Geoscience for decision making

A BGS Team introduces GeoConnexion readership to the power of underground mapping and 3-D modelling to assist major engineering projects while highlighting some barriers to data sharing and interoperability.

Glasgow, and neighbouring towns along the Clyde Valley in Scotland, are currently undergoing redevelopment and regeneration on a scale as large as any in Europe. Local and national Government and private developers are investing heavily in the construction of new housing, retail and industrial units, and infrastructure. Projects, which include the Clyde Waterfront cluster, Clyde Gateway (budget of c. £1.6 billion) (see main image), and the Commonwealth Games 2014, have timescales running into decades. Many of these major engineering projects are developing in brownfield sites. Consequently, there are complex environmental issues to overcome; undermining is widespread, many sites are contaminated due to previous use, and there is a need to provide sustainable drainage, prevent flooding, and consider potential sea level rise.

These environmental issues are geoscientific, and fundamentally 3-dimensional (3-D). Therefore, there is an increasing demand for high quality, up to date, environmental geoscience information (data on soil and rock properties, groundwater, minerals, etc.) to help address planning, development and resource management issues. Legislative, economic and environmental pressures on ground resource management (eg EU Water Framework Directive) also fuel requirements for geoscience data.

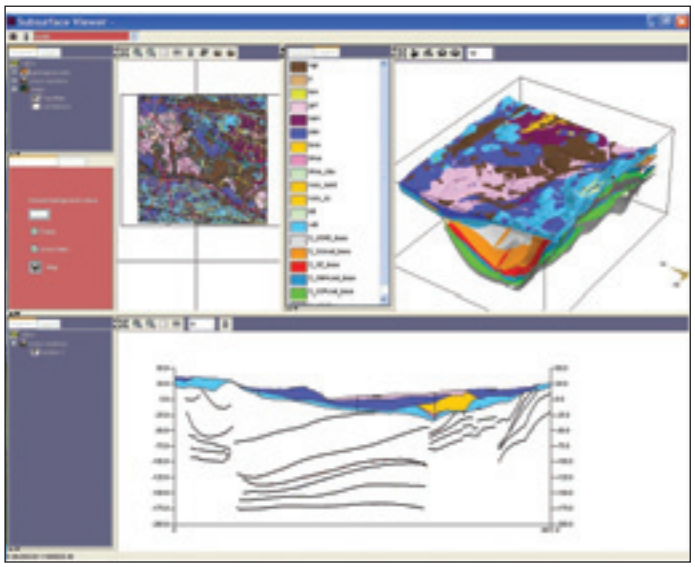
The British Geological Survey (BGS) is helping to meet these needs. Given the varied backgrounds of the potential users, the data must be in forms that are easily understood and integrated with other datasets.

Much of BGS's work in the Glasgow area is in partnership with Glasgow City Council and others, and focuses on:

- capturing and sharing geoscience data, especially borehole records, and in digital (e.g. AGS) format
- 3-D modelling (GSI3D (©Insight GmbH), and GoCAD™ software) of the superficial deposits (soils) and rocks, with quantified uncertainty,
- attributing the models (e.g. with engineering and groundwater properties),
- identifying key geological faults, and the extent of past mining and quarrying,
- integrating data sets to gain insights into environmental issues, identifying hazards (e.g. mining-related) and analysing risk (e.g. surface-to-groundwater pollution), and
- transferring knowledge to stakeholders by exporting the models:
- as layers to GIS platforms for display and integration with other non-geoscience data.
- to an interactive lithoframe (subsurface) 3-D viewer for use by specialists and non-specialists, for querying the model and generating synthetic boreholes and cross sections.

In urban areas, most geoscience spatial data come from site investigation boreholes and mine plans. BGS maintains a national database of borehole information and for Glasgow has about 35,000 records. The boreholes have sampled soils and rocks commonly from depths of metres to tens of metres, and sometimes hundreds of metres, beneath the surface. They are, therefore, ideal for developing detailed 3-D models of the different soils and rocks, providing that the spread of data is good.

BGS relies mainly on donations for most of its borehole data, including all site investigation data; only borehole data from boreholes >15m deep sunk for water and >30m deep sunk for minerals must be made available under current long-standing legislation. Other borehole data are held by public bodies and private organisations, and are variably accessible. Also, nearly 30% of borehole records held by BGS for urban areas of Scotland are confidential to BGS. Therefore, planning and development decisions are currently made on restricted access to all of the geoscience data potentially available in Scotland. This



GSI3D Subsurface Viewer interface showing 2D map window, 3D model window and cross-section window (borehole viewer window not shown). The model can be used to generate virtual cross-sections and boreholes to predict ground conditions for site investigations and planning

increases uncertainty and risk in developing projects, ground investigation is less efficient, and delays and resultant claims due to 'unforeseen ground conditions' are more likely. All have cost implications. This comes at a time when there is a drive to make public authority data more generally accessible. The European Parliament's INSPIRE Directive (2007/2/EC) promotes interoperability of data, and development of spatial data infrastructures. The benefits of doing so in Scotland will include increased efficiency and accelerated decision-making in the planning process and savings in development costs.

As the various data are held by many organisations in a variety of media, and in scattered locations, the ultimate vision is to facilitate interoperability of the data, using appropriate technology and standards. More government-industry-public partnerships are needed to share borehole and other data for mutual benefit through a web-based portal. Users could then have access to a more definitive database of metadata and a single repository for spatial geoscience data relevant to land use, and could download via 2-D map–based, and 3-D model-based interfaces.

Delivery of 3-D models

3-D digital geological models provide an up to date, easily understood, highly visual, interactive method for providing integrated geological information, and geoscience spatial data. They are a potentially more efficient and cost-effective solution than traditional geological maps which not only require expertise to interpret, but are also a limited representation of the subsurface.

The Clyde valley, and Glasgow in particular, is the initial focus for delivery in Scotland, but the ultimate vision is for national coverage, at appropriate scales. The BGS has also taken a similar approach to sustainable land development through modelling projects in areas of urban regeneration elsewhere in the UK, including the Manchester to Liverpool Mersey corridor and the Thames Gateway.

The 3-D models synthesise available digital data, in this case within about 200 metres of the surface, from boreholes, geological maps, mine plans and digital terrain models and are used to illustrate and interpret:

- the distribution and thickness of superficial deposits and artificial ground,
- variations in the rocks, and the extent and depth of past mine workings, and
- geotechnical, geochemical, hydrological and geophysical properties

The models are therefore powerful predictive tools and time saving assets that are an assimilation of large amounts of urban geodata in easy-to-use packages. They provide an initial geological model, as part of the desk study. This allows for a better designed site investigation and can be expected to help to make better use of available budgets and to reduce uncertainty in ground models to acceptable levels.

Potential benefits of the models

The 3D models and related GIS layers are the potential keys in Glasgow to:

- helping planners and developers in key decision making
- understanding problematic ground conditions,
- optimising developers' site investigation budgets,
- researching environmental issues such as the migration of surface contaminants into the groundwater system,
- finding ways to mitigate hazards
- ensuring that the land is redeveloped in a safe and sustainable fashion
- integrating geodiversity with biodiversity and archaeology as issues to consider in planning and development

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