index to mine abandonment plans.

The groundwater flooding susceptibility dataset launched last year has been updated and now provides even more detailed information. The dataset proved very useful in understanding flooding events during the extreme summer flooding events of 2007. Records of incidences of groundwater flooding associated with the anomalous events of last summer will be used to further refine the data.

Pilot products and data capture

Working with our economic minerals experts, historical land use information has been derived from mining permissions maps for England. These data will be released with associated mining permissions data captured from the same maps. Capture of offshore data has resulted in the creation of 1:1 000 000-scale Quaternary deposits dataset and bathymetry for the continental shelf. A database of springs was completed which incorporates information from a variety of BGS databases such as Wellmaster, historical topographical maps and the Karst database. Other collaborative ventures included the co-funding of the development of an underground asset management system.



Abandonment plan, dating from 1968, of the Castle Cary Mine, Dunbartonshire, showing workings in two beds of fireclay.



Firing a brick kiln at Jaber Khan, outside Kabul, Afghanistan

Business Development and Strategy

The Business Development and Strategy Directorate (BDSD) has a number of functions including corporate marketing, strategic planning, supporting the BGS Board and the Executive Committee, maintaining links with clients and stakeholders both in the UK and internationally, and managing large, multidisciplinary overseas projects.

In its marketing role, BDSD works closely with all parts of the BGS to promote capabilities, understand market needs, engage with clients and stakeholders and to prepare bids and tenders. Marketing activities are supported by weekly bulletins of new opportunities, prepared in-house, and by a small team which produces and manages exhibition and promotional materials

The UK Business Development (UKBD) team comprises a team leader and a number of sector marketing staff, who are based at all the principal BGS sites. The team has devoted a large amount of effort to marketing information products to current and new clients, including those in the insurance and home-buying markets. This has supported a further increase in revenue for 2007/08 within this sector. UKBD organised several exhibitions and seminars across a wide range of sectors including oil and gas, water, minerals, environment and information services. There has been further engagement with devolved, local and regional government that has secured new externally funded commissions and heightened the profile of the BGS. A priority has been to build stronger links with Government, at all levels.

There are three regional managers for overseas work, whose responsibilities



The BGS and Deutsche Montan Technologie GmbH are currently mapping the geology of the mountainous jungle region of the Papua New Guinea Highlands. Explaining our activities to remote village communities is an essential part of this work, along with seeking guides and temporary accommodation.

are based around language skills that are especially necessary in francophone and lusophone Africa. International activities included several large, long-term projects in Madagascar, Ghana, Afghanistan, Mali, Niger, Papua New Guinea, Montserrat and elsewhere. Their main focus was institutional strengthening through

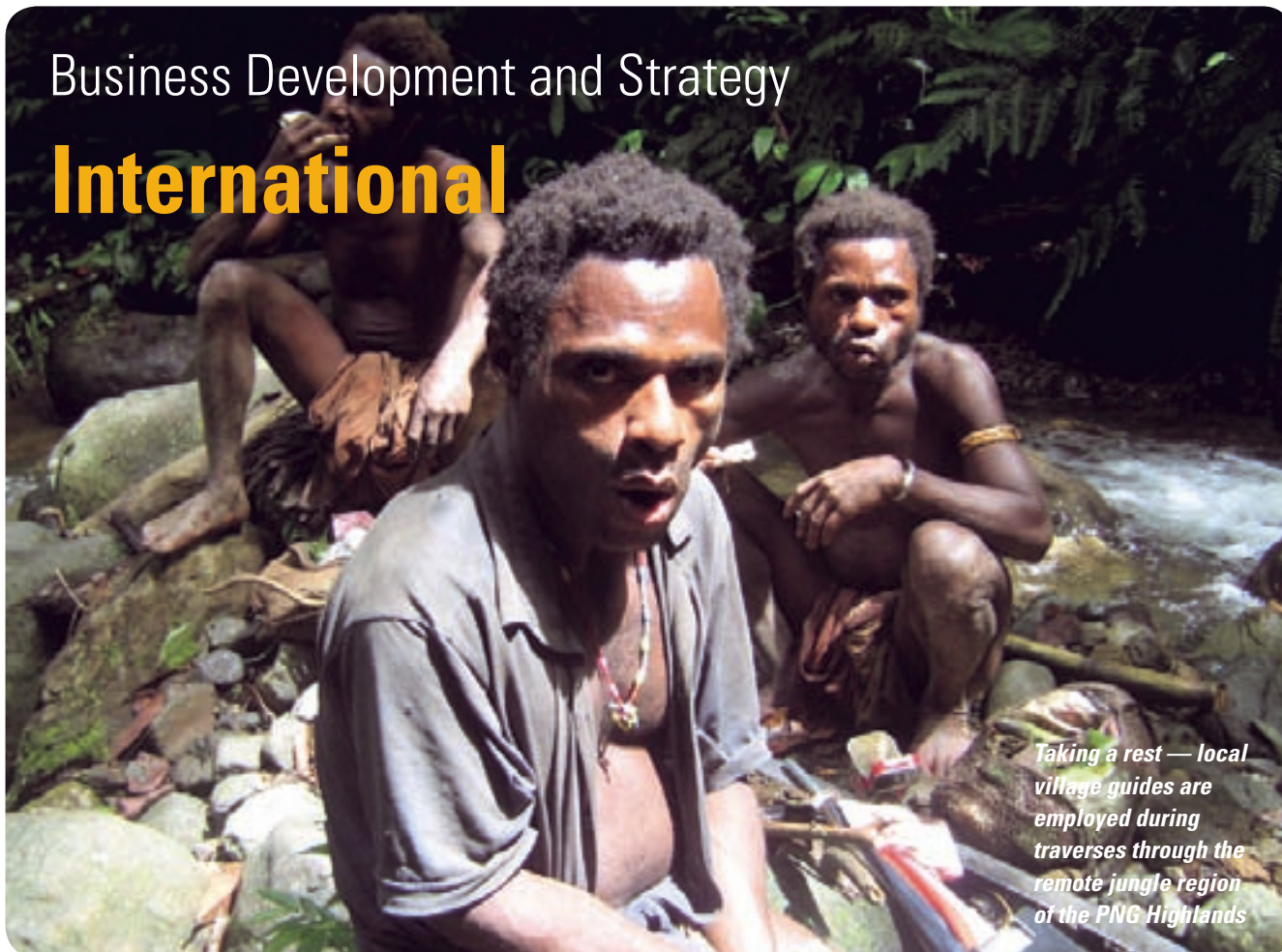
geological mapping, natural resource exploration, natural hazard mitigation and data management, with an emphasis on training and knowledge transfer. These projects are externally funded by clients such as the European Union, the World Bank, the Department for International Development or the government of the country.



Baggage train, northern Madagascar. The BGS's international projects often involve fieldwork in challenging terrain.

Business Development and Strategy

International



Taking a rest — local village guides are employed during traverses through the remote jungle region of the PNG Highlands

International activities involved continuing long-term projects in Madagascar, Ghana, Niger and Papua New Guinea; the main focus of which is institutional strengthening and natural resource exploration through geothematic surveys. Major projects were completed in Afghanistan, Ethiopia, Mali, Montserrat, Mozambique, Sao Tome and the UAE; while new projects were won in Nigeria and UAE.

hydrogeology. The results of the mapping project are described in a 1400-page report.

A stream sediment geochemical sampling project was also undertaken, which involved the collection of 20 000 samples for assessing mineral occurrences. We trained Malagasy students and counterparts from the Ministry of Energy and Mines to assist with this project. A total of 414 single-element maps have been produced for 18 sheet areas at a scale of 1:200 000. The fieldwork presented many challenges

Madagascar mapping project

We have recently completed, in conjunction with the US Geological Survey, a major World Bank-funded multi-thematic geological mapping project in northern and east-central Madagascar. We expect to complete delivery of 98 geological map sheets, at a scale of 1:100 000 covering an area of around 130 000 square kilometres, by the latter part of 2008. A larger reconnaissance area is also covered by a series of themed maps at a scale of 1:500 000, depicting geology, tectonic structure, minerals, geomorphology, and



BGS geological mapping and geochemical sampling team, east-central Madagascar.



All in a day's work! Negotiating a river crossing damaged by floods in northern Madagascar.

including the negotiation of jungle trails, deeply-rutted muddy tracks and impassable bridges in a mixed terrain of mountainous jungle and marginal savannah. Minerals of economic significance included gold, emerald, ruby-corundum and metalliferous sulphides; achieving some success in defining the controls on gold mineralisation. The project has significantly added to our understanding of the complex tectonic history of the region. All project deliverables will be submitted in a GIS database.

Handover of the Montserrat Volcano Observatory

Ever since the Soufrière Hills volcano on the Caribbean island of Montserrat erupted into the news headlines in July 1995 the BGS has been involved in monitoring the volcano's activity. Our role has been principally to advise the authorities — Government of Montserrat (GoM) and the Foreign and Commonwealth Office — and the public of any immediate danger presented by the volcano. It has been a challenging and at times difficult undertaking, with decisions about the designation of alert levels and their impact on the imposition of exclusion zones by the GoM a subject that naturally arouses mixed feelings among the island's inhabitants. Over the past few years the strategy has been to make the observatory more self sustaining and less dependent on outside help, through the employment of regional and local scientists. After nearly 13 years the BGS relinquished monitoring at the end of March 2008 and handed over the management of the observatory to a regionally-based consortium led by the Seismic Research Unit, based in Trinidad.

Geological mapping of the UAE

In March 2006, we completed a detailed geological mapping programme in north-eastern United Arab Emirates. The success of this project has now led to a further commission from the UAE Government to complete the geological mapping of

Afghanistan: establishing a basis for mineral development

In September 2007, we completed the main phase of a project (funded by the Department for International Development) aimed at creating a viable Afghan minerals industry by strengthening the capacity of the Afghanistan Geological Survey to assess and promote the development of the country's mineral wealth. This has been achieved through a variety of measures including training of Afghan staff, enhancement of laboratory and IT facilities, scanning and archiving of reports, establishment of a new library and museum, construction of a web-accessible database, mineral assessment studies, and production of promotional material on selected mineral commodities.

One important outcome has been the promotion of the Aynak copper deposit, near Kabul, as a world-class prospect with significant economic potential. We were able to develop a 3D technical model of the deposit, which formed an important part of the data package designed to attract investment from commercial mining companies. Following a tendering process a contract has now been let to develop the Aynak deposit. Other positive

outcomes from the project include new clients for Afghan marbles, which followed a showcase held at Dubai in September 2007, and input to the proposed establishment of a jewellery school by the Turquoise Mountain Trust, of which HRH Prince Charles is a patron. In addition, commercial exploration activity for alluvial gold is currently under way in the northern part of the country bordering Tajikistan.

the entire country. The project will take four-and-a-half years to complete. Sander Geophysics Ltd (Canada) has been sub-contracted by the BGS to undertake an airborne magnetic survey of the Western Desert and an airborne gravity survey of the eastern part of the country, both of which will assist in defining the three-dimensional structure of the region. The airborne geophysics will also help to reveal aspects of the geology that are concealed beneath a thick blanket of relatively recent (Quaternary) sediments.

The northern coastal area of the UAE is characterised by an association of evaporitic, tidal, and windblown deposits known as sabkha, which is still forming at the present time. The region is probably the best modern analogue anywhere in the world for this depositional environment. It is hoped that the proposed mapping of the sabkha will not only enhance our understanding of ancient evaporitic deposits, but will provide an opportunity to explore the history of climate change and fluctuating sea level over the past 20 million years.



Seven brochures have been produced by the BGS describing the potential for minerals in Afghanistan.

Administration and Finance

Finance

In the financial year 2007/08 we received £25.4 million from the NERC to fund the BGS core strategic science programme and the contribution to BGS infrastructure; approximately 53% of the BGS non-capital funding.

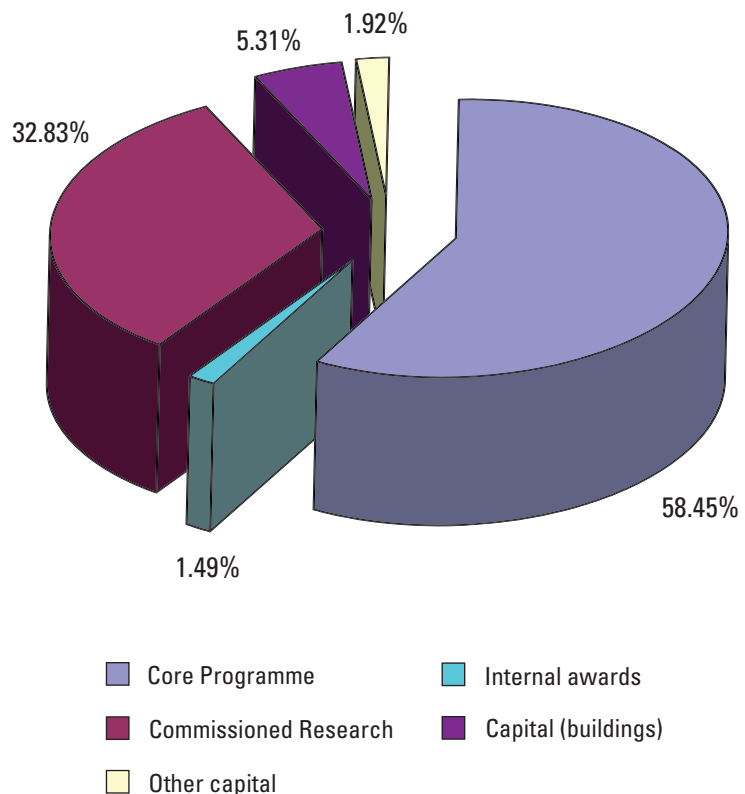
The NERC also provided capital funding and capitalised repairs, including £9.6 m over the life of the project, towards the construction of the William Smith Building open-plan office accommodation.

The BGS earns approximately 47% of the non-capital budget from external sources. This is from research commissioned by external partners and customers, from chargeable services, products and data licensing. Externally-funded projects accounted for £16.1 million of the £20.9 million of income. These projects enhance the Core Strategic Programme (CSP) through funding, ideas, data and review as well as making a vital contribution to our infrastructure. In 2007/08 this income came from varied sources including over £1 million from the Madagascan mapping projects, £778 000 from the Afghanistan minerals project and £208 000 from the airborne geophysical survey of Kosovo.

The BGS income graph shows the trends over the past nine years for different sources of income; figures have been adjusted to 2007/08 prices.

new classifications and categories prior to the introduction of the new system from 2009/10. FAB will involve increasing use of the Joint Electronic Submissions system within the Research Councils UK (RCUK) more generally and the BGS Finance team has facilitated the use of this throughout the year.

The introduction of a RCUK Shared Services Centre (SSC), which will undertake many operational finance tasks, has been put back to June 2009. SSC preparation has taken up a significant element of the finance team time over the year and in particular input into the various modules of the new SSC IT systems.



BGS expenditure during the financial year 2007/08.

Developments

There are significant changes proposed to the NERC funding and commissioning procedures known as Funding Allocation and Budgeting (FAB). We are reviewing its implications; in particular analysing our Science Budget expenditure into the

**Summary of income and expenditure 2007/08
(excluding the NERC Isotope Geosciences Laboratory)**

£ million

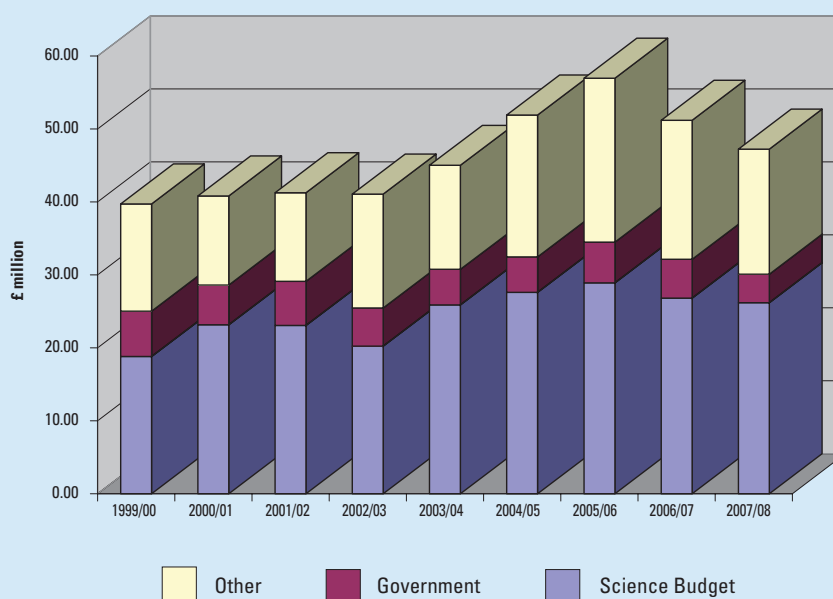
Income	
NERC Resource Allocation (Science Budget)	25.509
NERC Capital Allocation	5.215
Other Income	21.725
Total Income	52.449
Expenditure	
Salaries	30.891
Capital	3.592
Other Expenditure	15.333
Total Expenditure	49.817
Excess	2.632

How we spent the Science Budget (£m)

2007–08

	Summarised Allocation	Final DIUS* Outturn	Variance
Resource			
BGS resource allocation	25.413	24.612	-0.801
Capital			
Core Capital	1.454	1.175	-0.279
Capital Maintenance (Capital Investment Strategy)	0.704	0.652	-0.052
Keyworth Blocks A–F	3.318	1.985	-1.333
Profit on sale of assets & other asset adjustments	0.000	-0.372	-0.372
	5.476	3.812	-1.664

* Department for Innovation, Universities & Skills



Sources of income from 1999/00 to 2007/08 (at 2007/08 prices).

Personnel and Estates

Personnel

This has been a year of change, with a large number of internal reviews and physical moves for many staff. Further to the major structural reorganisation there have been reviews in: library services, internal services, laboratories and secretarial services. Staff have been relocated to alternative office accommodation as the William Smith Building work commenced. Personnel moved back into its refurbished open-plan accommodation. The year has been spent helping the staff through these changes as well as dealing with the challenges of the Shared Services Centre.

As a result of major structural changes the Personnel team have been involved with the selection and appointment of the new members of the Senior Leadership



Health and Welfare: the Keyworth fitness centre.

Team (SLT), Heads of Science, Heads of Information and Team Leaders. A total of two Directors, eight Heads of Science and Information as well as 57 Team Leaders were recruited. To help with the induction of the Team Leaders we also worked with Training to create a half-day course to explain roles and responsibilities.

Throughout the year Personnel and Finance staff were asked to work with the NERC and RCUK on continuing to design and define systems and processes for transition to the Shared Services Centre in Swindon. Uncertainty and the loss of key staff has been a major issue that has resulted in the appointment of a large number of temporary staff and a lot of extra pressure on the experienced staff in post.

Personnel have worked with the change team to help staff through the reviews where our work on pressure management has proved timely. We have been working with Goldsmiths College and the Health and Safety Executive on their academic research into the impact of stress. We have agreed to continue our participation into phase three of the work which will concentrate on producing training for managers in understanding the impact their role and actions have on their staff. A number of staff will participate in this phase and we then hope to be able to roll this out to all managers.

The health and welfare of staff is taken very seriously by the SLT and various initiatives are undertaken during the year. Their support of the fitness and leisure facilities on site is fundamental in ensuring that our staff remain healthy and helps to reduce stress. Edinburgh obtained the Scottish Health at Work (SHAW) Silver medal for the work that they have undertaken in health initiatives. The Keyworth onsite fitness centre has over 100 members and other onsite sporting facilities — tennis, football,



Career development mentoring: helping staff to realise their potential.

cricket, volleyball, badminton, judo and yoga — continue to flourish.

The second round of mentoring partnerships commenced after a successful first phase. There was also the appointment of new Diversity Contacts and preparation for the re-launch of the diversity contact guidance in 2008/09 on the intranet.

Estates

Construction work commenced on the William Smith Building on the Keyworth site. This sustainable and energy-efficient building, costing £6 million to construct, will provide accommodation for nearly 200 staff. The building is due to be completed early in 2009 with staff moving in from April of that year.

The year has been a busy one for the Estates team due not only to the increased workload caused by the William Smith

Building project, but also to the number of new projects funded by the NERC long-term maintenance programme. This is in addition to the routine maintenance and support activities. NERC also provided funding for uninterrupted power supplies and standby electrical generators for the main laboratory buildings at Keyworth. This will ensure that laboratory work is not disrupted by any interruption of mains electricity supply.

A process to produce a strategic plan for the BGS estate has been initiated. This will ensure that the estate can adequately support the activities of the Survey into the future. It is likely that the plan will be delivered during the 2008/09 financial year.

Environmental management

In March 2008, following a successful environmental management audit, the British Standards Institution (BSI) renewed our ISO 14001 certification, for Keyworth and Edinburgh offices, for a further three years. In their audit report the BSI commented that 'continual improvement is apparent in various areas of the organisation and includes large-scale and small-scale improvements'.

Energy

Although electricity for the Keyworth site costs approximately £1000 per day, there has only been a slight increase in consumption over the past five years, despite the installation of new plant and equipment across the site. Phase one of Keyworth's Building Management System has now been installed. Once the system is fully operational it will allow Estates staff to monitor energy use far more accurately, and to control plant and equipment, as well as the temperature of every building on site.

Savings of 70–80 per cent in energy costs have been achieved following the installation of energy-efficient lighting in the Murchison House library. The lights were purchased out of NERC's 'green fund'. Similar savings are expected to be seen following the recent installation of new lights in the Keyworth library.

Bids for new lighting in the National Geological Records Centre and 'green roofs' on the Keyworth site have also been successful and this work will be carried out during 2008/09.

A wind turbine was installed in Keyworth in June 2007. It is producing on average 6 kWh per day — only half the

William Smith Building

Work on the construction phase of the William Smith Building project started in December 2007. It is scheduled for completion in February 2009 with an official opening in the summer. The building is designed with a number of sustainable features including a structural timber frame, Termodec heating system, and ethylene tetrafluoroethylene (ETFE) atrium window panels, as used on the Eden Project

spheres. The building is expected to meet the indicators for the Building Research Establishment Environmental Assessment Method (BREEAM) 'Excellent' rating, which is the highest rating for this assessment.

The William Smith Building will be the first large-scale open plan office in the UK to use a timber frame in conjunction with a Termodec heating system. We expect it to be widely acknowledged for its pioneering design.



Construction of the William Smith Building, Spring 2008.

amount claimed in its specification. We have raised its poor performance with the manufacturer.

An environmental task force, appointed to identify energy savings in the Keyworth laboratories, has been making good progress. To date they have found ten ovens, a chest freezer and eight air conditioning units which were permanently switched on.

Waste management

This year, 21 tonnes of wood for recycling were collected from the Keyworth and Edinburgh sites; 53.3 tonnes of cardboard and paper, 7.2 tonnes of obsolete IT equipment; 4.1 tonnes of glass; and 35.3 tonnes of scrap metal.

Waste which was sent to landfill fell from 70 tonnes for the Keyworth site in 2006/7 to 30 tonnes in the current reporting year; a compactor has been installed and is expected to save us at least £5000 per annum.

Travel

Cars in the Keyworth fleet continue to average over 50 mpg. Garage staff are sourcing a local supply of biodiesel to add to the site's diesel tank.

Video conferencing has more than doubled since the installation of new equipment in June 2006.

A bicycle users' group was established at Keyworth in the summer of 2007 and has already achieved some success; the local Council has agreed to build a new local cycle path and install a set of traffic lights for cyclists.

Biodiversity

Over 500 native trees have been planted on the Eskdalemuir site including rowan, birch, oak and holly.

Despite the fact that a large part of the Keyworth site is currently inaccessible because of building work, over 100 orchids appeared in the spring.

Operations Support and Health & Safety

Operations Support

Quality management

We have continued throughout the year to progress and develop the management systems we employ. Review and audit undertaken during the year by the British Standards Institute (BSI) has resulted in on-going accreditation to the ISO 9001:2000 quality management standard. In addition to our external accreditation a series of internal audits has been carried out to benchmark performance against external and internal standards. Our internal audit team continues to drive improvements to our management systems to complement and enhance our ability to manage our science effectively. This demonstrates our continuing commitment to high quality management systems.

The change in BGS management structure resulted in a requirement to review and align our management systems to serve a redefined model for corporate governance. The work to complete this is ongoing.

Project management systems

Our in-house project management system supports the management of projects from bid stage through elements of project delivery and on to project closure and post project evaluation; the principles of the system are vested in PRINCE2 methodology. During the year, development work was completed on upgrading the project management system to introduce facilities for improved risk and opportunity assessment, and early warnings of 'expressions of interest' for tenders. However, the migration to the NERC Resource and Project Management System (RMS) has suspended the introduction of

these improvements and the development work will now be realised as part of the RMS implementation. Moving to a NERC-wide solution for project management will provide a single interface with the business support functions of the RCUK Shared Services Centre (SSC) and provide functionality across the NERC Research Centres to enhance collaborative working.

Health and Safety

The BGS health and safety support arrangements are continually reviewed to reflect organisational changes and business needs. Our health and safety systems are implemented in accordance with the NERC policies and guidelines and ensure that the requirements of current legislation and best practice are fully adopted.

Staff are encouraged to actively participate in all aspects of the management process and dedicated advisers are available at each site to assist with routine local health and safety issues and to monitor standards. Wider issues are addressed by the Senior Leadership Team who discuss these with the BGS and NERC Executive Teams.

Our open policy and proactive approach to promoting a positive safety culture is a key contributor to raising our standards and strengthening our market profile. Health and safety management makes good business sense and achieving the highest safety standards remains one of our key business objectives.

All accidents, near-miss and occupational ill-health incidents are investigated and reported to the NERC through the BGS Senior Leadership Team.

We have continued our commitment to staff training, engaging in a variety of methods to improve our skills base and

maintain competency levels. Appropriate training is arranged for all our staff to enable them to carry out their work safely and efficiently, whether in the office or out in the field.

Following a series of training and awareness sessions, the NERC has handed over the health and safety training modules to the individual research centre health and safety advisers, enabling them to deliver these in-house, in an effort to promote an efficient service and timely support for all staff.

Occupational health

External occupational health providers continue to support our staff on a wide range of health issues and provide expert advice, drop-in sessions, medicals for overseas trips and specialist clinics. Our investment in promoting a healthier lifestyle, through well-being, sports and relaxation sessions, has been welcomed with many staff reaping positive benefits.



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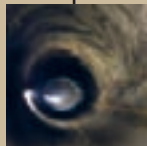
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