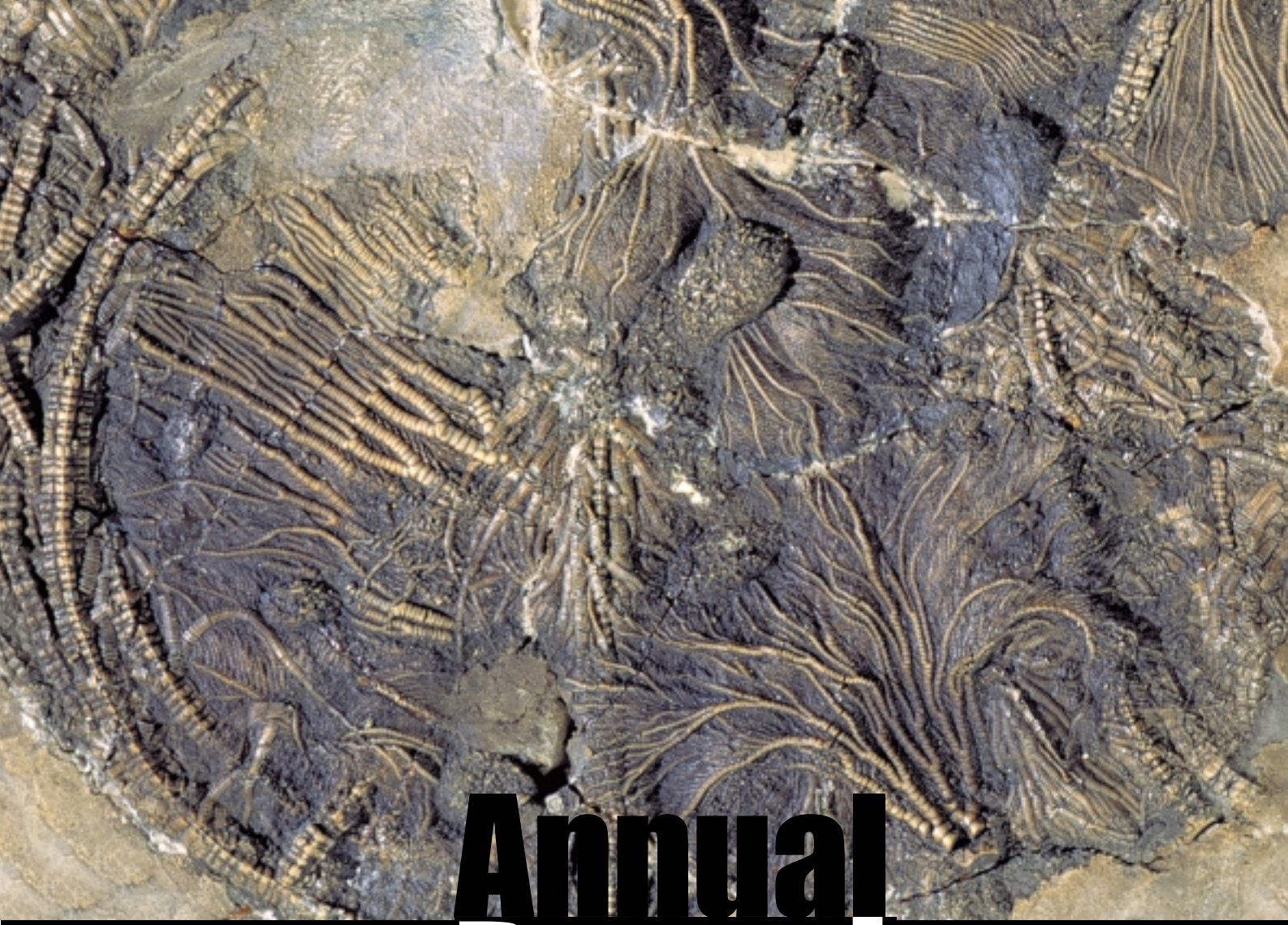

# Annual Report

2001–2002

British Geological Survey

NATURAL ENVIRONMENT RESEARCH COUNCIL

NAVIGATION

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*Bibliographical reference*

BRITISH GEOLOGICAL SURVEY, 2002.
*Annual Report of the British Geological Survey 2001–2002.*
(Swindon, Wiltshire: Natural Environment Research Council).

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Printed in the UK for the British Geological Survey by Hawthornes, Nottingham C40 12/02
Cover photograph: *Pentacrinites briareus* (Miller, 1821) (Lower Jurassic). A rare example of complete preservation of a crinoid skeleton. BGS photo no. GS692. BGS © NERC

ISBN 0 85 272 450 0

Editor: David Bailey
Design & Production: Adrian Minks
Print Production: James Rayner
Reprography: Jayne Kmieciak

The British Geological Survey (BGS) is a component body of the Natural Environment Research Council (NERC) — one of the seven UK research councils that fund and manage scientific research and training in the UK. The NERC uses a budget of just over £200 million a year to fund independent research and training in the environmental sciences. About half of its budget goes to universities, and half is invested in its own Research Centres.

The NERC is the research council that does Earth system science. Its main aim is to understand the behaviour of the complete biological, physical, and chemical interactions between the atmosphere, hydrosphere, geosphere, biosphere, and cryosphere. This provides us with the information we need to detect change, diagnose why change is happening, reduce uncertainty, and seek solutions.

The NERC's strategic priorities are to deliver world-class environmental sciences to understand the Earth system, to use NERC science to provide sustainable solutions to environmental problems, to train and develop skilled people, to provide effective leadership for the environmental sciences and to ensure the NERC is a flexible, fit-for-purpose organisation.

*Some of the research reported here is still in progress and may not yet have been peer-reviewed or published.*

# British Geological Survey

NATURAL ENVIRONMENT RESEARCH COUNCIL

## THE MISSION OF THE BRITISH GEOLOGICAL SURVEY IS TO:

Advance geoscientific knowledge of the United Kingdom landmass and its continental shelf by systematic surveying, long-term monitoring, effective data management, and high-quality applied research.

Provide comprehensive, objective, impartial, and up-to-date geoscientific information, advice, and services to the client and user community in the United Kingdom and overseas, enabling safe, sustainable and efficient choices to be made in managing the environment and utilising its resources, thereby contributing to national economic competitiveness, the effectiveness of public policy, and the quality of life.

Disseminate information in the community, and promote the public understanding of science, to demonstrate the importance of geoscience to resource and environmental issues.

## FUNDING BGS SCIENCE

The BGS is a public-good, not-for-profit organisation. BGS funding is split equally between government-funded strategic geoscience, distributed through the NERC's allocation of the Science Budget, and income from external sources for delivery of commissions, sales, and services. The commissioned portfolio itself includes a significant proportion of fully funded geoscience that directly enhances the Core Strategic Programme and increases the skill base of the organisation. Income from sales and chargeable services also feeds back into enhancing the Core Programme and developing additional products and services.

## THE CORE STRATEGIC PROGRAMME

The principal business of the BGS is the execution of the Core Strategic Programme in furtherance of the NERC's mission supported by, and in synergy with, an active portfolio of commissioned research. The Core Programme is delivered through three user facing Directorates — Lands and Resources, Environment and Hazards, and Information Services and Management — underpinned by development of capability projects administered by the Geoscience Resources and Facilities Directorate. The programme entails long-term surveying, monitoring, databasing, undertaking key environmental science research, and the provision of scientific advice (knowledge transfer).

## THE COMMISSIONED PROGRAMME

This Programme comprises strategic commissions — partnerships with a wide range of clients, which include government departments, agencies, local authorities, the European Union, international aid agencies, the World Bank and overseas governments, as well as UK industry, commerce and the public. The Commissioned Research Programme enhances the Core Programme through funding, ideas, data, and review. It facilitates more vigorous multidisciplinary work than could otherwise be afforded, including the development of expertise and the maintenance of critical mass of scientific expertise within each project area. This enhancement constantly demonstrates the relevance of BGS science to government, industry, and society.

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# Foreword

BGS © NERC

Dr Geoffrey W Robinson, CBE, FREng
*Chairman of the BGS Board*

It is my pleasure to introduce this annual report, my first as chairman. As a non-geologist by background, it has been a particular pleasure, and surprise, to discover the breadth and depth of the BGS's activities, the range of disciplines, the scope of commercially and socially valuable work, and the enthusiasm and commitment of the staff. I say surprised because, although I like to think of myself as a reasonably well educated, and interested, scientist — and one familiar with the Research Council scene — I had very little prior knowledge of the Survey and what it did.

The past year has brought a growing realisation by many people of the important relevance of the geological sciences to many aspects of everyday life. News headlines have touched on earthquakes in Manchester, land pressures in the South-East, volcanic eruptions in several countries and floods everywhere. This growing realisation brings great opportunities for the BGS.

I'm pleased to say that the BGS continues to be successful in seizing these opportunities. We are grateful to the NERC for their continued and active support of the BGS and its mission. At the same time, the BGS continues to be successful in winning external commissioned work, notwithstanding the difficult business climate in the UK and overseas. Among many other accomplishments over the year, the contribution of the BGS to dealing with the foot-and-mouth crisis, the winning of research contracts in Mauritania and the United Arab Emirates, and the launch of the digital geological map DiGMapGB-50K illustrate the diversity and quality of the Survey's activities.

But continued success cannot be taken for granted while the external awareness of the importance of the BGS's work is still limited. Why is it that so few people outside the immediate geological community are aware of the Survey's contribution to so many aspects of life? After all, geology ought to be a subject to which everyone can readily relate, since it deals with our everyday environment. Yet, whether it is the too ready use of jargon, the tendency of many geologists to see themselves as practitioners of a much narrower sub-discipline, or the inherent difficulty of explaining in print or words what is often best seen and explained in the field, the result too often seems to be a gulf between the geological sciences community and those who benefit from their work. Hopefully this report goes some way to bridging that gulf.

Finally, may I express my thanks to my predecessors John Mortimer and Eric Hassall for their advice and encouragement in taking on the role, to David Falvey and the other members of the BGS Board for their support, and to all the members of the BGS staff, for their patience, enthusiasm, and talent which have made the past year such great fun.

# The BGS Board during 2001/02

## Remit

As required in the Management Statement and Financial Memorandum agreed between the NERC and the BGS, the NERC has established the BGS Board to support the management and strategic direction of the Survey, taking into account the recommendations of the Executive Director, BGS. The Board was inaugurated in January 1998 with a remit to determine the overall objectives and to set the priorities for the whole BGS Programme. The Board meets five times a year.

## Board Members

| | |
|---|---|
| Mr J Mortimer | Chairman (Retired 12/01) |
| Dr G Robinson | Retired, former Director General of the Ordnance Survey (Chairman 01/02 –) |
| Dr D A Falvey | Executive Director, BGS |
| Dr O A Bavinton | Senior Vice President — Exploration, Anglo American plc |
| Dr M J Carter | Managing Director of M J Carter Associates |
| Professor A L Harris | Dean of Science Faculty, University of Liverpool (Retired 12/01) |
| Mr C M Read | NERC Finance & Information Systems Director (Retired 12/01) |
| Dr M Tricker | NERC Partnerships and Exploitation Policy Director (Joined 01/02) |
| Dr R A Scrutton FRSE | Reader in Marine and Applied Geophysics and Head of the Department of Geology and Geophysics, University of Edinburgh |
| Professor A Rogers | Former MP for Rhondda (Joined 01/02) |
| Professor P Styles | Head of School, School of Earth Sciences and Geography, Keele University (Joined 01/02) |
| Dr B R Marker | (Observer) Office of the Deputy Prime Minister |
| Mr J Smith | Managing Partner, Wardell Armstrong |
| Mr F G Curry | BGS Executive Committee Member |
| Dr C W A Browitt FRSE | BGS Executive Committee Member |
| Mr D C Holmes | BGS Executive Committee Member |
| Mr I Jackson | BGS Executive Committee Member |
| Dr M K Lee | BGS Executive Committee Member |
| Professor J A Plant CBE | BGS Executive Committee Member |

## Secretariat

Mr D K Talbot/Dr V L Hards of the BGS

## Membership

Board members are appointed by the NERC Chief Executive and approved by NERC Council. The membership includes between six and ten non-executive members and the members of the BGS Executive Committee. The non-executive members are appointed by reason of their qualifications and experience and represent a broad cross-section of the BGS's user community. They include senior representatives of industry, government agencies, and the academic community. Members may be appointed for up to four years in the first instance and may be reappointed for a further period of up to four years.

The BGS Board in July 2001. Back L to R: David Holmes, Geoff Robinson, Tony Harris, Ian Jackson, Colin Read, Owen Bavinton, Jeff Smith. Front L to R: Roger Scrutton, Marion Carter, David Falvey, John Mortimer, Jane Plant, Frank Curry and Chris Browitt.


BGS © NERC

# Director's introduction

BGS © NERC

David A Falvey, B.Sc., Ph.D., FGS, C.Geol.
*Executive Director*

The financial year ending in March 2002 has been a year of relative organisational stability for the BGS after the implementation of a new strategy and matrix management structure in 2000/01. It has been a year during which the BGS has built on its strengths and continued to develop both its strategic science and business.

One of the most significant national events of 2001 was the outbreak of foot-and-mouth disease (FMD). The BGS responded with the offer of its services to assist in the assessment of potential sites for the disposal of carcasses. We subsequently provided site-specific reports, detailing the potential risk to groundwaters to the relevant agencies and, on occasion, the Army, sometimes in a matter of hours. In short, BGS data and expertise proved invaluable during this national emergency. Although the FMD outbreak seriously affected the planned programme by restricting access to the countryside, staff effort was successfully redirected into office-based activities which resulted in completion of 18 Sheet Explanations, three Memoirs and 13 maps (at 1:50 000 or 1:25 000 scale), considerably more than in recent years.

Following last year's Programme Development Group report, monitoring and prioritisation of the BGS Onshore Survey programme is now informed by our clients through six Regional Advisory Panels. Dialogue with customers was also advanced through the Groundwater Forum and Advisory Groups, EA Research Coordination Group and the All-Party Parliamentary Group for Earth Sciences.

The importance of understanding the country's hydrogeology was highlighted by the FMD outbreak, and we have made many advances in this field. Our ongoing Baseline Project was redesigned to enhance its relevance to the Water Framework Directive, and the NERC Lowland Catchment Research project (LOCAR), designed to improve our understanding of the interactions between surface and groundwaters, saw the revision of geological mapping in three catchments. A new and radical approach for three-dimensional groundwater modelling that can incorporate methodologies from other scientific disciplines is also undergoing development using object-orientated modelling codes.

We have continued to build on our international reputation for geoscience/environmental information management and delivery, and this year has been marked by several noteworthy achievements. DiGMapGB-50 (the attributed 1:50 000 scale digital geological map for Great Britain), believed to be a world first, was launched at our stakeholders meeting in December 2001. In-house developments have allowed the relaunch of the BGS e-commerce site. The BGS also delivered an information web site, 'DEAL', for the petroleum industry. In the context of several commercial alternatives, DEAL has attracted several large contract extensions and won the AGI Public Sector GIS of the year award. The Information Management programme has also been subject to review by a Programme Development Group in order to ensure the maintenance of excellence in this field. Additionally, to take advantage of our best practice, the NERC Data Manager has been located at BGS Keyworth, and two senior managers are co-authors of IGGI best practice guides on Metadata Management, and Trading and Sharing Information.

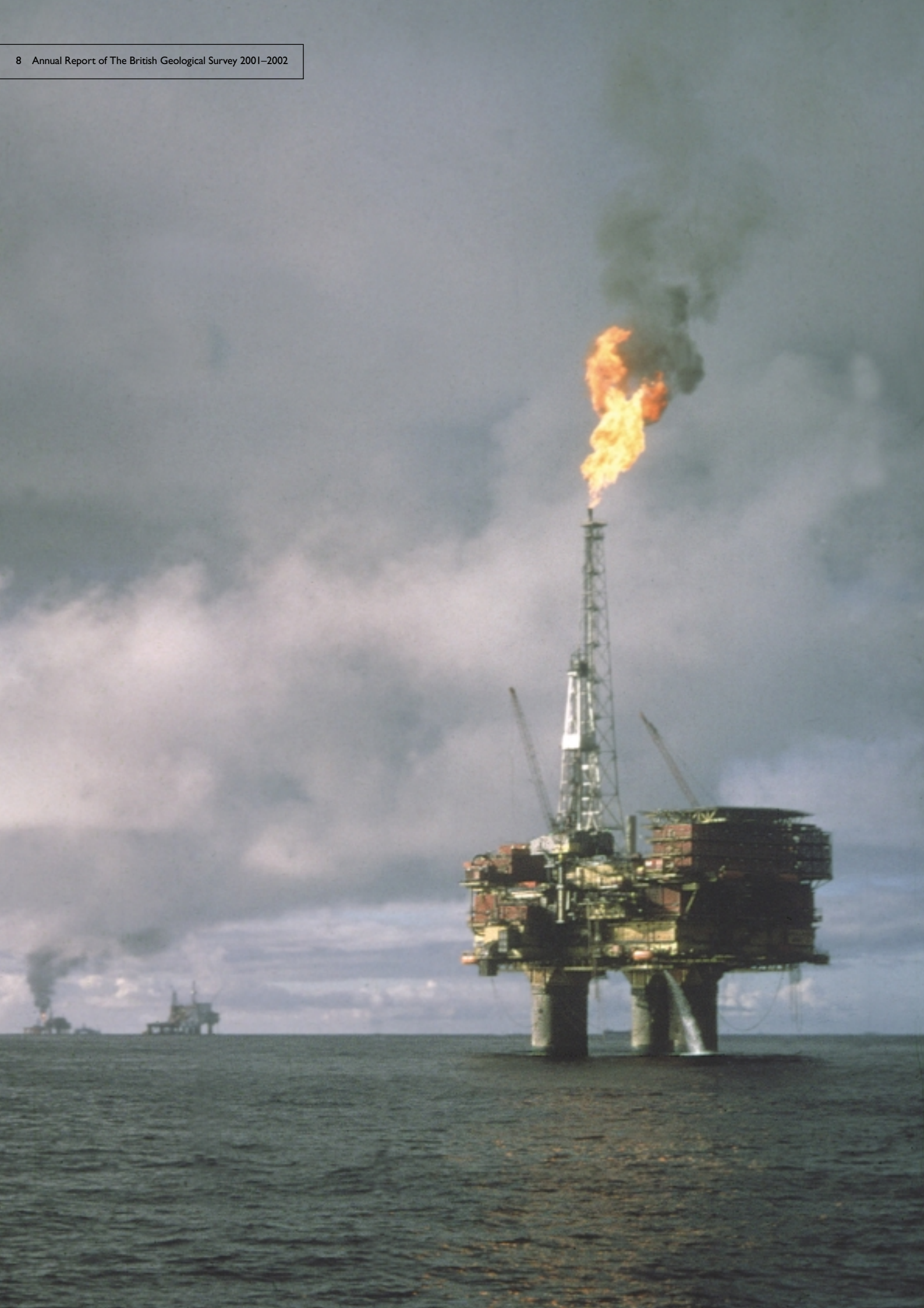
The BGS has also seen expansion of its overseas activities (entirely commissioned surveys and research) with the recognition by the development agencies that sustainable economic growth in many poorer countries can be underpinned by more effective use of their natural resources: minerals, hydrocarbons, and water. We currently operate in more than 60 countries and last year saw the extension of our traditional geographical areas to include francophone Africa and the Middle East.

Finally, a second successive recruitment exercise saw many high-quality new recruits added to the BGS's staff complement. During the year BGS staff have also held many high-level appointments in external committees or learned societies, such as the presidencies of the Institution of Mining and Metallurgy and the Mineralogical Society, and Managing Editorship of Geophysical Journal International.

I hope this introduction has given you a flavour of our achievements during 2001/02, and that you will agree that the BGS, the oldest geological survey in the world, has continued to deserve its reputation for excellence.

| | | | |
|---|---|---|---|
| **Executive Director** | | | |
| **Marketing, International and Corporate Development Directorate** | | | |
| BGS International® and Corporate Development | UK Business Sector Managers | Central Directorate Support | Press Office |
| **Environment and Hazards Directorate** | | | **Geoscience Resources and Facilities Directorate** |
| Coastal Geoscience and Global Change | Urban Geoscience and Geological Hazards | Groundwater Systems and Water Quality | Geochemistry, Mineralogy and Hydrogeology |
| Pollution and Waste Management and Extraction Industry Impacts | Earthquake and Forensic Seismology and Geomagnetism | | NERC Isotope Geosciences Laboratory |
| **Lands and Resources Directorate** | | | Geophysics and Marine Geoscience |
| Continental Shelf and Margins | Integrated Geoscience Surveys (Southern Britain) | Integrated Geoscience Surveys (Northern Britain) | Geology, Geotechnics and Palaeontology |
| Geological Survey of Northern Ireland | Economic Minerals and Geochemical Baseline | Sustainable Energy and Geophysical Surveys | Information Systems |
| **Information Services and Management Directorate** | | | Training and Career Management |
| Information Management | National Geoscience Information Service | Publications Production | |
| **Administration and Finance Directorate** | | | |
| Personnel and Administration | Facilities and Infrastructure | Finance, Accounts and Contracts | |

The BGS matrix scheme, separating the management of human and physical resources from the management of work programmes.



# Lands and Resources

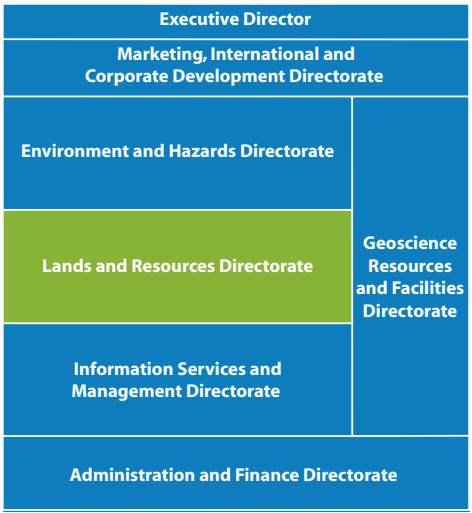
The **Lands and Resources Directorate** (LRD) operates through six multi-disciplinary programmes designed to define the surface and sub-surface geology, provide information on the distribution of energy and mineral resources, and carry out research on the sustainable utilisation of the land, sea bed, and natural resources. Work in the UK is supported by mixture of Science Budget funding, commissions from central, regional and local government, and industry-sponsored research consortia. The programmes also operate in Europe and worldwide through major international research projects and commissioned contracts. LRD projects directly underpin the work of the Environment and Hazards Directorate and generate many of the mainstream publications and digital products delivered through the Information Services and Management Directorate.

2001/02 was both exciting and frustrating in equal measure — the main frustration being the suspension of fieldwork in rural areas due to the outbreak of foot-and-mouth disease (FMD). The **Integrated Geoscience Survey** programmes were severely disrupted and only a limited field programme was possible in the spring of 2002. While this inevitably delayed many field-based projects, staff were redeployed on to other activities and output was maintained. In addition, the FMD outbreak graphically illustrated the value of the BGS's nationwide strategic survey activities, data archives and geological expertise by providing information vital in assessing the risk of pollution at proposed carcass burial sites. The **Sustainable Energy and Geophysical Surveys** programme saw rapidly increasing recognition of the role of underground carbon dioxide sequestration in slowing the build-up of greenhouse gases in the atmosphere. The team is building an international reputation in the field of sustainable energy and secured further external funding for its research during the year. The **Continental Shelf and Margins** programme saw the resumption of the offshore reconnaissance mapping of the UK Continental Shelf (the DTI funded programme ended in 1990 leaving just over half of the UK Designated Area unmapped). The offshore research consortia continued to enhance the Science Budget-funded programme and the Passive Margins Modelling Project was successfully completed, providing a new three-dimensional model and Geographical Information System over a 3000 kilometre segment of the north-east Atlantic margin. The **Economic Minerals and Geochemical Baseline** programme was also disrupted by the FMD outbreak with no geochemical sampling possible in rural areas. However, the opportunity was taken to upgrade the geochemical database for Scotland by reanalysing archived samples for additional elements. A major study was also completed for the (then) Department of Transport, Local Government and the Regions on sustainable mineral development in Dorset using newly-developed GIS-based methodologies. The **Geological Survey of Northern Ireland** continued to grow in response to demand for its expertise and was restructured to align its programmes more effectively with user sectors.

In addition to the six main programmes, two special projects were launched during the year to improve the effectiveness of onshore survey activities. **SIGMA (System for Integrated Geospatial Mapping)** will develop integrated digital survey methodologies and the **Quaternary Methodologies and Training** programme will develop new survey protocols and skills to provide better information on Quaternary deposits.

### Listening to you — Regional Advisory Panels

Monitoring and prioritising the onshore geological survey programme is now informed by you, the users of our data and knowledge, through six Regional Advisory Panels comprising representatives from industry, government, public bodies, and academia. Inaugural meetings were held around the country during 2001/02 in which the Panels' views were sought on the strategic role of the Integrated Geoscience Surveys (North and South) programmes, the priorities for project work during the coming year, and the long-term objectives. The first meetings were extremely valuable in identifying issues and defining priorities and we look forward to developing the Panels as a key link with our diverse user communities.




Lands and Resources Directorate. **Dr M K Lee.** *(0115 936 3356) mklee@bgs.ac.uk*

| | | |
|---|---|---|
| Continental Shelf and Margins<br>**Dr N G T Fannin**<br>*(0131 667 1000 ext 349)*<br>*ngtf@bgs.ac.uk* | Integrated Geoscience Surveys (Southern Britain)<br>**Mr P J Strange**<br>*(0115 936 3171)*<br>*pjst@bgs.ac.uk* | Integrated Geoscience Surveys (Northern Britain)<br>**Dr M Smith**<br>*(0131 667 1000 ext 285)*<br>*msmi@bgs.ac.uk* |
| Geological Survey of Northern Ireland<br>**Mr J W Arthurs** *(ret.)*<br>*(028 9066 6595)* | Economic Minerals and Geochemical baseline<br>**Dr M G Petterson**<br>*(0115 936 3493)*<br>*mgp@bgs.ac.uk* | Sustainable Energy and Geophysical Surveys<br>**Dr N J Riley**<br>*(0115 936 3312)*<br>*njr@bgs.ac.uk* |

## Lands and Resources

# Integrated Geoscience Surveys

### Programme overview

The Integrated Geoscience Surveys (Northern Britain) programme is responsible for providing up-to-date geological and rock mass data for northern England and Scotland. This information is delivered as printed maps and publications and, increasingly, as digital products. Strategic and commissioned geological surveys were halted during the year in response to the national foot-and-mouth disease emergency and restrictions on land access. Instead, effort focused on laboratory-based analysis and the acquisition and compilation of data resulting in the completion of 39 revised geological maps at various scales, one memoir, and two Sheet Explanations.

Chris Wardle, BGS © NERC

Groundwater nitrate vulnerable zones: proposed nitrate vulnerable zones of Scotland, developed by the BGS.

### Integrated approach for identifying groundwater nitrate vulnerable zones for Scotland

The Integrated Geoscience Surveys (Northern Britain) and Groundwater Systems and Water Quality programmes worked closely together to devise a methodology for identifying zones in Scotland where groundwater is vulnerable to agricultural nitrate contamination. The work was carried out to support the Scottish Executive in meeting its obligation under EU legislation to designate vulnerable zones in order to reduce and prevent further nitrate contamination. The nitrate vulnerable zones were identified on a Geographical Information System (GIS) using several data-sets. DiGMapGB 1:50 000 scale solid and superficial geology data were combined and interpreted, to give an indication of aquifer vulnerability, and linked to information on the risk of nitrate leaching provided by the Macaulay Institute. The final zones were then calculated by identifying local water catchments associated with areas of highest risk and vulnerability. To validate the nitrate vulnerable zones, information on nitrate concentrations in Scottish groundwaters was also collected and collated with existing data from the Scottish Environment Protection Agency's monitoring network, water authority boreholes, and private water supplies. These data reveal significant nitrate contamination in the vulnerable zones, but little contamination outside these areas. The nitrate vulnerable zones devised by the BGS were presented to the Scottish Executive for approval by the Scottish Parliament during the spring of 2002 and are available for public consultation.

### Stratigraphical framework for the Scottish Devonian

Completion of a new Devonian Stratigraphical Framework for Scotland south of a line between Aberdeen and Ben Nevis is the culmination of a three-year period of review by BGS geologists. Externally refereed by the Geological Society of London's Stratigraphy Commission, the report establishes the lithostratigraphical framework at Group, Formation, and Member level for the main outcrops of Devonian rocks in the Midland Valley of Scotland and outliers in the southern Highlands and Scottish Borders. In addition to detailed descriptions of lithology, definition of top and base, lateral relationships, thickness, type sections, origin of name, and palaeontological and radiometric age data, the report provides an outline palaeogeography for the Upper Silurian to Lower Devonian and Upper Devonian rocks. The BGS Lexicon of lithostratigraphical terms has been updated accordingly and is now available on the BGS web site. This framework is essential to enable geological mapping to modern standards and will underpin BGS and academic research on the tectono-stratigraphical history, sedimentology, palaeontology, and igneous petrology and will inform the ongoing Geological Conservation Review. A BGS lithostratigraphical framework for the Carboniferous rocks of the Midland Valley of Scotland (released in 1999) is also now available on the BGS web site.

### Public awareness of classic Scottish geology

BGS strategic mapping in the Assynt area of north-west Scotland, an area of classic geology, has secured financial support from BP to enhance the public understanding of the geological evolution of the Moine Thrust area. The area, one of outstanding natural landscape beauty, has an internationally acclaimed geological heritage and is visited by hundreds of geology students each year as part of their undergraduate or postgraduate training. A web site targeted

# Northern Britain

at the general public and schoolchildren is under development in collaboration with the University of Leeds; a Geological Guide book (with simplified geological map) for hillwalkers and contributions to a revised excursion guide to the Assynt area are in progress. Additional data pertinent to our understanding of the Assynt area, including satellite imagery, aerial photographs and historical geological maps, have been digitally captured and can be viewed and manipulated in GIS format. The GIS will contribute to the revision of the Assynt Special Sheet, capturing a century of academic BGS 'old' and 'new' survey mapping.

## Quaternary research across Scotland

The increasing recognition of the importance of the near surface (Quaternary) geology has led to new survey activity and research across much of Scotland. Quaternary studies in the Solway Firth area have led to new interpretation of the regional glacial history and ice-sheet movement. Micromorphological analysis of Quaternary thin sections has revealed data on the provenance of the glacial sediments and provided inferences on sub-glacial hydraulic conditions during glacial advance. Collaborative research with the University of Bochum/Ruhr and detailed mapping of Quaternary deposits and landforms has led to a major reinterpretation of the Loch Lomond Readvance in the Central Highlands. These new data suggest that the Gaick Plateau area, east of Drumochter Pass was not covered by a substantial plateau ice cap 11 000–10 000 years ago, instead a new pattern of deglaciation and westward retreat with evidence of former ice-dammed lakes is now favoured. However the timing of these events remains unclear and the application of new dating techniques including cosmogenic dating is being pursued. This work has direct relevance to understanding past climate change and also to identifying and evaluating sand and gravel resources across Scotland.

## Multidisciplinary surveys — northern England

Though dominated by restrictions imposed by the foot-and-mouth disease epidemic, the year also marked a turning point in the programme with completion of the last remaining work on the Lower Palaeozoic successions. New, high-precision, U–Pb zircon dates from the major Lower Palaeozoic volcanic and intrusive rocks in the Lake District have been obtained in a joint study with the NERC Isotope Geosciences Laboratory. The average of these results (*c.*452+0.9 Ma) shows that this major magmatic episode was confined within a very short period during Caradoc times. The diverse ostracod fauna from the Cautley district of northern England, which during Ashgill times lay on the flanks of the palaeocontinent of Avalonia, show strong similarities with those present in the Baltic region (palaeocontinental Baltica) and with America and Scotland (palaeocontinental Laurentia). The distribution patterns thus support models which show a close palaeogeographical proximity for the three continents in Ashgill times. Historical records from the Northern Pennine carbonate-hosted galena–fluorite orefield indicate levels of silver production which could not have been sustained from the silver-bearing galena recoverable today. This suggests that lead ores with much higher values of silver may have been formerly available. Investigations have continued into active fissuring in the Magnesian Limestone in County Durham in conjunction with the Urban Geoscience and Geological Hazards programme, and in collaboration with the universities of Durham, Newcastle, and Sunderland.

Stratigraphical framework: Upper Devonian 'Burnside' conglomerates and sandstones with basal breccia debris flow rest with unconformity on the Lower Devonian 'Scone' sandstone; now all part of a modern lithostratigraphical framework.

Fergus McTaggart, BGS © NERC

Quaternary research: Identification of till, containing rounded and transported clasts and angular debris from underlying strata, has informed the new regional understanding of glaciation in the Solway Firth.

Nick Golledge, BGS © NERC

## Lands and Resources

# Integrated Geoscience Surveys

### Programme overview

The Integrated Geoscience Surveys (Southern Britain) programme provides high-quality geological map coverage of southern Britain by undertaking a series of multidisciplinary survey and revision projects. The programme provides the geological framework for onshore England and Wales that underpins research and development activities undertaken in other BGS programmes. During the year, all rural field surveying activities were suspended due to the foot-and-mouth disease outbreak. Many geologists, who would otherwise have been undertaking field surveys, were involved in site assessments related to the foot-and- mouth epidemic. The programme was reprioritised to ensure some urban surveying took place and a significant number of publications were completed.

BGS © NERC

Geological survey of the 'English Riviera': Waterside Cove, Goodrington [SX 897 581]. A striking unconformity with the coarse basal beds of the Torbay Breccia Formation (Permian) resting on purple slates of the Meadfoot Group (Early Devonian).

### Responding to a national crisis: foot-and-mouth disease

Geological and hydrogeological information held by the BGS played a vital role during the foot-and-mouth disease outbreak in the UK. The BGS provided information and expertise to assist in the identification of suitable sites for burial and burning of carcasses. BGS data on the solid and drift geology and hydrogeology were collated from a variety of sources and reports prepared to indicate the risk of groundwater pollution from the proposed or extant disposal site. To ensure timely provision of reports within only a few hours, teams of BGS staff worked on 24-hour rotas across the regions and BGS offices. Requests for site reports came mainly from the Environment Agency and Scottish Environmental Protection Agency, but some requests came directly from the Ministry of Agriculture, Fisheries and Food and the Army. The work involved staff from BGS offices at Keyworth, Edinburgh, Wallingford, and Exeter. The BGS was able to provide site-specific written reports in a standard format by e-mail or fax within only a few hours. Good working contacts, including direct verbal communication between BGS geologists and hydrogeologists and the hard-pressed staff from environmental agencies, facilitated on-site selection within the very short time spans available. Strategic BGS data collections and knowledge of even the most remote of areas proved invaluable during this national emergency.

### Integrated geological survey of the York and Selby areas

New multidisciplinary methodologies in a Geographical Information System (GIS) environment are being developed to analyse diverse data-sets together with 3D air photo interpretations. The spatial data-sets include the existing BGS maps, detailed digital terrain models, and interpretations of soil mapping (licensed from Cranfield University, National Soil Resources Institute) together with BGS geochemical information interpreted by factor analysis. The borehole data held by the BGS have been digitised to provide information about surface and rockhead lithology, superficial deposit thickness, lithological domains, and rockhead elevation. The project also incorporates the borehole and seismic information from the Selby Coalfield and oil exploration. This method of combining a wide variety of data-sets has allowed field surveying to be undertaken in a very efficient, targeted, programme of work. The project is delivering digital 1:10 000 scale geological maps and thematic data, from which a 1:50 000 scale digital geological map tile and published map will be produced. The thematic digital data will be used for environmental studies — such as the modelling of flooding which has been exacerbated by recent coal mining subsidence — and land management practices, waste disposal, aquifer protection, water resource exploitation, and evaluation of construction and mineral resources.

### A new geological survey of the 'English Riviera'

The area around Torquay was one of the first parts of Britain to be surveyed by the fledgling Geological Survey between 1832 and 1835. At that time it was recognised to be of considerable scientific interest, not least for its part in the debate which led to the recognition of the Devonian system of strata, largely from the extensive and richly fossiliferous limestone outcrops. This interest has continued and, at the present day, no fewer than eleven geologically related Sites of Special Scientific Interest are listed in the Torbay area which remains an

# Southern Britain

important centre for geological teaching and research. The new geological survey at the scale of 1:10 000 provides much valuable information for planners, engineers, and builders with detailed data on superficial deposits and artificial ground, and considerably improved knowledge of the bedrock structures. It provides a good example of the relevance of detailed geological surveys to modern site investigation for construction and development projects.

## Revision surveys in the South Downs

This year has seen the completion of a revision of the Chalk stratigraphy and maps of the South Downs between Brighton and Eastbourne which has been undertaken in response to the demands of the hydrogeological community. Work has concentrated on the area east of the Sussex River Ouse towards Eastbourne and is co-funded by the Environment Agency (Southern Region). This area includes the famous Seven Sisters and Beachy Head coastal sections (areas of outstanding natural beauty) which together expose most of the Chalk sequence known in southern England. The integrated use of historical maps and other archival data, with additional material from modern workers in the field and the digital interpretation of large scale stereoscopic photographs has permitted the rapid reappraisal of over 440 square kilometres of ground. This work has seen the introduction of the new Chalk stratigraphy over the whole of the South Downs. It has also provided the key set of base-line data that is greatly enhancing the understanding of the hydrogeology of this major aquifer and forms the basis of modelling projects being completed within and external to the BGS. These downstream projects form a fundamental part of the management plans for water abstraction and environmental control that result from the implementation of European legislation.

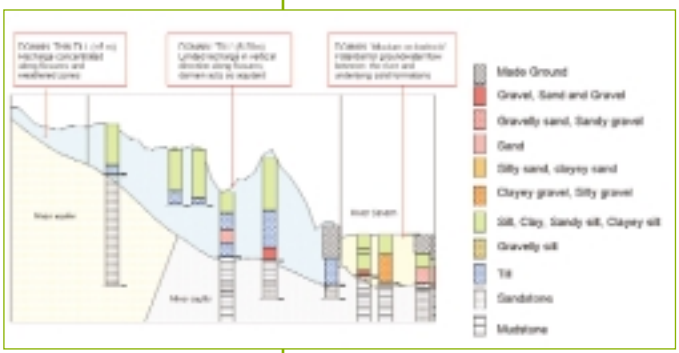
Revision surveys in the South Downs: Beachy Head from Cow Gap/Head Ledge. The vertical feature at the top of the cliffs is Devil's Chimney which collapsed spectacularly months after the photograph was taken, the second major collapse here within the past three years.

P M Hopson, BGS © NERC

## Geological characterisation of superficial deposits in east Shropshire

The Permo-Triassic sandstone aquifer system of east Shropshire is an important source of groundwater for public supply and agricultural use.
Precipitation recharge of the aquifer is affected by the distribution of glacial and post-glacial deposits which form a thick mantle to bedrock in parts of the district. During the past year, the BGS has been working in partnership with the Environment Agency to produce a geological and hydrogeological characterisation of these superficial deposits in two key abstraction areas: one bordering the River Severn upstream from Shrewsbury, the other in the Tern catchment.
Information on the three-dimensional variability of the deposits is being assessed using data from some 4000 boreholes and synthesised in digital form. The outputs, which include serial cross-sections, rockhead, drift thickness, and domain maps, will be incorporated by the Agency in a groundwater model of the aquifer system. This will be used operationally by the Agency to address issues related to groundwater resources licensing and should ensure the current and future sustainability of groundwater supplies in the county.

Geological characterisation of superficial deposits in east Shropshire: a hydrogeological cross-section showing rockhead and drift across part of the Severn Valley.



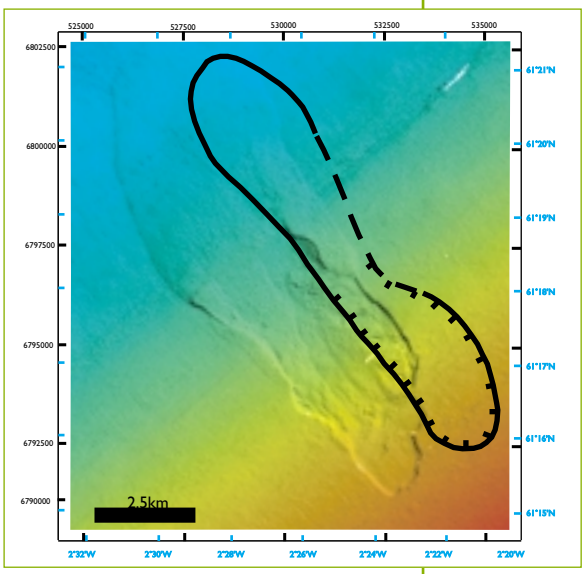

BGS © NERC

## Lands and Resources

# Continental Shelf and Margins

### Programme overview

The Continental Shelf and Margins programme is concerned with all aspects of geology offshore of the UK and the marine environment worldwide. Studies around the UK include investigations of crustal structure and the infill and tectonic history of the sedimentary basins, including hydrocarbon assessments of the petroleum provinces. Other studies are concerned with the Neogene development of the western margin, sediment dynamics and geohazards, environmental geology, and marine habitat investigations.




BGS © NERC

This sea-bed image, derived from 3D seismic first signal (sea bed) return, shows the outline of the AFEN slide, located 60 kilometres north-west of Shetland in 800 metres water depth. The slide measures 13 x 15 kilometres on a sea-bed slope of 1.5 degrees. A buried slide, about 50 metres below the sea bed, offset to the north-east, is also outlined on the image.

### Reconnaissance mapping programme

The Offshore Mapping Programme has restarted after a gap of ten years. A series of seven sheet areas are planned (at 1:500 000 scale) for the areas north of Shetland and in Hatton/Rockall. The first map, the Central Rockall Basin Solid sheet, has been published and new data are being collected in other sheet areas.

### Passive Margins Modelling Project

The Passive Margins Modelling Project has been successfully completed and delivered to the five sponsoring oil companies. It provides a new three-dimensional framework of the north-east Atlantic margin. Novel methods have been devised to build three-dimensional models of the crust and upper mantle over the whole region. These have been used to test assumptions about the isostatic state of the margin, and to integrate gravity modelling with seismic control to build a better picture of the architecture of the sedimentary basins and the underlying crust.

### Isle of Man

TotalFinaElf Exploration UK PLC in partnership with Enterprise Oil plc and Amerada Hess Limited (the TotalFinaElf/IoM Group), in collaboration with the Isle of Man (IoM) Government, sponsored the BGS to review the geology of the IoM territory. This provided the opportunity to bring together over 50 years of disparate work on and around the island by the BGS, several University groups, and the hydrocarbon industry, as well as supporting new data acquisition. A new 1:50 000 scale solid and drift geological map has been published along with a Regional Geological Report, and a popular booklet. Field data were integrated within a customised Geographical Information System (GIS) along with new biostratigraphical field observations.

### Environment and habitat mapping

In response to the forthcoming EU Habitat Directives, the DTI is undertaking a programme of strategic environmental assessments (SEAs) covering the UK Designated Area. The BGS has participated in studies in SEAs areas 1 (the Faerøe–Shetland Channel) and areas 2 and 3 (the North Sea) and is actively involved in planning work in area 4 (north and west of Scotland). The projects have included the collection of swath bathymetry and high-resolution seismic and sidescan sonar data along with sea-bed cores, samples and photographs. The BGS has also provided the GIS-organised database and archive curation for the geological samples.

### EU projects

Six EC-funded projects under the Fifth Framework are managed within the offshore programme. The results of the STRATAGEM[1] project, now in its final year, will be integrated into a unified stratigraphical atlas. The COSTA[2] project has contributed to a catalogue of historical submarine landslides and slope failures, an assessment of slope failure dynamics, and an investigation for evidence of gas hydrates and their impact on slope

stability. The EMIDOI[3] project has established an Internet-based portal providing a wide range of information for the decommissioning of offshore installations. The BGS is also collaborating with scientific organisations in the Caspian Sea region to develop an information system in the CASPSCIENCE-NET[4] project to provide an inventory of environmental data-sets for the region. The HYACINTH project addresses the development of laboratory techniques required to operate HYACE[5] equipment to collect gas hydrate cores at *in situ* temperatures and pressures. The Joint European Ocean Drilling Initiative (JEODI[6]) aims to bring a distinctive European component to the ocean drilling programme (IODP).

[1]www.stratagem-europe.org
[2]www.costa-europe.org
[3]www.decomplatform.com
[4]www.caspinfo.net
[5]www.tu-berlin.de/fb10/MAT/hyace/status/hyacestatus.htm
[6]www.jeodi.org/

## Marine operations

The Bridge Drill (a remote rotary rockdrill) successfully recovered high quality oriented (scribed) cores from water depths of 4600 metres on the Mid-Atlantic Ridge. This is believed to be the deepest water coring ever achieved using a remote rotary drill. The BGS five-metre rockdrill/vibrocorer (now being operated in water depths greater than 2000 metres) was used in the BGS Rockall programme and off the Antarctic Peninsula, for the British Antarctic Survey. The BGS wireline drilling equipment was also used to provide specialist coring on the Ormen Lange field off Norway, where there are top-hole safety concerns. BGS operations staff drilled and cored a borehole over 480 metres in depth and designed an approved 'in-string' blow-out preventer. The BGS specialist drilling equipment has now been operated in water depths in excess of 1650 metres with sub-seabed penetration of almost half a kilometre in a wide variety of environments in 'difficult' drilling conditions.

## Rockall Consortium

The Rockall Consortium (comprising the BGS, the DTI, and ten oil companies) carried out a series of projects synthesising the work of the past decade. These include:

- A regional analysis of the circum-North Atlantic pre-rift geology providing evidence of the scale, structure, and development of recently recognised pre-Cainozoic sedimentary basins beneath Hatton Bank. It also provides vital evidence of the possibility that hydrocarbons may be present in the area.
- An integrated interpretation of several seismic surveys with a comprehensive GIS and a digital library of reports has been prepared as a three-volume CD-ROM.
- The Consortium has also contributed to the collection and analysis of more than 60 short sea-bed rock and sediment cores in the Hebrides–Rockall area and has funded a post-doctoral Research Assistant at the NERC Isotope Geoscience Laboratory for two years. Petrological, geochemical, isotopic characterisation, and dating studies of the metamorphic basement are under way.

Rockall Consortium: part of a 4.4 metre long core of Cainozoic, carbonate-cemented volcanic agglomerate overlain by a thin chalk layer that was recovered from 963 metres water depth on an outcrop of the Sandastre volcanic centre in the Hatton/Rockall Basin approximately 250 miles west of St Kilda.

BGS © NERC

Marine operations: the BGS oriented rock drill recovered oriented cores of basalt from the Kane Fracture Zone on the Mid-Atlantic Ridge in 4000 metres water depth.

Nigel Fannin, BGS © NERC

## Lands and Resources

# Economic Minerals and Geochemical

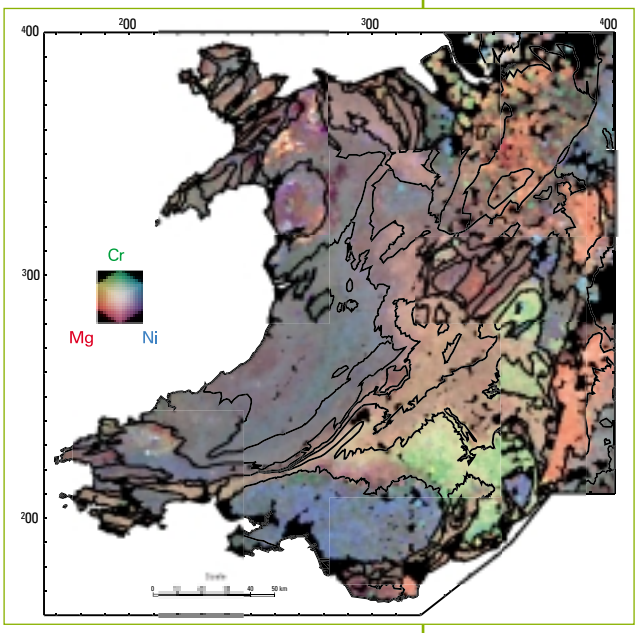
### Programme overview

The Economic Minerals and Geochemical Baseline programme (EMGB) develops products and services aimed at increasing our knowledge of natural and anthropogenic environmental geochemistry and the onshore metallic, non-metallic, industrial and solid coal mineral resources both of the UK and internationally. The EMGB programme comprises a portfolio of projects funded by UK government departments, international agencies and the BGS Science Budget. EMGB is an applied scientific programme which applies the BGS's science base to solve key strategic problems for a wide range of customers.

### Sustainable Mineral Development in Dorset

How do we ensure that essential minerals are available to support the economy without degrading our environment or quality of life? Resolving this issue by encouraging the sustainable management of Britain's mineral resources is one of today's challenges. The problem occurs nationwide and, for minerals that are relatively widespread, there may be a broad range of options. However, if the mineral is scarce and geographically restricted, the options may be more limited. If the same area is also subject to extensive environmental designations it may be very difficult to identify acceptable sites for mineral extraction. These issues are particularly acute in the Wareham Basin of Dorset. Because of its attractive scenery and rich variety of habitats, the area has extensive landscape and nature-conservation designations. It has also important mineral resources, including ball clay, sand and gravel, and hydrocarbons. Britain is a leading world producer and exporter of ball clay — a clay used in the manufacture of high quality ceramics — and Dorset accounts for 20% of national output. The BGS has recently completed a basin-wide, multidisciplinary strategic survey* on behalf of the Department for Transport, Local Government and the Regions. It provides comprehensive and impartial information on the distribution and quality of the mineral resources of the Wareham Basin, and their spatial relationship to environmental designations. The study will assist sustainable resource management, planning and policy development in the Basin.

** Sustainable development issues for mineral extraction in the Wareham Basin, east Dorset. BGS Commissioned Report CR/01/137N.*




BGS © NERC

G-BASE: a map from the geochemical baseline survey of Wales showing the stream sediment results for magnesium, chromium, and nickel as a coloured three-component image.

### Geochemical Baseline Survey of the UK (G-BASE)

G-BASE is a systematic survey to establish a geochemical baseline across the UK. The overall objective is to support UK environmental sustainability and development as defined under Agenda 21 at the UN 'Earth Summit' in Rio in 1992. The strategy is to provide the user community with an accessible, well-documented, and quality-controlled geochemical database of the UK surface environment. This is achieved by the collection of data at a high spatial resolution (approximately one sample per 1.5 square kilometres) using a variety of sample media (soil, water, panned concentrates, and stream sediment). Progress on systematic sampling was halted in 2001 by the outbreak of foot-and-mouth disease and all fieldwork was postponed until 2002. However, this provided an opportunity to upgrade the geochemical database for Scotland by reanalysing some 12 000 stream sediment samples from the Northern Highlands for elements not previously determined when the samples were collected in the 1970s. Work also commenced on compiling the geochemical atlas of the Humber–Trent area. A new atlas — *Regional geochemistry of Wales and part of west-central England: stream sediments and soils* — was published as a companion volume to the previous atlas of the same area based on stream waters.

# Baseline

## Platinum in Scotland

Platinum is only one of a series of 'platinum-group elements' (or PGEs) forming a group of six precious metals (also including palladium) that have many important industrial applications, notably as key components in catalytic converters in car exhaust systems. PGE deposits are rare and production is dominated by South Africa and Russia. Increased demand and concern over the security of supply resulted in considerable new exploration and research activity worldwide in recent years. New BGS research has been carried out at selected localities in Scotland where PGEs have previously been recorded, principally in Shetland, the East Grampians, and in the Assynt district of north-west Scotland. Studies of the Caledonian alkaline syenite–pyroxenite intrusions in north-west Scotland have identified PGE enrichment of low-temperature origin in the Loch Borralan complex in Sutherland. Normally, PGEs are concentrated by high-temperature magmatic processes, so this new finding not only helps to improve our understanding of how PGE deposits are formed, but also opens up potentially new sources of these rare metals.

The rugged terrain of the Assynt district, Sutherland, north-west Scotland is host to deposits of low-temperature platinum and related elements.

BGS © NERC

## Building sustainability: planning for the supply of brick clay

Brick is an important building material and is one of the most visible components of the built environment in our towns and cities. A number of critical issues face those involved in planning for the future supply of the clay for the manufacture of bricks and other clay-based products such as roof tiles and drainage pipes. The Department for Transport, Local Government and the Regions commissioned the BGS to carry out research into planning issues related to the supply of clay raw materials to the brick industry in mainland Britain. The research team has worked closely with the brick industry, local planners, and other stakeholders to identify key trends affecting the industry. Analysis of these trends and their effect on supply and demand for brick clay has resulted in recommendations being made for a number of changes to the planning process for brick clay supply. The recommendations, together with supporting evidence, were published in October 2001 and presented at a well-attended stakeholder workshop held in Stoke-on-Trent in November 2001. The main aim of these recommendations is to provide the brick industry with a sustainable supply of raw materials at the least cost to the environment.

An urban landscape in brick, Nottingham. A sustainable supply of a variety of brick clays is necessary to maintain and enhance the quality of our built environment.

Tim Cullen, BGS © NERC

## Arsenic in UK soils and the new intervention values

Trace metals and metalloid elements such as arsenic occur naturally in all soils, typically at low concentrations. Guidance has recently been published by the UK government on the assessment of risks to human health from land contamination, including soil guideline values (SGVs) for a range of inorganic contaminants. The SGV for residential areas and allotments for arsenic is 20 milligrams per kilogram. As part of its G-BASE project in the UK, the BGS collects and analyses soils for their chemical composition, including arsenic. Appreciation of the typical concentrations of a range of potentially harmful compounds in soils that develop over different parent material types is useful, as it puts into context the results of site-specific investigations. A regional survey comprising 6400 topsoil samples in rural areas in north-east England was completed recently, at an average density of one sample per two square kilometres. Natural arsenic concentrations above the SGV are common throughout the region, occurring at around 20% of sites. This does not imply that soils in these areas pose a significant risk to human health, but indicates where risk assessments may be required.

## Lands and Resources

# Sustainable Energy and Geophysical

### Programme overview

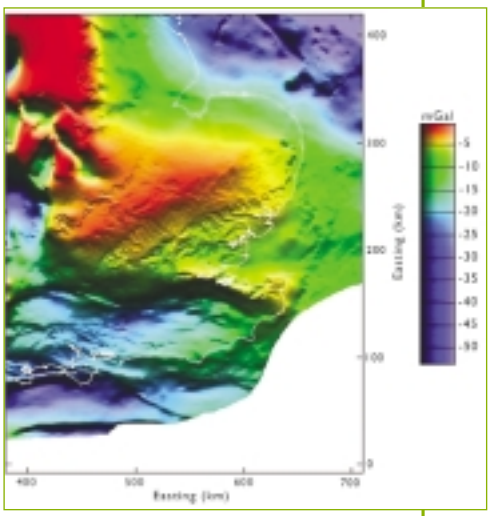
Low carbon energy technologies, including underground carbon dioxide and hydrogen storage, and geothermal energy, are key goals of the Sustainable Energy and Geophysical Surveys programme. Enhancing energy security through improved exploration and extraction capabilities is also a priority. The programme is responsible for improving understanding of the UK's subsurface geology to sustain energy-related activities, and to underpin other BGS operations.

### Reservoir characterisation, storage and production

This project develops and supports the BGS capability in reservoir geology. A variety of studies are being undertaken, ranging from gaining more understanding of fluid flow in fracture reservoirs (including university collaboration supporting two NERC Micro-to-Macro projects and a BCURA project on carbon dioxide interactions with coal) to geochemical experiments on fluid–rock interactions. The UK's increasing dependency on imported fuels in the medium term, particularly gas, will require a better knowledge of UK gas storage options and these are being investigated. The need to develop a better understanding of reservoir architecture, diagenesis, and seal continuity in field appraisal is being addressed through refining high-resolution stratigraphical, geochemical, and petrographical techniques.

### Regional subsurface structure of the UK

This project includes a series of tasks with an overall long-term rationale of mapping, analysis, synthesis, and modelling of the subsurface geology of the UK and its geophysical expression. It is progressively leading to a thorough understanding of the structure and stratigraphy of the UK in three dimensions by the cross-disciplinary integration of diverse data-sets via the Digital Geoscience Spatial Model (DGSM). The Subsurface Memoir series forms part of this project and includes subsurface structural and isopach maps, structural cross sections and models, together with regional descriptions of subsurface geology. The latest memoir, of the Cheshire–Staffordshire area, is now approaching final draft stage, with many new insights into the sub-Permian structure and stratigraphy. Work for the latest of the Geophysical CD series of south and east Britain, another task in this project, is now nearly complete and a start has been made on south-west England and Wales. This series presents displays and analysis of geophysical signatures in terms of crustal structure on a more regional scale (four will cover the entire UK onshore area). The Atlas of Subsurface Structures, a publication describing the subsurface form and evolution of well-known surface structures as revealed by seismic data onshore UK, is also at final draft stage.




Regional subsurface structure of the UK: calculated gravity anomaly due to the Mesozoic cover sequence in south and east Britain.

### High-Resolution Resource and Environment Survey (HiRES)

This project is developing low-altitude airborne geophysical applications. Fieldwork confirms the presence of both electrical conductivity and gamma radiation anomalies detected during recent airborne geophysical surveys. Ground conductivity traverses combined with electrical soundings made in the vicinity of landscaped colliery spoil heaps in north Nottinghamshire confirm the airborne electromagnetic indications of highly conductive fluids extending to depths in excess of 50 metres, thus penetrating well into the important Permo-Triassic sandstone aquifer. The high conductivities probably reflect dissolved salts leached out of the spoil by percolating rainwater. The airborne electromagnetic data also indicate a subtle increase in background conductivities between areas of ancient woodland cover and agricultural land to which fertilisers have been applied. Elsewhere, landscaped landfill sites have been detected as relatively conductive features by both airborne and ground measurements. Colliery spoil heaps in north Nottinghamshire are also shown by airborne radiometric data to be high in all three

# Surveys

radioelements: potassium, uranium, and thorium. It is clear that the HiRES data enjoy a very broad spectrum of applications and we continue to seek funding in support of further systematic airborne geophysical surveys.

## Underground carbon dioxide storage projects

Five carbon dioxide projects co-funded by the BGS, the DTI, the EU, and oil companies continue to develop this important area, which holds great promise for dealing with carbon dioxide emissions from fossil fuel use. A third of UK emissions could be prevented if fossil-fuelled electricity generating plant had its carbon dioxide captured and stored underground. Significant progress has been made on a number of fronts. Carbon dioxide is an excellent gas for enhancing oil recovery, with underground storage of the gas being an important by-product. The BGS, along with international teams is monitoring baseline conditions for an enhanced oil recovery operation which uses carbon dioxide to release oil that otherwise would be left in the ground. We are also involved with Statoil and partners in developing monitoring technologies for gas storage operations at Sleipner (East of the Shetlands), which isolate from the atmosphere one million tonnes of carbon dioxide from gas clean-up operations at the production platform. Detailed mapping of potential target structures and reservoir intervals for carbon dioxide storage under the UK Economic Zone is progressing well and giving a clearer picture of storage volumes. Storing carbon dioxide in dedicated underground reservoirs has the largest potential, with hundreds of years of capacity available under the North Sea. The BGS-led Nascent project is gaining understanding about natural occurrences of carbon dioxide in the subsurface, and the way in which this gas interacts with the geological environment. Such research provides a unique insight into the long-term fate of carbon dioxide in the subsurface.

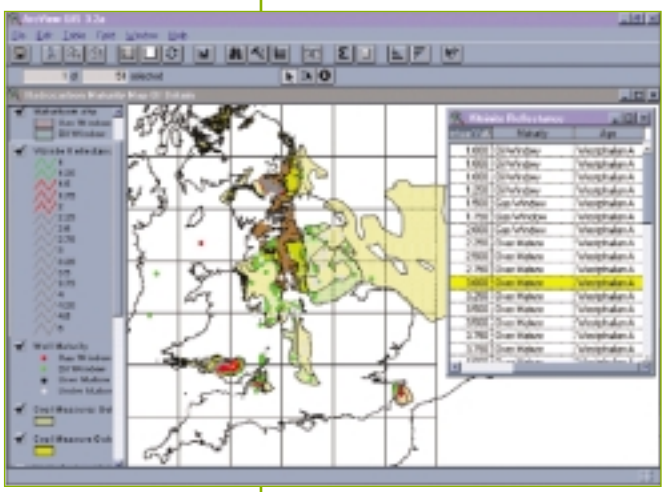
Underground carbon dioxide storage: natural carbon-dioxide-rich groundwater discharging from a borehole into a channel used for irrigating maize in Greece.

Nick Riley, BGS © NERC

## Onshore hydrocarbons and coal resources

This project's role is to improve regional knowledge of the UK's onshore hydrocarbon resource through populating and manipulating digital databases. Three Caledonian (Acadian) unconformity maps, representing hydrocarbon economic basement, have been completed, at 1:1 million scale. These maps show that, within the Variscides, there is no evidence of an unconformity at this level (base Middle Devonian). Hydrocarbon maturity maps are being generated from the database. Oil and gas windows are being delimited on data combined from different indices. Progress is being made on various hydrocarbon and coal databases which will underpin future BGS work and satisfy commercial enquiries. In particular, the 'hydrocarbon shows database' records oil and gas indications and drill-stem tests on all available onshore boreholes by depth, geological formation, or group. The database includes test results, production figures and other information. A colliery and shaft database tied to individual coalfield stratigraphies and downhole formations and using BGS Lexicon codes for coals, marine bands, and sandstones is also being populated.

Onshore hydrocarbons and coal resources: Geographical Information System output for Westphalian source rock maturity values onshore UK and adjacent offshore.



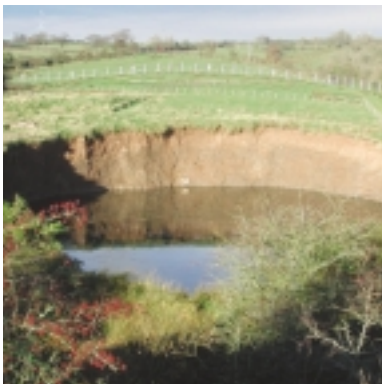
Nigel Smith, BGS © NERC

## Lands and Resources

# Geological Survey of Northern Ireland

### Northern Ireland

The Geological Survey of Northern Ireland (GSNI) is an office of the Department of Enterprise Trade and Investment (DETI). It is staffed by BGS scientists under an agency agreement which allows the GSNI to draw on expertise in other parts of the BGS. The GSNI also carries out work for other Northern Ireland departments and collaborates closely with the Geological Survey of Ireland (based in Dublin) on cross-border projects.



GSNI © Crown Copyright 2002

Collapse of the abandoned Maidenmount salt mine, County Antrim, in August 2001.
Reproduced with the permission of the Director, GSNI.

### Minerals and energy resources

Mineral and petroleum rights in Northern Ireland are vested in the Department of Enterprise Trade and Investment. The GSNI maintained and developed its advisory role for the Department in monitoring licensed minerals and hydrocarbons exploration, maintaining databases on minerals and quarries statistics, and assisting with the promotion of commercial investment in the Province's minerals and hydrocarbons heritage. Current exploration includes gold and base metals in the Sperrin Mountains and in the 19th century lead mining district in south Armagh, evaporites and base metals in the Clogher Valley, County Fermanagh, and four new gas exploration wells in south Fermanagh. Ballymoney Power Ltd carried out extensive drilling operations in north County Antrim and indicated its intention to apply in the coming year for a lease to mine the Ballymoney lignite deposit.

| | Current licences | | Relinquished in the year | | Applied for in the year | |
|---|---|---|---|---|---|---|
| | Number | Total area km$^2$ | Number | Total area km$^2$ | Number | Total area km$^2$ |
| Hydrocarbons | 8 | 2800 | 1 | 350 | 1 | 350 |
| Minerals | 10 | 1093 | 1 | 244 | 0 | 0 |

The quarry statistics database was revised and expanded. The Planning Service commissioned a pilot study on mapping sand and gravel in the Limavady District, locating current and past commercial sources and including statutory designations and planning zones, in a Geographical Information System (GIS) format.

### Environment

The GSNI continued to provide advice and technical assistance to the DETI Abandoned Mines Committee and monitored subsidence in the Carrickfergus salt mining field, County Antrim. A major collapse occurred at the abandoned Maidenmount salt mine on 19 August 2001, forming a crater 50 metres wide and 15 metres deep that is still expanding. The inspection and survey of mines elsewhere in Northern Ireland continued, as did databasing of other abandoned mines records. An Earth Science Conservation Review report, *Structural Geology of Northern Ireland* was completed for the Environment and Heritage Service. The GSNI continued as a statutory consultee to the Planning Service and made significant inputs to regional planning and policy documents, as well as consulting on an increasing number of planning applications.

### Hydrogeology

The hydrogeology function in the GSNI is currently wholly funded by the Environment and Heritage Service (EHS) which is an agency service within the Northern Ireland Department of the Environment. Provision of hydrogeological expertise on a wide range of groundwater resource and quality issues was continued throughout the year with support from the BGS Groundwater Systems and Water Quality team. In particular, essential advice for policy support was given to EHS relating to agricultural nitrates in groundwater in Northern Ireland (required for a submission to the European Commission), abstraction regulation and monitoring, and through hydrogeological site reports for the Office of the First Minister's Foot-

and-Mouth Disease Committee. The EC Water Framework Directive, implemented in December 2000, presents each member state with significant challenges and opportunities relating to sustainable management and protection of the water environment. The GSNI is assisting EHS with interpretation of the directive as it applies to Northern Ireland and with planning for meeting its requirements. Through this work, links have been strengthened with groundwater experts elsewhere in the UK and in Ireland.

## Landscape heritage and public awareness of science

The completion of the cross-border project, 'Landscapes from Stone', was marked by a celebration at Parliament Buildings, Stormont, hosted jointly by the Northern Ireland Minister for Enterprise, Trade and Investment and the Irish Minister for Public Enterprise. The project was a joint venture between the GSNI and the Geological Survey of Ireland, and was funded by the European Union and local authorities. It produced a series of non-specialist guides and booklets promoting public awareness of Earth science and niche-market tourism in the northern twelve counties of Ireland. The Environment and Heritage Service commissioned a series of reports to identify and describe sites of local nature conservation throughout Northern Ireland. The GSNI also continued its role in public awareness of Earth science by giving media interviews and lectures to local interest groups.

## Mapping and publications

The 1:50 000 scale geological map of the Ballymena area (Sheet 20), which includes additional marginal material, was published in October 2001. The 1:50 000 scale geological map of the Ballycastle area (Sheet 8) was revised and prepared for publication early in the next financial year. Mapping of the Dungiven (Sheet 18) and Maghera (Sheet 19) areas was completed. GSNI geologists were trained to use ERDAS® software for digital photogeological interpretation on a new PC workstation. This will assist in the completion of the mapping of the Killeter (Sheet 24) and Newtownstewart (Sheet 25) areas and of the remainder of Northern Ireland. A paper revising the age of Devonian rocks in the Fintona area was published externally. A joint project between BGS staff in GSNI and in Edinburgh investigated the geochemistry of the Dalradian Green Beds and showed them to be of significance for stratigraphical correlation.

## Information systems and databases

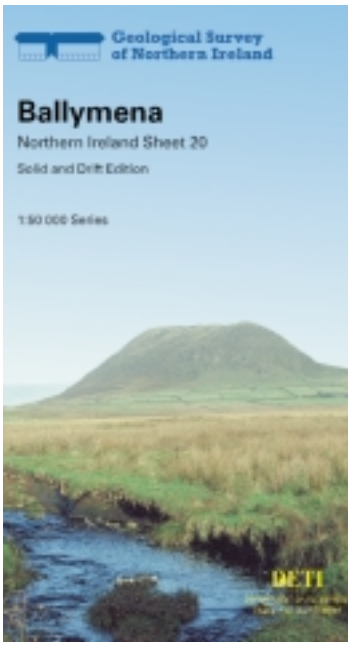
The GSNI continued to develop its capacity to manage information in a digital environment. Work continued on coding for the abandoned mines, site reports, and boreholes databases. Eight maps at 1:50 000 scale were digitally captured for the DiGMapNI project. The GSNI uses GIS software to integrate a wide range of digital data for internal and external business use. During the year the GIS was enhanced by the inclusion of additional data-sets from internal sources and topographical and environmental data acquired under licence from external bodies. The GSNI Public Information Service answered a total of 557 enquiries for information and advice, an increase for the fifth year in succession. The main clients are civil and environmental engineering companies and other government departments, including Planning Service, Roads Service, and Construction Service.

### GSNI evaluation

In response to increased demand, the staff compliment of the Survey has now grown to sixteen. In April 2001 the GSNI was restructured to enable it to develop its focus on local issues and further enhance its service to the Department and to the community as a whole. As part of the five-yearly cycle of Northern Ireland government policy reviews, an evaluation of the GSNI was completed at the end of the year. The study entailed a customer survey which returned very high satisfaction ratings and the report concluded that the GSNI provides an essential service.

Solid & Drift geological map of Ballymena (Northern Ireland 1:50 000 series, Sheet 20). The cover photo is of Slemish Mountain.

Reproduced with the permission of the Director, GSNI; photograph © Environment and Heritage Service, Department of the Environment.




GSNI © Crown Copyright 2002

# Environment and Hazards

The **Environment and Hazards Directorate** operates through five programmes to deliver information on the ways in which geoscience impacts on humans and their environment. A new sub-programme, the **Electrical Tomography Service,** was created near the end of the financial year to exploit the near-surface monitoring, imaging, and technological developments of this important geophysical technique. We aim to understand the science of the many physical and chemical processes that interact to influence the landscape, how and where they occur, and the consequences to people as they go about their business.

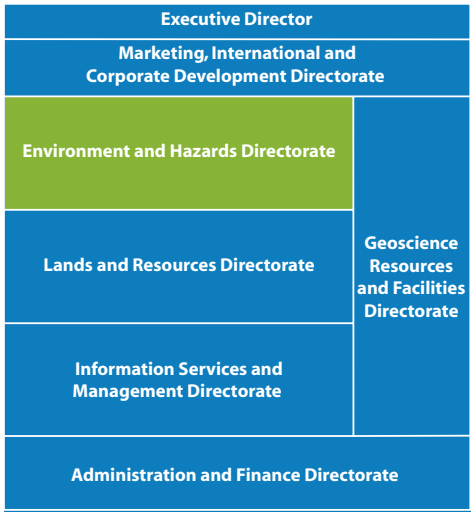
The **Groundwater Systems and Water Quality** programme produces high-quality research on processes and information relating to both groundwater quality and resources. A multidisciplinary approach dramatically increases our understanding of how aquifer systems work and how they interact with surface water bodies. This information aids better sustainable management of finite water resources.

The **Earthquake and Forensic Seismology and Geomagnetism** programme continues to monitor seismic events and geomagnetism efficiently and effectively. It is also progressing research into fracture anisotropy and fluid content that is exploited by the hydrocarbons and water industries. Industry consortia continue to grow, helping to ensure the quality and relevance of the science and services provided. Detailed geomagnetic information is increasingly used by directional drilling practitioners.

The **Urban Geoscience and Geological Hazards** programme is using protocols established last year to collect, collate, and establish risks associated with the hazards of living in cities. The frequency of landslides, floods, and collapses remains high. Urban studies have shown the value of bringing geologists, engineers, remote sensors, geochemists, and modellers together with planners and developers to improve safe land utilisation.

The second year of the **Pollution and Waste Management and Extractive Industries Impacts** programme has resulted in the development of a wide variety of activities in the areas of geochemistry, mineralogy, geophysics, and hydrogeology. A major achievement is the production of an experimental data-set for gas migration in clays that has been used to validate modelled novel processes. Advanced statistical techniques have related transport properties of clays to simple index measurements.

The **Coastal Geoscience and Global Change Impacts** programme aims to understand past and present patterns of erosion, transport, and storage of sediments (and associated materials including pollutants) in order to predict and better manage future change. Work on climate change is showing the importance of methane hydrates to the Earth's carbon balance. Hydrates have been created, stored, and released experimentally in sediments to determine how they react in natural environments.

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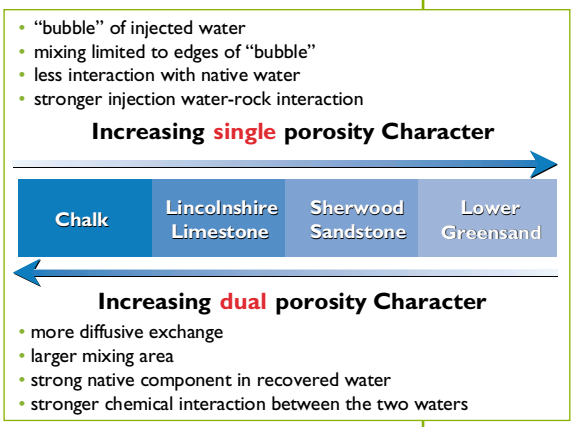
## Environment and Hazards

# Groundwater Systems & Water Quality

### Programme overview

This programme is built around Core Strategic Programme activities and has been defined in consultation with a wide variety of UK and international organisations, including the Environment Agency, UKWIR, English Nature, Water Companies, and the Centre for Ecology and Hydrology (CEH), as well as the academic community. Overseas, we work with DFID, WaterAid, Oxfam, Save the Children Fund, and other NGOs involved in international development, as well as international development banks. The BGS is a WHO Collaborating Centre and a UNEP GEMS Collaborating Centre. The Groundwater Systems and Water Quality Programme comprises around eighty projects split equally between UK commissioned research, international commissioned research and science budget/co-funded research.




Chris Wardle, BGS © NERC

ASR-UK: the response of aquifers to water storage and recovery varies in a predictable manner that is controlled by the proportion of fracture and matrix porosity.

### Water Framework Directive characterisation methodology

The EU Water Framework Directive (WFD), which came into force in December 2000, is the most significant single piece of new European water legislation for many years. The directive expands the scope of water protection to all waters — surface waters and groundwater — with the aim of achieving 'good status' by 2015. Assessments and management of water bodies will be carried out on a River Basin District (RBD) basis and at the heart of the directive is the requirement to produce a strategic management plan for each RBD, setting out how the WFD objectives will be achieved. For groundwaters, a vital precursor to the management plan is the characterisation of all bodies of groundwater by December 2004 to assess their uses and the extent to which they are at risk of failing to meet the environmental objectives of the Directive. The BGS and the Environment Agency have jointly undertaken a project to produce a methodology for the delineation and characterisation of groundwater bodies. The work has involved careful interpretation of the requirements of the WFD and the development of a methodology which follows both the letter and spirit of the directive, while being pragmatic and practicable in the prescribed WFD timescale. It is intended that the methodology will be subjected to trials in late 2002.

### LOCAR Infrastructure Installation

The NERC Lowland Catchment Reserch (LOCAR) Thematic Programme is designed to improve understanding of the hydrological cycle at the catchment scale. LOCAR focuses on the Pang Lambourn and the Frome/Piddle catchments on the Chalk and the Tern catchment on the Permo-Triassic sandstone. The BGS and CEH are responsible for the technical and scientific aspects of the installation of infrastructure. Revision geological mapping has almost been completed and a drilling programme of over 70 boreholes has commenced. The whole hydrogeological infrastructure installation programme is planned to be completed by late autumn 2002. Detailed logging of boreholes and sampling of drill cores has been carried out and boreholes are being equipped with digital logging devices to monitor groundwater heads — often at several different depths. Facilities will exist for collection of groundwater samples for chemical analysis at a number of sites. Several sites consist of a number of boreholes providing integrated facilities to permit research into such topics as groundwater–surface water interaction, the functioning of a wetland, transport within the saturated and unsaturated zones, and the impact of surface flooding on groundwater recharge.

### ASR-UK

Aquifer Storage and Recovery (ASR) is a technique for storing potable water in aquifers during times of surplus for recovery and use in times of high demand. It is one of the few environmentally sustainable options available to water companies in the United Kingdom, particularly south-east England. Uncertainties relating to the hydraulic properties of aquifers and geochemical interactions were modelled and tools were developed to guide future investigations. The three-year (1998–2001) project was co-funded by a Foresight LINK award and United Kingdom Water Industry Research Ltd (UKWIR).

## Object-oriented groundwater model code development

The object-oriented groundwater model code project is an exciting venture which aims to change the face of groundwater modelling both in the United Kingdom and internationally. The aim is to apply object-oriented techniques to the development of a regional groundwater model. The project is undertaken as a collaboration between the University of Birmingham, the Environment Agency, and the BGS. Building on the work undertaken at the University of Birmingham, the groundwater model has been further developed at the BGS. The main thrust of the project has been to create a regional groundwater modelling code that has the same functionality as the ubiquitous MODFLOW.

## Sustainable management of the West Bank and Gaza aquifers

The UK's Department for International Development (DFID) is supporting a major Technical Assistance project entitled 'Sustainable management of the West Bank and Gaza aquifers' (SUSMAQ). Work began in 1999 with a partnership between the Palestinian Water Authority (PWA), Newcastle University, and the BGS. The overall aim of the project is to build technical and social science capacity within PWA for the management of scarce water resources in Palestine. The BGS is providing assistance with recharge modelling and hydrogeological mapping and leads the socio-economic study. The project is multidisciplinary, bringing together hydrogeologists and groundwater modellers with economists and policy/institutional experts. In this way, greater hydrogeological understanding can inform, and be informed by, insights from the social sciences.

## Groundwater studies in the Chagos Archipelago

A hydrogeologist from the BGS made two visits to the British Indian Ocean Territory (BIOT) to install equipment to investigate the occurrence of, and to monitor, groundwater on two remote and uninhabited atoll islands in the Chagos Archipelago. Recording tide gauges, monitoring boreholes, and meteorological instrumentation were commissioned. Data were downloaded by visiting Royal Marine patrols for several months and forwarded to the BGS to determine the hydrogeological characteristics of the islands. The project is a precursor to a larger water resources study. This in turn is part of the ongoing feasibility study for resettlement of the islands. Additional work investigating atoll island hydrogeology was undertaken in Diego Garcia from where the project was undertaken and facilitated by the Foreign Office and the Royal Marines.

## FRACFLOW

Geoscientists from Denmark, Britain, Germany, and Israel collaborated on a three and a half year project to investigate the physical and geochemical controls on contaminant transport in the European fractured chalk aquifer. They focused their studies on a quarry in Denmark and field site in Kent where they undertook a range of experiments, measurements, and tests. Samples were also collected for laboratory analysis and models were developed and tested. The final report has now been submitted, and sets out recommendations and methodologies developed for characterising and remediating contamination in the chalk aquifer through field investigations, monitoring, and modelling.

Sustainable management of the West Bank and Gaza aquifer: irrigated vegetables in the Gaza Strip. Balancing the competing demands of agricultural and municipal users will be a growing challenge in Palestine.

BGS © NERC

Groundwater studies in the Chagos Archipelago: levelling tide gauges to borehole datum levels, Ile Boddam, Chagos Archipelago, British Indian Ocean Territory.

A S Butcher, BGS © NERC

## Environment and Hazards

# Earthquake and Forensic Seismology

### Programme overview

The Earthquake and Forensic Seismology and Geomagnetism programme runs the UK seismic network and magnetic observatories. These monitor seismic activity and geomagnetic variations in the UK. They also provide a wide spectrum of customers in government, industry and academia with rapid access to data relevant to the understanding of the hazards posed by earthquakes and 'space weather'. The programme also includes research into advanced seismic methods. These improve determination of rock properties and have applications in reservoir imaging and management.


David Galloway, BGS © NERC

National earthquake monitoring: map of the felt effects of the magnitude 4.1 ML Melton Mowbray earthquake of 28 October 2001. Contours show the felt intensities assigned using the European Macroseismic Scale.

### National earthquake monitoring

The 146-station UK seismic network monitors seismic activity and recorded events are interpreted promptly to provide information to the public, government, and the private sector. The broad customer base co-funding the project includes the Department of Transport, Local Government and the Regions; the Health and Safety Executive; the Welsh Assembly; and companies in the nuclear, oil, and water industries. The largest onshore earthquake in 2001, of magnitude 4.1 ML, occurred on 28 October with its epicentre near Melton Mowbray. More than 6500 members of the public responded to a macroseismic questionnaire published in newspapers and on the BGS web pages, revealing that the earthquake was felt up to 140 kilometres from the epicentre over an area of 25 000 square kilometres. The largest earthquake offshore, felt on three platforms in the Ekofisk oilfield, was on 7 May 2001 in the central North Sea, with a magnitude of 5.0 Mw. Overseas, on 23 June 2001 a magnitude 8.4 Mw earthquake off the coast of Peru, 600 kilometres southeast of Lima, caused the deaths of over 81 people, (26 in the tsunami which followed), injured 2734 more and left over 220 000 homeless. In March 2002, two fatal and damaging earthquakes occurred in the Hindu Kush, Afghanistan. The combined death toll was over 1500, thousands were injured, and 20 000 left homeless. The BGS is participating in the Swiss PEGASOS seismic hazard study involving teams of international experts; seismic hazard studies were completed for sites in Taiwan and Angola, and for several locations in the UK.

### Calibration of the UK for forensic seismology

Forensic seismology is used to monitor nuclear test ban treaties through detection and identification of underground explosions. The BGS operates the UK National Data Centre, under contract to the Atomic Weapons Establishment and interacts, on behalf of the UK, with the Comprehensive Test Ban Treaty Organisation (CTBTO) in Vienna. The CTBTO monitors data from a global network of sensors, including seismometer stations. The UK Eskdalemuir seismic array, designed to detect and enhance small seismic signals, is the UK contribution to the CTBTO global network and is maintained and operated by the BGS. Accurate location is essential in forensic seismology and calibration data, such as local seismic velocity information, is required so that the CTBTO can allow for inhomogeneities in the Earth's structure along the wave path. The BGS is collaborating with British universities in the determination of the velocity structure for the UK region, and is providing travel time corrections to the CTBTO for Eskdalemuir for local, regional, and distant seismic events. BGS-sponsored students have found new velocity anomalies in the crust and upper mantle and identified features in seismograms attributable to scattering of seismic signals under the Scottish Borders.

### National Geomagnetic Service

This service provides information about variations in the Earth's magenetic field to interested parties and is supported by co-funding from several organisations. Activities include: running magnetic observatories (three in the UK and three on Atlantic Ocean islands), operating a World Data Centre for geomagnetism, modelling the geomagnetic field, and participating in INTERMAGNET (an international programme promoting timely exchange of magnetic data). The Ordnance Survey publishes magnetic information on its maps derived from a UK

# and Geomagnetism

regional model. The Ministry of Defence and a consortium of oil companies support global data collection and modelling efforts. Oil companies require near-real-time information on short-term geomagnetic field changes to process survey data collected while drilling wells. Information on geomagnetic storms is important for the electricity industry, and the BGS provides Scottish Power with a geomagnetic prediction and monitoring service, supplying information directly to the grid control room. A notable achievement this year was the successful completion of two marine survey campaigns in the North Sea to map the geomagnetic field vector around a number of drilling platforms. Another highlight was the release of the 2001 version of the BGS Global Geomagnetic Model, incorporating data from the Danish magnetic survey satellite Ørsted. Research was commissioned by the European Space Agency into the effects of solar and geomagnetic activity on the orbit of its Envisat satellite, launched in March 2002.

## The Edinburgh Anisotropy Project

This project has been supported by a consortium of oil operating and service companies for 14 years. Theoretical advances in understanding the effects of rock anisotropy and heterogeneity on seismic waves were made and tested on data-sets supplied by members of the consortium. A collaborative study with Edinburgh University, supported by Veritas DGC and Texaco UK, showed how images of structures beneath strongly reflecting basalt layers could be improved by using low-frequency seismic waves. A major highlight was the production of theoretical models in which the effect of rock anisotropy is dependent on the frequency of the seismic waves. This opens up the prospect of determining fracture size and spacing from seismic data, and of distinguishing different causes for changes in the seismic response of reservoirs during oil production. A study of seismic, core, and well-log data collected in gas-bearing sandstones in the Ordos Basin, one of the most important gas provinces in China, demonstrated the value of using shear waves to map the reservoir. This work was supported by Trade Partners UK and carried out in collaboration with the Langfang Research Institute, PetroChina.

## Environmental monitoring

Sensors monitoring a range of environmental parameters are operated at four sites in Scotland and one in England. The data recorded at three of the sites are transmitted through UHF radio links to local collecting nodes and then sent to BGS Edinburgh for analysis and archiving. Data from Eskdalemuir and Hartland observatories are relayed directly to Edinburgh through an Internet link. Parameters measured include air and ground temperature, humidity, wind speed and direction, surface wetness, sunshine, solar and nuclear radiation, and concentrations of pollutant gases. Collaboration with the Meteorological Office has enabled the integration of a standard automatic weather station into the system. Software allowing direct access to data recorded at the remote field sites has been developed. This web-based package can be used on any PC connected to the Internet. The infrastructure provided by the UK seismic network offers the possibility of monitoring environmental variables in rural locations across the country at relatively low cost by installing other sensors. The data-logging and transmission techniques developed for environmental monitoring are entirely compatible with those used in the UK seismic network.

National Geomagnetic Service: the BGS, in partnership with TECH-21 Ltd, chartered the 35-metre trimaran 'Adventurer' to carry out high-accuracy vector magnetic field surveys over a number of North Sea oil fields, to provide data applied in directional drilling.

Toby Clark, BGS © NERC

Environmental monitoring: an automatic weather station under test at Hartland Observatory, Devon.

John Riddick, BGS © NERC

## Environment and Hazards

# Urban Geoscience & Geological Hazards

### Programme overview

The aim of the Urban Geoscience and Geological Hazards programme is to provide the user community with information on, understanding of, and solutions to, problems associated with ground conditions and land quality, particularly in urban areas. These problems include:

- The likely occurrence of geological hazards.
- The location and nature of geological resources.
- Geotechnical and engineering characteristics of rock and soil formations.
- Chemical, physical, and mechanical properties of materials.

### Field-scale collapse test of loessic brickearth

Quaternary loessic deposits (wind-blown silts, often termed 'brickearth' in the UK) exhibit the potential to collapse as a result of bond weakening when subjected to wetting under engineering loads (known as hydrocompaction). A BGS study into the genesis, distribution, and engineering behaviour of these materials forms part of an ongoing research initiative in conjunction with Nottingham Trent University. Although the identification and quantification of hydrocollapse characteristics may be carried out on laboratory samples, such tests do not fully replicate field conditions. Current research activities have included the successful instrumentation and monitoring of water and ground movements during a field-scale collapse trial at a brickearth quarry at Ospringe, Kent, undertaken as part of a NERC research study in collaboration with Birmingham, Loughborough, Nottingham Trent, and Royal Holloway Universities. Collaborative interpretation and analysis of the data is under way to enable a better understanding of how loess collapse mechanisms operate, and to determine how collapse hazard recognition and quantification, and hence stabilisation methods, can be more effectively applied.

### Decision support systems in planning for development

Although there is an increased awareness of the importance of environmental issues in planning for development, too often the relevant information is inaccessible or presented in a format that cannot be readily used within the planning process. An initiative — co-funded by the former Department of Transport, Local Government and the Regions and the NERC URGENT thematic programme — is aimed at encouraging better use of environmental information through development of customised data-sets and models which can be interrogated as part of the normal planning process. The prototype system is being developed as a demonstration project by a consortium involving the BGS, the Centre for Ecology and Hydrology, and the University of Nottingham. Initially, the system will provide selected local authorities with access to information on flood risk, air quality management, biodiversity, and land stability issues, with electronic service delivery via the Internet. By adopting an integrated approach to environmental issues, it is intended that the system will make it easier for planners to weigh up options and alternatives and to ensure that proper consideration of environmental issues is given at each stage of the planning process.

A Forster, BGS © NERC

Decision support systems: better use of environmental information during the planning process can influence decisions such as whether or not to build on floodplains. Trent valley, November 2000.

### Sustainable Urban Drainage Systems

Sustainable Urban Drainage Systems (SUDS) offer an alternative approach to managing surface water run-off. The systems depend on engineered structures (such as infiltration devices, ponds, and swales) to control and attenuate excess water close to source. Where successfully installed, they offer advantages over conventional drainage techniques by reducing flood risk and pollution. Given the increasing need for housing and the possible increase in rainfall within the UK, this area of scientific research is of particular interest to the Environment Agency, government departments, local authorities, and the con-

struction and building sectors. As part of a broader study of the urban environment the Manchester urban geoscience pilot project is developing a prototype SUDS suitability model, based initially on three digital data-sets.

## Impact of abandoned mineworkings on urban planning

Perhaps best known, and almost certainly best understood, of the wide variety of environmental problems which follow mine abandonment are those of subsidence and rising groundwater levels with the potential for surface discharge of contaminated water. Less well known and understood issues include the generation and migration of a number of gases, renewed subsidence, and the reactivation of faults. The BGS, in collaboration with local authorities and the Universities of Newcastle, Durham, and Sunderland, is researching these phenomena, in north-east England. Of particular concern here are surface emissions of deoxygenated air, known locally as 'stythe'. Northumberland has the dubious distinction of being one of the very few parts of Britain in which a member of the public has been killed by stythe gas. The BGS is developing predictive models to inform the formulation of planning and development policies to safeguard public health. A growing body of evidence points to reactivated movement of faults within the Magnesian Limestone of the east Durham Coalfield. Many case histories are being investigated and already the need to understand the nature and extent of this phenomenon has influenced local authorities on issues of landfilling, planning, public safety, and highway maintenance. As work proceeds it is likely that these studies will have a major impact upon a wide range of development issues across the UK and beyond.

Impact of abandoned mineworkings: cracking of south-bound carriageway of A690 road at Houghton-le-Spring, Sunderland may be caused by the reactivation of faults as a consequence of mine abandonment.

B Young, BGS © NERC

## Nefyn Bay landslide hazard assessment

On 2 January 2001 a coastal landslide at Nefyn, North Wales, caused the death of one person and serious injury to a second. In response, a programme of research co-funded by the BGS and Gwynedd Council was initiated to establish the cause of the landslide and assess the slope instability hazard of Nefyn Bay to minimise future risks. Nefyn Bay is a three kilometres long embayment on the north-west coast of the Lleyn Peninsula comprising a complex succession of glacial till and glacio-fluvial sands and gravels bounded by rock headlands. Geological mapping allowed the deposits to be characterised into three lithological groups, each of which demonstrated different engineering behaviour:

- A stiff impermeable till overlain by permeable outwash deposits.
- Glacio-fluvial outwash deposits.
- Glacio-tectonised glacio-fluvial outwash deposits with widespread deformation and lateral variation.

An unusual type of coastal instability was identified during the survey. When cliff recession breached a silt-filled kettle hole, the saturated infill flowed rapidly from the cliff leaving a 60 metre wide bowl-shaped cavity cutting deeply back from the cliff edge. Such a hazard may have little topographical expression in advance of the failure and may be widespread in coastal areas where pro-glacial outwash deposits are present.

Nefyn Bay landslide: a zoned landslide hazard map has been created with recommendations for incorporating the hazard into local planning policy whilst minimising the impact on local tourism. Photograph © North Wales Police Air Support Unit, used with permission.

## Environment and Hazards

# Pollution and Waste Management and

### Programme overview

This programme focuses on providing geoscience-based solutions to environmental problems confronting local authorities, government, and industry. Areas of work include the science of containment and disposal of waste, pollutant transport, the provision and interpretation of land quality data, specialist chemical and radiochemical analysis, mathematical modelling, and environmental geophysics.

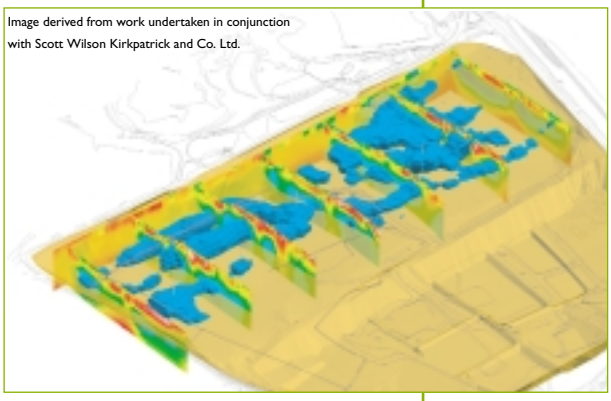
### Contaminated land solutions for local authorities

The BGS provides geoscience data and expertise to help local authorities meet their responsibilities under Part IIa (Contaminated Land) of the Environmental Protection Act 1990. Digital geological, geochemical, and hydrogeological data with interpretations have been provided for specific clients. We have also produced customised modules based on a Geographical Information System (GIS) so that the delivery of data and prioritisation of potentially contaminated sites are more user-friendly for local authority officers. A reporting module allows the user to interrogate the GIS for environmental data within a predetermined radius of a site or property under investigation. The data are presented in a report format using a series of maps and tables making a major saving on staff time for manual searches. The BGS has also developed a GIS site-screening tool to prioritise potentially contaminated sites. The customised GIS generates a report document for each site as required, listing the sources, receptors, and pathways identified and a final 'score' to allow comparison of sites. The GIS, programmed to apply the pollution linkage concept, can also portray the information spatially, indicating sites that may meet the statutory guidance criteria and will require further on-site examination.

### Depleted uranium in Kosovo

The UK government is committed to enhancing its environmental surveillance programme in the Balkans. The BGS, in conjunction with the Defence Science and Technology Laboratories Radiation Protection Services, has developed a cost-effective method for locating and investigating the nature of depleted uranium (DU) contamination in soils. Sites in Kosovo were screened for total uranium by analysing soil samples using X-ray fluorescence spectrometry. The source of uranium at individual sites was investigated by determining uranium isotope ratios. By comparing natural and depleted uranium isotope ratios, it has been possible to identify the presence of less than five per cent DU against a natural background in samples with two to three parts per million of total uranium. Fragments of metallic DU showing evidence of corrosion and dissolution have been identified using scanning electron microsopy, which reveals that many of the finer uraniferous particles have altered in the soil environment.

Image derived from work undertaken in conjunction with Scott Wilson Kirkpatrick and Co. Ltd.



BGS © NERC

A 3D electrical tomography survey of an operating landfill. The objective was to map the volumetric distribution and concentration of leachate (opaque blue) within the waste body. The survey directly assists sustainable waste management, as the leachate will be recirculated to further enhance the production and control of landfill gas, and subsequently the generation of electricity for the national grid.

### Electrical Tomography Service

Collaborative research has continued on the development of advanced electrical resistivity imaging techniques for a wide range of Earth science applications. A new prototype Spectral Induced Polarisation (SIP) system is under development for the non-invasive mapping of contaminated land and Non-Aqueous Phase Liquids (NAPLs) such as oils and solvents. Laboratory-scale SIP measurements indicate that NAPLs can be imaged in the complex frequency domain. The results also confirm that SIP could be used for the non-destructive monitoring of permeable reactive barriers for in-situ groundwater remediation. A new Capacitively-coupled Resistivity Imaging (CRI) system has been designed to detect shallow voids and pollution in the built environment. The CRI prototype allows towed, near-continuous data acquisition with a high lateral resolution. Kinematic global positioning provides real-time navigation and location recovery. The BGS-designed

# Extraction Industry Impacts

CRI system is a significant advance on existing technology and is ideally suited for mapping below engineered surfaces such as roads and masonry.

## PADAMOT project

The BGS has embarked upon a new palaeohydrogeological project (PADAMOT), co-funded under the EU Fifth Framework Programme, with partners in the UK, Sweden, Spain and the Czech Republic. The impact of Quaternary climate changes on deep groundwater systems, is being investigated within the context of safety assessments for the deep disposal of radioactive wastes. Together with the NERC Isotope Geosciences Laboratory and Ion Probe Facility, the BGS is investigating the use of variations in the chemical and physical characteristics of fracture-filling calcite correlated with modern groundwater flow, to record Quaternary climate change impacts on deep groundwater systems. The BGS-developed coupled-code, PRECIP, is being used to model the processes controlling mineral precipitation. A database is being developed for handling palaeohydrogeological information and is being populated with data from the earlier EQUIP project, as well as new data from PADAMOT, and background information on palaeo-climate, site-specific hydrology and geology, and geochemistry.

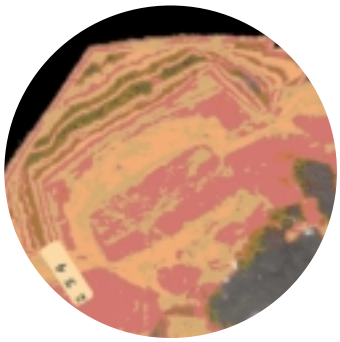
## Natural attenuation of chiral herbicide

The phenoxyacid herbicide, mecoprop, exists as two mirror-image forms (enantiomers) which have identical physical and chemical properties, but behave differently in biological systems. Their differential metabolism means that any change in their ratio with time is indicative of biodegradation and can be used as evidence of natural attenuation. This approach has been used to assess the potential for mecoprop degradation in the Lincolnshire Limestone aquifer following the landfill disposal of 40 tonnes of mecoprop. The results indicate that the suphate-reducing and methanogenic conditions in the landfill inhibit degradation, since the enantiomeric ratio is unchanged. In the nitrate-reducing zone of the landfill plume (R)-mecoprop degrades but (S)-mecoprop is unaltered, while in the aerobic part of the aquifer (S)-mecoprop degrades faster than (R)-mecoprop. the enantioselective degradation of (R)-mecoprop under nitrate-reducing conditions has now been reproduced in laboratory microcosm experiments. These also reveal the build-up of the metabolite 4-chloro-2-methyl phenol which, in aquatic systems, is more toxic than the parent compound. Since many agrochemicals are enantiomeric, this approach has the potential to provide subtle information their fate under different environmental conditions.

## Arsenic — bioavailability and mining

The BGS is currently investigating the transport and fate of heavy metals in the vicinity of an abandoned arsenic works at Devon Great Consols Mine, near Tavistock, Devon. On the site of the arsenic works, which operated from 1921 to 1925, were two Brunton calciners in which arsenopyrite was roasted. Widespread contamination of the site has resulted from the disposal of calciner wastes, scattered waste rock dumps, acid rock drainage, and widespread aerial deposition of particulate matter derived from ore processing and chimney fumes. In order to examine the mechanisms that control the dispersion of arsenic and its bioaccessibility at the site, over one hundred soil samples have been collected for physical and chemical characterisation.

PADAMOT: cathodoluminescensce image of late-stage calcite from the Sherwood Sandstone Group, west Cumbria. A change in crystal growth morphology is evident in the growth zoning, representing a change from saline to fresh water during calcite growth (field of view is 3mm).



BGS © NERC

Arsenic bioavailability: remains of the arsenic mill, Devon Great Consols Mine. Exploitation of tin deposits, alongside natural dispersion from copper-tin-arsenic mineralisation, has resulted in arsenic-contaminated wastes and soils in South-West England.

Ben Klinck, BGS © NERC

## Environment and Hazards

# Coastal Geoscience & Global Change

### Programme overview

The role of the Coastal Geoscience and Global Change programme is to predict and better manage future environmental change on the basis of an understanding of past and present patterns of erosion, transport, transformation, and storage of sediments and associated materials. The programme addresses issues ranging from the geological controls on drivers of climate change to the impacts of sea-level rise or increased storminess on coasts.

BGS archives © NERC

Futurecoast: resistant coastline at Lands End.

### Cliff stability

With the aim of enhancing our understanding of the retreat of cliffed coasts, the cliff stability project has developed a satisfactory methodology for producing accurate three-dimensional terrain models following field visits to the twelve coastal study sites. This has involved two principal components, terrestrial laser scanning and global positioning. New equipment has become available within the BGS, which permits this monitoring capability to be deployed either periodically or in a responsive manner. Monitoring of cliff and beach sections has taken place at six- or two-monthly intervals. Volume changes have been calculated permitting geomorphological changes to be identified and sediment budgets to be calculated. This provides an important, yet hitherto neglected, input to process modelling and scoping studies of coastal erosion. Collaboration has been extended with the surveying departments of both Nottingham and Newcastle Universities. The remote sensing group at the BGS has provided photogrammetry and modelling capabilities and interpretation.

### Futurecoast

The Futurecoast project resulted from a review of the first round of Shoreline Management Plans (SMPs) for England and Wales which identified weaknesses in the understanding of long-term coastal change. The Ministry of Agriculture, Fisheries and Food (now the Department for Environment Food and Rural Affairs) commissioned Halcrow in association with the BGS and Risk and Policy Analysts to undertake an outline geomorphological and coastal processes study. The specific objectives were:

- To undertake a prediction of coastal evolution over at least the next 100 years.
- To assess the sensitivity of these predictions to a set of standard potential climate change scenarios as produced by the UK Climate Impacts Programme (UKCIP).
- To allow contemporary coastal processes and management decisions to be placed within a longer-term and wider-scale framework which provides a vision for the coast and a scientific basis for a sustainable, strategic management response.

The study provides an appreciation of long-term evolution of the coast, based upon a nationally consistent approach.

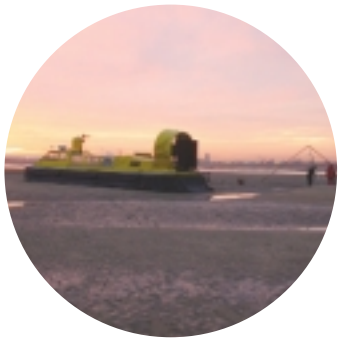
### ICZMap

The coastal zone is a dynamic environment under pressure from human and economic activity as well as physical and environmental forces, some of which are associated with climate change and rising sea levels. An integrated approach to the management of the coastal zone is therefore required. The provision of geographical information is important in this context. A major problem is the way this information is made available to the public, managers, and policy makers. Currently, it is only available as diverse terrestrial and marine data-sets from various providers, not as an integrated and accessible common package from a single source. The aim of ICZMap, which is a project under HM Treasury's 'Invest to Save Budget' initiative, is to enable the integration of terrestrial and marine geographical data held by the BGS, Ordnance Survey, and UK Hydrographic Office across the coastal zone, so that they can be accessed readily by users.

## Estuarine contamination

Material from shallow (half to one-and-a-half metre) cores, collected during the systematic survey of contaminants in the Mersey Estuary has been subjected to detailed chemical analysis. Mapping of the distribution of inorganic components suggests that some of the highest levels of contamination are related to very local sources on the banks of the estuary. The internal structure and texture of selected cores have been examined by X-ray photography, while particle size analysis and clay mineralogy have been used to study sediment movement and provenance. Analysis of the degree of chlorination in polychlorinated biphenyls (PCBs) suggests that this might provide a tool for 'fingerprinting' pollutant sources and movement of organic contaminants.

Estuarine contamination: collecting vibrocores on the central mud flats of the Mersey Estuary at low tide, early morning, October 2001.



Mick Strutt, BGS © NERC

## PROTECT

The PRediction Of The Erosion of Cliffed Terrains (PROTECT) project is a BGS-led European consortium of five research groups and four user organisations supported by the EU Fifth Framework Research and Development Environment and Sustainable Development Programme. It aims to measure physical changes within the rock mass behind a cliff face prior to a catastrophic collapse. A non-invasive geophysical technique, azimuthal apparent resistivity (AZR), is being applied to measure temporal changes in anisotropy of the rock mass near the cliff edge.

## Geosynth

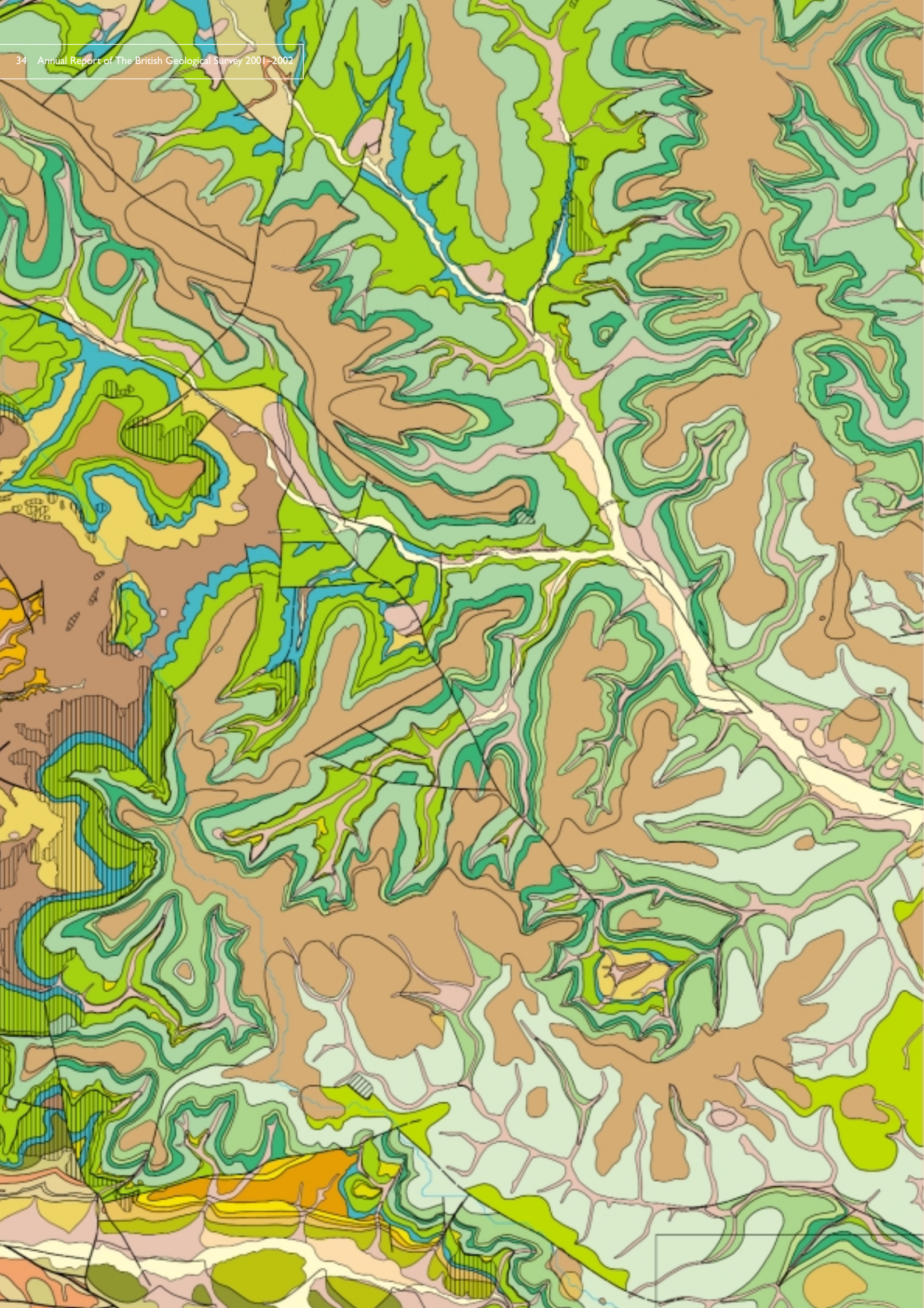
The project provides, on CD-ROM, a bilingual synthesis of the geology and sedimentology of the Dover Strait and its coastal limits in Geographical Information System (GIS) and multimedia formats. The area covered includes the coasts of Kent and Nord–Pas de Calais and the offshore area between these two regions, including the Dover Strait and the Thames Estuary. Analysis of environmental pressures from factors such as sea-level rise, climate change, marine aggregate extraction, fisheries and tourism, both now and in the future, requires an understanding of the geology and sediments of the Dover Strait and its coastal hinterland. To implement and co-ordinate the project a Transmanche partnership was set up between the two national survey organisations — the BGS and the Bureau des Recherches Géologiques et Minières — in association with Kent County Council and the Nord–Pas de Calais Conseil Régional.

PROTECT: resistivity measurements being made to measure physical changes within the rock mass behind a cliff face in Denmark.

J Busby, BGS © NERC

## Hydraphys

The study of natural gas hydrates is currently limited by their instability at ambient conditions. Proposals to sample hydrates during the summer of 2002 on Ocean Drilling Programme (ODP) Leg 204 using pressure-coring techniques and sample-transfer chambers onboard ship are in place. The need to characterise the nature and extent of any gas hydrate within the pressurised sample prior to depressurising, opening, and subsampling is being addressed by the Hydraphys project. Experiments to manufacture a range of gas hydrate morphologies in typical sediments are under way in the laboratory, forming the basis for non-invasive geophysical characterisation of hydrate morphologies.



# Information Services and Management

The role of the **Information Services and Management Directorate** (ISMD) is to ensure maximum benefit to external clients and users of BGS data and information, and to provide the information infrastructure to underpin efficient delivery of all BGS programmes — Core Strategic and Commissioned. It fulfils this role through two ongoing programmes: **Information Management** and the **National Geoscience Information Service;** two major projects: **Digital Geoscience Spatial Model** and **GeoHazarD;** and the operation of an internal service: **Publications Production.**

Within the **Information Management** programme highlights included: the completion, on schedule, of a major extension to the National Geoscience Data Centre building; continued enhancement of the DEAL Internet site, resulting in the winning of a major national Geographical Information System (GIS) award; and success in gaining approval for a multi-national European Commission-funded proposal (EUROSEISMIC), which will compile metadata for seismic survey information of 13 European maritime nations. Under the **National Geoscience Information Service** (NGIS) programme, 2001 saw a major achievement for the BGS in the completion and launch of the first version of DiGMapGB-50 — digital geological map coverage of Great Britain in Geographical Information System (GIS) format at 1:50 000 scale. The Enquiry Service continued its restructuring and, with the introduction of more information technology and web-based systems, saw significant increases in efficiency and levels of service. The BGS Intranet was restructured, and the Internet site experienced a 50% increase in visitor access. Additionally the new e-commerce Internet Bookshop was launched. The **Publications Production** programme published 26 maps and five memoirs during 2001 but a significant amount of effort was devoted to the capture of data for DiGMapGB-50.

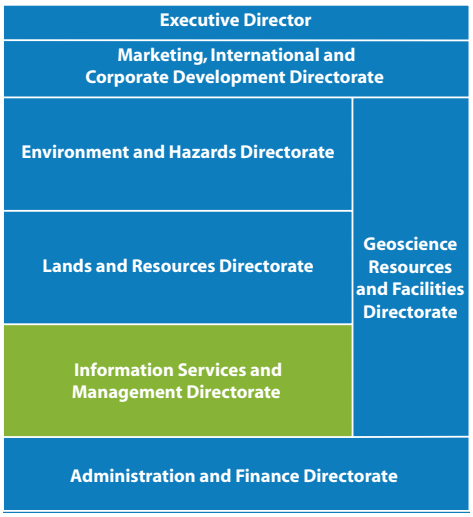
The **Digital Geoscience Spatial Model** (DGSM) project continued work on the development of the framework and procedures, while a number of pilot studies across the UK explored the technologies and tested the developing DGSM protocols. The first full year of the **GeoHazarD** project saw the digitisation of a large number of data-sets required to develop the underpinning geological hazard GIS coverages which will ultimately deliver a much-enhanced BGS Enquiry Service.


BGS © NERC

GeoReports: a new service that allows customers to order site-specific reports online and provides streamlined access to BGS geoscience information and expertise. The area covered by the report may be defined by postal address, grid reference, or by sending us a site plan.

New editions of the North and South Solid Geology Maps were published during 2001/02. These are the best-selling maps published by the BGS and are both now in their fourth edition.


BGS © NERC




Information Services and Management Directorate, **Mr I Jackson.** *(0115 936 3214) ij@bgs.ac.uk*

| Information Management | National Geoscience Information Service | Publications Production |
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## Information Services and Management

# Information Management

### Programme overview

The Information Management programme is responsible for the management of all data and information within the BGS. This includes all digital databases, paper archives, and material collections including rocks, minerals, fossils, and borehole core. The aim is to manage the information in a coherent and integrated manner for the benefit of BGS scientists, industry, and the citizen.

Tim Cullen, BGS © NERC

Core boxes in the new extension to the BGS core storage facility in the National Geoscience Data Centre.

### National Geoscience Data Centre

The National Geoscience Data Centre building at Keyworth has been extended and new facilities built to incorporate the Coal Authority's Prime Geological Record Collection and the material and reports from the Nirex site investigations. The cost of the work has been partly supported by the DTI and Nirex. The area of the National Geological Records Centre was more than doubled and new mobile racking installed, with improved facilities provided for registration staff. The building was completed at the end of August 2001. During the first week of September 2001 the Coal Authority collection of over 6000 record boxes was transferred from the Mining Records Office and a further 3000 boxes of ex-British Coal records incorporated. These data are now available for consultation. All the opencast site data from the complete collection of 7708 sites have been digitally indexed and the site outlines digitised and made available via the Geoscience Data Index for geographical searches. A complete set of 2641 Nirex Reports was also integrated within the Centre collections. Concurrently, the main core storage hall was extended by one third to house over 21 kilometres of drillcore and other samples, from the 32 deep boreholes drilled during the Nirex investigations around Sellafield and Dounreay. This material is now available for academic research. The additional storage provided should allow for continued acquisitions over the next 25 years.

### EUROSEISMIC

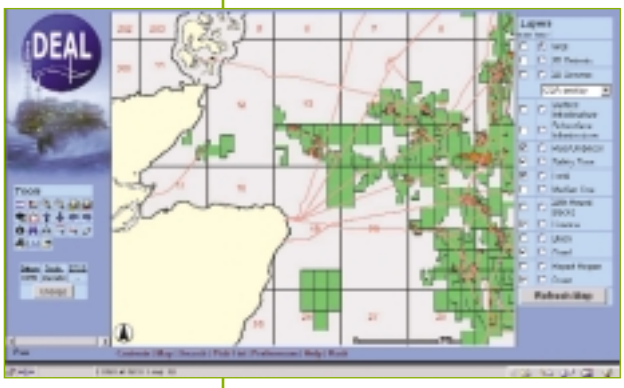
The EC-funded European Marine Seismic Metadata and Information Centre (EUROSEISMIC) project started in January 2002 and will run for three years. BGS staff co-ordinate the work of the 16 project partners that include the marine geology departments of the 13 maritime nations of the European Union and Norway. The main project objective is to compile metadata for all seismic survey data collected by the project partners, which will be added to the existing EU-SEASED web site (www.eu-seased.net), which holds metadata for all samples and cores held by the surveys and collaborating organisations. The EU-SEASED web site was developed during the EC's Fourth Framework Programme and currently holds metadata for over 220 000 sample stations. It is estimated that the EUROSEISMIC project will compile over 1.5 million line-kilometres of seismic profile and sonar data which, combined with sea bed sample and core data, will provide a comprehensive inventory of marine information in the European seas. This data resource will be of value to industry, government, and academic researchers who need to know where existing data have been collected and can be accessed. As such, the project will encourage reuse of archived data and reduce costs to each sector by avoiding the need to collect data where it already exists.

### The DEAL project

DEAL is an Internet site (www.ukdeal.co.uk) which provides a web-based Geographical Information System (GIS) for the offshore hydrocarbons industry. A wide range of offshore spatial features such as wells, two-dimensional and three-dimensional seismic surveys can be downloaded by the user. A full-text search capability allows users to select features by a combination of attributes. The project, funded by Common Data Access Ltd, a wholly owned subsidiary of the UK Offshore Operators Association (UKOOA), provides a definitive set of spatial and associated metadata for the offshore UK continental shelf. A comprehensive list of products

supplied by the offshore industry is linked to spatial features so that users can display and list items available from a set of vendors, offshore operators, and data brokers. Data can be selected online and delivered dynamically to the user through vendor repositories. Subsea and surface infrastructure and pipelines are also included in the database, and these are supplied to the Sea Fish Industry Authority for use in the offshore fishing industry. The DTI Oil and Gas Department will supply DEAL automatically with data resulting from the DTI consents process for offshore planning, surveying, and well-drilling activities, thus establishing DEAL as a fundamental part of the data-release process.

An example page from the DEAL web site, developed for the offshore hydrocarbons industry.

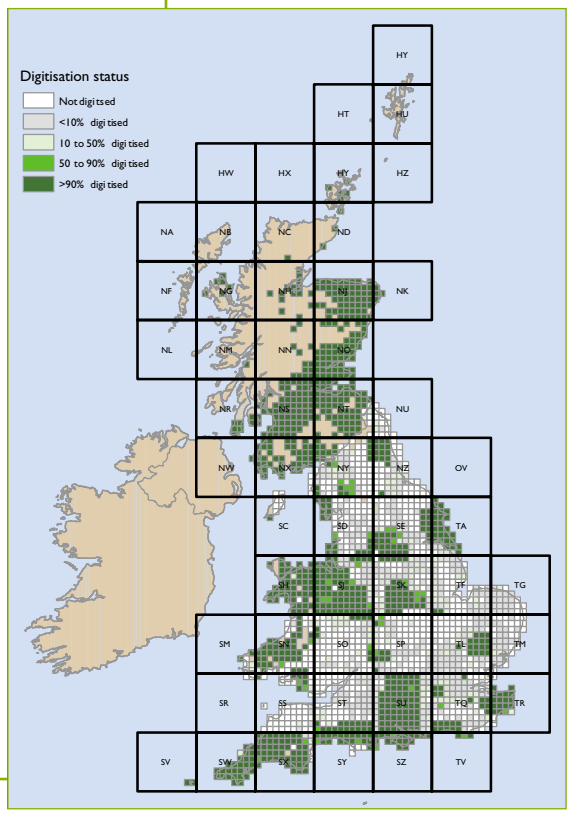



BGS © NERC

## Market sector extension to iGDI

The Internet Geoscience Data Index (iGDI) product developed by the BGS within ESRI's ArcIMS® software has been a resounding success with both customers and staff. We have been maintaining the product, including further functionality, and updating the data behind the scenes since its release on to our web server. The map themes in the iGDI were originally focused on geoscience disciplines rather than market sectors. This met initial BGS aims and those of the higher education and university markets but was a limiting factor for customers who felt they needed to be able to access a map theme focused upon their particular market sector. A second series of themes were created for the Civil Engineering, Local Government, and Minerals sectors. The map themes were created after discussion with customers and specialists in these particular sectors to ensure they encompass the appropriate data layers required for meaningful querying of the BGS data holdings.

WellMaster database project: status of digitisation of the national well records archive.




BGS © NERC

## WellMaster — serving the water industry

The BGS holds a unique repository of data on the groundwater resources of the United Kingdom. These data, consisting largely of paper records, are used by BGS staff and external users to assess and evaluate potential water resource developments, and to investigate environmental risks to water supplies. The WellMaster database project is systematically digitising the records. In digital form users can rapidly review key hydrogeological parameters on a site specific or regional basis, increasing the utility of the data. WellMaster now includes 40 per cent of the approximately 100 000 water wells in the UK. Data can be accessed from scientists' desktops, or sent via CD-ROM to partners in the water industry, simplifying and improving access to the information. The work was initiated by the BGS, but has also been supported by the water industry, local government, and, most importantly, by the Environment Agency in England and Wales and the Scottish Environmental Protection Agency, who have made substantial contributions to the cost of digitisation in recognition of the value of WellMaster in disseminating data to users. The project is due for completion at the end of 2003.

## Information Services and Management

# National Geoscience Information Service

### Programme overview

The National Geoscience Information Service (NGIS) is the programme responsible for all activities related to the delivery (internally and externally) of BGS data, knowledge and information. Activities managed and operated under the NGIS programme are the Electronic Dissemination of Information project, Enquiry Service, Sales, Public Understanding of Science, the BGS Library, Intellectual Property Rights, and Digital Geological Map of Great Britain.

### Electronic Dissemination of Information

The BGS Intranet underwent a design overhaul and major restructuring to enable it to cope with a large increase in content and usage. It now has over 38 000 pages. The BGS Report Management System (RMS) has been augmented and now has a key role in handling the Survey's extensive output of scientific reports. The RMS integrates the BGS Library information systems, the Intranet and the Internet. Over the year, the availability of BGS reports to view internally online and to download from the Internet site has increased substantially. The Internet site continues to prove very popular with a steadily rising rate of access. There are now over 35 000 visitors to the site each month — about 50 per cent more than last year. Many sections are now dynamically generated from databases to reduce maintenance of the web site and make it easier to update. The content of the site is in a continual state of growth and update, increasing the information about the BGS and providing a wealth of free reference information.

### Enquiry Service

The BGS Enquiry Service dealt with over 20 000 uncharged enquiries from the public and academic communities, 10 000 of which were recorded in detail on the new Intranet-based Central Enquiries Database. This database allows detailed statistics to be compiled on the type of enquiries and customers that come to the BGS, feeding back into continual improvements in the level of service. The enquiries were coordinated by a strengthened Central Enquiries Desk using a network of over 200 BGS staff, which ensured a highly responsive and professional service was maintained at all times. Income from the commercial section of the Enquiry Service increased by about five per cent; with over 7000 geological site reports and 12 000 copies of NGDC records for commercial site developers and other professionals provided. Enquiry Service web pages were further refined on the BGS web site, including the addition of a much improved borehole records ordering facility on the Internet Geoscience Data Index which resulted in a noticeable increase in orders for copies of the records.


BGS © NERC

Electronic dissemination of information project: Building on expertise gained from a prototype venture with a commercial developer, the BGS built in-house, and launched in December 2001, an all-new Internet Bookshop. The experience gained in this work is already being put to use in other e-business developments.

### Sales

Sustained work continues into widening the market base, increasing brand-recognition and raising awareness of the range of publications and services offered by the BGS. The year saw an overall growth in BGS Sales income of eight per cent. Publication sales have been consistently strong, and an active campaign to increase the numbers of outlets selling BGS publications is succeeding. The increase in income was helped by the launch of the new BGS Internet Bookshop; customer feedback on the site has been extremely positive. A new design for Regional Geology Guides was launched with the publication of the guide for the Pennines and adjacent areas. This publication has attracted a high level of praise from reviewers and sales have been excellent. Also published this year were the fourth editions of the North and South solid geology maps of the UK. These are without doubt the best-selling maps we publish; the new editions have achieved good sales and a wide uptake into trade outlets.

## Public Understanding of Science

The BGS promotes the Earth sciences and publicises its work via events such as National Science Week and Scottish Geology Week, and our magazine *Earthwise.* In 2001/02 *Earthwise* covered the themes of *Geology & Health* and *Geology & Planning*. A major market research exercise was initiated in collaboration with BGS Sales to define the requirements for teaching Earth sciences in the UK. 35 000 schools were sent questionnaires; the responses will help us to develop a strategy for future educational products and to compare the suitability of, and demand for, web-based and multimedia products against traditional publications. The BGS regularly provides placements for Nuffield Bursary students and participates in the NERC-sponsored CREST scheme. During the year, the BGS was closely involved with the inauguration of the Earth Science Education Forum (England and Wales). The forum has been established to bring together organisations with an interest in Earth science education. The BGS is also represented in the Scottish Earth Science Education Forum, an equivalent body for Scotland established in 2001.

## Library

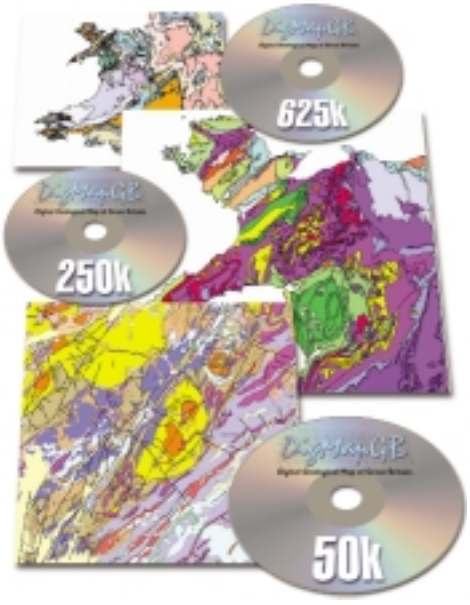
Following the introduction of the GEOLIB library management system in 2000, work has continued with the implementation of a service module for loans. This involved conversion of thousands of existing manual loans records to the new system, and the issuing of cards to library users. The new module, together with the introduction of further e-journal services, has significantly improved the internal delivery of information. External users can access some aspects of the BGS Library's database via the web view of GEOLIB and this has proved popular with users. Progress has also been made in preparing a large number of BGS publications dating back to 1839 for scanning, opening up the possibility of linking full texts to the relevant GEOLIB records. Some experimental work has also been carried out with scanning historic maps such as the William Smith map of 1820. As well as having an important role in the conservation of such items by reducing the need to handle the originals, the scanning also allows the BGS to produce attractive facsimiles of important documents for sale.

## Intellectual Property Rights

The IPR Section offers general and specific guidance on Intellectual Property (IP) matters to staff and external parties on the terms and conditions relating to the use of BGS materials. Income generated from digital data licences, copyright fees, and royalties more than doubled during the year, demonstrating that specialist information is a valuable tradable commodity which merits protection. IP advice to the GeoHazarD programme has ensured that the transfer of analogue materials from a variety of external sources to an electronic format for use by the BGS has been consistent with copyright requirements. Links are maintained with counterparts in many UK government departments and agencies, and with regional government offices. The Controller of HMSO led a workshop at the BGS on Crown copyright and licensing, and this was followed by one-to-one discussions on core and enhanced data definitions. A series of presentations and workshops about IPR and licensing for BGS technical, finance, and contracts staff reinforced the message that IP management contributes significantly to income and the promotion of the value and worth of the geosciences. The IPR Manager represents the BGS on the NERC Best Practice Network.

## DiGMapGB

The purpose of this project is to prepare nation-wide digital geological map data in vector GIS format at a range of scales from 1:625 000 to 1:10 000. A major achievement was the release in December 2001 of the first version of DiGMapGB-50, the 1:50 000 scale layer in the database. This is the most complete national cover of digital geological data at this resolution in the world. It includes all available map tiles, totalling 97 per cent of Great Britain at this scale. All the geology in the data-set was reviewed with significant revision being needed in many places. The data-set is now available for licensing by customers, and within the BGS where it is invaluable for major projects. The demand for DiGMapGB-10 data continued to rise, especially in urban areas for contaminated land issues. DiGMapGB-625 data were used with a new topographical base to publish new editions of the Solid Geology of the UK sheets. Offshore, the 1: 250 000 scale Sea Bed Sediment maps were digitised and released as the DigSBS-250 data-set.




Chris Wardle, BGS © NERC

## Information Services and Management

# Publications Production

### Programme overview

The Publications Production programme delivers the formal published output from the BGS Core Strategic Programme in the form of maps, books, reports, and other publications. These are delivered in both digital and printed formats. Publication Production provides a major contribution to the BGS digital data holdings, in particular the Digital Geological Map of Great Britain (DiGMapGB). It is also responsible for the population and management of the National Archive of Geological Photographs.


BGS © NERC

*Building Stones Resources of the United Kingdom*, an entirely new map produced during 2001/02 in partnership with a number of heritage and industry sponsors.

### Cartographic Services

Cartographic Services publishes maps and diagrams for a wide range of projects at a variety of scales. Geographical Information Systems (GIS) are employed and customised to build digital geological map databases. These provide not only map data suitable for hard-copy publishing, but also the comprehensive geological attribution of graphic detail that modern scientific interrogation of the data demands. These techniques were employed to deliver DiGMapGB output. Publications over the past year included the following:

- 26 maps released as print-on-demand or litho-printed sheets.
- A 1:50 000 scale map and accompanying book covering the Isle of Man.
- New editions of the 1:625 000 scale Solid Geology maps.

More digital information has been made available at a variety of scales:

- 1:50 000 scale data for the UK where field survey mapping exists.
- More 1:10 000 scale data.
- Off-shore 1:250 000 scale data:
  - Sea Bed Sediments.
  - Solid Geology for UTM Zone 30.
- Opencast data provided by the Coal Authority has been scanned, digitised, and databased.

Cartographic Services has produced work to support in excess of 150 different projects undertaken by the BGS during the year.

### Reprographic and Print Services

Reprographic and Print Services meets the reprographic needs of all parts of the BGS, in particular map and book production, photography, and remote sensing. Services include high-resolution scanning, film plotting, colour proofing, print management, and provision of print-ready data and artwork for BGS publications. Advances made during the year included the development of digital reprography to enable provision of digital files for maps and books to the printer, resulting in greater efficiency, time-saving, and reduction of internal costs.

### Photographic Services

Photographic Services provides studio and location work in support of scientific publications, web pages and presentations. Integrated workflows were introduced to incorporate digital images into the new ORACLE-based image database. These activities underpin the National Archive of Geological Photographs, available on the BGS web site. Detailed planning for the creation of a BGS commercial picture library was undertaken with the aim of exploiting the best of the photographs and images in the Survey's extensive collections.

### Book Production

Book Production provides a range of high-quality litho-printed reports and popular publications. The service also produces corporate stationery including business cards, letterheads, and promotional material such as the Map Catalogue and new corporate brochure.

Some products are published digitally and available free of charge to gain a wider readership. The following were published for the Lands and Resources Directorate:

- Five memoirs providing a comprehensive description of the geology of certain areas or districts.
- One Sheet Explanation and one Sheet Description.

In addition several commissioned research and special publications titles were produced:

- Seven Technical Reports, one published as Portable Document Format (PDF).
- One 'special' publication.
- One Regional Geochemistry Atlas.
- Four magazines/journals.
- Four Annuals.
- One Popular Publication book.
- Six Holiday Geology/Tourist Guides as part of the Popular Publication series and commissions.

Book Production staff support the BGS Report Management System (part of the Electronic Dissemination of Information project) by converting BGS reports to PDF files for digital download. These files are linked to the relevant GEOLIB (library catalogue) and Intranet Data Access (IDA) entries allowing staff to access electronic versions of non-confidential reports online. Archive data is converted into formats suitable for XML mark-up in order to populate the Digital Geoscience Spatial Model.


Examples of new books published in 2001/02: *Geology of the Kilmarnock district* (Sheet Explanation), fourth edition of *The Pennines and adjacent areas* (British Regional Geology Series), and *Geology of the Aboyne district* (Geological Memoir).

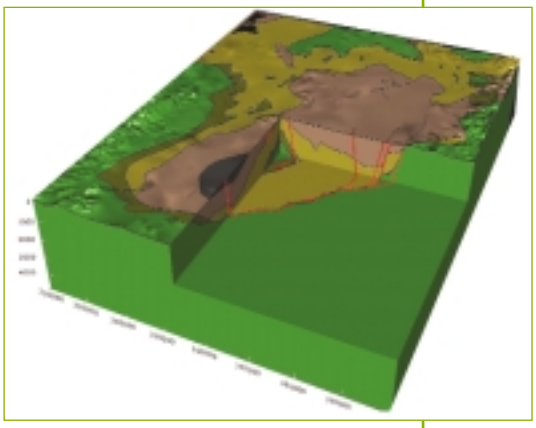
A selection of images contributed to the National Archive of Geological Photographs by Photographic Services during the year.

BGS © NERC

## Information Services and Management

# Digital Geoscience Spatial Model

Many geoscientific studies involve spatial modelling, increasingly using computer applications. Our understanding of the Earth and its processes can be significantly enhanced by visualising models in three- and four-dimensions on the computer screen. In order to build such models, a wide range of data needs to be scrutinised, validated, and evaluated so that the model is the core of a geoscientific information system. The Digital Geoscience Spatial Model (DGSM) is establishing the methods for building these models, and is exploring the data and applications needed to do this consistently across the BGS.



John Rowley, BGS © NERC

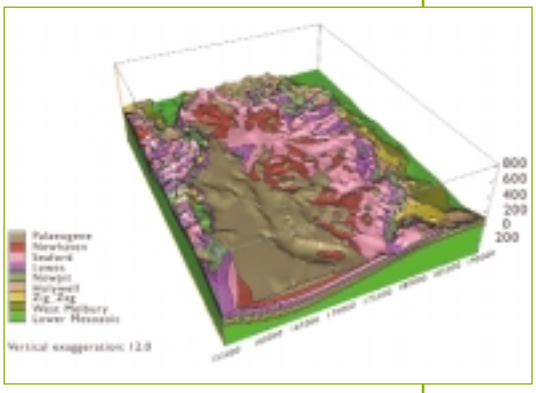
A three-dimensional model of the Cheshire Basin viewed from the south. The Mesozoic succession is faulted against Carboniferous and earlier rocks. Created using earthVision®.

The first part of the programme deals with the technical infrastructure for modelling, developing standards and methodologies: it is called the DGSM Framework. In 2001 it made progress in the following major areas:

- Geoscience Large Object Store — stores a wide range of proprietary model files.
- Geoscience Spatial Framework — designed to deal with shareable spatial data.
- Metadata — allows users to find and evaluate relevant models.
- Best Practice — to record procedures and standards used in modelling.
- 'Mark-up' language — to code digital text, enabling users to select thematic data.
- Applications — developing a Data Portal to access databases.
- Linkage — to establish means of exploring the results of modelling over the World Wide Web.
- Evaluating modelling applications.

The second part of the programme, known as the DGSM-UK, is designed to test that the data structures and procedures are appropriate for a range of geological environments. Models of the following regions were developed during the year:

- South-east England — with an initial focus on the Chalk.
- Midland Valley of Scotland — emphasising the coal-bearing formations.
- Cheshire Basin — a Permo-Triassic structure with significant oil, minerals, and groundwater resources.
- Atlantic Margin — a frontier area for offshore hydrocarbons exploration.
- Humber Estuary — active coastal processes and Quaternary succession.
- UK Regional model — low resolution model of major unconformities.
- Nottingham–Melton area — based on recent mapping, seismic, and borehole data.



Kate Royse, BGS © NERC

The Berkshire Downs viewed from the south-east, showing the newly-recognised seven-layer stratigraphy of the Chalk, the underlying Lower Mesozoic strata, and the localised veneer of Palaeogene rocks. Created using earthVision®.

This has been the second of five years of funding by the Natural Environment Research Council's Science and Technology Board in support of the Digital Geoscience Spatial Model programme. The funding is matched by modelling projects within the BGS, the output from which will follow the emerging DGSM standards.

# GeoHazarD

A growing need for a national data-set covering geological hazards (geohazards) led to the initiation of the GeoHazarD project. The objective of the project is to deliver information that identifies and assesses the potential hazards posing a risk to the human environment in Great Britain.

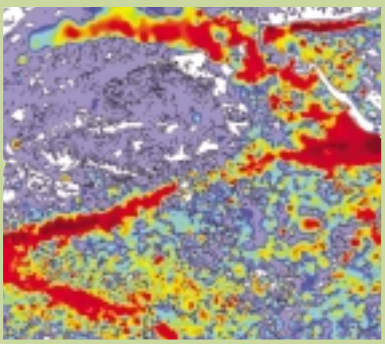
A large number of existing data-sets are being digitised and new interpretations made to provide layers of geohazard information at 1:50 000 scale. Data capture and the development of methodologies are well under way and processing to generate geohazard layers has begun. A huge data capture exercise to identify the base of Quaternary deposits from borehole data has so far input around 453 000 data points. Based on the DiGMapGB-50 data, areas across the country which may be potentially affected by radon and natural subsidence hazards such as swell–shrink clays or landslides are being mapped.

The geohazard data-sets and new Geographical Information System (GIS) coverages produced will form the basis for a more comprehensive and efficient BGS Internet-based enquiry service.

The data-sets being developed include:

- Areas of potential radon hazard.
- Potential for swell–shrink clay deposits.
- Potentially compressible and collapsible deposits.
- Potential for landslides and running sands.
- Thickness of superficial deposits.
- Ground permeability.
- Potential mining-related hazards.
- Scanned borehole logs for onshore geology.
- Scanned BGS reports and mining publications.
- Scanned Ordnance Survey historical maps.

The scanned borehole logs and reports will enable improved data provision and identification of particular geological and hazard information. At the same time, the BGS is building a digital archive and thus will be better equipped to provide customers with a responsive enquiry service and detailed geological information in digital form.



BGS © NERC

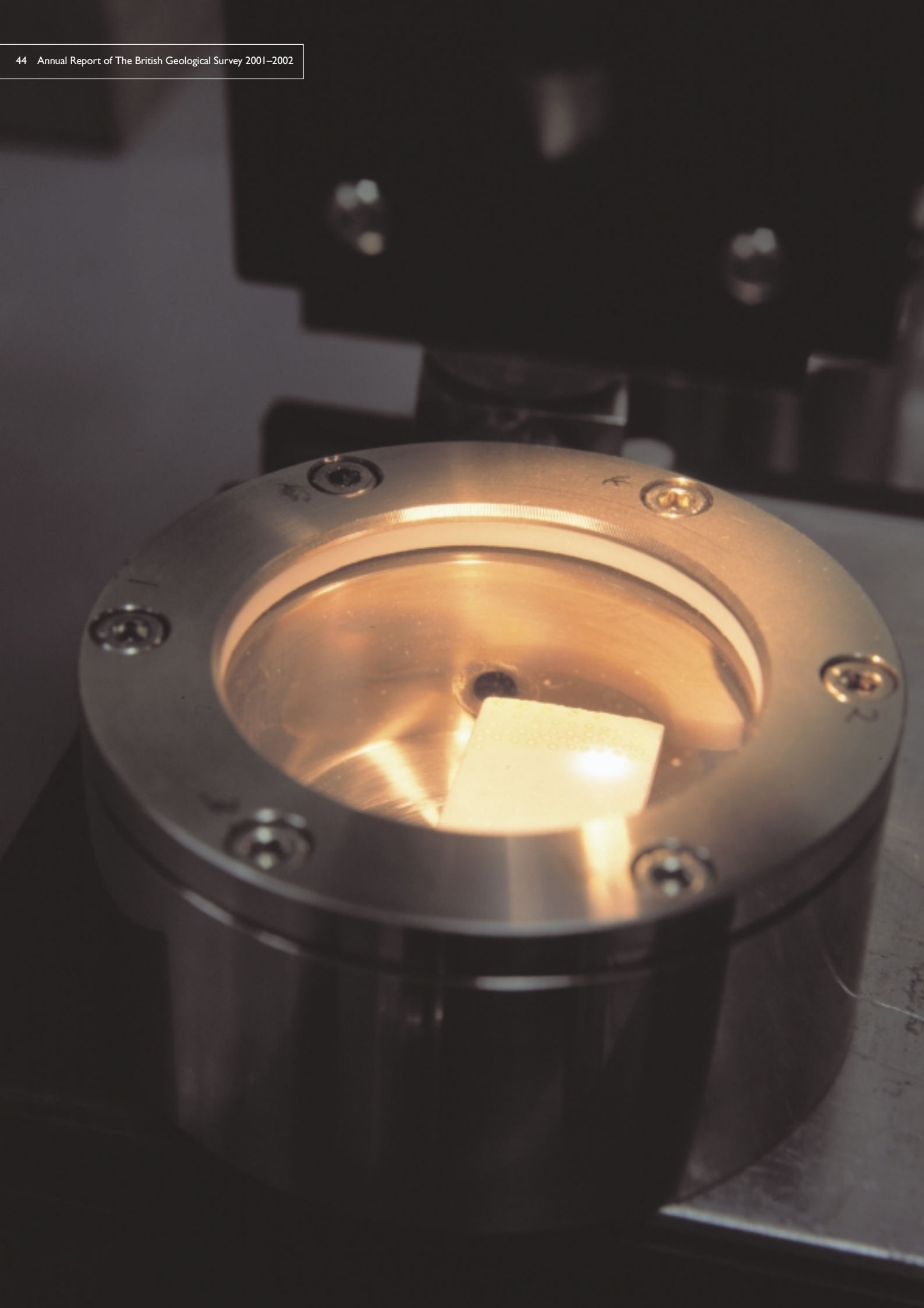
About half of the UK is covered with superficial deposits less than 1.6 million years old; they are mostly natural, but some derive from human activities. The thickness of the superficial layer influences geohazards, such as the likelihood of an area suffering from swell–shrink clay activity, or whether an important water resource is adequately 'sealed' from pollutant leakages at surface. Information from over one million borehole records has been linked to geological map data held in DiGMapGB to model the approximate thickness of the superficial layer. This allows us to analyse the land surface prior to the deposition of the superficial layer and see how deeply bedrock is buried. The map on the left is a detail showing the modelled thickness of superficial deposits for part of the Midland Valley of Scotland. Warm colours (red and yellow) indicate the greatest modelled thickness, cool colours (blue and purple) indicate thinner deposits.

Old and partially collapsed pillar-and-stall workings in a long-abandoned coal mine at Plessey Woods, Northumberland. Large volumes of poisonous 'stythe' gas may form and accumulate in such workings.

Fergus MacTaggart, BGS © NERC

Severe cracking of a road surface due to landsliding at Coombs near Ainthorpe, North Yorkshire.

Alan Forster, BGS © NERC

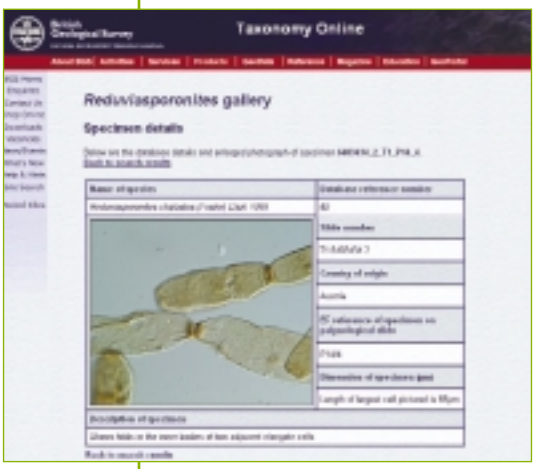


# Geoscience Resources and Facilities

The role of the **Geoscience Resources and Facilities Directorate** (GRFD) is to ensure that adequate human and physical resources are available to the Programme Directorates to enable them to deliver their scientific programmes and to develop scientific capability. Scientific staff are managed and deployed by four Heads of Discipline covering the areas of **Geology, Geotechnics, and Palaeontology; Geophysics and Marine Geoscience; Geochemistry, Mineralogy, and Hydrogeology;** and **Information Systems.** A separate Head of Discipline is responsible for **Administration and Finance** staff.

The BGS carried out a second successive 'new blood' recruitment exercise in the summer of 2001. Most of the recruits were recent first- or higher-degree graduates, but we made a limited number of more senior appointments to address needs arising within the commercial part of the scientific programme, especially those resulting from an increase in international survey activities. New recruits are given a two-day induction course and have an experienced member of staff, outside their line management, to 'mentor' them through their first year. GRFD has developed in-house a database to monitor bids for staff time and to track changes to project allocations. The database now provides 'live' information on project allocations to project leaders and programme managers, and this has significantly improved the efficiency of staff deployments during the year. Work commenced on a staff skills database that will help in identifying long-term staffing needs.

Taxonomy Online: Digital, image-bearing databases are a powerful tool in taxonomy. This project will make the BGS fossil collections available to geologists andpalaeontologists and form an important educational tool.




BGS © NERC

The BGS **Training and Career Management** programme is regularly revised in response to changing scientific and business requirements. We have established new training courses in Quaternary geology and, in support of the overall drive towards digital product production, provided extensive training in a number of GIS and database packages. Training in foreign languages has been provided to support a number of recently won international contracts. We have initiated a major health and safety training programme and this included placing 85 staff on a Land-Rover familiarisation course. In 2001/02 we also provided training to external organisations, including a World Bank contract to deliver a training-needs analysis to the Department of Mining, Papua New Guinea.

GRFD funded attendance at 50 scientific conferences and meetings, and supported over 50 staff serving as members of external scientific committees or learned societies. During the year, BGS staff held many high-profile appointments, including the Presidencies of the Institution of Mining and Metallurgy and the Mineralogical Society of Great Britain and Ireland, and the Managing Editorship of Geophysical Journal International.


Geoscience Resources and Facilities Directorate. **Prof J A Plant** *(0115 936 3521) japl@bgs.ac.uk*

| | | |
|---|---|---|
| Geochemistry, Mineralogy and Hydrogeology<br>**Dr D J Morgan**<br>*0115 936 3138)*<br>*djmo@bgs.ac.uk* | NERC Isotope Geosciences Laboratory<br>**Prof R R Parrish**<br>*(0115 936 3427)*<br>*rrp@nigl.nerc.ac.uk* | Geophysics and Marine Geoscience<br>**Dr J R Evans**<br>*(0131667 1000 ext 213)*<br>*jre@bgs.ac.uk* |
| Geology, Geotechnics and Palaeontology<br>**Dr J H Powell**<br>*(0115 936 3123)*<br>*jhp@bgs.ac.uk* | Information Systems<br>**Dr W Hatton**<br>*(0115 936 3217)*<br>*wha@bgs.ac.uk* | Training and Career Management<br>**Dr I E Penn**<br>*(0115 936 3187)*<br>*iep@bgs.ac.uk* |

## Geoscience Resources and Facilities

# Development of Capability

### Programme overview

The Geoscience Resources and Facilities Directorate (GRFD) carries out strategic scientific research that is designed to underpin both the Core Strategic and Commissioned Programmes of the BGS. The Geology, Geotechnics, and Palaeontology discipline supports BGS geoscience in the fields of Quaternary geology, stratigraphy, palaeontology and the digital capture of field data. The Geophysics and Marine Geoscience discipline provides baseline funding to maintain equipment pools used for applied geophysical surveys, onshore and offshore. The Geochemistry, Mineralogy, and Hydrogeology discipline manages most of the BGS laboratories and sustains the development of laboratory-based techniques for analysing a range of natural materials. The Information Systems discipline delivers enhanced software solutions and geoinformation processing.

BGS © NERC

Sampling road dust in Swansea as part of a study into pollution from traffic and contaminated land sources.

### Geology, Geotechnics, and Palaeontology

The BGS initiative in Quaternary science was supported through the Superficial Deposits Advisory Group, which is providing a revised lithostratigraphical scheme for the Quaternary of the UK in collaboration with academia and industry. Stratigraphy research through the StratBase project underpinned the generation, organisation, and dissemination of multidisciplinary stratigraphical information via the World Wide Web, in collaboration with the Geological Society of London. Capability in palaeontology was further enhanced through Taxonomy Online *(see previous page),* a web-enabled, searchable taxonomic database of BGS fossil material; the first release features a gallery of *Reduviasporonites*, developed in conjunction with Geoscience Australia.

### Geophysics and Marine Geoscience

Deep-water sampling systems, such as the one-metre oriented rockdrill, have been further developed and this led to a successful bid to the NERC Infrastructure budget. This part of the programme also supported work co-funded by NERC and the EPSRC through the Pollution and Waste Management programme to develop Induced Polarisation Tomography *(page 30)* methods for imaging and monitoring barrier performance. The effectiveness of planning, commissioning, and interpreting the results of airborne geophysical surveys *(page 18)* has been substantially developed, and a key member of staff has been invited to present this knowledge to other organisations under the auspices of the EAGE Distinguished Lecturer Programme.

### Geochemistry, Mineralogy, and Hydrogeology

A multi-site study of the impact of both natural and anthropogenic sources on rainwater chemistry across the Swansea conurbation found that sea-spray dominated a natural multi-element fingerprint from rural sites. However, two urban sites were heavily influenced by diffuse traffic pollution, and a third urban site was influenced by the point source of a local steel works. A local study of road dusts in the city was able to discriminate between pollution from diffuse traffic sources and that derived from contaminated land. Lead isotope data allowed separation of elevated concentrations into those associated with 'petrol' lead from those associated with other industrial sources. Significant organic contamination with poly-aromatic hydrocarbons (PAH) from combustion sources was also found.

### Information Systems

A major refocus of the programme provided underpinning development of technologies for the System for Integrated Geospatial Mapping Project (SIGMA) despite restrictions on field testing caused by the outbreak of foot-and-mouth disease. Key delivery and organisational technologies continued to be developed, such as the implementation of ESRI's Arc8® software, testing of ERDAS® stereo analyst software, and input to the development of text-based knowledge capture using Oracle® as the core storage medium. Novel surveying techniques were developed in collaboration with various organisations. A prime example is the measurement of subtle ground displacements from space using radar interferometry, a techniques now being applied in the Urban Geoscience and Geological Hazards Programme.

# NERC Isotope Geosciences Laboratory

This year developmental work focused on using the stable and plasma ionisation mass spectrometry facilities to measure a range of isotopes. These included silicon isotopes as a proxy of organic productivity for palaeoclimate studies, uranium isotopes in urine and other environmental matrices, and quantification of subtle isobaric molecular interferences pertaining to strontium isotopes in carbonates and phosphates by laser ablation.

## Blood of the Vikings

A few days before his defeat by the Normans at Hastings in 1066, King Harold won a decisive victory against the last Viking invasion forces at the Battle of Stamford Bridge. Archaeological evidence of the battle is scant, but skeletons of the right age, with evidence of severe injuries, were found in a mass grave at Riccall, 12 miles south of the battlefield. Sponsored by the BBC2 Series 'Blood of the Vikings', NIGL analysed the $^{18}O/^{16}O$ ratios of the teeth of people found in the grave and calculated that the $\delta^{18}O$ composition of water consumed during their childhood was in the range -9 to -11‰. These values are too low for English waters (-5 to -8‰), but similar to waters in north-western Norway and the Baltic. The results provide strong evidence that the grave on the banks of the River Ouse holds remains of Vikings, killed or mortally wounded in the battle, and buried at the place where the defeated army retreated to its longships.

## Lead isotope composition of particulates in London air

A complex mixture of local and remote sources contributes to the particulate budget of London air, which varies with local meteorological conditions and direct emission sources. In a collaborative study with Kings College London, the lead isotope ratios of PM10s (particles with an aerodynamic diameter of less than ten microns) trapped on collection filters were measured during the period when leaded petrol was being phased out. A large shift in lead isotope signatures from North American and Australian-dominated lead compositions towards those typical of western European (continental) aerosols occurred within 1999. This shift almost certainly results from the decreasing contribution of leaded-petrol-derived particulates relative to local industrial and distal sources.

## Authenticating wine

Food and drink authentication is becoming increasingly important as the general public become more concerned about the origins and quality of the products they consume. As part of a joint project with a laboratory instrument manufacturer, the NIGL has recently demonstrated that it is possible to characterise and authenticate the origin of wine through analysis of strontium isotope ratios. Wines acquire their strontium isotope signature from the soils in which the vines grow and this signature is characteristic of the underlying rock. By matching the signatures of the wines with their respective rocks, this technique becomes a sensitive tool that can be used for authentication. Analysis of samples of wine and port indicates that not only can the difference between vines grown on very different rocks (such as basalts and granites) be determined, but that different vineyards can be differentiated, even when situated on very similar lithologies.

### Programme overview

The NERC Isotope Geosciences Laboratory (NIGL) is funded directly from the NERC Science Budget to conduct fundamental and applied research and to provide post-graduate student training involving isotope measurements for scientists in NERC institutes and the UK academic community.

Blood of the Vikings: the tooth in this jaw is an example of archaeological material used for analysis.

J Montgomery © University of Bradford

# Marketing, International and Corporate Development

The **Marketing, International and Corporate Development Directorate** (MICDD) contains **BGS International®** which is responsible for co-ordinating the delivery of the BGS's activities outside the United Kingdom; the **UK Business Development** team, which spearheads the marketing of the BGS's domestic projects; the **Press Office** which communicates the activities of the BGS to the media and politicians; and the **Central Directorate Support Group** which backs up the Executive Director's office and services the requirements of the BGS Board.

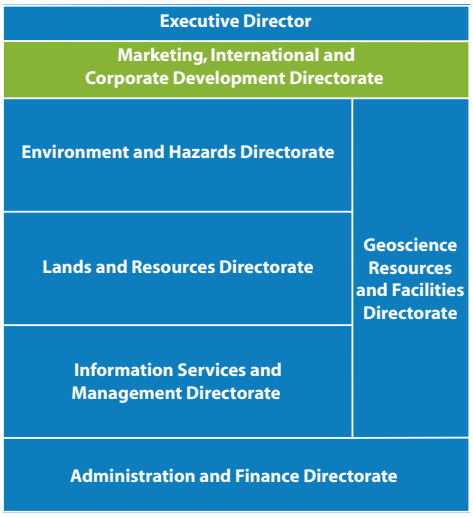
The overall strategy for the marketing and exploitation of BGS science is to engage with a wide variety of external supporters, particularly in co-funding arrangements that support and enhance the core programme. The BGS undertakes commissioned research projects that are appropriate to its core science and, by so doing, not only demonstrates the relevance of the science but enhances the facilities and skills base available to all programmes.

The work of **BGS International®** is funded entirely by external commissions, principal among them being projects funded by aid agencies and development banks. Such activities grew considerably during 2001/02, partly because of a recognition by the development agencies that long-term and sustainable economic growth in many poor countries is predicated on using their natural resources, such as minerals, hydrocarbons and water, more effectively. BGS International® extended its traditional geographical areas of activity into francophone Africa and the Middle East by successfully winning contracts in Mauritania and the United Arab Emirates.

The **Press Office** was much engaged in communicating BGS activities and information during the foot-and-mouth crisis that affected much of Britain in 2001. It also supported the work of the All Party Parliamentary Committee on the Earth Sciences, at which BGS staff members gave a number of talks.

Geological mapping, Mauritania *(see page 51)*: testing for radioactive minerals at an abandoned rare-earths mine at Bou Naga. The terrain varies from Saharan desert plains and dune belts with scattered hills, to rocky badlands with limited road access.

Mike Hawkins, BGS © NERC




## Marketing, International and Corporate Development

# BGS International®

### Programme overview

BGS International® co-ordinates the overseas activities of the BGS, operating in recent years in over 60 countries, mainly in the developing world. The applications of geoscience, water resource, and geohazard understanding in these countries is often key to their economic and social development and is funded by clients such as the Department for International Development (DFID), the World Bank, and the European Union.

BGS © NERC

Low-cost lime: a crop of maize successfully grown with the application of dolomite in Mkushi, Zambia. Crop trials using locally ground dolomite show a threefold increase in yields from limed maize plots, compared with unlimed plots.

### Volcanic hazard assessment, Tristan da Cunha

The Foreign and Commonwealth Office and DFID commissioned the BGS to undertake a volcanic hazard assessment of the Overseas Territory of Tristan da Cunha in the South Atlantic. Sitting on the eastern flank of the mid-Atlantic ridge, the island forms the emergent top of a near-perfect volcanic cone, which rises from a water depth of about 3500 metres to an altitude of 2060 metres above sea level. New radiometric dates acquired during the assessment indicate that the volcano emerged above sea level at between about 140 000 and 20 000 years ago. There has been no activity around the upper flanks of the cone for almost 11 000 years. However, young parasitic volcanic centres have erupted along the occupied coastal strips over the past few tens of thousands of years, the last such eruption having occurred close to the Settlement in 1961/62. The BGS study has concluded that there is a 25 per cent probability of an eruption occurring on one or other of the two coastal strips during the next 100 years. The project builds on experience gained in the course of an ongoing volcanic monitoring and risk assessment programme on the island of Montserrat, and earlier work undertaken in Chile and Cost Rica.

### Low-cost lime for small-scale farming

The occurrence of acidified soils in many developing countries often leads to poor crop yields, a situation that could easily be remedied if agricultural lime were used. However, subsistence farmers often fail to do so, in part due to lack of knowledge but also because agricultural lime is too expensive. Local production of low-cost lime from suitable carbonate resources within farming districts improves the access of small-scale farmers to this valuable additive. The present study, which is being funded under the DFID's Knowledge and Research programme, is focusing on the development of a small lime production facility in the farming area of Mkushi in central Zambia using local dolomite resources. The project builds on an earlier study, also funded by the DFID, which evaluated a number of Zambian limestone and dolomite deposits suitable for the production of cheap lime. The BGS, in conjunction with the Zambian Geological Survey Department and the University of Zambia, is conducting tests on grinding dolomite using an adapted hammer mill originally designed for maize milling. The hammer mill design has already been copied by local entrepreneurs at Solwezi in north-west Zambia, with the result that agricultural lime production is now taking place there.

### Iodine deficiency disorders

Iodine has long been recognised as a trace element essential to human nutrition and health, yet iodine deficiency disorders (IDD) continue to be a major concern in some parts of the developing world. Iodine deficiency is the most common cause of mental retardation and brain damage, and one of its more visible manifestations is an enlargement of the thyroid gland, leading to the condition known as goitre. Although medical techniques, such as the iodisation of table salt, are widely used to overcome this problem, the primary cause of IDD — a lack of readily available iodine in the environment — has hardly been addressed. Furthermore, some of the poorest communities in the areas affected often prefer traditional methods of making salt and so deny themselves iodine supplementation. At the same time, many IDD areas of the world occur in environments that are apparently not iodine deficient.

With funding from the DFID's Knowledge and Research programme, the BGS has been analysing samples of soil, water, and foodstuffs from an iodine-deficient area of Xinjiang Province in China. The study aims to show how iodine migrates through the food chain, what factors are responsible for fixing iodine in the environment, and which agricultural practices promote the transfer of iodine into crops.

Iodine deficiency disorders: soil sample collection for iodine analysis in Wushi District, Xinjiang Province, China.

Fiona Fordyce, BGS © NERC

## Geological mapping and minerals GIS, Mauritania

The BGS has begun a three-year project to survey the geology of an area of 500 000 square kilometres of southern Mauritania in north-west Africa. BGS geologists, in partnership with the Mauritanian Department of Mines and Geology (DMG), are working under demanding conditions, one of which is the constant threat from sand and dust storms. The areas being mapped encompass part of the Precambrian cratonic basement known as the Reguibat Dorsal, and the Mauritanide belt. These areas are prospective for gold, copper, chromium, nickel, platinoids, tungsten, and iron ore. The basement rocks also contain rare earths, uranium, thorium, lithium, beryllium, and diamonds. Training of DMG counterpart staff is an integral aspect of the project. A separate, but related, component involves the design of a minerals GIS for the whole country. The project is being undertaken on behalf of the Government of Mauritania with support from the World Bank and is part of a larger initiative to reform the mining sector and promote inward investment.

## Appropriate technology for low-cost geological mapping

The BGS has been investigating whether technologies such as remote sensing and global positioning systems (GPS), together with the use of the Internet, can provide cost-effective and rapid techniques for gathering geological data and making it available to a wider public. With funding from the DFID's Knowledge and Research programme, two countries with very different climate and geography — Guyana and Mongolia — have been selected as case study areas. Both have mineral-based economies that would benefit from the application of low-cost mapping and data-gathering techniques. The two regions are characterised respectively by tropical forest and arid desert. The main output from this project is a web-based information reporting tool with worldwide application, which is now accessible on the BGS web site.

Low-cost geological mapping: Landsat TM enhanced false-colour image of the Gobi region of south-western Mongolia. Surface alteration of the rocks in this region, which is largely bare of vegetation, lends itself to geological discrimination on satellite imagery. Thus zones of mineralisation can be located and verified more rapidly than by conventional field methods.

Raw data © EOSAT; enhanced imagery, BGS © NERC

## Augmenting Groundwater Resources by Artificial Recharge (AGRAR)

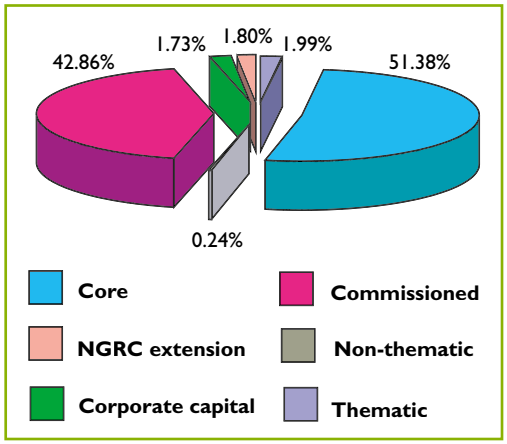
Groundwater is the main source for rural water supplies in many developing countries. Overexploitation has led to a sustained decline in resources. Recently there has been considerable renewed effort and investment to maintain and restore traditional artificial recharge facilities and to build new structures. However, there has been little systematic assessment of the technical or socio-economic effectiveness of these schemes. Phase 1 of the DFID-funded AGRAR project (2001/02) undertook a review of methodologies and controls on effectiveness and identified the benefits, constraints, and uncertainties associated with aquifer recharge. A network of partners — mainly in India — in government, non-governmental organisations (NGOs), and universities was established. The results of this work can be accessed through a web site (www.iah.org/recharge) created to promote information dissemination and networking.

## Administration and Finance Directorate

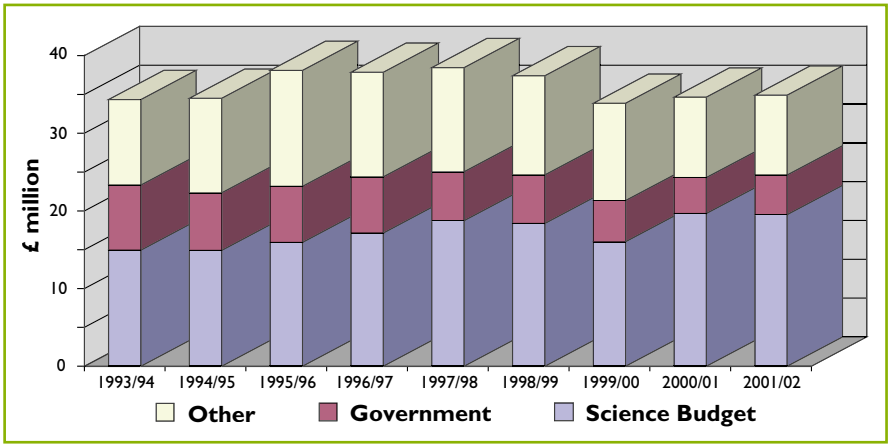
# Finance

### The Financial Year 2001/02

| CORE STRATEGIC ACTIVITY | |
|---|---|
| Lands and Resources Directorate | £5 834 710 |
| Environment and Hazards Directorate | £3 677 882 |
| Information Services and Management Directorate | £7 119 804 |
| Development of Scientific Capability | £1 042 399 |
| Additional core activities | £259 229 |
| **Total Core** | **£17 934 024** |
| Commissions and co-funding | £14 963 228 |
| Thematic | £694 936 |
| Seedcorn & Non-thematic | £83 722 |
| Corporate capital | £604 969 |
| NGDC Extension | £627 094 |
| **Grand total** | **£34 907 973** |




BGS expenditure during the financial year 2001/02.




Sources of BGS income 1993/94 to 2001/2002 (at 2001/2002 prices).

### BGS funding for research

The BGS receives funding from the NERC to carry out a broadly based Core Strategic programme of long-term surveying, monitoring, databasing, environmental research, and provision of scientific advice. This is our principal business and is in furtherance of the NERC's mission. The programme was enhanced in 2000/01 through two major projects, the Digital Geoscience Spatial Model and GeoHazarD. The NERC also makes a contribution to our infrastructure of £5.9 million which is subsumed within the total Core funding for 2001/02 of £17.9 million.

We also earn external funding through commissioned and co-funded research. This comprises strategic commissions, partnerships, and contracts with a wide range of clients, including government departments, agencies, local authorities, the European Union, international aid agencies, the World Bank, and overseas governments as well as industry, commerce, and the public. The Commissioned programme enhances the Core Strategic programme through funding, ideas, data and review, and increases the relevance of the Survey's capability to meet the requirements of governments, industry, and the wider community. The value of the programme rose from £14.9 million gross in 2000/01 to £16.2 million in 2001/02, including receipts from BGS participation in NERC's competitive thematic projects. As well as enhancing the range and quality of research, the Commissioned programme makes a vital contribution to the Survey's infrastructure.

The BGS has an obligation to the NERC to balance its income and expenditure and was able to do so again in 2001/02, carrying forward a balance into 2002/03 for investment in specific projects. Late in the financial year it was announced that the BGS had bid successfully for three major capital projects valued at £3.5 million from the Office of Science and Technology's Research Centre Modernisation Fund. The funds will be invested over the period 2002–2005.

# Personnel

The BGS has continued to inject new skills into the organisation to meet future business needs and to fill the gaps resulting from forthcoming retirements. As a result the BGS Personnel Section was committed to a significant recruitment round during the year. This included the appointment of science and IT/IS graduates to positions at Band 6 (HSO) and Band 7 (SO) level. This round of appointments will help to ensure that the BGS is fully prepared to support its Core Strategic and Commissioned Programmes. Normal recruitment exercises for replacement staff also continued. In summary, a total of 86 staff appointments (over ten per cent of the total staff complement) were made during the year.

| | 2000/1 | 2001/2 | Total |
|---|---|---|---|
| Asian-Bangladeshi | | ● | 1 |
| Asian-Chinese | ● | ●● | 3 |
| Asian-Indian | ●● | ●● | 4 |
| Asian-Other | | ● | 1 |
| Black-African | | ● | 1 |
| Black-Caribbean | | ● | 1 |
| **Total** | 3 | 8 | 11 |

Chris Wardle, BGS © NERC

Ethnic recruitment statistics for 2001/02.

The Personnel Section has continued to be proactive in the area of equal opportunities in recruitment, although recruits to the science area are still not as even in gender terms as in the administrative area. The year saw an increase in the recruitment of ethnic minorities due to efforts in addressing the issue, although the number of such applicants remains low. It has been suggested that universities are failing to attract ethnic minorities to key Earth science degree courses. Personnel continues to provide support to those with disabilities, thereby maintaining its 'Two Ticks' accreditation. Family-friendly policies are supported with the provision of opportunities for job share, part-time working, and career breaks for family purposes. There has also been an increase in childcare support and the payment of an after-school care allowance to some staff.

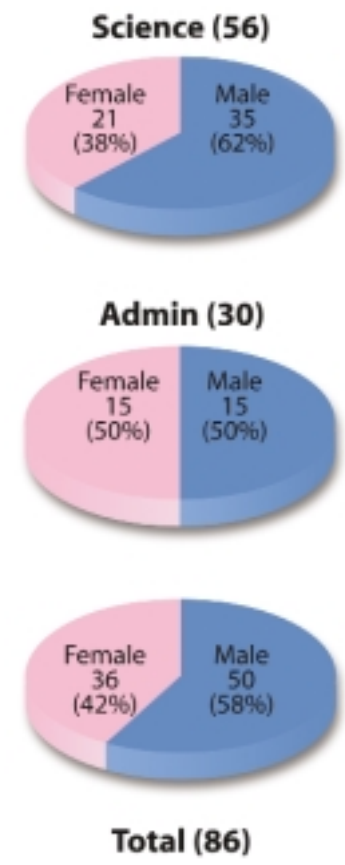
The conversion of fixed term appointments (FTAs) to open-ended status has continued throughout the year, resulting in a reduction from 101 to 28 FTA staff, although some conversion dates commence in 2002/03. While the BGS continues to make FTA appointments, these have been kept to a minimum, and are only made to meet a specific need for a limited period. Every effort is made to provide alternative positions to FTA staff at the end of their appointment, in line with employment requirements.

Staff in Personnel Section provide professional support to the Geoscience Resources and Facilities Directorate (GRFD). There is continuous close liaison between personnel staff and members of the GRFD regarding human resource issues.

The NERC Merit Promotion Scheme operated for the first time during the year and the BGS Personnel Section was closely involved in the administration of the delegated Science Promotion Panels. The scheme provides new opportunities for IT/IS, Technical, and Administrative staff to gain promotion.

The development of the personnel database continues with the introduction of a new version being planned for the forthcoming year. The Personnel Section has been leading the development and implementation of skills and CV databases; the next phase of the project will see employees and managers having direct access to relevant personnel data.

Recruitment of staff by gender 2001/02.




Chris Wardle, BGS © NERC

## Administration and Finance Directorate

# Facilities Management

Tim Cullen, BGS © NERC

The NGDC extension at Keyworth now houses data-sets and core acquired from the Coal Authority and Nirex, and provides much needed spare capacity to receive additional future contributions.

Caroline Adkin, BGS © NERC

As part of our efforts to make the Keyworth site more attractive to wildlife, a pond and small wildflower meadow were created in 2001 and bird and bat boxes erected around the grounds.

### Facilities and infrastructure

A highlight of the year was the completion and commissioning of an extension to the core store and records room of the National Geoscience Data Centre (NGDC) at Keyworth. This £1.07 million project, supported in part by financial contributions from the DTI and Nirex Ltd, was achieved within two weeks of the expected completion date and within the planned budget. The floor area of the main hall has been increased by 740 square metres, an expansion of some 40 per cent, while the records area has been extended by 50 per cent.

Facilities Management continued to evaluate the feasibility of a Combined Heat and Power installation at the Keyworth site, and we have installed metering equipment to quantify and profile the energy consumption. This will allow us accurately to size the proposed plant to ensure maximum efficiency, and thus realise the expected financial savings. In tandem with this evaluation, we are investigating the possibility of replacing some of the main gas-fired boiler plant with ground-sourced heat pumps. This technology uses low-grade heat from the ground and offers substantial efficiency savings and lower emissions, even when compared to the most efficient conventional boiler plant.

Both routine and major maintenance tasks have continued to both the fabric and the services at all the Survey's sites. We have made significant progress with the heating refurbishment at Murchison House and the replacement of double-glazed windows and doors at Keyworth and expect both these major projects to be completed by 2004/05. To allow the task of maintenance and refurbishment to carry on in an effectively managed and ordered way, Facilites Management has drawn up a plan targeting the effort of the department over the next five years. This takes the form of a list of requirements that can be addressed in a flexible way when funding allows.

In the light of financial pressures on the Survey, specific attention has been paid to those services which are contracted out, with particular emphasis being placed on service levels and value for money. Several contracts have been retendered during the year and we have been generally successful in either holding costs steady, or reducing them, while at the same time achieving increased levels of service.

### Improving our environment

The BGS now recycles a wide range of materials, from metal to paper and plastic bottles. We have more than halved the waste sent to landfill over the past four years, and saved up to £10 000 a year in disposal costs. We are also committed to making our grounds more attractive to wildlife.

In 2001/02 the BGS commissioned the Royal Institute of British Architects (RIBA) to run a competition to design the 'Geological Gardens'. The gardens will be a permanent educational exhibition, providing a showcase for the scientific research undertaken, not just within the BGS, but across all the NERC Research Centres. The competition attracted entries from as far afield as Japan, Canada, the USA, and Sweden. A sponsorship campaign to fund constructions of the gardens will be launched shortly.

# Health and Safety

## NERC Health and Safety procedures and guidance

The Natural Environment Research Council (NERC) Safety Management Group (SMG) has continued to work on the production of Health and Safety guidance and procedures. The BGS is using these either in their original form or, where necessary, adapted to meet our specific needs. These include:

- Risk management of high risk groups.
- Laboratory procedures.
- Safety at sea policy.

## Occupational health

During the year we have made greater use of our occupational health advisers, the Queen's Medical Centre in Nottingham and the Institute of Occupational Health in Edinburgh. These advisers have both provided information and treated individuals with occupational-related conditions. This has proved very effective and it has been possible to deal with conditions quickly and appropriately.

## Laboratory safety

We have made further progress with the introduction of generic risk assessments for common procedures and identified sources of online information to make the risk assessment process more manageable for laboratory staff. A programme of upgrading has been carried out on many of the fume cupboards at the Keyworth site to improve both performance and reliability. Work has been completed on existing machinery to ensure compliance with the Provision and Use of Work Equipment Regulations 1998.

## Office safety

The past year saw a significant investment made in the purchase of more suitable workstation furniture. This has resulted in a substantial improvement in the level of provision and the exercise will be repeated in the new financial year. To allow new priorities to be set, an assessment of all workstations has been carried out. This process has also served to generate information which will be used by our occupational health advisers.

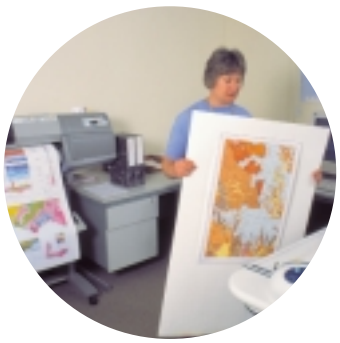
## Contractor and vehicle safety

A contractor's handbook has been produced which will be used in the induction process for contractors working either on BGS sites or elsewhere under contract to the Survey. This is an important step forward and will help the BGS meet its responsibilities to manage contractors safely and effectively. A major review of the BGS vehicle fleet was carried out and this identified a need for the introduction of vehicles that would provide a combination of comfort for extended road journeys and good off-road performance. In the first instance, three new vehicles will be bought to address this need, with capital funds being set aside both this year and next.

A vertical laminar flow hood, one of many fume cupboards at the Keyworth site which have been upgraded to improve performance and reliability.

Paul Tod, BGS © NERC

The newly installed scan-to-print system at Keyworth which is used to produce maps for sale to the public. This replaces a dyeline process which required the use of hazardous chemicals and reduces our need to use large format photographic processors.



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