A model of the Ipswich Urban area, geological mapping in 3D.

Steve Mathers **British Geological Survey, Keyworth, Nottingham**
E-mail **sjma@bgs.ac.uk**

Background

Over the last ten years the British Geological Survey has started to produce 3D digital geological models in formats that will ultimately replace traditional geological maps (Kessler & Mathers 2004). Initially these models were produced in trial areas to explore the capability of various modelling softwares to construct the geology in 3D. Consolidation of this experience and approach has now led to the launching of an initiative to begin deployment and the construction of a multi-scaled National Geological Model. Similar progress is being made in several other leading Geological Survey Organisations in Europe and North America.

The Ipswich Model

One of the major testbeds for this development has been the area around Ipswich-Sudbury-Colchester-Harwich which was resurveyed and modelled on a tile by tile basis from 2003-10 as part of an integrated revision of the geological maps and the production of models. All BGS-held borehole data were examined as part of this programme together with information from published literature in particular contour, isopach and subcrop distribution maps of the geological units. Essentially the exercise involved examining all the available data in its geospatially correct position within a single workspace to build a consistent 3D model i.e. 3D geological mapping.

The work was undertaken using the GSI3D software (Kessler, Mathers & Sobisch 2008, Mathers & Kessler 2007). The small model presented here is a cookie cut from that large regional model and covers the urban area of Ipswich as defined by its major ringroads and the Orwell Bridge crossing (Figure 1) It is intended to make this example model available as a free download (for academic and educational purposes) in various formats from the BGS website in early 2012.

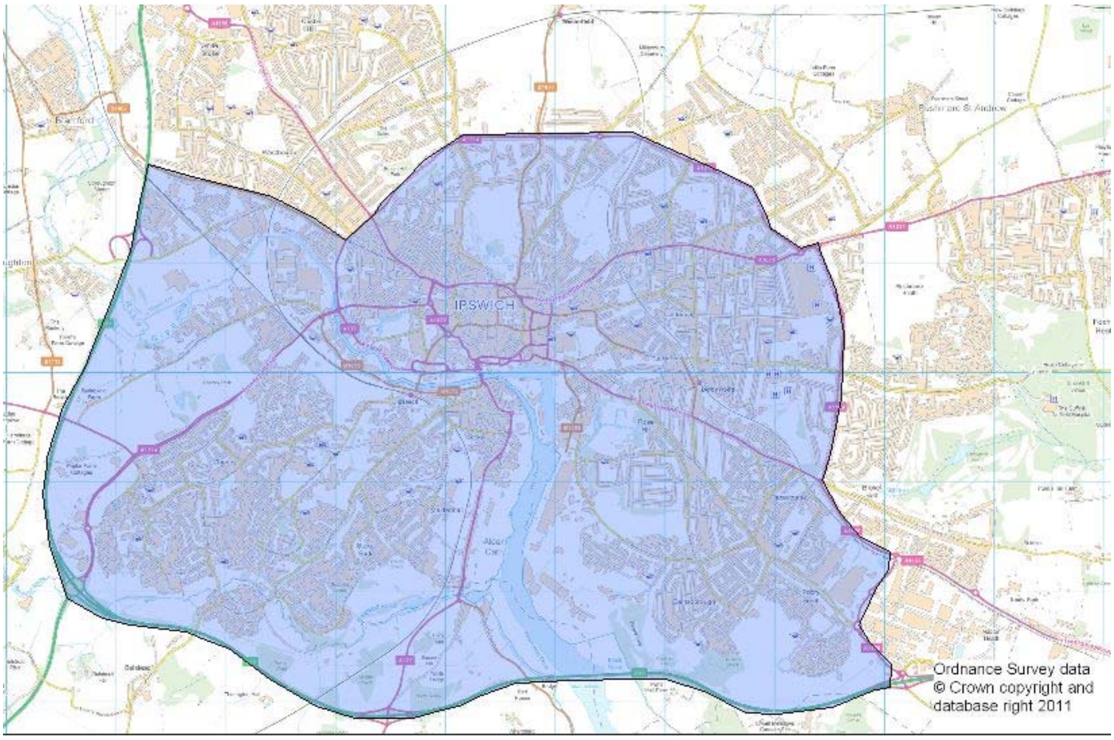

Figure 1. The extent of the Ipswich urban model presented in this article. OS Topography Crown Copyright BGS10007897/2011.

The block model shown in Figure 2 represents the geology at the surface i.e. its cap is the geological map (fitting the 1:10 000 primary survey scale).

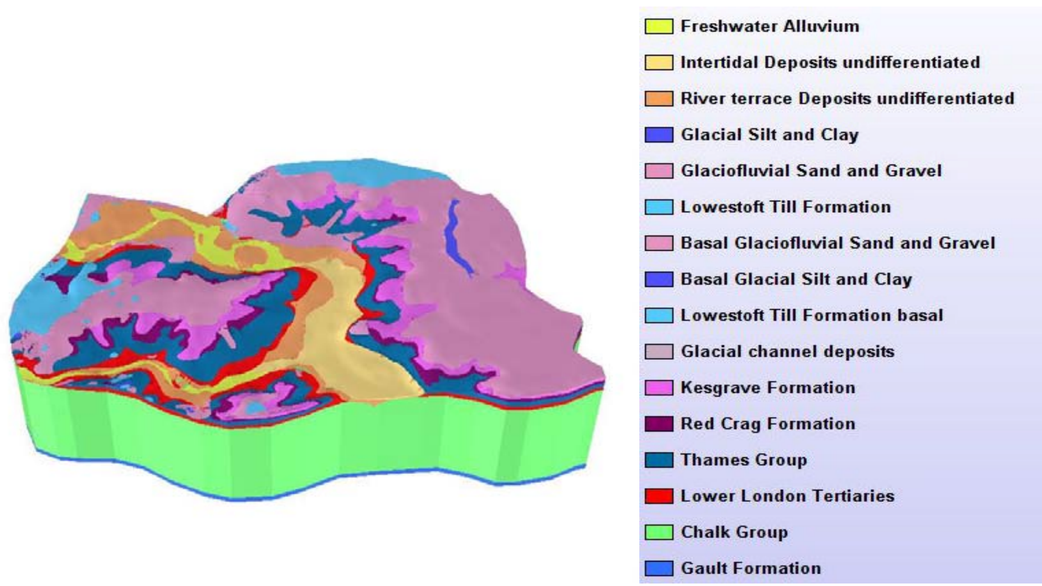

Figure 2 the complete block model showing the Quaternary and Bedrock geology down to the top of the Palaeozoic basement. VE x10. NEXTMap Britain elevation data from Intermap Technologies.

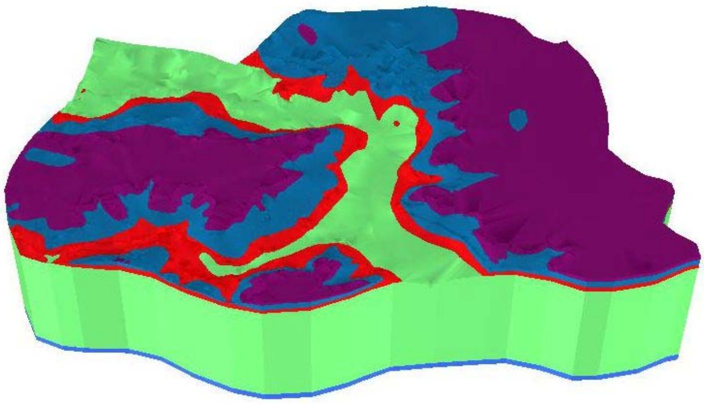

Figure 3 The Bedrock geology, key as for Figure 2 VE x10.

Geology of Ipswich in summary

The model straddles the alluvium of the River Gipping and its southerly transition into the intertidal flats of the Orwell Estuary. These valley floor deposits are locally flanked by river terrace deposits that accumulated during downcutting of the valley to its current level.

To either side of the main valley-estuary the interfluves and underlain by a complex sequence up to 30m thick of periglacial braided outwash deposits of a proto Thames river system (Kesgrave Sand and Gravel) together with the suite of sediments laid down by the Anglian ice-sheet including the Lowestoft Till (a.k.a. Chalk Boulder Clay) and glacifluvial outwash and fine-grained glacilacustrine sediments. At its maximum the Anglian ice sheet extended farther south in eastern England than the more recent ice-sheets, so these deposits are well preserved here, with Ipswich marking the maximum limit of this ice-sheet in this area. Preservation allows ice marginal outwash fans to be mapped including traversing palaeochannels infilled with fine grained glaiclacustrine sediments. Together these superficial deposits range in age from about 1.5 -0.5 Million years.

The bedrock geology comprises several distinct layers. The youngest late Pliocene deposits of the Red Crag comprise up to 20m of heavily ironstained shelly shallow marine sands famous for their fossil content and phosphate pebbles (coprolites) which were formerly dug to manufacture fertilizers In Ipswich. The Thames Group and Lower London Tertiaries are Palaeogene in age and comprise mainly clays, silts and sands with thin pebble beds. The Thames Group consists of the Harwich and the overlying London Clay formations combined and are is marine origin whilst the Lower London Tertiaries are here made up of the mainly non-marine mottled clays of the Lambeth Group with very thin Thanet Sands at the base, the latter contain glauconite indicating their marine origin. The Palaeogene deposits are up to 30m thick in total and dip south-eastwards at less than 1 degree.

The entire area is underlain by the Upper Cretaceous Chalk which is up to 250m thick comprising fine grained white and grey chalk with abundant flint nodules in its upper parts. The Chalk comprises a significant aquifer and most large farms around Ipswich are supplied by at least one deep well sunk into the Chalk. The basal layer of the model is the Lower Cretaceous marine Gault Clay up to 20m thick; it is only encountered by the deepest boreholes in the region and forms the base of the calculated model.

Analysis of the Ipswich block model

With the block model calculated, it can be analysed in several ways either within the GSI3D software or delivered in frozen form to clients for analysis in a subset browser version of the software called the LithoFrame Viewer. In addition exports can be generated for GIS packages, other modelling softwares, and also 3D PDF's and screen grabs can be generated to illustrate reports.

Selection of a point within the model in plan view produces a synthetic borehole (Figure 4) at that point to be produced in an instant , useful applications might include site investigation, ground source heat pump location and aggregate resource estimation.

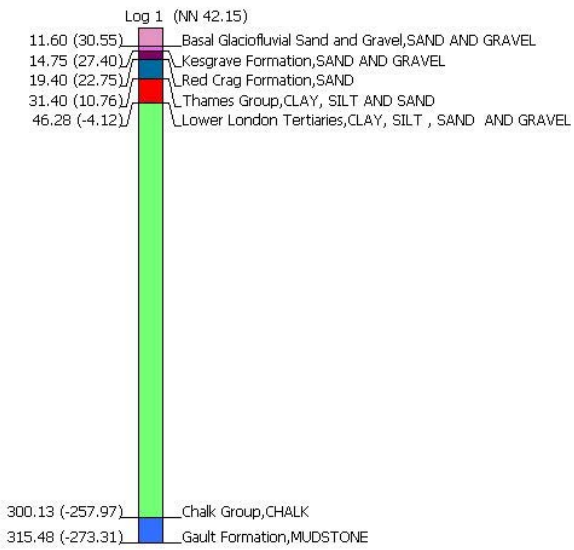

Figure 4. Synthetic borehole log annotated with depths, stratigraphic units and lithology information, key as Figure 2

The construction of a line of section in the map window also allows the instant generation of a cross section as shown below in Figure 5. Obvious applications for this sort of analysis are examining proposed routes for linear infrastructure, including transport (road, rail) services (pipelines, power lines) and civil engineering (especially for tunnelling and bridges)

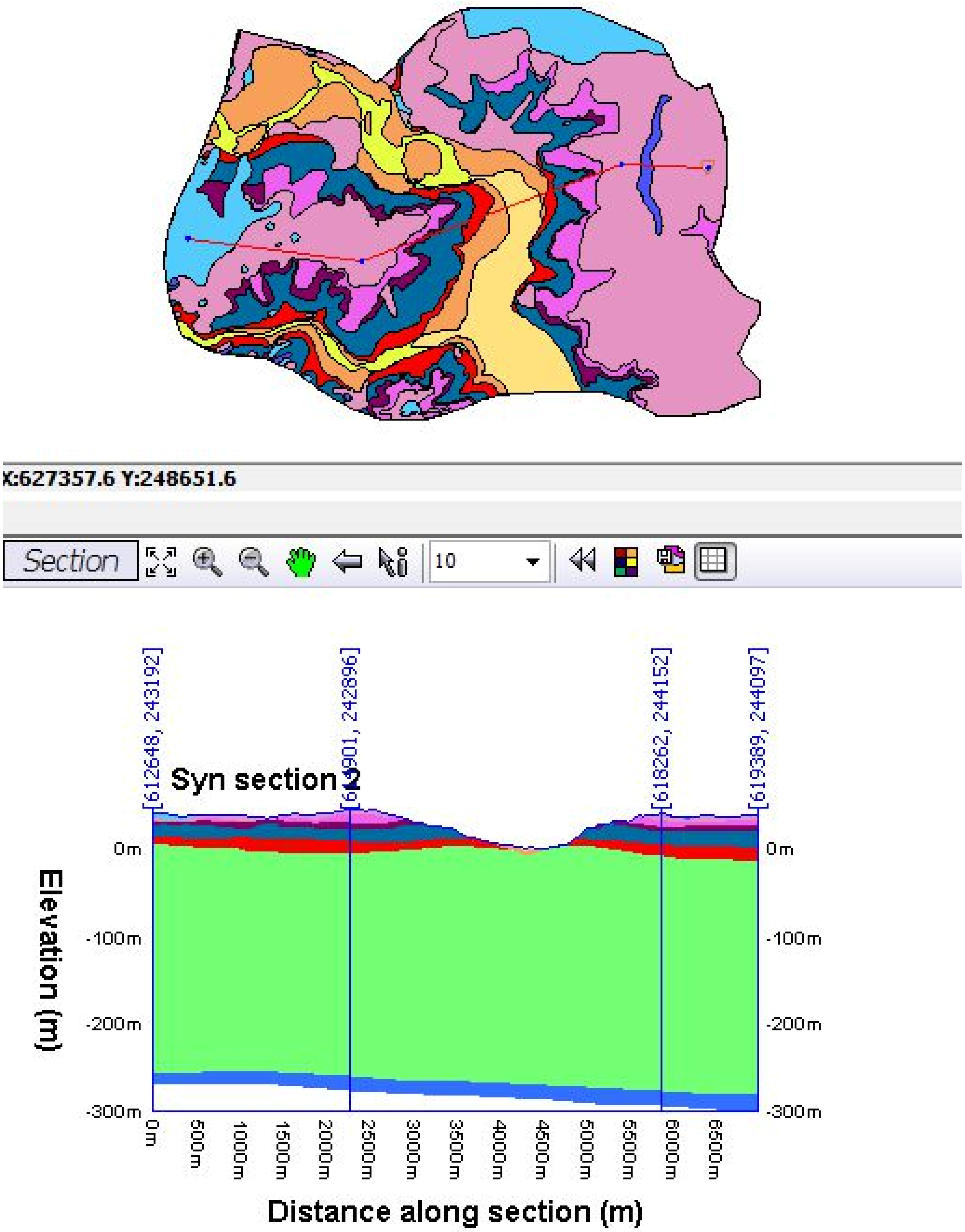

Figure 5 Auto-generated section for the line shown in red in the map view, key as Figure 2. Blue vertical lines with grid references are the turning points along the section. NEXTMap Britain elevation data from Intermap Technologies.

Finally horizontal cuts or slices can be generated through the block model at a predefined elevation as shown in the example below where the model has been sliced at OD; the white areas in the Orwell estuary reflect areas below OD. Applications include the assessment of foundations conditions at predetermined elevations and tunnelling.

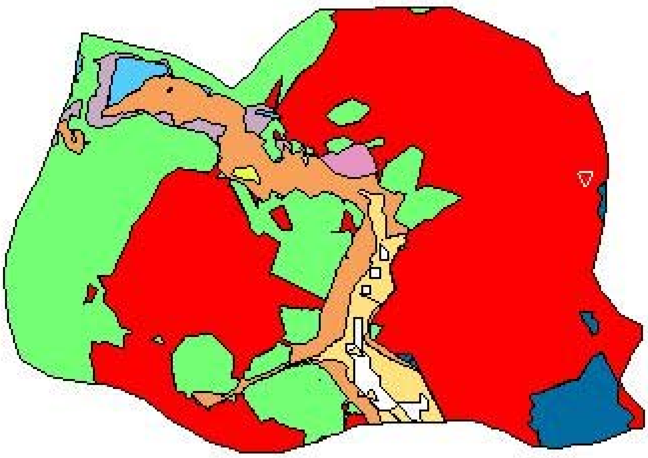

Figure 6. The Ipswich Urban model sliced at OD, key as Figure 2.

Summary

With modern computers able to display and analyse complex geoscience data of many different types in a single working environment traditional geological maps are now being translated into full 3D block models of the geology. Once calculated these models can be drilled, sliced and diced to help resolve sub surface issues and predict ground conditions. Leading Geological Survey Organisations are beginning to deploy this approach to produce 3D geological maps that will become a standard output in future years.

References

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