

3D GEOSCIENCE MODELS AND THEIR DELIVERY TO CUSTOMERS

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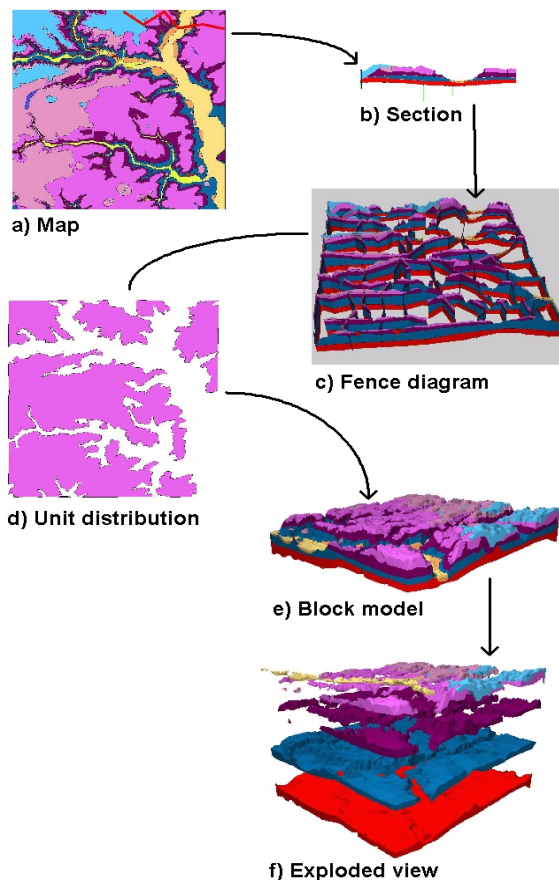
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BACKGROUND

Over the past few years, the creation of systematic three dimensional (3D) geological subsurface models has become standard practice of national Geological Surveys. The methods for construction of 3D models are well documented (e.g. Hinze et al., 1999; Sobisch, 2000; Kessler et al., 2004) and software tools like GSI3D (Geological Surveying and Investigation in 3 Dimensions; ©INSIGHT Geologische Softwaresysteme GmbH) use section-building techniques that are familiar to all geologists. (Kessler and Mathers, 2004)



The GSI3D method utilizes a digital terrain model, geological surface linework and downhole borehole data to enable the geologist to construct regularly spaced, intersecting cross sections. These are combined in a fence diagram (Figure 1, a-c) which displays the correlation of individual units and their lateral extent in the subsurface. Mathematical interpolation between nodes that define the base of each unit produces a solid model comprised of a series of stacked triangulated objects corresponding to each of the geological units present (Figure 1d-f).

Geologists interpret their sections based partly on factual information where the borehole information and correlation is secure and partly on geological experience - the shape 'looks right'. This 'looks right' element pulls on the modellers' wealth of understanding of geological processes and knowledge gathered over a career in geology. For example, something observed in sediments at the margin of a glacier in Iceland might well influence the way a geologist draws the base of a till unit on a geological section in Scotland. In a fluvial environment, the erosive power of a river in flood might inspire the geologist to draw a scoured base to a braided river deposit.

Figure 1. GSI3D workflow (Kessler and Mathers, 2004)

Following 5 years of research into systems and methods for 3D modeling the BGS has now embarked on a campaign to systematically build 3D models, at various scales, and to national standards across the entire country. The task, known as LithoFrame, will be organised regionally and linked to local and national environmental and development policies. The LithoFrame concept is described more fully on the BGS website <http://www.bgs.ac.uk/science/3dmodelling/home.html>

The LithoFrame models will be structured and attributed to meet the needs of a wide range of applied users, and ultimately, may take the place of the traditional geological map. However, this will only happen if the models are accessible, can be delivered to the user community at realistic costs, and the underlying databases are maintained to

allow rapid model update. The following table lists some of the main customers and related outputs from a standard 3D geological model.

Table 1. Typical customers and products of systematic 3 dimensional models

Water Industry and Environment Agency Sections with hydrostratigraphical attribution, grid export of thicknesses and bases of aquifers and aquitards for groundwater flow modeling.
Minerals Industry Isopachytes of resources and overburden, predictive boreholes.
Town Planners and Civil Engineers Maps of unstable ground, subsurface maps for planning excavations, sections along roads and tunnels.
The Public and Academia Standard geological maps, 3D geological animations, exploded views.

RECENT APPLICATIONS

The principal application for 3D modeling in Britain is for groundwater protection and management. The main driver is the EU Water Framework Directive (European Parliament, 2000), which has clear objectives to improve the status of all waters (surface and subsurface) and to reduce the pollution of these waters by hazardous substances. In implementing this Directive, there is a recognition by both water companies and the regulator that the 3D geological model has an important role in conceptualising the geological setting of the aquifer and determining surface-groundwater interactions.

The following are examples of three recent projects commissioned to solve problems in groundwater management and abstraction licensing as well as town and environmental planning.

The first 3D model (Ford et al., 2003) was commissioned by the Environment Agency (EA) York, north-east England, in order to aid regional groundwater modeling and gain an overview of the Quaternary deposits overlying the Triassic Sherwood Sandstone Group, one of the UK's major aquifers. The Vale of York is filled with up to 25 m of thick clay and silt deposited in an ice dammed a glacial lake formed during the Last Glaciation by meltwaters draining to the North Sea. Several regional sections were constructed using boreholes coded according to their lithological properties. Figure 2 displays the 40 x 60km large open fence diagram coloured by a) lithostratigraphy and b) hydrostratigraphy. These sections formed the main part of the deliverable to the client.

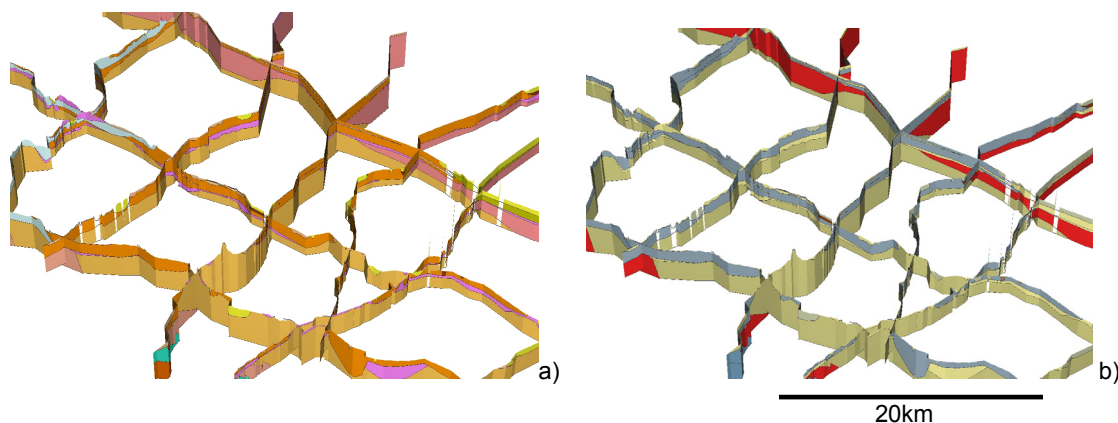


Figure 2. Regional fence diagram (Ford et al 2003) showing clayey deposits in grey and sandy deposits in yellow overlying sandstone aquifer in green and non-aquifer in red.

The second example is a full geological block model of 100 km², commissioned by the EA in Warrington, north-west England (Kessler et al., 2004). The main focus of the study was Trafford Park one of the biggest industrial estates in Europe. There are important issues of over-abstraction, contaminated land, surface sealing and waste water treatment. A critical part of the study was an examination of the hydrogeological role of the Manchester Ship Canal, a major waterway that links Manchester to the Irish Sea. The geological setting is comparable to the Vale of

York with the Sherwood Sandstone aquifer, here covered by up to 50 m of glacial and post-glacial deposits (outwash sand, till, lacustrine clay and alluvium). Man-made deposits (canal dredgings, colliery spoil) are a ubiquitous feature of this heavily industrialised area (Bridge, 2004). The full block model of the superficial deposits enabled the construction of customer-defined sections, annotated with the groundwater piezometric surface in the Sherwood Sandstone aquifer. Figure 3 displays one of these sections along the Ship Canal. The user can clearly assess in which areas the canal may be in direct contact with the aquifer and where clayey deposits such as till or lacustrine sediments may be forming a barrier to contaminant flow. A second major deliverable of this project was the creation of an aquifer vulnerability map (Figure 4). This map was created by GIS calculation directly from the model, following classification of the system into hydro geological domains. The client was also provided with the tops and bases of all geological units as grids for use in quantitative groundwater flow modeling.

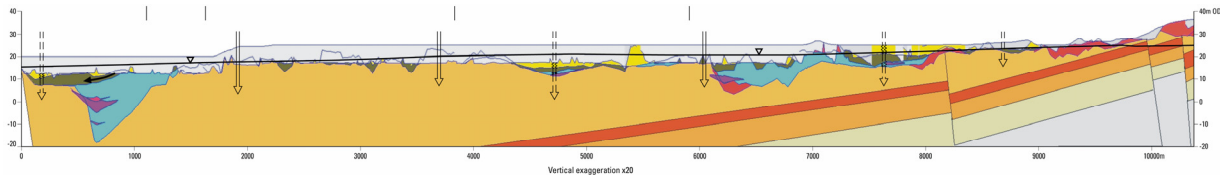


Figure 3. Synthetic section (8 km) along the Manchester ship canal showing areas of direct and indirect potential recharge and the groundwater piezometric surface in the Sherwood Sandstone aquifer. (Kessler et al 2004)

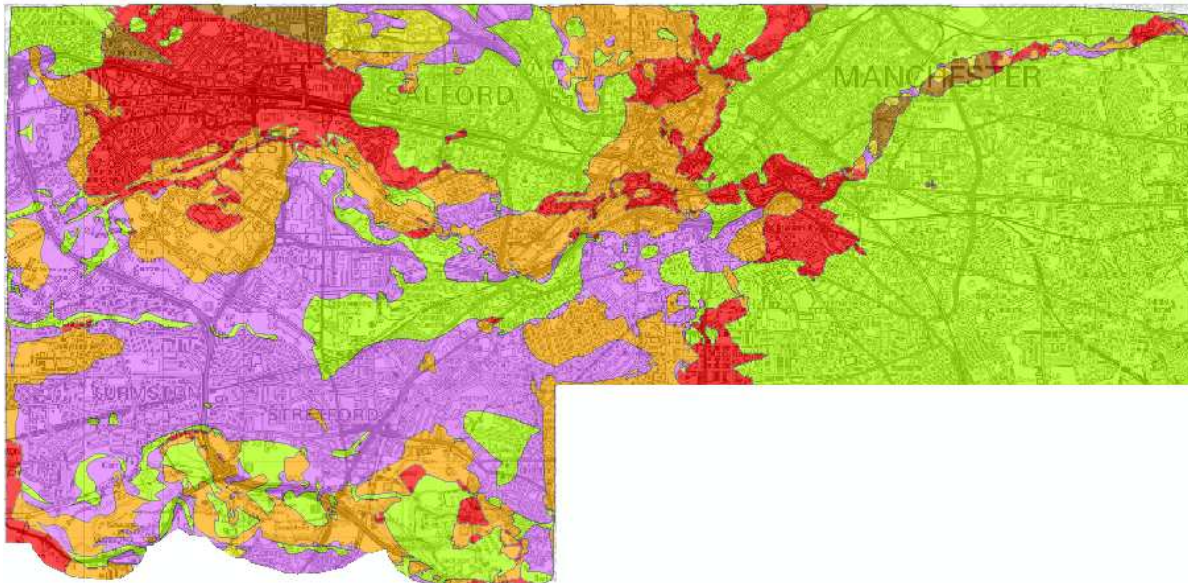


Figure 4. Hydrogeological Domains, red: high recharge potential, green: low recharge potential, purple: possible perched aquifer (Kessler et al 2004)

These 2 examples have illustrated the most common requirements of the hydrogeological community. They highlight the diversity of formats, scales and interpretations demanded from the standard geological framework model. In order to deliver the full richness of the models and its attributes avoid inefficiency in data handling a cheap and simple to use viewing system had to be found which must allow the client to interrogate the model without specialist knowledge.

The final example is from work carried out in collaboration with Glasgow City Council, where a standard LithoFrame model has been commissioned to assist the town planners with everyday decision making. Using cutting edge viewing and delivery software the model and its attributes are encapsulated together with maps and the software in one single file and can then be distributed by the customer in an unlimited way. Figure 5 displays this 5 by 5 kilometre tile of 3D geological data. The software enables the user to create predictive drill logs and vertical and horizontal sections, contoured views of all geological units, as well as subcrop and supercrop maps. All data can be exported as images and GIS compatible files (polygons and contour lines). The 3D window enables the full view of the geology with moving sections and exploded views. These views have long been the dream of geoscientists and truly help to communicate the geological vision to experts and laymen alike.

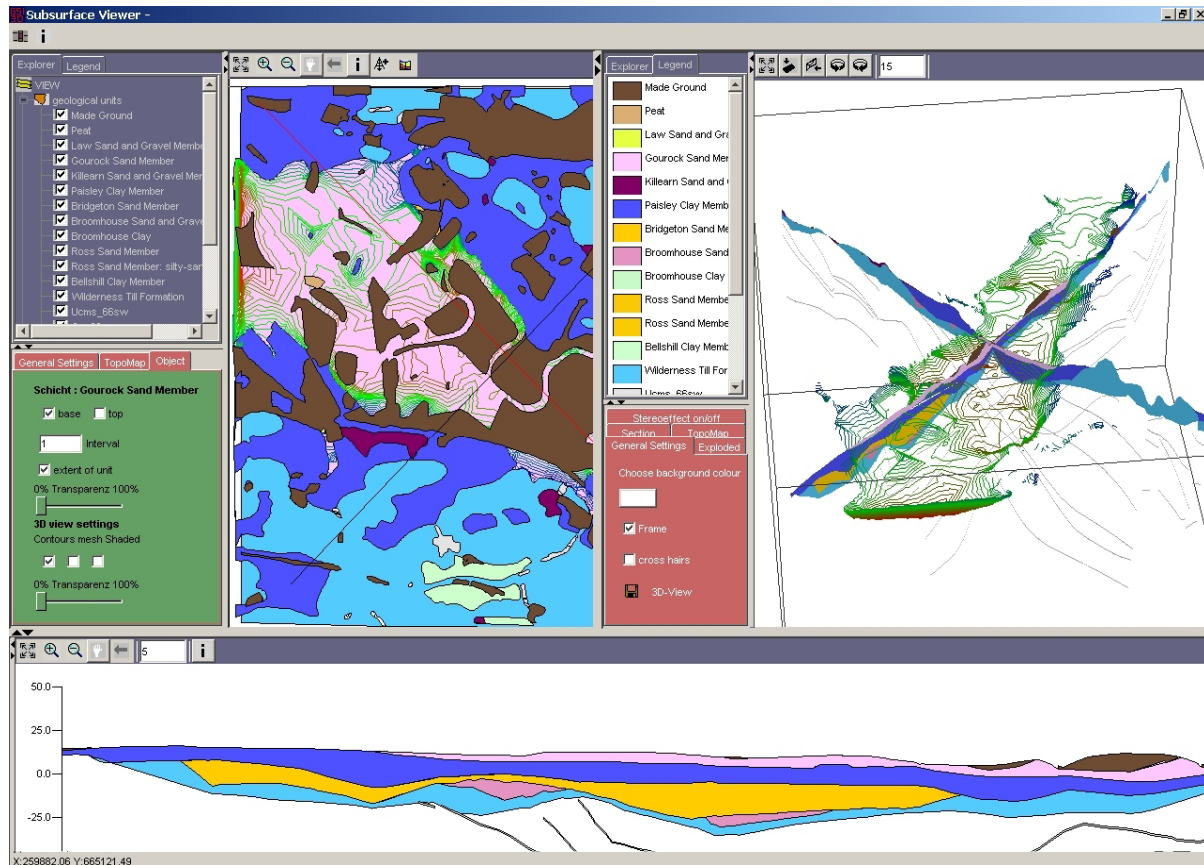


Figure 5. The user interface of the 3 dimensional geological map of the city centre of Glasgow, showing examples of contouring, synthetic sections and 3D views of the model. (SUBSURFACE VIEWER © INSIGHT)

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