Geohazards Globally

Prof John Ludden, Executive Directory, British Geological Survey

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Unless you have studied geology you probably would not know very much at all about the British Geological Survey. Even geology students probably think about it mainly as the originator of those brightly coloured maps showing the rocks under our feet, and perhaps think "Why do we still need 650 staff doing this? Geologists have been mapping the UK since the 18th century; surely we have done it all by now?" The date at which much of this activity started is the clue: geology was undoubtedly at the exciting and controversial cutting edge of pure science in those early days, but what got the landowners excited was the prospect of riches: would they find coal or other valuable minerals on their estates?

To a large extent that is still the role of the BGS: to understand where we might find minerals such as tungsten or potash, oil, gas as well as aggregate for building roads. How much is there? Can we get it out safely and without environmental damage? How do we protect the public interest as well as supporting essential industrial development? Our underground space is also increasingly in demand for a wide range of other activities, especially in cities like London, where tunnels are extensive. However, in other less populated areas we need places to store radioactive waste and possibly compressed carbon dioxide produced by carbon-capture-and-storage recovery at fossil fuel plants. Prof. Ludden pointed out the inevitability that much of the likely capacity of low-carbon power-generation scenarios will depend on some form of geological disposal. We need to know where it can be done safely.

Most geology students learn early on that what they see on geological maps is largely "interpretation". In most parts of the UK, the underlying rock is covered with soil, we only see it when someone digs a canal or a mine, or makes a railway or road cutting. The bits of the maps in between these "exposures" are informed guesswork. Hence, whenever *anyone* drills an exploratory borehole in the UK, they are obliged to offer their rock samples to be BGS, who hold a giant repository of material for future reference. The new observations either validate or correct what we previously believed and the gaps in the data mean that that is a process which still has a long way to go.

Boreholes, like mines, allow the 2D surface mapping representation to be interpolated into the third dimension and most importantly provide the ground truth for interpreting the results of seismic surveys (which then tells us about underground structures that we will never actually see). Increasingly much of this data is being published on-line. I have myself used the excellent interactive digital maps, and was delighted and intrigued to learn that 3D versions will soon become available to all. Fifty percent of the work of the BGS is commercially funded (for example, by companies wishing to explore mineral resources), but all the data generated from such activities feeds the 3D model.

However, the BGS has a growing focus on geo-hazards, which are extraordinarily diverse, including flooding, landslips, magnetic storms, volcanoes, earthquakes and issues such as human-driven

climate change. We have all been made aware recently of the possibility that climate change may increase extreme weather events, and cause more frequent flooding threats. It will, of course, always be a political decision to determine how much we spend on flood defences, but if politicians wish to be informed by evidence (which is not always the case) the BGS can supply the models that will predict what happens when *so* much water falls *here* or *there*, in a short period, and how high rivers are likely to rise. They can also estimate the likelihood that steep slopes will become landslips – always of course with some uncertainty, but some knowledge is better than none.

There is also growing awareness of our vulnerability to "space weather" – geomagnetic storms which in the extreme can cause large perturbations on the national electricity grid. (The "Carrington Event of 1859 – possibly the largest magnetic storm to hit the Earth in historic times – induced such large currents in the ground that sparks flew from telegraphic equipment. More recently, in 1989, much of Quebec's electricity grid was lost for about nine hours.) Such events, of course, would now have even more impact in a society increasingly relying on electricity and computers, so grid operators need to be informed in advance in order that systems can be placed in the optimum configuration to withstand the disturbance.

Although the UK is in a geologically stable area of the Earth, we cannot escape some exposure to the effects of volcanoes and even earthquakes. The Eyjafjallajökull eruption in 2010 reminded us that even if we suffer no direct physical harm it is still possible to experience considerable disruption of parts of our normal activities. Prof. Ludden explained that it seemed likely that Iceland was entering a phase of increased volcanic activity and we needed to understand more about potential impacts. Earthquakes of significantly damaging magnitude are relatively unlikely in the UK. We might, however, still feel the indirect effects of more distant quakes as a result of tsunamis. We know, for example, that landslips on the Norwegian continental shelf occur at intervals of thousands of years, and about 8000 years ago a slip at Storegga produced a tsunami with a 20 meter run-up in Shetland – something that would be extremely damaging on inhabited coastlines. (Indeed, I know from my career in the nuclear industry that this is a risk to which one must pay attention. Dungeness B power station is now surrounded by a high artificial bank to provide protection against such improbably but not impossible events.) It cannot be excluded that earthquakes further away, for example off Portugal, could produce a significant wave in the south west UK. (However, they take so long to travel here that in a country with good communications, such as the UK, it would be possible to clear vulnerable areas.)

The BGS has a global reach, having involvement in a number of international partnerships, including the "Global Earthquake Model" that informs the re-insurance industry. It also undertakes risk assessments for UK dependencies, such as Montserrat in the Caribbean, where half of the island is now uninhabitable as a result of the 1995 volcanic eruption.

In summary, the BGS holds a massive physical database and also possesses the skills to provide advice on a number of highly controversial and important issues of considerable relevance to everyone living in the UK. Its expertise is sought in a range of projects from potash mines in national parks to fracking in Preston and the safety of nuclear repositories in Cumbria. I left the information-crowded talk having learned much about the range of unexpected work carried out under the aegis of the British Geological Survey.

Michael McEllin, 14 January 2016