

CONTENTS

Introduction	I
What is Geoscience?	4
Geoscience—Powering the Economic Engine	6
Irish Geoscience Graduate Programme	9
A Knowledge-Driven Sector	11
Agenda for Action	14
Geological Survey of Ireland (GSI)	19
Supporting Quality Research	21
North–South Cooperation	24
International Context	26
Support from Society	28
Appendix A: Legislation and Policies where Implementation is Informed and Supported by Geoscience	
Appendix B: List of Acronyms	30



INTRODUCTION

The overarching goal of the National Geoscience Programme (2007–2013) is to enhance and highlight the contribution that geoscience makes to Irish society. Geoscience impacts on many important aspects of national life, including the sustainable management of our environment, the development of our natural resources and infrastructure, and understanding and predicting natural hazards (for example, landslides, tsunamis and earthquakes). Critically, through research it provides an understanding of how the Earth works. The term of the National Geoscience Programme purposely coincides with that of the new National Development Plan (2007–2013). This will ensure geoscience's contribution to society is focused on supporting this plan. Its aims are to:

- Support the government's Strategy for Science, Technology and Innovation (SSTI).
- Increase the level and quality of research investment nationally, including in particular private sector participation.
- Position the geoscience sector to increase its contribution to the government's agenda on the knowledge economy by developing its industry, services, research and education.
- Enable the geoscience sector to provide expert advice to the government on key issues, which are relevant to the sector.
- Maximise the effectiveness of the geoscience sector by prioritising key themes and mobilising resources to tackle them.

- Derive maximum benefit from Ireland’s natural advantages—its resources and its geographical position within Europe.
- Increase the coherence and efficiency of the sector by ensuring the provision of excellent and networked education and research infrastructure—recognising the competitive nature of the modern science and technology (S&T) environment.
- Build on the increasing levels of North–South cooperation in the sector thereby contributing to the aims of the British and Irish governments in this regard.

The National Geoscience Programme will assist the geoscience sector to evolve over the coming years in order to fulfil its aims. While the sector will continue to provide excellent and improved services to its traditional customers in the petroleum and minerals sectors, it will also continue to serve a wide range of other sectors, including planning, environment, agriculture, water services, energy, infrastructure, transport, tourism and heritage. At the same time it will strive to change the fundamental nature of its services so that geoscience climbs the value chain and shifts from its traditional task of predominantly supporting manufacturing activities, to knowledge-generation for both national and international priorities. Ireland has the capacity to be world-class in certain aspects of geoscience (for example, marine and water services) and these have a particular emphasis



in this programme. On an international scale, geoscience has a growing coherence in Ireland, reflected in this programme, which is not evident widely at European level, and the programme will take advantage of this opportunity.

The National Geoscience Programme has been prepared in the context of the National Development Plan (2007–2013) and is explicitly comprehended in the recent SSTI (Section 6.6). The National Geoscience Programme is published jointly by the Royal Irish Academy (RIA) and the Geological Survey of Ireland (GSI), a division of the Department of Communications, Marine and Natural Resources. The initial draft of this document was prepared by the GSI on behalf of the geoscience sector and the final version was completed after input from the broad Irish geoscience community, including the heads of geoscience institutes. It is based on consultation since early 2004 with the heads of these institutes (in both Northern Ireland and the Republic of Ireland), the National Geosciences Committee of the RIA, Science Foundation Ireland, the Chief Science Adviser and the geoscience community at large (including the results of a public workshop held in July 2005).

Provided the necessary investment is made in the geoscience sector, then the National Geoscience Programme will deliver the following benefits over the period 2007–2013:

- Geoscience will contribute more effectively and on a larger scale to Ireland's knowledge economy, thereby creating greater wealth and a better

quality of life on the whole island through the results of targeted and prioritised research and development (R&D).

- Additional and more effective geoscience services will support important national objectives in the energy, environment, water, infrastructure and marine sectors.
- Higher participation rates in geoscience research and education will contribute to national objectives relating to education and the knowledge economy, as the research infrastructure is enhanced and more overseas students and researchers are attracted to Ireland.



WHAT IS GEOSCIENCE?

In the past geoscience was associated predominantly with the discovery and extraction of natural resources, but has become increasingly relevant to a wide range of important national issues in recent decades. Geoscience includes a diverse range of interlinked disciplines including geology, geophysics, geochemistry, hydrogeology, physical geography, meteorology, climatology, oceanography, geotechnical engineering and spatial analysis. It includes both field- and laboratory-based components. In Ireland today, geoscience addresses issues such as:

- Providing and monitoring of adequate and clean water supplies;
- Maximising the security of indigenous energy supplies through the discovery and development of conventional (oil, gas, coal etc.), renewable (geothermal, wind) and unconventional (hydrates) sources;
- Discovering and developing the wide spectrum of materials needed by society, from zinc ores, which are extracted at Navan, Galmoy, and Lisheen, to aggregates (gravel and crushed rock) that underpin the development of our national roads and construction infrastructure;
- Maintaining the security of transport routes, including minimising construction costs and delays due to unexpected ground conditions, and enhancing maritime safety in the offshore environment;

- Protecting communities from natural hazards as diverse as landslides, flooding, indoor radon, earthquakes and tsunamis, as well as from human-induced hazards such as ground subsidence and contaminated land;
 - Informing national and international bodies on issues such as climate change and its likely implications for society, and providing expert guidance on planning responses to such issues;
 - Sustaining our landscapes and seascapes through informed decision-making regarding competing land and seabed uses, as well as ocean, coastal zone and landscape management;
 - Informing planning decisions on construction projects, the development of infrastructure to meet society's needs, and the preservation of landscape and geological heritage;
 - Developing a national scientific skills base to support the government's drive to nurture our knowledge economy through investment in science-driven innovation;
 - Undertaking fundamental research of the highest international calibre and contributing to the global knowledge-base of how our planet works.
- Many sectors of Irish society benefit from the services provided by geoscience, including:
- The European Union (EU) and government departments and agencies—the implementation of a wide range of legislation and policies is supported by geoscience (see Appendix A).
 - Local authorities—it is important that full account be taken of geoscience in planning decisions relating to water supplies, construction, road development and waste disposal.
 - The education sector—the development of this sector is essential to ensure an adequate supply of skilled geoscientists.
 - A wide range of extractive, industrial and service sectors—for example, construction, engineering, exploration, mining and quarrying, energy, agriculture, fisheries, heritage, environment, leisure and tourism.
 - Tourism—the areas of natural beauty in Ireland are shaped by their underlying geology. An understanding and appreciation of their geological evolution can enhance the attraction of such areas (for example the Giant's Causeway of Antrim or Waterford's Copper Coast).
 - Individual communities and the general public—geoscience information, while still used by experts, will be increasingly processed and interpreted for wider use and will eventually be customised for all end-users.

GEOSCIENCE — POWERING THE ECONOMIC ENGINE

The geoscience sector comprises the providers of geoscience-based commodities, services, research and education, together with their customers and stakeholders. There is sufficient coherence in the sector to ensure that the additional investment foreseen in this programme will nurture multi-disciplinary world-class research thereby driving increased economic competitiveness in line with government policy.

Geoscience-based industry contributes more than €2 billion annually to the Irish economy. Zinc-lead mines at Navan, Lisheen and Galmoy account for an annual output valued at €260 million and employ over 1,200 people. A total of 130 million tonnes of quality aggregates, which underpin the country's extensive construction sector, are produced annually by 10,000 employees across the country. Plasterboard production involving gypsum mining, and dimension stone based on limestone extraction, are examples of further raw materials for our thriving construction industry. A significant proportion of Irish gas needs (13% in 2005) is met from offshore gas production at Kinsale Head, Ballycotton and Seven heads gas fields off the south coast. Output from the Corrib gas field off the west coast is expected to reduce Ireland's dependence on imported gas by at least 50% during its peak production years. Our offshore regions are only very lightly explored and offer very significant further energy potential.

Geoscience services in the private sector in Ireland are estimated to generate €130 million turnover



annually with 1,000 employees, a significant proportion of which have graduated with degrees from our third-level institutions. These services are provided by a range of consultancy and contracting companies, many of which have integrated with larger engineering firms in recent years, and a few examples are provided here. With between 100,000 and 200,000 individual boreholes across the country providing 25% of our domestic water supplies, groundwater discovery, production,

monitoring and protection remain important services. The evaluation of ground conditions for construction, road-building and other infrastructure projects is another critical area where geoscience contributes to effective planning and budgeting. Such evaluation allows for the avoidance of cost over-runs or completion delays through encountering unforeseen conditions. Geoscience consultancies based in Ireland also offer a range of exploration and related services to onshore mining and quarrying as well as to offshore oil and gas exploration. These services are offered on a global basis and, within the developing world, form a key component of international EU, World Bank, United Nations (UN) and Ireland's bilateral aid programmes. In parallel, junior Irish companies participate in mining and energy projects around the world and, with a successful track record, make significant contributions to the economies of many developing nations.

State agencies in recent years have had a combined geoscience budget of about €32 million per year. Several agencies contribute significantly to the geoscience sector, in many cases in partnership with the GSI and the third-level sector. These agencies include the Environmental Protection Agency, the Marine Institute (MI), Met Éireann, Ordnance Survey Ireland and Teagasc. The GSI is the national geological agency and works within the geoscience sector. These agencies all provide services relating to various aspects of geoscience, including database acquisition, research, consultancy and training. Some also have regulatory and funding roles.

The third-level sector has had an annual geoscience research income, when combined with that of the state agencies, of €11.5 million in recent years. This comes from a mixture of national (for example, Science Foundation Ireland, Enterprise Ireland), international (for example, the EU) and industrial (for example, oil companies) sources. There is potential for a structured programme of collaboration between the third-level and private sectors. The third-level sector, in both jurisdictions, has recently produced a total of approximately 50 geoscience graduates per annum. In addition, approximately 25 PhD students and 15 postdoctoral researchers commence research training each year in Ireland in the fourth level. Geoscience university departments and schools in the Republic (at Trinity College Dublin; National University of Ireland, Galway; University College Cork and University College Dublin) have approximately 35 faculty members. In Northern Ireland although there is no dedicated Department of Geology at either Queen's University Belfast or the University of Ulster, it is estimated that another 35 faculty members based in a variety of disciplinary departments are committed to geoscience research in these universities.

As a concluding statement, it is significant that annual business turnover in the geoscience sector, which exceeds €2 billion is supported by state investments of about €40 million. An increase in this latter figure can be expected to contribute to even greater business turnover.



IRISH GEOSCIENCE GRADUATE PROGRAMME

The development of an Irish Geoscience Graduate Programme would be an important achievement over the period of the National Geoscience Programme (2007–2013) and indeed it could play a key role in ensuring the success of the programme. It will comprise a networked, all-island graduate programme whose management board will be representative of all third- and fourth-level bodies and with formal links to non-academic stakeholders. Its purpose will be to facilitate and coordinate specialised geoscience modular courses to provide the skills training for new graduate students embarking on research. Its objectives will be to:

- Coordinate the provision of specialist modular training in specific and generic competencies for all graduate geoscience researchers in Irish research institutions, and ultimately for continuing professional development of geoscientists working in industry.
- Promote excellence in Irish geoscience training and research by attracting foreign expertise and by pooling national resources.
- Assist in the management and maximisation of the national value of large-scale equipment.
- Meet the requirements of the private sector—consultants, contractors, developers and investors.
- Enhance mobility of academic staff and students, both nationally and internationally.

This initiative is in line with the government's new strategy on fourth-level training, being implemented by the universities through the provision of a structured PhD programme involving specific taught courses as part of a four-year degree programme. With appropriate investment in



accommodation, supervision, technical infrastructure and participant funding, the geoscience sector can double the number of graduate (PhD and MSc) students and postdoctoral researchers in the period up to 2013. Course participants will gain a thorough knowledge of Earth system science through taught specialised courses and research activities that will enhance their research training. The training schedule will take the form of modular short courses and research activities, both field- and laboratory-based, focused on modern geoscientific methods and techniques. Students will acquire skills such as scientific observational skills, specialised empirical and interpretational skills, numerical and analytical skills, and teamwork skills. Graduates of the programme will be sought after to pursue careers in academia, government and in particular industry.

Ireland, North and South, has important international strengths in geoscience research and can build on a history of effective all-island collaboration, thereby increasing the geoscience contribution to the government's Strategy for Science, Technology and Innovation.

Ireland has a unique opportunity arising from the closure of several geoscience departments at third-level institutes across the United Kingdom—some now belatedly being reversed. As a result, relevant geoscience courses on strategic disciplines (for example, hydrogeology and engineering geology) at Irish institutes are likely to attract strong participation rates in the coming years.

A KNOWLEDGE-DRIVEN SECTOR

The creation of comprehensive, harmonised, high-quality databases is an essential component in delivering economic competitiveness and disseminating knowledge, and is one of the primary functions of state organisations involved in the geoscience sector.

Probably the best-known geoscience databases are those recently generated through the Irish National Seabed Survey (INSS) by the Geological Survey of Ireland and its partners, especially the Marine Institute (MI). The MI and the GSI are now jointly undertaking a new programme of seabed mapping called INFOMAR. This programme is designed to complete data acquisition in all nearshore areas of the Irish seabed and build a world-class data management system capable of providing easy access to its information. The benefits will include support for policy and regulation across a spectrum of national and EU maritime issues, more informed decisions on the management of offshore energy, biological and aggregate resources, and increased research and commercial opportunities through value-added activities.

In the onshore area, the Geological Survey of Northern Ireland (GSNI) has recently demonstrated the effectiveness of systematic geophysical and geochemical surveys through its TELLUS Project. Concluding its data acquisition in 2007, this project will provide real benefits to Northern Ireland by providing high-quality data on its physical environment, mineral and other natural resources, thereby promoting inward investment in

exploration, as well as informing future land use and spatial-planning decisions. A number of similar pilot studies were undertaken in 2006 in the Republic of Ireland as a basis for proceeding to nationwide surveys whose results are managed in an integrated data management system and supported by North–South cooperation. This is the Resource and Environmental Survey of Ireland (RESI), mentioned in the section on the GSI below, which can be completed in the time frame of the National Development Plan (2007–2013). It will assist in delineating and protecting areas with important groundwater resources, assessing the suitability of areas for specific land uses, and identifying areas with potentially high-indoor radon levels and for discovering new mineral deposits. There will be considerable research spinoff in the processing, integration, visualisation and ground-truthing (validation) of these data.

Additional initiatives, which may be undertaken during the period of the upcoming NDP, will target key national issues relating to environmental protection and infrastructural development. The programmes of county-based groundwater protection schemes and aggregate potential mapping, managed by the GSI with research support from the third-level sector, will be advanced to provide effective planning tools to local authorities. These programmes provide information to ensure that groundwater is not contaminated and that aggregate resources are not sterilised by inappropriate land uses. An offshore monitoring programme will include a tsunami warning system,





involving collaboration between Met Éireann, the MI, Dublin Institute for Advanced Studies and the GSI. This system is intended to protect coastal communities from a hazard now recognised as a potential threat to the Irish coastline. Inland, additional studies will target the potential incidence of landslides especially in peatland areas.

All of these programmes rely on the availability of high-quality bedrock and subsoil mapping, on detailed 3D knowledge of our subsurface, and sufficient research to support the methodology and standards employed. Increasingly society looks to geoscience to provide information on our future as well as our past. This can be achieved effectively through modelling the behaviour of our environment and subsurface. It requires comprehensive geological, geophysical and geochemical databases incorporating time series based on monitoring, both *in situ* networks and through initiatives, which aim to improve integration of remote sensing and *in situ* data such as the Group on Earth Observation (GEO) and Global Monitoring for Environment and Security (GMES)—see *International Context* below.

AGENDA FOR ACTION

To contribute effectively to national objectives, geoscience in Ireland is striving to become world-class in terms of the quality of its research and services. A key factor in this is a shared focus on building a critical mass of staff and equipment in key areas where a nucleus of research excellence already exists within our institutions. All players in the Irish geoscience sector have accepted the need to develop a number of key issues, which will have important national significance. They have been prioritised to demonstrate the sector's shared focus should funding become available. The objectives summarised below rely critically on the timely availability of satisfactory research infrastructure (see *Supporting Quality Research* below). Continuing and enhancing participation in international programmes is strongly encouraged in order to ensure world-class standards and participants.

Research goals—a summary

- Evaluate the potential for geothermal energy to depths of up to 5km.
- Improve our understanding of Ireland's hydrocarbon potential through study of offshore deep geology.
- Evaluate the options for long term carbon storage in geological formations.
- Model the impacts of climate change on the quality and quantity of groundwater resources.
- Prioritise the surveys of the inshore environment to provide support for optimum use of the marine resource.
- Develop high-resolution assessments and monitoring networks for natural hazards such as landslides, urban subsidence, tsunamis and indoor radon.
- Provide databases to ensure aggregates resources are available as efficiently as possible and where appropriate are protected from sterilisation.



ENERGY: Geoscience will contribute to national energy objectives for secure diversified energy supplies by evaluating the potential for innovative renewable sources and additional conventional sources.

- Geothermal energy, an innovative renewable resource for Ireland, is competitive, reliable and environmentally friendly. Areas of high potential for geothermal energy will be identified through the evaluation and subsequent monitoring of heat distribution and fluid flow in deep (up to 5km) boreholes and surface springs.
- The development of additional conventional energy sources, mainly in the form of offshore oil and gas, requires significant commercial investment, which this objective is intended to stimulate and support. The objective seeks to improve our understanding of Ireland's offshore deep geology, its vast sedimentary basins and their potential for oil/gas recovery (including integrated coalbed methane recovery and carbon dioxide storage). In addition Ireland needs to store strategic gas stocks to ensure the security of supply at acceptable pricing and geoscience can contribute to the evaluation of suitable underground reservoirs. The current level of information is inadequate to confirm that Ireland's limited exploration success to date is a true reflection of its hydrocarbon potential. The Petroleum Affairs Division of the Department of Communications, Marine and Natural Resources has regulatory responsibility for the offshore hydrocarbon sector and periodically assesses its potential.

ENVIRONMENT AND WATER

SUPPLIES: There are accelerating pressures on our environment resulting from increased urbanisation and infrastructure as well as from climate change driven by our high usage of fossil fuels. Geoscience in Ireland will contribute to effective ameliorating and mitigation strategies in relation to priority environmental issues. Specific issues that will be addressed in the period 2007–2013 are:

- The national strategy for climate change, while acknowledging the value of carbon sequestration, has yet to recognise the potential to store carbon in geological formations beneath our land and seas, something that Norway has been implementing since 1996. Given the high level of international attention devoted to such storage as a mitigation strategy, it is critical that it be analysed in a national context in Ireland. A key objective here is to identify options for such carbon storage in several settings (for example, deep saline aquifers, exhausted gas reservoirs, large geological structures) and in integrated options (for example, enhanced oil recovery, methane recovery from coal seams and seafloor hydrates), as well as to establish techniques to monitor the stability of gas storage. In addition geoscience can assist in the development of a national adaptation strategy, for example in relation to sealevel rise, flooding and drought management.
- There is a continuing need to evaluate water resources and supplies as part of the integrated water cycle under the EU Water Framework



Directive and to support balanced regional development across the country. This objective will also seek to model the impacts of climate change on the quality and availability of our groundwater resources in the context of coastal inundation, flooding and sealevel rise. In addition to predicting pollutant behaviour, developing better protection strategies and identifying deep strategic supplies, systematic geophysical and geochemical observations and surveys are required for baseline information and subsequent monitoring.

MARINE: To support the development of the marine sector, the focus of geoscience will be on surveying the inshore environment on a prioritised basis to provide a framework for water quality

monitoring and improved navigational safety, as well as to contribute value-added information on fish habitats, biodiversity and offshore engineering. Specific objectives, the first three of which are included in the INFOMAR programme (see *Geological Survey of Ireland* below), are:

- Data acquisition, management and interpretation to ensure data are fully and comprehensively exploited.
- Develop the capability to integrate datasets derived from a variety of sources.
- Ensure customer needs are fully met through customised development of advanced decision-support tools and solutions to sustain the full spectrum of innovative marine activities.

- Strong involvement by Irish institutions in world-class research through the Integrated Ocean Drilling Program.

TRANSPORT: Ireland's economic competitiveness requires the continued and effective development of its transport infrastructure. Geoscience contributes to this through the assessment of aggregates resources to ensure efficient development, and through research on natural hazards with the aim of supporting mitigation and remediation. The 2006 publication *Landslides in Ireland* was the product of sector-wide collaboration and it has set the future agenda in this area. In summary the objectives were two-fold, and each relates to infrastructure development in general as well as transport:

- Provide databases to ensure aggregates resources are available as efficiently as possible and where appropriate are protected from sterilisation by prior development.
- Develop high-resolution assessments and monitoring networks for natural hazards such as landslides, flooding, urban subsidence, tsunamis and indoor radon.

(For more information see *The Case For Geoscience Funding (2005)*, which is available at www.gsi.ie).



Proposed onshore boreholes (up to 5km deep) to support key energy and environmental objectives as developed at a public workshop in July 2005.

GEOLOGICAL SURVEY OF IRELAND (GSI)

As the national geological agency, the GSI's role is to serve Irish society through the provision of relevant and efficient information. Its information supports important national objectives in the areas of natural resource development, environmental protection and infrastructure development. Its core competence lies in the way it manages and provides information and knowledge. Its organisational status and governing legislation are likely to be reviewed in the currency of this strategy to ensure that it provides the most effective service to its customer base.

Should increased investment be available then the GSI will support the provision of a range of services and databases during 2007–2013, including the following:

- The INFOMAR programme, jointly managed with the Marine Institute, aims to undertake data acquisition in priority offshore areas of the Irish seabed and build a world-class data management system capable of providing easy access to its information. The benefits will include support for policy and regulation across a spectrum of national and EU maritime issues, more informed decisions on the management of offshore energy, biological and aggregate resources, navigational safety, and increased research and commercial opportunities through value-added activities.
- The Resource and Environmental Survey of Ireland (RESI) will comprise nationwide geophysical and geochemical surveys. Its results will be managed in an integrated data

management system, supported by North–South cooperation and building on the success of the TELLUS Project in Northern Ireland (see *A Knowledge-Driven Sector* above). The results will assist in delineating and protecting areas with important groundwater resources, assessing the



suitability of areas for specific land uses, identifying areas with high potential for indoor radon and helping in the discovery of new mineral deposits.

- A series of programmes devoted to water supplies, transport and planning will address issues such as availability of aggregates as well as subsurface and geological heritage information to support new transport routes, continued access to quality groundwater despite the pressures of development and climate change, and the evaluation and monitoring of natural hazards such as landslides and tsunamis. Some of these programmes may be managed by service-level agreements with key stakeholders.

Traditionally, GSI has provided services relating to the development of our landscape and natural resources and, by their nature, much of their focus related to the past and to the near-surface environment. The demands of society are such that this focus is likely to change during the currency of this strategy: firstly, to a digital and three-dimensional appreciation of our subsurface and secondly, to forecast future environmental changes through modelling the effects of continuing climate change and development of infrastructure. In support of these objectives the GSI, as the national agency for the geoscience sector, is committed to providing timely access to its evolving databases whether for commercial or research purposes. Terms and conditions for licensing data are available on www.gsi.ie.

SUPPORTING QUALITY RESEARCH

This strategy is a challenging one that seeks to put Ireland at the forefront of international geoscientific research and at levels that ensure Ireland's geoscience research contributes significantly to the government's Strategy for Science, Technology and Innovation. This can happen only if we invest in the development of an excellent infrastructure for geoscience research. Two key components of such an infrastructure, which are urgently required, are described here. They have been identified by the sector as the key priorities in the event that adequate funds become available.

ANALYTICAL FACILITIES: Third-level institutes in Ireland all possess some analytical facilities but in virtually every case the equipment is old, long-past a reasonable lifespan, difficult to maintain and incapable of offering the performance demanded by contemporary science. Critically it does not match the facilities available in virtually every other European country. Indeed at present our most active researchers must travel abroad in order to undertake many relatively basic research procedures. This limits our capacity to recruit, sustain and train high quality postgraduate students and post-doctoral researchers, and strongly deters the best overseas geoscience graduates from taking up positions here. It is also likely to lead to a brain drain of our best and brightest academics and senior researchers.

The investment proposed here will equip Irish institutes with efficiently networked analytical facilities, which will be located on a strategic basis.

These jointly managed facilities and equipment will be made available on an agreed basis to all researchers in industry, third-Level and government, both in Northern Ireland and the Republic of Ireland. The facilities will include geochemical and geophysical equipment, selected to contribute maximum impact to Irish geoscientific research. These facilities need to be serviced by high quality research and technical staff. They also require a programme of planned replacement of equipment to maintain cutting-edge research capacity. The Scottish Universities Environmental Research Centre (SUERC) at East Kilbride outside Glasgow (<http://www.gla.ac.uk/suerc/>) could form a blueprint.

One example is a seismic data processing facility, which is required to support studies of Ireland's offshore basins for their hydrocarbon potential. Another example is a geochemical facility including equipment for elemental, radiogenic and stable isotope analysis, both of bulk samples and especially for *in situ* analysis of minerals at high-spatial resolution. Purpose-built clean laboratories for preparation of mineral, rock, water and soil samples for analysis will be essential. Such facilities will be state-of-the-art and staffed by dedicated research technicians and managers to carry out analyses, maintain equipment and conduct research to constantly improve analytical capabilities. An emphasis on numerical predictions and simulations, already in evidence through the Irish Centre for High-End Computing, will support hazard estimation, reservoir prediction and numerical weather prediction.

IRELAND IN 3D: In earlier decades much geological research was based on two-dimensional geological maps. The challenge for the Geological Survey of Ireland and the Irish geoscience community is how to develop a digital 3D model of Ireland's subsurface in order to support the strategic research and services being planned under this strategy. In reality a 4D approach, with the added dimension of time, is required but an initial 3D model must be the first step.

There are two distinct elements to this data infrastructure. Firstly there is the need to acquire 3D (and locally 4D) information on Ireland's geology, especially at depths of up to 5km and even deeper. At present this information is limited and there is a need to augment it with new data from strategically located boreholes. Drilling is expensive and every effort will be made to leverage maximum research activity around each borehole by employing as many techniques as possible in order to develop our 3D databases as comprehensively and economically as possible. Assembly, analysis and strategically planned acquisition of geophysical data (especially seismic, gravity, magnetic and magnetotelluric) is required to build the 3D models while monitoring of fluid flow and detailed neotectonic movements in selected areas are needed for future 4D models. Initial targets for a programme of deep drilling have been developed (see the map in *Agenda for Action* above).

The second component in providing this infrastructure is to ensure data that can be shared

effectively with all relevant institutes and organisations. The corporate memory of the subsurface is contained on a retrievable basis only in geological databases—not in those of the stakeholders who in many cases generated the data in earlier times. Only by continuing this action

will geoscience information underpin the full range of research objectives envisaged. Already under the Irish National Seabed Survey there is a strategic link between GSI and NUI, Galway, and further networked links are planned under this programme.



NORTH–SOUTH COOPERATION

This strategy has explicitly been created in an inclusive all-island context. There is a long-standing tradition of North–South cooperation in geoscience, which acknowledges, amongst other drivers, the reality that the political border is not reflected in geoscientific parameters. This was emphasised in the recent publication of the Bedrock Geological Map of Ireland (1:500,000), a symbol of the effectiveness of North–South cooperation by the Geological Survey of Ireland (GSI) and the Geological Survey of Northern Ireland (GSNI). Moreover the annual Irish Geological Research Meeting, a forum on progress in geoscience research, has always been organised on an all-island basis and reaches its fiftieth anniversary in 2007.

While the cooperation is perhaps underpinned most intensively by the working relationship between GSI and GSNI, there have also been considerable recent achievements based on third-level sector collaboration. Since the mid-1990s such cooperation has been co-funded by, for example, the EU INTERREG and Peace and Reconciliation Programmes and the International Fund for Ireland. The recently-formed Committee of Heads of Geoscience Institutes includes representation from academia and government in both parts of the island.

Geoscience continues to make key contributions to the island economy through development of natural resources, the protection of the environment and tourism. For example geological models for mineral exploration developed in one part of Ireland can be



applied in the other (for example, models for zinc-lead have been developed in the South and for gold in the North). In relation to tourism, projects on landscape heritage have not only pointed to opportunities for community enterprise but have led to an enhanced appreciation of the landscape that all communities on the island share. The impact of this on long-term reconciliation should not be underestimated.

Geoscience is now poised to accelerate its contribution to the shared objectives of the British and Irish governments in the area of North-South cooperation and this can increase its impact on the knowledge economy through cross-fertilisation and the creation of synergies and a critical mass. This will be considerably assisted by the growing coherence of the geoscience sector, an aspect that has been nurtured by the Royal Irish Academy, with its all-island remit.

INTERNATIONAL CONTEXT

Ireland seeks to be a world-class player in geoscience and accordingly it must operate on European and international stages. The geoscience sector will seek to increase and enhance its participation in European and international research programmes and to attract high-quality researchers from abroad. It will also seek to take advantage of excellent infrastructure and facilities abroad wherever this provides strategic advantage.

The Integrated Ocean Drilling Program (IODP) is an example of the type of international programmes where researchers at Irish institutes can have access to international skills and databases, as well as opportunities to participate in world-class research issues. During the past decade Irish geoscientists have participated actively in EU-funded international research programmes, especially those of the fourth, fifth and sixth Framework Programmes. Examples of these are the STRATAGEM, GEOMOUND and ECOMOUND research projects, focussed on aspects of marine geoscience. Opportunities are likely for further research collaboration under the forthcoming seventh Framework Directive. The proposed Topo-Europe programme, coordinated by the European Science Foundation, is designed to stimulate collaborative research on the complex interactions between subsurface, surface and atmospheric processes and if implemented will form another example of such an international programme.

Ireland is participating in major earth observation initiatives, which can provide important support for its geoscience activities. GEOSS (Global Earth Observation System of Systems) is led by the



United States and aims to coordinate diverse earth observation systems, promoting interoperability and data exchange on environmental and climatic conditions for societal benefit. At the European level, Global Monitoring for Environment and Security (GMES) is a flagship EU programme led by the European Commission and the European Space Agency (ESA) to develop user-driven services to support informed decision-making on the environment and civil security. GMES aims to further exploit space-borne remote sensing data from orbital satellite platforms, and Ireland is already participating in its TerraFirma project, which studies subsidence in urban areas. The spatial data generated under GMES will be managed under the INSPIRE Directive, aimed at providing harmonised and quality geographic information for users across Europe. Following a government decision in 2006, Ireland will join the ESA Earth Observation Research Programme in 2008, which will open up

new research opportunities for Irish geoscientists in terrestrial, atmospheric and oceanic sciences. However a more formal national strategy is necessary to ensure that Ireland gets maximum value from such initiatives and geoscience can help in its development. GSI participates in trans-European initiatives organised by Eurogeosurveys, the association of geological surveys of Europe. There are additional opportunities for bilateral cooperation, for example with the United Kingdom and North America, all of which can provide value-added to our geoscience activities.

There are opportunities to increase the export of training and services to overseas countries by the third-level and private sectors. This would significantly broaden the range of geoscience problems in which Irish geoscientists might work, especially in areas of hazards such as landslides, volcanoes and earthquakes.

SUPPORT FROM SOCIETY

There are important reasons for mounting an effective outreach element as part of the National Geoscience Programme (2007–2013). Support from the general public is essential if geoscience is to win and sustain significant government investment. The geoscience sector, as an important component of national life, adds considerable value to economic development and its activities underpin sectors as diverse as infrastructure, water supplies, agriculture, fisheries, tourism, energy supplies and heritage. However unless the general public is aware of this its importance may be ignored.

Through exposure to media coverage of global issues such as climate change and events such as earthquakes, volcanoes and their associated hazards, the general public has become increasingly aware of the fragility of human existence on this planet. This provides us, as geoscientists, with a special opportunity to try to deepen the public's understanding of the broader geoscience strategy.

If the government's objective to boost economic competitiveness through science and technology is to be met, it is essential that there is an increased intake of high quality science students at undergraduate and postgraduate levels. Working towards this objective, the GSI, the RIA Geosciences Committee and the third-level sector are working actively with geography teachers on services relating to the first- and second-level geography curriculum. The falling numbers of second level students taking mathematics and the

sciences is a serious concern and will make the task of increasing geoscience graduate numbers more difficult. Geoscience can be presented as exciting and relevant to the lives of young people through concentrating on its recent achievements and recent events, thereby attracting more young people to science both from Ireland and overseas.

Geoscience also has the potential, through its investment in the management of geospatial data and its cross-links with other disciplines, to stimulate the greater use of data in digital format

throughout the community, thereby contributing to the government's broader aims related to the knowledge economy, access to broadband and the EU INSPIRE Directive.

An unrivalled opportunity has arisen for geoscience outreach with the declaration in December 2005 by the United Nations General Assembly of 2008 as the International Year of Planet Earth. The geoscience sector in Ireland will be seeking to take full advantage of this exciting development and the geoscience community will be actively participating.



APPENDIX A

LEGISLATION AND POLICIES WHERE IMPLEMENTATION IS INFORMED AND SUPPORTED BY GEOSCIENCE

(1) National

Water Quality (Dangerous Substances) Regulations 2001 (S.I. No. 12 of 2001).
The European Communities (Drinking Water) Regulations 2001 (S.I. No. 439 of 2000)
Waste Management Act 1996
Minerals Development acts 1940 to 1999
Continental Shelf Act 1968
Petroleum and Other Minerals Development Act 1960
Wildlife (Amendment) Act 1995
Heritage Act 1995
Planning and Development Regulations 2001 (S.I. No. 600 of 2001)

(2). EU

Water Quality Framework Directive (WFD)—2000/60/EC
Towards a thematic strategy for soil protection—COM (2002) 179 Final
Groundwater Directive
Thematic strategy on sustainable use of natural resources—COM (2003) 572 Final
Dangerous Substances Directive—will be repealed by WFD on 22 December 2013
Drinking Water Directive
Council Directive on the Landfill of Waste—1999/31/EC
Proposal for a directive on the management of waste from the extractive industry—COM (2000) 265 final, COM (2003) 319 final
Re-use Directive
UN Framework Convention on Climate Change (UNFCCC)

APPENDIX B

LIST OF ACRONYMS

ESA	European Space Agency
EU	European Union
GEO	Group on Earth Observation
GEOSS	Global Earth Observation System of Systems
GMES	Global Monitoring for Environment and Security
GSI	Geological Survey of Ireland
GSNI	Geological Survey of Northern Ireland
INSS	Irish National Seabed Survey
IODP	Integrated Ocean Drilling Program
MI	The Marine Institute
NDP	National Development Plan (2007-2013)
R&D	Research and Development
RESI	Resource and Environmental Survey of Ireland
RIA	Royal Irish Academy
SSTI	Strategy for Science, Technology and Innovation
ST	Science and Technology
SUERC	Scottish Universities Environment Research Centre
UN	United Nations