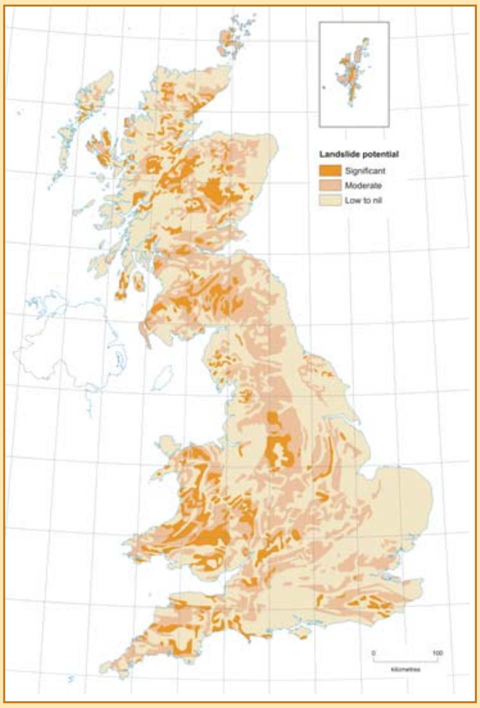
Keeping it **real**

Adler de Wind talks to the BGS's Katherine Royse about how the Survey turns its data into products relevant to decision-making.*

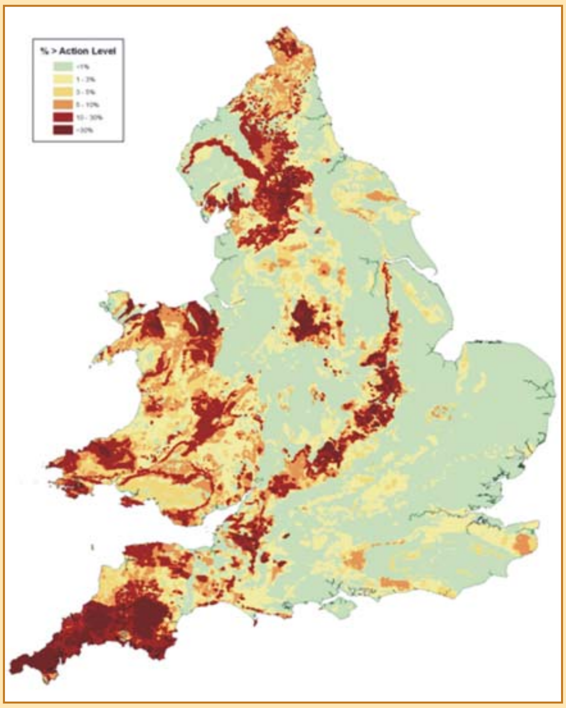
Many of our society's most important decisions - sustaining energy supplies, mineral and water resources, coping with climate change and so on - rest on geological information. Ever since founding the world's first Geological Survey in 1835, Britain has looked to its geoscientists for advice about finding and exploiting natural resources, and on securing a safe living environment for its people. But if sound policy decisions are to be made, those making the decisions need access to all the relevant information, in a form that they can readily use. Geoscientists need to consider how they present their geoscientific information very carefully.

As leader of BGS's "Derived Products" team, the information delivery process is very much Katherine Royse's business. After she contributed (with Diarmad Campbell) a *Geoscientist 'Soapbox'* article on communicating geoscience to government (see *Further reading*) I spoke to her about how Survey scientists are working to achieve their aim of providing geo-information in useful and accessible forms. I wanted to find out more about the fascinating and revealing new datasets that BGS is collating, and learn something of the emerging technological and scientific developments that will influence the way geoscientists in the future will communicate these complex facts to our policy makers. I began by asking her about her team.

The 2001 Nefyn landslide



Landslide potential map for England, Scotland and Wales. Ordnance Survey data are used with the permission of the Controller of Her Majesty's Stationery Office, Crown Copyright. All rights reserved. Licence number 100037272/2008



Radon potential map of England and Wales indicating the highest percentage of homes at or above the radon Action Level in each 1km grid square. © British Geological Survey and Health Protection Agency copyright [2007] Ordnance Survey data are used with the permission of the Controller of Her Majesty's Stationery Office, Crown Copyright. All rights reserved. Licence number 100037272/2008

"BGS's Derived Products team has been set up to develop methods, and create products, that deliver geological and geo-environmental data, interpretations and knowledge for the shallow sub-surface - or the 'zone of human interaction' within the UK – and to do so in a form that is both relevant and accessible. The work we do covers everything from geochemical hazards (like radon and potentially harmful elements such as arsenic and lead), natural hazards (landslides and flooding) to underground asset management (pipeline and concrete corrosion) - and then the impacts of climate change on all of these. The team brings together specialists from a wide variety of sub-disciplines – including geologists, GIS specialists, hydrogeologists, geochemists and geoengineers.

"The key questions we try to answer are: what geoscientific information do policy and decision makers need? What data formats should this information be in, to meet these needs? And then, of course, we have to ask why geoscientific data are not fully utilised today – a key issue behind the United Nations' *International Year of Planet Earth* initiative.

"Over the last decade, we have witnessed a major increase in the availability of digital geoscientific data. BGS has invested a lot of resources in producing digital equivalents to its paper archives. One of the first breakthroughs we made - and still probably the most significant - was the launch of the 1: 50 000-scale seamless geological map for Great Britain (DiGMap-GB) in 2001. We have also seen parallel improvements in computer-processing capability, especially of standard GIS-packages. These technological advances have made it possible to manipulate, compare, and analyse these vast new national digital datasets in a way that simply was not possible before the desktop PC became a piece of the geologist's standard kit."

Hazards

In order to produce new national datasets that will be relevant to a wide range of users, the Derived Products team has had to consult its stakeholders, and then combine its own geoscientific knowledge with national digital data to produce new national models and datasets that will satisfy those demands.

"Since 2003, the BGS has produced a National Natural Geohazard Model (*GeoSure*), which indicates not only where hazards (like landsliding, shrink–swell, soluble rocks) occur across the UK, but also indicates their likely severity. Using Arc-GIS - a standard package – we have modelled the national distribution and degree of shallow geohazards. We have carried out research into the extent and nature of landslides and karstic features, and done laboratory rock-testing to characterise the shrink-swell characteristics of various rock types in the UK. This helps to identify the factors that cause shallow geohazards. The team then combines the information with the BGS digital map, to give the whole country a *GeoSure* rating for six different shallow geohazards - landslides, shrink-swell, soluble rocks, compressible ground, collapsible deposits, and running sand. That model can then be fine-tuned using the local knowledge of our network of BGS regional geologists, and by the experience of the research teams involved.

"Mining is another area we have tackled. Many minerals other than coal have been mined in the UK, including metalliferous minerals (mainly as cross-cutting veins), and strata-bound resources (like sedimentary iron ores, building materials, evaporite minerals, clays and so on). This assessment, which we first piloted on the Chalk, is managed in a GIS-based system that predicts the likelihood of hazards associated with former or current underground (non-coal) mining activity for any given location in the UK. It can also provide an indication of hazard magnitude. The principal hazard we consider is subsidence and catastrophic collapse of workings; but other hazards, including stability of surface tips, chemical toxicity and mine-waters may also be considered in due course."

Radon

Geology is the most important factor controlling the source and distribution of radon, which according to the latest research (published in the *BMJ* this January) is responsible for around 1100 lung cancer deaths in the UK each year. Although most of those (85%) arise from a combination of radon exposure *and* smoking, radon is nevertheless implicated in 3.3% of total UK lung cancer deaths – a minority, but by no means an insignificant one.

Radon-222, a naturally occurring radioactive gas with a half life of just four days, derives from the radioactive decay of uranium-238 and is found everywhere - in all rocks and soils. Some radon will enter buildings, and it is here, especially where there is poor ventilation, that dangerously high concentrations can be reached.If the active decay products of radon gas are inhaled, although short-lived, they may deposit on cells in the bronchial epithelium, and so expose sensitive cells to alpha radiation. The evidence from radiobiology suggests that even cells exposed to just one alpha-particle can be appreciably damaged.

To limit the risk to individuals, the government has adopted an “action level” for radon in dwellings of 200 becquerels per cubic metre (Bq/m^3). Says Royse: “Research at BGS has demonstrated that variation in radon level is mainly controlled by underlying geology. So our team, in collaboration with the Health Protection Agency, set about developing national radon potential maps. This involved assessing the radon potential of the ground from a geologically and geographically based interpretation of indoor radon measurements. These maps indicate the probability that new or existing houses will exceed the “action level”.

“These maps have important applications, especially in controlling radon through environmental health and building legislation. They are also used to assess radon risk in existing buildings for homebuyers and sellers. However, radon levels often vary widely between adjacent buildings – because of local variations in radon potential in the substrate, and to different construction styles and use. This means that although the map can indicate the relative risk for buildings in a particular locality, it cannot predict the *actual* radon risk for an *individual* building.”

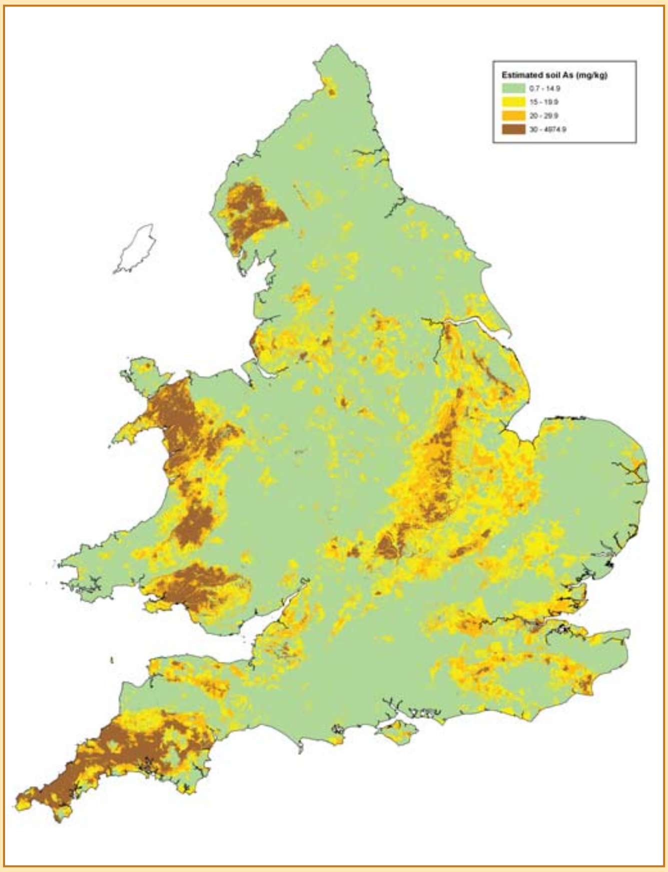
Harmful elements

The radon map leads our conversation naturally to the BGS National Potential Harmful Element (PHE) maps. “The first PHE map to be developed was for arsenic. Arsenic is found widely in rocks soils and drainage sediments, and there are many anthropogenic sources as well. How toxic it is depends on its chemical form. The most common inorganic forms in water, soils and sediment are probably arsenite and arsenate (the former being the more toxic).

“Previous work has demonstrated that in recently glaciated landscapes like ours in the British Isles, parent material (‘PM’) is the main control on soil geochemistry. This is why a significant proportion of soils underlain by ironstones and other such parent materials has naturally elevated arsenic concentrations.

“The *BGS-Estimated Soil PHE* dataset for Great Britain is derived from national, high-resolution geochemical data (from BGS Geochemical Baseline Survey of the Environment (G-BASE) and Imperial College Wolfson surveys) combined with PM maps derived from the BGS DiGMapGB-50 digital geological data. Our team has developed a new method for estimating soil PHE concentrations, by combining a series of geochemical datasets for soil and stream sediment with differing geographical extents using PM polygons as mapping units. Known statistical relationships exist between regional soil and stream sediment geochemistry data, and we use these to estimate soil PHE concentrations based on stream sediment data, in areas where soil data are not yet available. The *BGS-Estimated Urban Soil PHE* data set provides more detailed information for 20 urban centres.”

Opencast mine at Parys Mountain, Anglesey



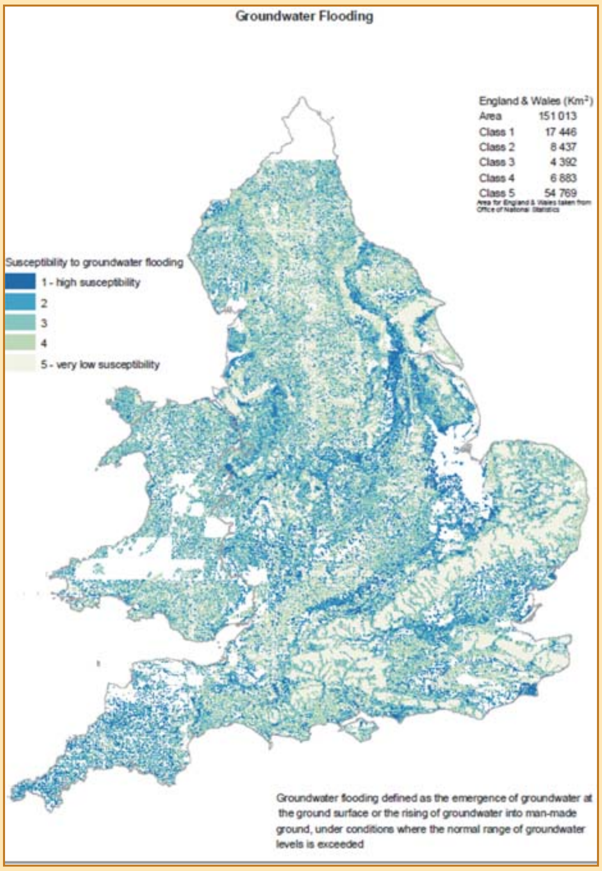
Estimated soil arsenic in England and Wales. Ordnance survey data are used with the permission of the Controller of Her Majesty’s Stationery Office, Crown Copyright. All rights reserved. Licence number 100037272/2008

Groundwater flooding

Mention of streams brings me to ask about flooding, and especially one uniquely geological form of it. "Groundwater flooding is increasingly being recognised as a hazard" says Royse. "In response, BGS has recently produced its first national hazard susceptibility map relating to it."

"The datasets have been produced using a 'rule-based' approach, in ArcGIS software. The first step applies 'rules' to identify - based on geological considerations - areas where groundwater flooding could *not* occur - areas where non-aquifers are present at surface. For all areas that *are* geologically susceptible, a second suite of rules is used to produce a national groundwater level surface - using data taken from published BGS groundwater level contours, levels recorded in the BGS 'WellMaster' database, and modelled groundwater levels derived from river base levels.

"A further suite of rules we have developed modifies the groundwater level surface so that it represents conditions of groundwater flooding. Finally, this modified groundwater surface is compared with a digital terrain model (DTM) of the ground-surface elevation, and a final set of rules zones the modelled depth of the groundwater surface based on the degree of susceptibility to groundwater flooding. Once GW flooding data are available they can be used in the context of risk or asset management planning."



Potential effects of Groundwater flooding on Primary Roads and Rail networks in England and Wales. Ordnance Survey data are used with the permission of the Controller of Her Majesty's Stationery Office, Crown Copyright. All rights reserved. Licence number 100037272/2008

Human interaction

Many processes can affect the zone of 'human interaction', across which a wide range of physical, chemical, biological and anthropogenic processes operate. Understanding these processes presents a major challenge to scientists studying the impacts of environmental change. Climate change will have significant consequences for UK planning policy and major development initiatives - developments on floodplains, or the effect of climate change on natural hazards.

Where changes alter the frequency and magnitude of storms, an understanding of process interaction will enable us to predict, for example, the transport and fate of contaminants, and any consequent impact on human health. So the Derived Products team is also developing new datasets - and new ways of using digital geoscience data - to help answer some of these questions. So I asked Katherine about how her team's work might impact directly on health issues, through their *Geology and Health* project.

"The link between geology and human health issues in the UK is poorly understood" Royse told me. "This project will therefore link geoscientists with environmental health specialists to explore ways we can improve this situation. It will do it by collating geological information that may have an impact on human health, drawing on data captured as part of the G-BASE, and data generated as part of research projects investigating the "bio-accessibility" of geology-based hazards. It will then investigate the potential for developing hazard ratings for the effect of geological factors on human health – ratings that are specifically designed for use by environmental health specialists.

Another area in which Royse's team is involved is urban geology, especially the 3D-modelling of hazards in this most complex environment. "Geological modelling in 3D can give a readily understood, detailed picture of subsurface conditions. Rapid developments in modelling software have provided challenging and exciting possibilities for constructing high resolution geological models of the shallow subsurface.

Adding in hydrogeological and engineering data allows full value to be gained from the 3D geological model - something that has already been achieved in the Thames Gateway. Work is now underway to produce high resolution 3D natural geohazard data, with a view to developing geohazard susceptibility ratings within this 3D environment. Pilots have already been produced for superficial deposits and associated running sand hazards in part of the Clyde Gateway, Scotland.

Managing the underground environment is also a big feature of the team's work. The cost to the national economy of corroding underground infrastructure was originally highlighted by the Hoar Report some 30 years ago, at about 3.5% of Gross National Product. Says Royse: "Although new materials have reduced this toll, it is still a significant concern to industry. Corrosion is a major cause of pipeline leakage; and a pipeline's susceptibility to corrosion and degradation is determined by several environmental factors, as well as by how old it is and what it's made of. We all know that the UK has a huge network of ageing sewage, water, gas and electricity pipelines. Maintaining them presents an increasing financial burden, and we must be able to direct resources towards priority regions where underground structures have been identified as most at risk.

"The 'Underground Asset Management tool', under development now, will assist in the maintenance of pipelines, ducts, cables, building foundations, tunnels and any other ferrous materials at risk from attack. Information is provided to aid initial ground investigations and structural design; it also produces a retrospective assessment, and helps managers to prioritise their work on existing structures and pipelines accurately. Eventually the tool will consist of a set of GIS layers for the whole of Great Britain, which, when combined, will provide a corrosivity value, based on information on sulphate and chlorate vulnerability, mineral corrosivity,

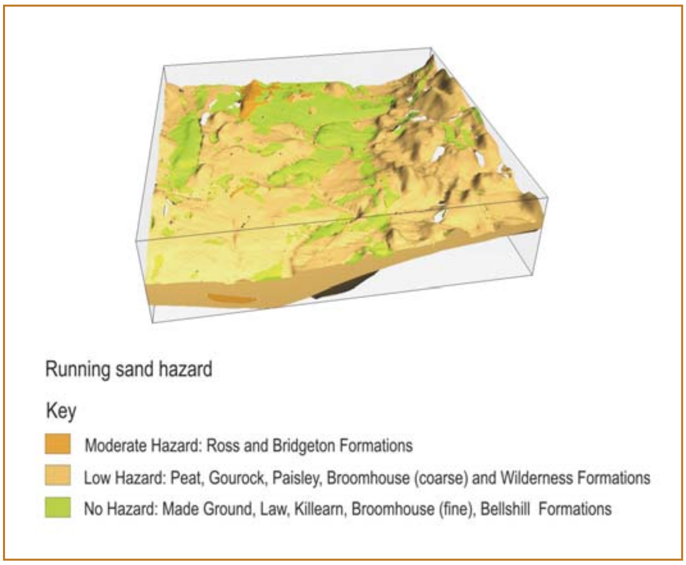


Diagram showing what a 3D Geohazard model of Running Sand looks like for superficial deposits in Clyde Gateway, Scotland

Pipeline construction in England

bedrock and drift geology, shrink-swell, permeability, groundwater levels, and electrical resistivity.”

In future, the hazard susceptibility map idea will be taken to the next stage, by investigating (in collaboration with universities, research institutes and industry partners) various ways of recording national vulnerability to geological hazards. According to Royse, the first phase will look at work carried out by other research councils and academic institutions.

“Eventually we will be able to produce maps of the potential for each geological hazard, with a forward look to the next 10 to 50 years, for the whole of the UK” she says. “Work will also focus on the relationship between climate change and hazard susceptibility.”

LWEC

Industrialists, regulators and decision makers need geo-environmental information to solve the problems created by a growing population, depletion in natural resources, and in response to changes in climate and land-use. For this to happen, BGS will need to provide geoscience data and information that will enable them to understand, as never before, how the Earth system works, how human development is changing it, and how to predict and manage the impacts on the planet, its ecosystems and people.

As Royse says: “Delivering relevant geoscientific knowledge of our dynamic Earth in an accessible way is central to the new BGS Strategy, unveiled at the Royal Society earlier this year. By doing what we do, it is our intention in the Derived Products team to help our wider society make the right choices, in order that it can live with environmental change.”

Further reading

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