Extended abstract for paper to be delivered at Innovative Geological Cartography, 24-26th Nov, Kazimierz Dolny

Urban geology: integrating surface and sub-surface geoscientific information for development needs

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ABSTRACT: The British Geological Survey (BGS) operates an urban geoscience programme that aims to provide up-to-date information on ground-related issues for the towns and cities of the UK. Research in the major conurbations of Manchester, Swansea and Glasgow is demonstrating the value of integrating surface geological mapping with sub-surface geoscientific information through the use of 3D models. This approach provides a more holistic view of the near-surface environment and provides a means of identifying potential problems and opportunities at an early stage in any proposed development. If implemented over a wider area, it could assist in designing site investigation strategies and reduce costs by ensuring a more focused approach to strategic planning.

Introduction

The role of geoenvironmental information is becoming increasingly important as legislative changes have forced developers, planning authorities and regulators to consider more fully the implications and impact on the environment of large-scale development initiatives. To comply with the principles of sustainable development, developers are increasingly required to demonstrate that proposals are based on the best possible scientific information and analysis of risk. Nowhere is this more relevant than in the context of urban regeneration. In the UK, studies commissioned by the Department of the Environment in the 1980s and 1990s promoted the use of applied geological maps to identify the principal geological factors which should be taken into account in planning for development. Since this work was completed, advances in the use of Geographical Information Systems (GIS) and modelling packages have meant that there is now far greater opportunity to develop geoenvironmental products that take greater account of the third dimension. Because the information is captured and manipulated digitally, the outputs can be tailored to user needs, and more readily updated. The potential that the new technology offers is illustrated in this short communication, which focuses on the Greater Manchester conurbation in north-west England. Additional details are published in Hough et al. (2003) and Ellison et al. (2002).

Geological setting

Geologically, Manchester straddles the southern part of the South Lancashire Coalfield and the northern part of the Permo-Triassic Cheshire Basin (Figure 1). The coalfield was extensively worked up until the late 1970s. The overlying Permo-Triassic rocks of the Sherwood Sandstone Group form part of the second most important aquifer in the UK.

Quaternary superficial deposits laid down during the Devensian glaciation mantle most of the area, locally reaching thicknesses in excess of 40 m (Figure 2). The deposits include glacial till (pebbly and sandy clay), glaciolacustrine deposits (laminated clays and sands) and glaciofluvial outwash (sands and gravels). Extensive areas of made ground are present, and include colliery spoil tips, material dug during the construction of the canal network, and general inert and biodegradable fill. Many of the natural watercourses have been culverted and their valleys infilled.

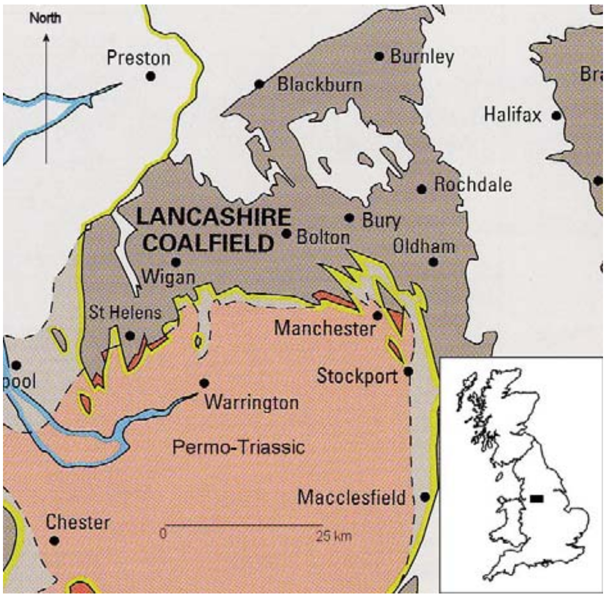


Figure 1. Regional geological setting

Figure 2. Quaternary geology of Manchester and Salford (Trafford Park Industrial Estate outlined in red).

Geoscientific issues

Difficult ground conditions are a material consideration throughout much of the conurbation because of the heterogeneous nature of the superficial glacial deposits and the significant thickness of man-made deposits in certain areas. Damage caused to housing and roads as a result of piping or collapse of glaciofluvial sands is well documented, as are the subsidence effects caused by undermining for coal. There are also issues of contamination and groundwater protection. On a regional scale, uncertainty about the shallow groundwater regime, and the role played by the surface drainage (natural and canals) are issues of strategic concern.

Building the model

Software currently under development by Dr Hans Georg Sobisch of the University of Cologne is being used to construct a 3D model of the inner city area. The three dimensional configuration of the Quaternary superficial units in the sub-surface is built-up from serial cross-sections, drawn interactively by integrating surface mapping with site investigation data (Figures 3). Correlated surfaces are then gridded and stacked to produce the final geological model. Attribution of the model with a range of parameters (geotechnical, hydrogeological, geochemical) allows rapid generation of a range of thematic products.

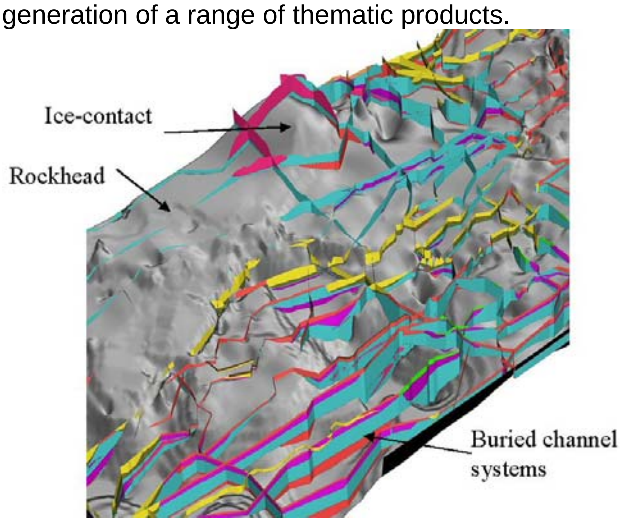
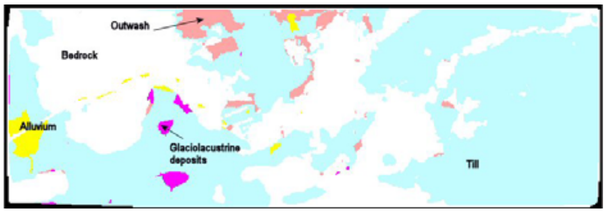


Figure 3. Section framework for Quaternary superficial deposits, above rockhead (grey) in the Trafford Park area (Figure 2).

Use of the model for thematic mapping

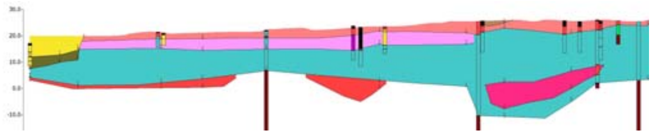
The model has the potential to deliver information in a format relevant to a wide range of planning issues. Four examples are cited:

a) Subsurface map at user-defined depth below ground surface

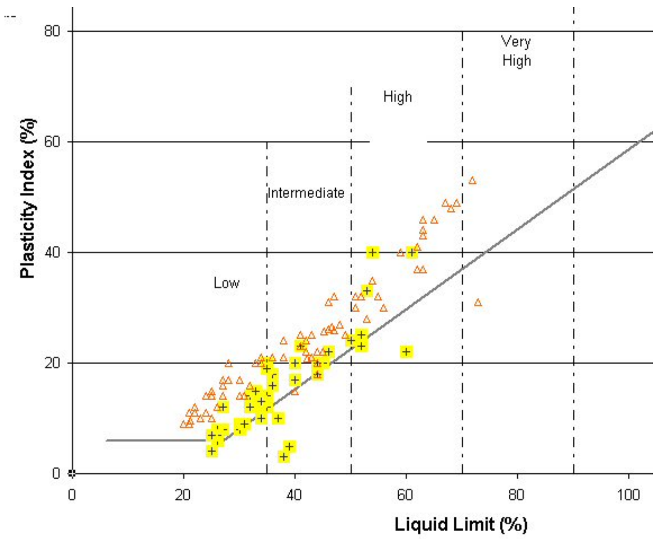


Quaternary deposits at 10m below ground surface (compare with Figure 2).

b) Synthetic cross-sections along user-defined transect (e.g. proposed pipeline/sewer route)

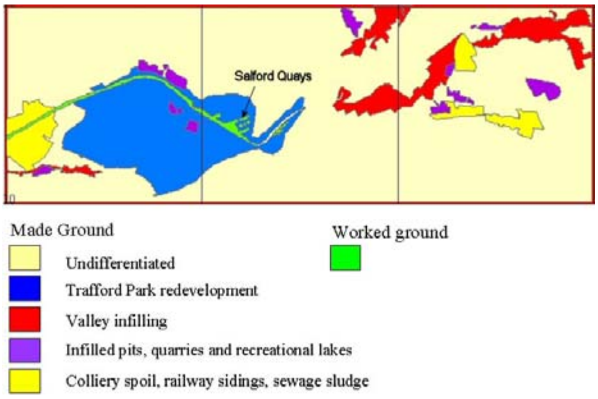


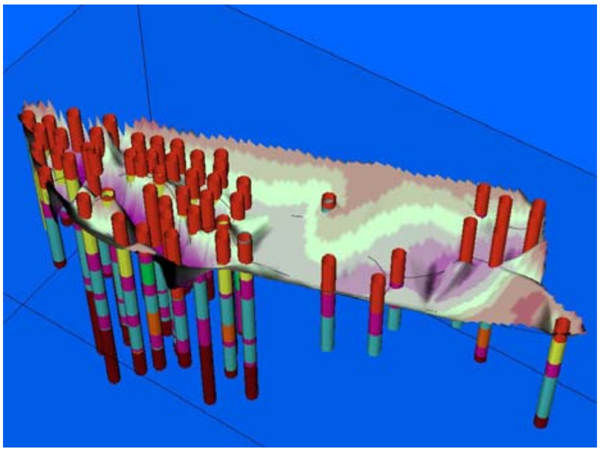
c) Geotechnical properties of selected modelled units (e.g. for shrink-swell susceptibility)



Plasticity chart for alluvial silts (+) versus glaciolacustrine clays (Δ). Under normal ground conditions, low and intermediate plasticity values generally indicate a low shrink-swell potential whereas high and very high plasticity values indicate a high shrink-swell potential.

d) Distribution and classification of artificial deposits





Extract from model showing base of Made Ground in Salford Quays and infilled former river course.

Conclusions

This abstract illustrates some of the potential uses and benefits of integrating geoscientific information in a 3D framework. There is the potential to:

- understand better the processes that bring about change,
- deal with uncertainty,
- provide interpreted outputs of spatial information in exactly the form required by the users.

Previous experience of applied mapping studies suggests that the success of this approach will ultimately depend on engaging more fully with a range of users (consultants, planners) and demonstrating that there are real benefits (financial and environmental) in taking a more holistic approach to environmental assessment.

Reference

Hough, E, Kessler, H, Lelliott, M, Price, S J, Reeves, H J, and Bridge, DMcC. 2003. Look before you leap: the use of geoenvironmental data models for preliminary site appraisal. 369-375 in *Land reclamation extending the boundaries* H M Moore, H R Fox and S Elliott (editors). (Swets &Zeitlinger, Lisse.)

Ellison, R A, McMillan, A A, and Lott, G K. 2002. Ground characterisation of the urban environment: a guide to best practice. *British Geological Survey Report*, RR/02/05