GeoSure; a bridge between geology and decision-makers

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From: LIVERMAN, D. G. E., PEREIRA, C. &MARKER, B. (eds) Communicating Environmental Geoscience. Geological Society, London, Special Publications, 305, 81–87.
DOI: 10.1144/SP305.9 0305-8719/08/$15.00 # The Geological Society of London 2008.

Abstract: How many people understand a geological map and use it to assess the ground on which they live or plan to develop? How many town planners, house owners or insurers know that geologists can identify areas prone to flooding, radon gas emissions, landslides and subsidence? Do decision-makers understand the relevance of geology? Concerned about these questions, geological and geographic information system (GIS) professionals at the British Geological Survey (BGS) have created datasets that make information about geological hazards ('geohazards') easy to obtain, use and understand. The term 'geohazard' is emotive. Many people think of natural hazards as being large-scale disasters, such as tsunami and major earthquakes. Appropriate terminology is required to explain the relevance of factors such as the potential cost and health implications of the usually less dramatic British geohazards. Using the vast data holdings and geoscientific knowledge within BGS and building on past thematic mapping activities, a series of national geohazard datasets has been developed. GIS datasets with 'plain English' descriptions have been created for natural gas emissions, landslides, swell–shrink clays, compressible and collapsible deposits, soluble rocks, running sands and groundwater flooding. Geological information is thus brought before a wider audience and in a form that reveals to the British public and industry how geology can be used in conjunction with other information and why it is relevant to their lives.

Geological information has been used in Britain for many decades to aid decision-making in regard to land use and property, in particular by central and local government, engineers, builders and farmers. Historically most of the reports, maps and verbal communications were provided using expert language, mainly for use by people with geoscientific knowledge, and with limited 'translation' into lay terms. Scientists at the British Geological Survey (BGS) have increasingly recognized the need to provide information in different ways as different user groups have acknowledged the importance of geology to their activities.

During the 1980s and 1990s a diverse set of mainly hard-copy outputs evolved. Examples of these were sets of more customer-focused and less geologically oriented maps and reports, including assessments of foundation conditions, landslip potential, aquifer vulnerability and mineral resources. These thematic maps were provided mainly to restricted audiences, including government departments and local authorities, and their consultants, for planning and exploitation purposes. The language used in these outputs was less geological, but full understanding of their implications still required some expert knowledge. The maps provided for the Stoke on Trent planning report (Wilson et al. 1992) are a good example, with communication styles ranging from detailed geotechnical information on the foundation conditions map to simple explanations of landslip potential on the environmental geology map.

As personnel in organizations change the knowledge of how to use specialist products such as BGS thematic maps can be lost and subsequently the information holding falls into disuse. It is therefore important to provide a product that has longevity from a communication point of view, but at the same time currency of information is also vital. Digital maps and reports allow regular updates to be created and made available by various means. Many government and private organizations use digital systems (e.g. geographic information systems; GIS) to collate and report on environmental issues such as ground stability. Use of a digital GIS allows access to corporate and departmentally held datasets by a wide group of people, including managers, nonspecialists and others, who might need additional information to help them understand specialist data and their relevance to their working practices.

BGS has acknowledged that such information needs to be accessible to a wider audience in a variety of delivery formats. An example of this enlightened approach involves Internet report generation, whereby digital information for a user's specified area is extracted into a PDF report and the selected geoscience topic is described in user-friendly terms. Map data from which report extracts are created are also available as GIS data and each point, line and polygon is attributed with its geological description. Thematic information is provided where the geology has been reclassified in terms of geohazard properties.

This paper looks at a process by which geologists are trying to make their information understandable to decision-makers. The thinking and technical process are described for which mapped
geology and sample data have been collated, interpreted and classified in terms of geohazard potential and described in lay terms; and how the move from paper maps and reports to digital data and thematic output was driven by technological change and user
demand. Growth in demand for easy-to-use reports that collate national datasets for use by solicitors, insurers, house buyers and development consultants
was a leading driver.

Building a dataset to characterize ground stability: GeoSure

During the 1990s, BGS transformed its map output into a fully digital production system. Map production methods were further developed in line with the growth in use of GIS technology and cartographic data developed into spatially referenced geological data items that could be viewed, manipulated and queried in GIS and modelling software. By 2000 GIS use was commonplace both in the geoscience community and within many of the non-science communities with which BGS needed to communicate.

Once in place BGS's digital map information system allowed the capture of archive maps and the presentation of all new mapping in digital form. By 2001 the first nationwide 1:50 000-scale digital geological map dataset was produced: DiGMapGB-50 (which includes four layers: bedrock, superficial deposits, mass-movement and artificial deposits). This opened the door for further national datasets based upon the digital geology.

With knowledge of a growing demand for geoscience information to aid land-use planning and property transactions, BGS initiated the GeoSure programme to generate 1:50 000-scale ground stability characterization of Great Britain. Geological point, line and polygon data are reclassified using geologists' knowledge in combination with various datasets, including mapped and modelled surface geology, boreholes, terrain models and groundwater, to produce potential hazard assessments for six ground stability geohazards. These are swell–shrink, landslides, compressible and collapsible deposits, running sands, and soluble rocks. Database records of hazard incidents then are used to validate these geohazard assessments.

There has been an international emphasis on monitoring and creating inventories of hazard events. However, records of past events are variable and monitoring is rare in the UK (ESFS 2004). As a result, BGS developed a deterministic rather than probabilistic approach, whereby the influence of various causative factors is assessed and used to classify the six ground stability geohazards. For example, in simple terms:

clay þ steep slope þ water ¼ landslide:

Each geological polygon (that is, an area of ground identified as having specific geological characteristics) is labelled in DiGMapGB-50 with its stratigraphical name 'LEX' code (e.g. Wasperton Sand and Gravel Member ¼ WAT) and its main lithology 'RCS' code (e.g. sand and gravel ¼ XSG); creating a LEX_RCS code for each polygon (e.g. WAT_XSG). Geologists with knowledge of the rock units, their lithology and their regional characteristics identified the geohazard propensity for each LEX_RCS combination. For example, parts of Britain are underlain by Permian and Triassic rocks containing gypsum that can dissolve quickly and cause subsidence. Other datasets, such as surface slope, were incorporated to enhance the capacity for defining engineering characteristics.

A database table of the geohazard classification details for each LEX_RCS combination is created and the geological polygons are converted into 25 m grid squares. GIS software is then used to translate the data automatically, to give a hazard rating for each 25 m grid square. The ratings range from null, through 'A' (low hazard potential) to 'E' (high hazard potential) (Figs 1 and 2). The output data are then compared with available records of hazard occurrences, and checked by experienced geologists who have working knowledge of specific areas. Anomalies are identified and corrected where possible, feeding new information back into the classification method.

Data into products

Once the GIS maps are created for the six ground stability geohazards, additional text attributes can be added to each of the null and A–E classification areas to enhance users' understanding of the data. For example, Figure 1 shows how brief but informative descriptions can be provided of the implications for land use in areas of potentially unstable ground. This text can be updated regularly along with the underlying geometries, as understanding progresses and as data are improved. The text descriptions can also be taken further to meet the requirements of particular groups of end users, as in Creath's (1996) booklet, where, for a described geohazard, advice is given on what to do about each hazard and who to consult

CLASS	COLLAPSIBLE GROUND	RUNNING SAND	COMPRESSIBLE GROUND	LANDSLIDES (SLOPE INSTABILITY)	SOLUBLE ROCKS (DISSOLUTION)	SHRINK–SWELL
NULL	Collapsible ground not thought to be present.	No NULL class in this data layer.	No NULL class in this data layer.	No NULL class in this data layer	Soluble rocks not thought to be present in this area.	No NULL class in this data layer
A	N/A	Running sand conditions are not thought to occur whatever the position of the water table. No identified constraints on land uses due to running conditions.	Compressible strata are not thought to occur.	Slope instability problems are not thought to occur but potential problems of adjacent areas impacting on the site should always be considered.	Soluble rocks are present, but unlikely to cause problems except under exceptional conditions.	Ground conditions predominantly nonplastic.
B	N/A	Running sand conditions may occur if the water table rises. Constraints may apply to land uses involving excavation or the addition or removal of water.	Compressibility and uneven settlement problems are not likely to be significant on the site for most land uses.	Slope instability problems are not likely to occur but potential problems of adjacent areas impacting on the site should always be considered.	Significant soluble rocks, but few dissolution features and no subsidence; unlikely to cause problems except with considerable surface or subsurface water flow.	Ground conditions predominantly low plasticity.
C	Deposits with the potential to collapse when saturated and loaded may be present in places.	Running sand conditions may be present. Constraints may apply to land uses involving excavation or the addition or removal of water.	Compressibility and uneven settlement potential may be present. Land use should consider specifically the compressibility and variability of the site.	Slope instability problems may be present or anticipated. Site investigation should consider specifically the slope stability of the site.	Significant soluble rocks, where there are dissolution features, and no or very little recorded subsidence, but a low possibility of it occurring naturally or in adverse conditions such as high surface or subsurface water flow.	Ground conditions predominantly medium plasticity.
D	Deposits with the potential to collapse when saturated and loaded are probably present in places.	Running sand conditions are probably present. Constraints may apply to land uses involving excavation or the addition or removal of water.	Compressibility and uneven settlement hazards are probably present. Land use should consider specifically the compressibility and variability of the site.	Slope instability problems are probably present or have occurred in the past. Land use should consider specifically the stability of the site.	Very significant soluble rocks, where there are numerous dissolution features and/or some recorded subsidence with a moderate possibility of localized subsidence occurring naturally or in adverse conditions such as high surface or subsurface water flow.	Ground conditions predominantly high plasticity.
E	N/A	Running sand conditions are almost certainly present. Constraints will apply to land uses involving excavation or the addition or removal of water.	Highly compressible strata present. Significant constraint on land use depending on thickness.	Slope instability problems almost certainly present and may be active. Significant constraint on land use.	Very significant soluble rocks, where there are numerous dissolution features and/or considerable recorded subsidence with high possibility of localized subsidence occurring naturally or in adverse conditions such as high surface or subsurface water flow.	Ground conditions predominantly very high plasticity. NOTE: There is no Class E in this data layer in the UK.

Fig. 1. Legend for GeoSure: ground stability GIS datasets showing the null to E hazard ratings and the simple descriptions of hazard and advice for any action. N/A, not applicable.

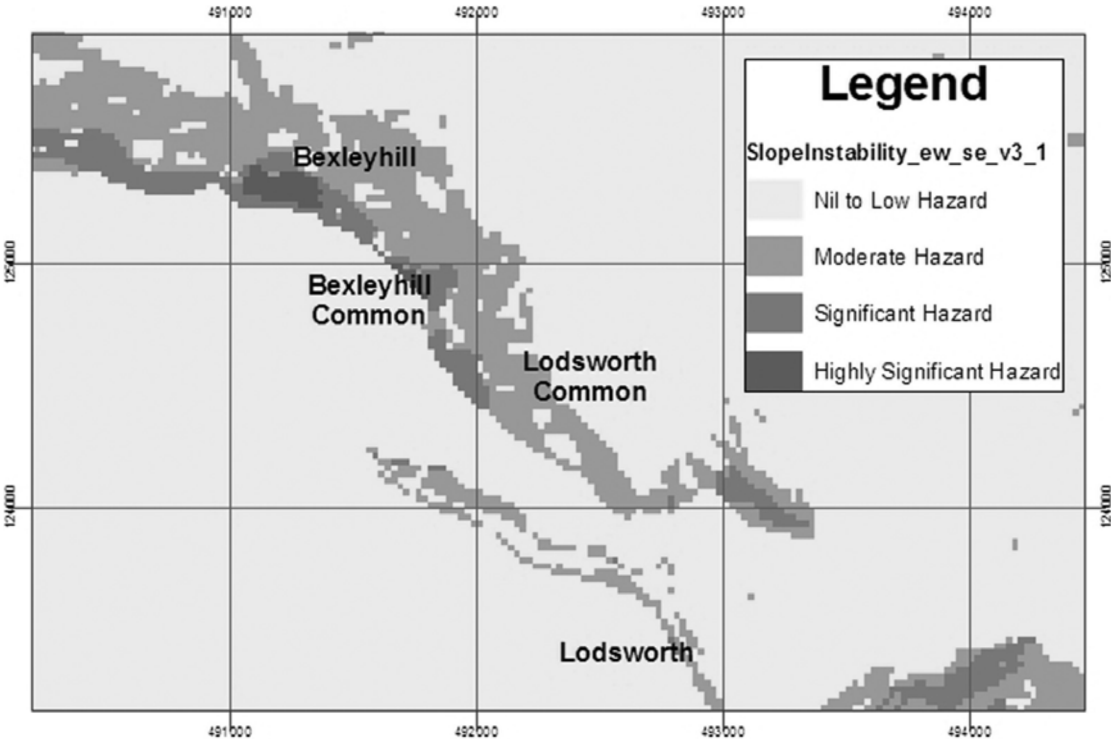

Fig. 2. Map of potential landslide hazard data north of Lodsworth, Sussex (the key gives the minimum and maximum hazard ratings in the area).

BGS was aware that previous outputs, such as thematic maps and reports, had not reached a sufficiently wide audience. To address this, BGS invested in 2000 in a report delivery system called GeoReports, fronted by an online shop (http://shop.bgs.ac.uk/georeports/). This proved a breakthrough in communication for BGS and has been very popular amongst users; in 2006–2007 BGS sold around 9000 GeoReports. It uses a semi-automated method of delivering national geoscience information in simple and understandable terms. Paper or PDF files are supplied containing extracts of the geology and geohazard maps (such as in Fig. 2), enhanced by the additional text descriptions of the hazards taken from the database tables (such as Fig. 1). Where more detailed descriptions are required by users, these reports can be expanded by manual input from BGS geologists, thereby providing a vehicle for full transfer of BGS knowledge to users; 2200 of the requested reports in 2006–2007 were for those with geologists' input. In the example extract from a GeoReport in Fig. 3, the hazard assessments are set out as a series of questions related to a client's site, and explained in simple terms for ease of use. A range of other reports is provided, tailored to meet the requirements of a range of land users, from developers to planners, property purchasers or owners.

BGS aims to match its geohazard products to the need for relevant and understandable information, through succinct but advisory attribute text with GIS data and through focused simple geohazard reports for a development site, a single house plot or a planning area. Detailed, more scientific, reports are also available. Provision of Internet access to reports has also been most helpful to members of the public looking for simple explanations, or to specialists looking for information for professional searches, output as paper or PDF. For example, a BGS report advising that 'Your home is not in an area susceptible to subsidence' might give a home owner all the information they need, but 'This site might be affected by swell–shrink damage; do not plant or remove trees without getting further advice' should lead an inquirer to seek additional information, and an engineer would normally also require more detail to make a full assessment. BGS works closely with client groups to adapt the format of geohazard reporting to meet their needs. For example, in consultation with a value-added reseller for insurance companies the GIS geohazard data were merged with postcode data to create new insurance hazard polygons. Added flexibility is provided for a growing number of BGS data users by supporting the incorporation of geohazard (and many other) datasets into their own decision-support and reporting systems. This facility is especially useful for local planning and environmental health officers, and for commercial companies that provide reports to development consultants and conveyancing solicitors via the Internet.

Provision of geohazard information via a third party, such as a commercial reporting company, has many advantages for BGS, including wider and more focused communication and market research.

Question 1	**Answer**
Is significant natural ground instability possible in the area?	*YES*
Question 2	**Answer**
What is the level of hazard on a scale A to E (low to high)? NOTE: Only levels C, D and E are shown and described below, as Levels A & B are considered insignificant	Level D
Question 3	**Answer**
Which natural geological hazards could be contributing to the ground instability in the area? *How much ground instability each hazard may cause is indicated by the Level C to E in brackets.*	Clays that can swell when wet and shrink when dry, causing the ground to rise and fall ('Swelling Clays Hazard') (LEVEL C) Sand that can wash away or flow into holes or fissures due to water flowing through it ('Running Sand Hazard') (LEVEL C) Weak or unstable rocks that could slip downhill on steep slopes (greater than c. 5 degrees) or into excavations ('Landslide Hazard') (LEVEL C) Very soft ground that might compress and progressively sink under the weight of a building ('Compressible Ground Hazard') (LEVEL D)
Question 4	**Answer**
What action should be taken?	If natural ground instability has been indicated, then this means there is potential in your area for some properties to suffer subsidence damage. However, it does not necessarily mean that your property will be affected, and in order to find out if this is the case or not, you should obtain further advice from a qualified expert, such as a building surveyor. Show them this report and ask them to evaluate the property and its surroundings for any signs of existing subsidence damage as well as advise on the likelihood for subsidence to occur in the future. The notes at the end of this report may be useful in this regard. Note that the type of building and its surroundings (e.g. the presence of trees) are also very important when considering subsidence risk. Many types of properties, particularly newer ones, are very well constructed and unlikely to be affected by subsidence, even in areas of very significant ground movements.

Fig. 3. Extracts from ground stability GeoReport for the BGS Keyworth office site.

Communication issues

Language

The understanding of the terms hazard and geohazard is highly dependent on a person's life experience and education. For many, a hazard indicates potential danger such as a hole in the road or a warning for floods or bad weather; but they may not be sure which of these is a geohazard. However, if geohazards are listed, many words would be recognized by the general public and related impacts readily envisaged. Those reading terms such as earthquake, landslide, volcanic eruption or mining collapse would immediately be aware of potential outcomes even if the underlying conditions and mechanisms were not understood. Other user-perspectives must also be considered; an insurance company, for example, might view a geological hazard as being the cause of a problem, but see the symptom as a financial cost (hazard).

General assistance to geoscientists eager to share their knowledge is still lacking in terms of clear guidance on how best to communicate in a form that is accessible to a variety of audiences. In 1996 Creath published the *Home Buyers' Guide to Geologic Hazards in America*, describing each hazard in lay terms and aiding property owners in identifying whether a hazard could affect their property. Although the level of scientific terminology used would still challenge many readers, it is written in a non-technical style and it set a good precedent for user-oriented (rather than scientist-oriented) information provision. BGS used its connections with commercial companies and educational institutes to aid understanding of their needs and to adapt its presentation styles. Improvement continues in these areas thanks to this kind of market intelligence. Other geoscience organizations have also embraced the need for appropriate presentation of scientific ideas; Geoscience Australia in particular, and a number of American institutes have good records in producing geohazard leaflets suitable for a broad-spectrum technical audience and also informative to members of the lay public who have some technical knowledge (Forster & Freeborough 2006)

The study by Forster & Freeborough (2006) advocated the use of good visual material, clear simple language and consideration of the knowledge and needs of the intended audience. They also highlighted that successful communication is an emotional rather than a technical skill, in which many scientists might need training.

Although plain English might be understandable to most British citizens, some business sectors will look for their own professional terminology (jargon) before identifying a dataset as being relevant to them. For example, planning officers will look for references to legal or government requirements such as Planning Policy Guidance relating to unstable land for geohazard information (Anonymous 1990, 1996). These documents are aimed specifically at the planning community and associated professionals, and are written in a style that includes planning terminology with reference to other regulations familiar to planners and conveys the information in a precise manner. It is human nature to respond positively to recognized terminology and look for easy ways to meet such policy requirements. The more easily an individual can identify with a piece of information the more readily they will accept and use it. BGS's association with some insurers, and their guidance on expected information format and content, has allowed better BGS communication and a more positive reception of geohazard information in the insurance arena.

The message

Following any geohazard-related event such as a landslide on the British coast, awareness of potential hazards in the affected area is raised, but this might not increase awareness of the term 'geohazard'. More important, and of greatest interest to those affected, is gaining an understanding of what has happened and why, what can be done to prevent repetition or how to be prepared for future events. Long-term impacts and any related safety implications must also be communicated. Organizations such as BGS that traditionally are linked with central government commonly are called upon to provide definitive information and to offer explanations and advice. Therefore, maintaining user confidence in any data provided and taking care with the language used to describe geohazard data are issues of paramount importance.

Public outreach

For many decades the relevance of earth-science research results to decision-makers, politicians, industry and the lay public has been promoted by prominent bodies such as the Royal Society (1985, 2006). More recently, the International Geographical Union's Commission on Hazards and Risks has reported on the role of science in public policy decision-making, reviewing who uses information, what information is used, and the purposes for which it is used (ESFS 2004). Emphasizing the importance of widespread dissemination of scientific knowledge, the Royal Society also acknowledged the difficulties caused by lack of guidance for scientists and the perceived professional stigma associated with communicating their results to a lay audience. Any such stigma associated with interacting with the media and promoting public dissemination of science has diminished markedly, thanks partly to the many radio and television programmes that have been presented during the past 10 years. Nevertheless, peer disapproval of publication in popular rather than scientific journals and of the use of lay terms continues to be identified as a barrier to 'popular' communication (Van Loon 2003)

Conclusions

Many personal, public and business decisions have a scientific aspect that might include geohazards. In response, geoscientists have to be increasingly focused on societal vulnerability to natural hazards as much as the scientific causes and physical consequences of such hazards.

The provision of geohazard information to nongeologists and the creation of thematic output are not new ideas. More novel are considerations of users' understanding of geology and the provision of such information using formats and language that are recognizable to particular groups. To communicate well there must be comprehension of the topic's relevance to the recipient. To allow a good understanding of scientific information that is being presented, minimal scientific jargon should be used and when focusing on a particular group, concepts and language familiar to them should be included.

Internationally there have been great steps forward in the successful communication of geohazard information by geoscientists to a broadly based audience, and the BGS contribution has been a part of that trend. The provision of GIS data for recipients to use in their own systems, supported by text that describes the geohazards in lay terms, and especially the provision of tailored reports for non-technical persons have been enormous steps forward in the development of BGS geohazard knowledge transfer.

In answer to the question: ‘Can geologists make geology relevant to others?’ I would say ‘Emphatically yes’. However, we have yet to develop a still more versatile bridge across the gap between helping users understand that geology is relevant to them and making geological information understandable to all.

References

ANONYMOUS, 1990. Planning Policy Guidance 14. Development on Unstable Land. Department of the Environment and the Welsh Office. HMSO, London.

ANONYMOUS, 1996. Planning Policy guidance 14 (Annex 1). Development on Unstable Land: Landslides and Planning. Department of the Environment. HMSO, London.

CREATH, W. B. 1996. Home Buyers’ Guide to Geologic Hazards. An AIPG Issues and Answers Publication. American Institute of Professional Geologists.

ESFS 2004. Hazards—Minimising risk, maximising awareness. Earth Sciences for Society prospectus for a key theme of the International Year of Planet Earth, November 2004. Earth Sciences for Society Foundation. World Wide Web Address: http://www.iugs.org/iugs/downloads/iype/03_hazards.pdf.

FORSTER, A. & FREEBOROUGH, K. 2006. A guide to the communication of geohazards information to the public. British Geological Survey Internal Report, IR/06/009.

Royal Society 1985. The Public Understanding of Science. Royal Society, London.

Royal Society 2006. Science and the Public Interest. Communicating the Results of New Scientific Research to the Public. Royal Society, London.

VAN LOON, A. J. 2003. Towards a public-friendly publishing attitude in the earth sciences. (AESE 2003 Annual Meeting Program.) Blue Line, Newsletter of the Association of Earth Science Editors, 36, 000–000.

WILSON,A.A.,REES, J.G.,CROFTS,R.G.,HOWARD,A.S., BUCHANAN, J. G. & WAINE, P. J. 1992. Stoke on Trent: A Geological Background for Planning and Development. British Geological Survey Technical Report, WN/91/101.