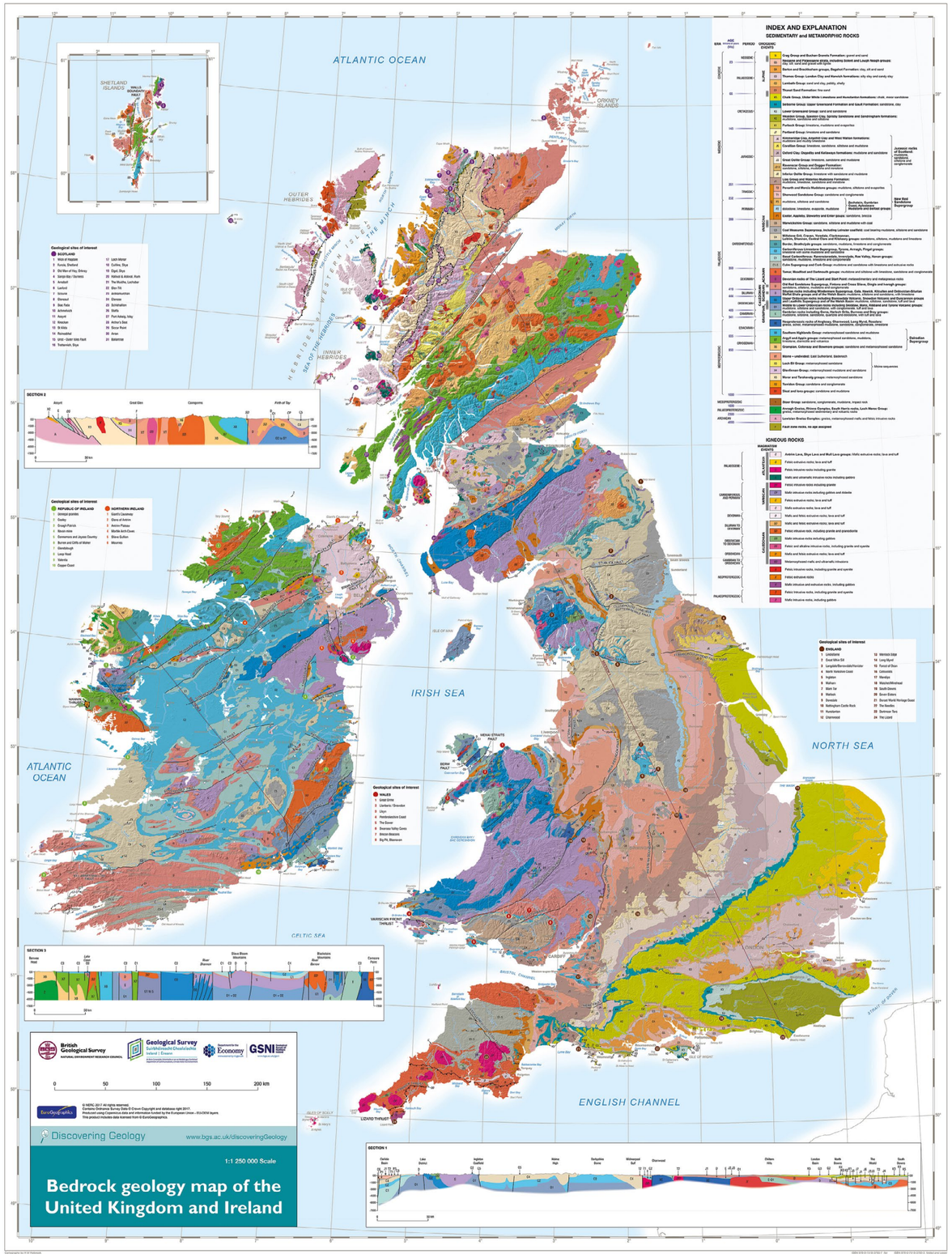

The British Geological Survey: Helping the world understand Earth

The British Geological Survey (BGS) is the world's oldest national survey and the premier centre in the UK for earth science expertise. The BGS's Executive Director **Professor John Ludden** is dedicated to advising the government and industry on how to face the geological challenges of today and in the future. We caught up with Professor Ludden at *Research Features* to discuss the BGS's focus of understanding earth and environmental processes as well as delivering impartial advice in all areas of geoscience in the UK and internationally.

The British Geological Survey (BGS) was established in 1835 as the world's first national geological survey under Henry De la Beche. In 1965, the Geological Survey and Museum was combined with the Overseas Geological Surveys to make the Institute of Geological Sciences, which then became known as the British Geological Survey in 1984. Today, the BGS focuses on research to understand the Earth and environmental processes as well as public-good science and information to help society use its natural resources responsibly, manage climate change and be resilient to environmental hazards. The BGS is a component body of the UK Natural Environment Research Council (NERC) and, as a public-sector organisation, it provides independent advice to government, regulators, industry, academia and the public on all aspects of geoscience.

Since 2006, the BGS has been under the leadership of Executive Director, Professor John Ludden. Professor Ludden has held numerous directorial and management posts, including a leading position at the Earth Sciences Division at the French National Centre for Scientific Research (CNRS). He was also the former president of the European Geosciences Union and EuroGeoSurveys. *Research Features* caught a moment with Professor Ludden to discuss the role of the BGS and its contribution to geoscience research.

Hello John! Please can you tell us more about the British Geological Survey (BGS) and how it works?
The BGS was originally established to locate the natural resources such as coal and ironstone that were essential for underpinning the industrial revolution in the UK. Today, geological surveys exist all over the world but the concept was originally developed in the 19th century at a time when countries sought mineral resources such as copper, gold and coal to support their economies and aid national development.

Today we advance understanding of the structure, properties and processes of the solid earth system through interdisciplinary surveys, monitoring and research for the benefit of society.

Why is the BGS an international survey? Doesn't it make more sense for each country to conduct its own survey?
In general, most countries today have their own individual surveys. The BGS was formed by the merger of the Overseas Geological Survey and the home geological survey, and so we have experience of working in many countries in Africa, south-east Asia and South America in addition to our domestic role. Our reach expanded over the years and our vast experience has contributed greatly to aid projects in other countries.

Much like its French equivalent, the BGS has evolved into a survey with a large international component. In fact, recently the Koreans came to us for knowledge exchange on mapping techniques and Quaternary geology. Currently the BGS is developing a new programme of research partnerships as part of the UK Government's drive for International Development that will focus on key topics related to the United Nations Sustainable Development Goals, such as water and food security, urbanisation and understanding geological risk and natural hazards.

Today there is very little mining in the UK – can you tell us what BGS's focus is?
On the contrary, minerals are extracted at about 2000 mines, quarries and boreholes around the UK. There is also major extraction of hydrocarbons and construction aggregates from beneath the

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seabed around our shores. These materials are especially important in maintaining and improving both our infrastructure and our energy security. BGS has built a good understanding of the extent and quality of UK minerals and hydrocarbon resources. We also monitor mineral production and trade. This knowledge and information is used extensively by government, regulators and civil society to inform decisions on new mineral extraction. It helps to minimise environmental impact whilst improving resource efficiency and supply security.

Would you be able to locate shale gas all around the world?
We could do although we don't go out and drill resources. Rather, we provide a general evaluation, indicating the potential resources of an area. Essentially, the government entity or company we've been commissioned by would then refine its exploration based on our assessment.

The BGS operates the National Geological Repository (NGR) of geological reference materials. For example every borehole that's been drilled in the UK deeper than 50 m is held including the offshore drilling in the North Sea, so if a company wants to look for oil and gas offshore, they can come to our repository to examine or sample the material we have. The company will then get the data and the scientific analysis they need without having to drill the areas they are interested in. The background information we provide helps them target their exploration. The procedure for shale gas would be no different.

You could say that this can be viewed as a map of opportunities – what are your thoughts on this?
Absolutely. As a geological survey our role is all about describing what is below ground and making geological models that might help us understand resources such as groundwater, soil, oil, gas and the like. In other words, we deal with anything underground.

In addition to this, we also look at geohazards such as volcanoes, earthquakes and landslides and we work around the world analysing and advising on them. In the UK, we run a seismic network so if there's an earthquake in the UK, for example, we can locate it and provide advice.

We also contribute to the Global Earthquake Model, modelling earthquake risk around the world and how to mitigate these risks. We'll even travel to countries like Kazakhstan to advise on earthquake hazards and potential risks, help install seismic networks and set up monitoring systems to determine areas where there is a real problem.

Professor John Ludden

BGS is very much a problem-solving organisation. We're focused on trying to provide solutions to subsurface geology problems, and we'll advise governments about geological matters

Are you responsible for people's safety?
No. However we do provide advice on geohazards and we monitor environmental impact. This information is then utilised by other professionals with safety responsibilities. For example, we look at groundwater to see if it's been contaminated.

Our science is very relevant to the country's infrastructure and we provide data products to insurance companies and for conveyancing. For example, if someone is selling or building a house, they can get a Natural Ground Stability Report from us which can reveal the type of rock the property is built on. Today, there's a geological map and a wealth of supporting geological information on Great Britain available online at www.bgs.ac.uk. Furthermore, with our iGeology app you can download over 500 maps of Great Britain and see exactly what kind of geology is under your feet.

British Geological Survey building

You once declared that scientists should be responsible not just for finding information, but for also advocating it among politicians as well as advising and making sure solutions are implemented. Does the BGS promote this approach to science?
Yes, the BGS is very much a problem-solving organisation. We're focused on trying to provide solutions to subsurface geology problems. We provide governments with an independent scientific evidence base, which they can take into account in their political decision-making.

Again, going back to shale gas – the government came to us with a problem. Companies were claiming that there is a decent sized resource to be tapped into and the government wanted to know what the BGS thought about it. We then conducted a pre-study based on the regions of the UK with future potential. From our findings, we believe that the companies are probably right, at least in terms of potential. We provided the government with advice on the resource, on environmental issues surrounding extraction, and whether there are any major obstacles.

Of course, this is just one single example to give you an idea of how we can provide geoscientific advice to government. Whatever the situation or audience, at BGS we aim to provide independent evidence on environmental issues that affect policy or society. Our advice is always based on the scientific evidence.

What about radioactive waste? Does the BGS deal with that as well?
Yes. When it comes to storing radioactive waste underground, we are quite involved. Our scientists do a lot of work advising the government on how and where best to store it.

If you visit the Radioactive Waste Management Ltd website, you'll discover that there is an active programme of work focused on identifying suitable rocks to store radioactive waste, currently led by the BGS. Shortly there will be an open call for volunteer communities to consider hosting a repository in their area. It's very likely that communities in the UK will volunteer. Storage will be deep underground and there will be a significant amount of investment around it. It is a rather controversial and sensitive subject to discuss because a lot of people get worried when they hear the word radioactive, despite the waste being stored at surface in West Cumbria for decades. While countries like Finland and Sweden have started constructing radioactive waste repositories, followed closely by France, the UK has nothing established yet. It may take another 20 to 30 years for the British to put radioactive waste underground, but we're still advising the government on how it could be done should it come to that.

Finally, does fracking cause earthquakes?
Hydraulic fracturing is generally accompanied by microseismicity that is too weak to be felt at the surface. However, there are rare instances where earthquakes associated with hydraulic fracturing have been felt at surface. There have been some 1.8 million hydraulic fracture treatments in the US and there are presently only three documented cases of induced earthquakes linked to hydraulic fracturing for shale gas recovery. In the UK, one case of induced seismicity was during hydraulic fracturing at the Preese Hall 1 well in Lancashire in 2011. The two main induced earthquakes in Lancashire in 2011 were minor, at 2.3 and 1.5 Richter local magnitude (ML). This scale is an exponential scale, meaning that a 1ML earthquake is ten times weaker than a 2ML earthquake and a hundred times weaker than a 3ML earthquake. To put them into context, they were less powerful than some of the earth tremors that have been associated with coal mining in the 1950s and 1960s and that occur today.

In the UK, a 'traffic-light system' has been developed by the Oil and Gas Authority to limit the risk of earthquakes associated with hydraulic fracturing. The guidance will be reviewed as exploration proceeds. Where magnitudes of seismicity below 0.0ML are recorded, injection can proceed as planned; up to 0.5ML, injection can proceed with caution and possibly at reduced rates. Where magnitudes greater than 0.5ML are detected, operations will be stopped and pressures of fluids will be reduced.

• *For more information on the BGS, its research and what it can do for you, then visit their website at www.bgs.ac.uk*

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