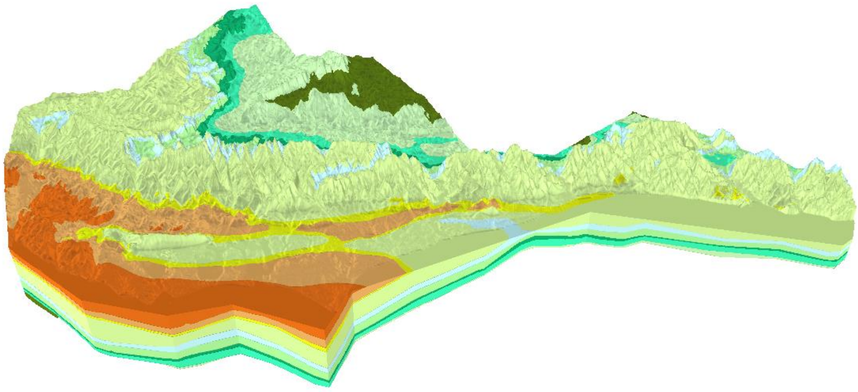
Model metadata report for the South Downs teaching model

Modelling Systems Programme

Open Report OR/18/003



BRITISH GEOLOGICAL SURVEY

MODELLING Systems PROGRAMME

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Model metadata report for the South Downs teaching model

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Front cover

3D view of the South Downs teaching model, looking from the south. Vertical exaggeration x20

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Foreword

This report describes the methodology and geology of the South Downs 3D geology model, produced by the British Geological Survey (BGS). This bedrock model covers approximately 3,100 km^2 and comprises ten geological units. The South Downs model is intended as a teaching aid for educational purposes.

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Summary

This report describes the South Downs 3D geological model, which was constructed by the British Geological Survey (BGS) using GSI3D software and methodology. The model covers an area of approximately 3,100 km^2 from Winchester to Beachy Head in the south of England. Ten bedrock units are modelled, which correspond with the published 1:250 000 scale geological maps of the area. The South Downs model was developed under a BGS project entitled "3D Models for Teaching" and as such is created with a very broad approach to the regional geological understanding, and is intended as a teaching aid for educational purposes.

1 Modelled Volume, Purpose and Scale

The South Downs 3D model represents a conceptual understanding of the bedrock geology of the South Downs National Park in southern England. The model covers an area of approximately 3,100 km^2 from Winchester to Beachy Head (Figure 1). This model consists of ten geological units that correspond with the current 1:250 000 scale geological map of the region. The model is intended for use as a teaching aid for educational purposes. It provides an overview of the regional bedrock geology and is not suitable for use at site-specific level.

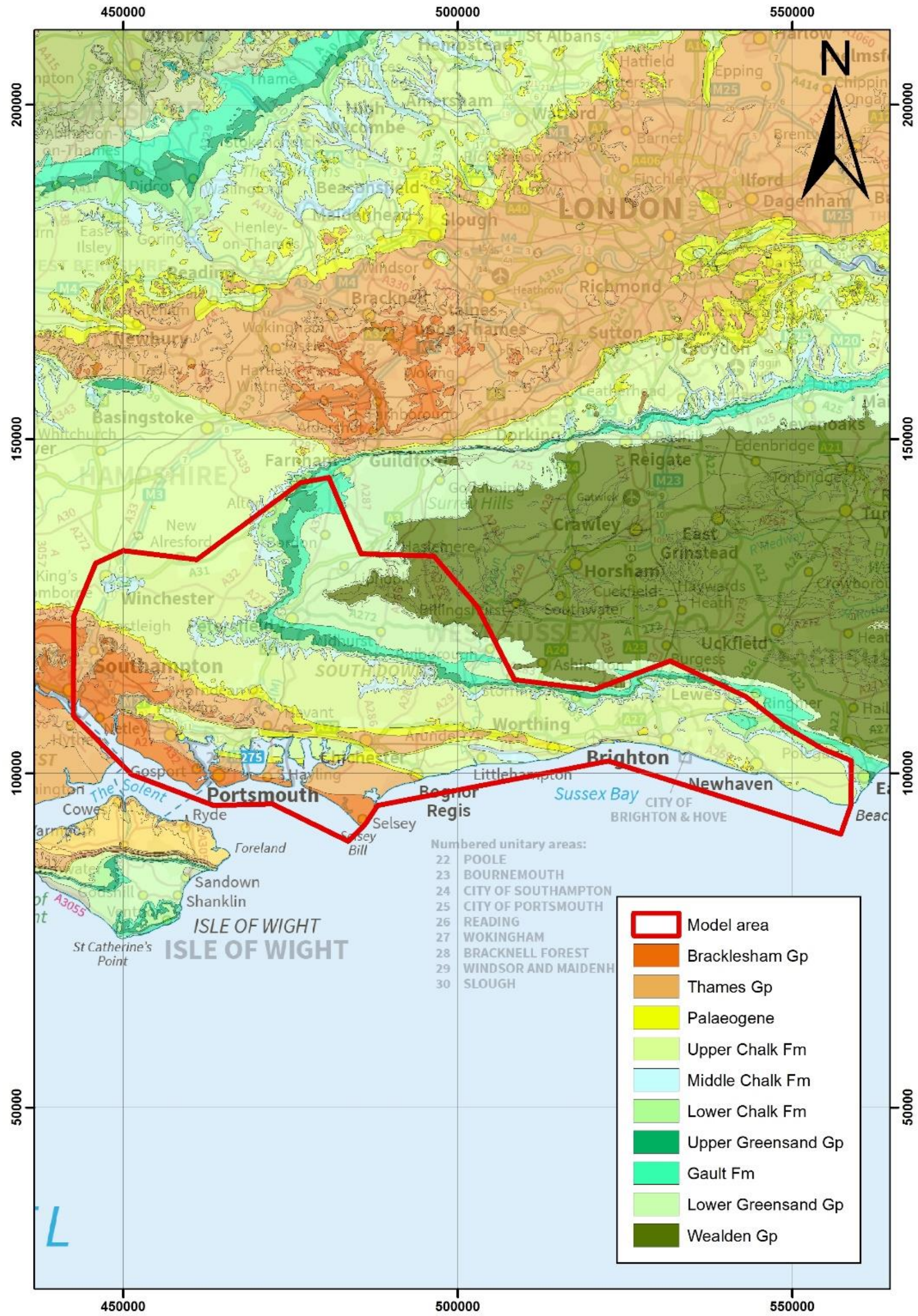

Figure 1 Location map of the South Downs model area (outlined in red) with 1:250 000 scale bedrock geology shown (DiGMapGB-250). © Crown copyright and database rights (2018) Ordnance Survey (100021290 EUL).

2 Modelled Surfaces/Volumes

The South Downs 3D model comprises ten bedrock units based on the corresponding 1:250 000 scale mapping. These bedrock units are listed in their relative stratigraphic order in Table 1. Groupings are shown where modelled units are subdivided on the geological map. Table 1 should be used as the key for viewing images of the model in this report. Lithological descriptions are taken from the BGS Lexicon of Named Rock Units on the BGS web site at: http://www.bgs.ac.uk/lexicon/

Name/LEX-RCS	Full name	Description
BRB	Bracklesham Group	Interbedded to interlaminated clays, silts and mostly fine to medium grained sands, locally shelly. Glauconite occurs in the mod part of the sequence. Minor coarse grained sands, gravelly sand, gravel beds, sandstones or ironstone concretions occur in places
THAM	Thames Group, comprising London Clay Formation and Bagshot Formation	Silty clay/mudstone, sandy silts and sandy clayey silts of marine origin
PAL	Palaeogene (Lambeth Group and Thanet Formation)	Lambeth Group: vertically and laterally variable sequence, mainly of clay, some silty or sandy, with some sands and gravels, minor limestones and lignites and occasional sandstone and conglomerate. Thanet Formation: glauconite coated nodular flints at base, overlain by pale yellow brown fine grained sand, which can be clayey and glauconitic. Rare calcareous or siliceous sandstones
UCK	Upper Chalk Formation (Lewes Chalk Formation to Portsdown Chalk Formation)	White chalks with beds of flint, nodular chalks, hardgrounds and marl seams
MCK	Middle Chalk Formation (New Pit Chalk Formation to Holywell Chalk Formation)	White pure chalk with some flint seams and very shelly beds. Comprises from base: hard indurated chalk with flaser marls (Melbourn Rock) to exceptionally shelly chalk with flints into chalk with well-defined marl seams
LCK	Lower Chalk Formation (Grey Chalk Subgroup)	Grey marly flint-free chalk with mark content decreasing upwards. Comprises a thin basal glaugonitic marl (Cambridge Greensand) overlain by a more typical Lower Chalk sequence that is usually divided into a lower 'Chalky Marl' with rhythmic alternations of chalk and marl, and an upper 'Grey Chalk' separated by a distinctive hard band (Tottenhoe Stone)
UGS	Upper Greensand Formation	Sand and sandstone, fine grained, silt, glauconitic, shelly
GLT	Gault Formation	Pale to dark blue-grey clay or mudstone, glauconitic in part, with a sandy base. Discrete bands of phosphate nodules (commonly preserving fossils), some pyrite and calcareous nodules
LGS	Lower Greensand Group	Mainly sands and sandstones (varying from well sorted, fine grained to poorly sorted medium to coarse grained) with silts and clays in some intervals
W	Wealden Group	Interbedded thick sandstones, siltstones, mudstones ('shales'), limestones and clay ironstones of predominantly non marine facies

Table 1. List of the ten modelled bedrock units in relative stratigraphic order

3 Modelled Faults

Although a number of mapped geological faults are shown in the model area in more detailed scales of mapping, the model uses 1:250 000 scale geological map data and no faults are featured in the model area at this scale. Therefore, no geological faults are represented in the model.

4 Model Workflow

The standard GSI3D modelling workflow was followed for this project. GSI3D software utilises a range of data such as boreholes, digital terrain models (DTM) and geological linework to enable the geologist to construct a series of interlocking cross-sections. Borehole data is represented in GSI3D by two proprietary files; a borehole identification file (.bid) that contains ‘index’-level information including location and start-heights; a borehole log file (.blg) that contains the borehole interpretation. Constructing cross-sections is intuitive and flexible, combining borehole and outcrop data with the geologist’s experience to refine the interpretation.

Using both the information from the cross-sections and the distribution of each unit a calculation algorithm creates the triangulated surfaces for the top and base of each unit. In order to control the relative vertical ordering of the calculation, a generalised vertical section file (.gvs) is established. A proprietary legend file (.gleg) is created to control symbolisation of the cross-section and model. The modeller can view all the units in 3D and iteratively return to the cross-section to make amendments or add further cross-sections to refine the model. This process is a standard methodology within BGS for modelling Quaternary and simple bedrock horizons and is fully documented in Kessler *et al* (2009).

5 Model Datasets

This section lists the datasets used to inform the South Downs teaching model.

5.1 GVS AND GLEG FILES

The generalised vertical section (.gvs) and geological legend (.gleg) files were assembled and iterated as the model expanded and new units were encountered. The GVS and GLEG were created using BGS DiGMapGB-250 data.

5.2 GEOLOGICAL LINEWORK

The model uses BGS DiGMapGB-250 bedrock mapping. Some of these units are grouped together in the model, such as the Thames Group (THAM), which is composed of London Clay Formation and Bagshot Formation.

5.3 DIGITAL TERRAIN MODEL

The model is capped by the Ordnance Survey Terrain 50 Digital Terrain Model (DTM), which is subsampled to a cell size of 100m. Offshore the ground elevation is taken as sea level.

5.4 BOREHOLE DATA

The model uses borehole data extracted from BGS corporate databases. A review of borehole records in the BGS *Single Onshore Borehole Index* (SOBI) in the model area was carried out and those that held sufficient geological information were selected for coding in the BGS *Borehole Geology* database (BoGe). Boreholes were coded with bedrock units from the BGS Lexicon http://www.bgs.ac.uk/lexicon/

The Rock Classification Scheme (RCS) http://www.bgs.ac.uk/bgsrcs/ was used as appropriate to record lithologies and named geological units.

A total of 482 boreholes were used in the South Downs teaching model. These were used to inform 30 cross-sections, including six from the UK3D model (Figure 2).

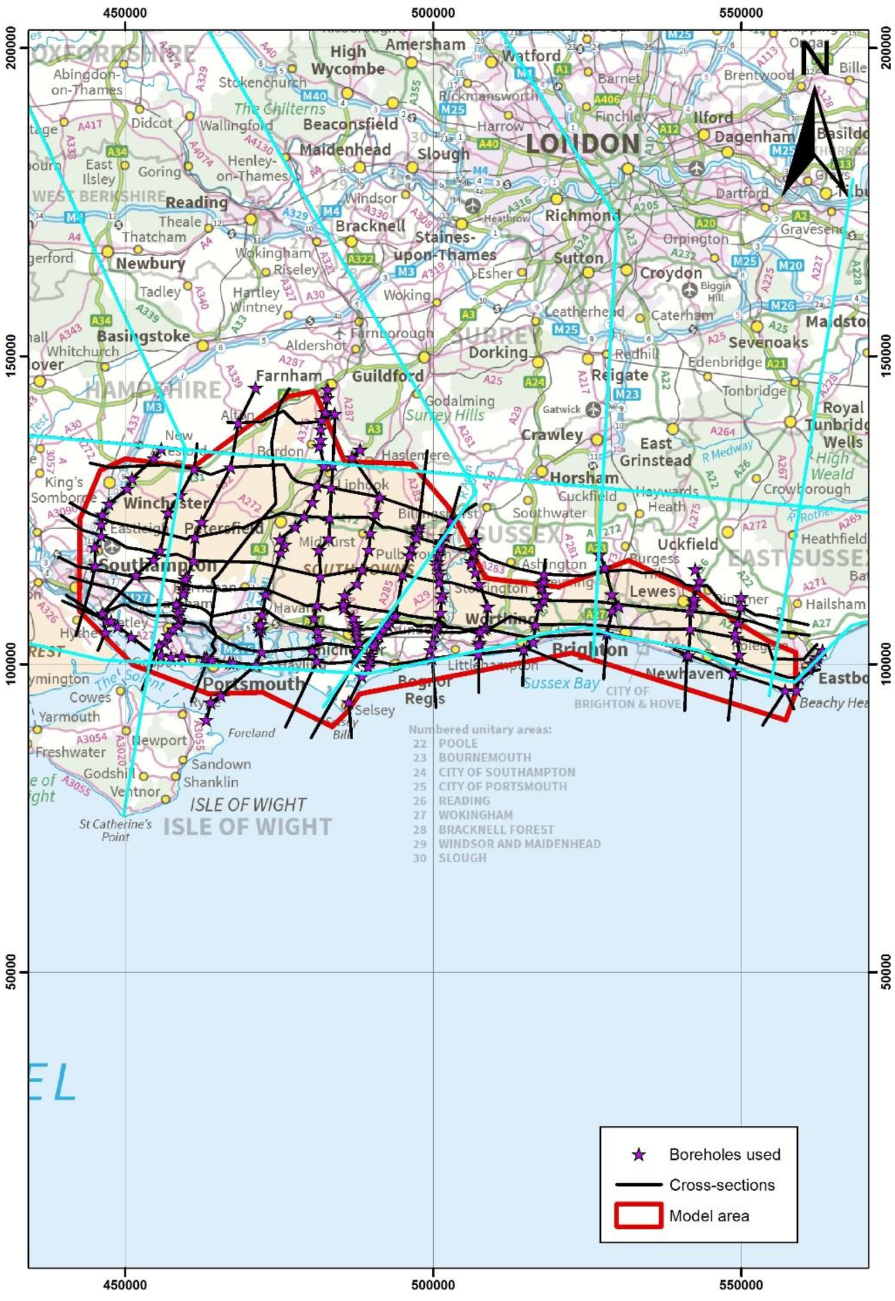

Figure 2 Distribution of borehole logs used to inform the 30 cross-sections in the South Downs teaching model. UK3D sections are shown in blue. © Crown copyright and database rights (2018) Ordnance Survey (100021290 EUL).

5.5 ADDITIONAL DATA

The South Downs teaching model uses data from pre-existing geological models. Base surfaces for the Palaeogene, Chalk Group, Gault Formation and Wealden Group were imported from the Weald Basin geological model (Hulbert and Terrington, 2014) were used to inform the South Downs teaching model.

A base Chalk surface from the Itchen model was also used to inform the South Downs model, as well as surfaces from the Chichester model (Terrington et al, 2016).

The South Downs teaching model is matched to cross-sections from the BGS UK3D geological model of the United Kingdom (Waters et al, 2015).

6 Model Development Log

A separate Model Development Log accompanies the South Downs teaching model. This records decisions made by the modeller during model construction and lists the datasets used to inform the model.

7 Geological Rules Used etc.

Whilst every effort has been made to match the modelled units to the borehole logs and geological map data, there are occasions when the two datasets disagree. In these instances, precedence is given to the boreholes and adjustments were made to the modelled geological boundaries where boreholes prove that a unit extends beyond its mapped distribution.

The start heights (recorded ground level) of borehole logs were honoured during cross-section construction.

Extensive superficial deposits are mapped in the area, including clay with flints, head and river terrace deposits. However, these have not been modelled. Instead, the bedrock units are modelled up to the Digital Terrain Model (DTM), which makes them slightly thicker than in reality where they are modelled at the ground surface.

8 Model Limitations

8.1 MODEL SPECIFIC LIMITATIONS

The South Downs teaching model shows only the bedrock geology of the region. It matches the corresponding 1:250 000 scale geological map data and is therefore suitable for use on a regional scale, not site-specific scale. The model is intended for educational and demonstration purposes.

The southern edge of the model extends offshore along the south coast of England where the elevation values in the Digital Terrain Model (DTM) are at sea level. In these offshore areas the geological units are modelled up to sea level rather than the sea floor.

8.2 GENERAL MODELLING LIMITATIONS

- Geological interpretations are made according to the prevailing understanding of the geology at the time. The quality of such interpretations may be affected by the availability of new data, by subsequent advances in geological knowledge, improved methods of interpretation, improved databases and modelling software, and better access to sampling locations. Therefore, geological modelling is an empirical approach.

- It is important to note that this 3D geological model represents an individual interpretation of the data available; other interpretations may be valid. The full complexity of the geology may not be represented by the model due to the spatial distribution of the data at the time of model construction and other limitations including those set out elsewhere in this report.

- Best endeavours (detailed quality checking procedures) are employed to minimise data entry errors but given the diversity and volume of data used, it is anticipated that occasional erroneous entries will still be present (e.g. boreholes locations, elevations etc.) Any raw data considered when building geological models may have been transcribed from analogue to digital format. Such processes are subjected to quality control to ensure reliability; however, undetected errors may exist. Borehole locations are obtained from borehole records or site plans.

- Digital elevation models (DEMs) are sourced externally by BGS and are used to cap geological models. DEMs may have been processed to remove surface features including vegetation and buildings. However, some surface features or artefacts may remain, particularly those associated with hillside forests. The digital terrain model may be sub-sampled to reduce its resolution and file size; therefore, some topographical detail may be lost.

- Geological units of any formal rank may be modelled. Lithostratigraphical (sedimentary/metasedimentary) units are typically modelled at Group, Formation or Member level, but Supergroup, Subgroup or Bed may be used. Where appropriate, generic (e.g. alluvium – ALV), composite (e.g. West Walton Formation and Ampthill Clay Formation, undifferentiated – WWAC) or exceptionally informal units may also be used in the model, for example where no equivalent is shown on the surface geological map. Formal lithodemic igneous units may be named Intrusions or Dykes or may take the name of their parent (Pluton or Swarm/Centre or Cluster/Subsuite/Suite), or if mixed units Complex may be used. Highly deformed terranes may use a combined scheme with additional rank terms. Artificially Modified Ground units (e.g. Made Ground (undivided) – MGR, Landscaped Ground (undivided) – LSGR) are currently regarded as informal.

- The geological map linework in the model files may be modified during the modelling process to remove detail or modify the interpretation where new data is available. Hence, in some cases, faults or geological units that are shown in the BGS approved digital geological map data (DiGMapGB) may not appear in the geological model or vice versa. Modelled units may be coloured differently to the equivalent units in the published geological maps.

- Borehole start heights are obtained from the original records, Ordnance Survey mapping or a digital terrain model. Where borehole start heights look unreasonable, they are checked and amended if necessary in the index file. In some cases, the borehole start height may be different from the ground surface, if for example, the ground surface has been raised or lowered since the borehole was drilled, or if the borehole was not originally drilled at the ground surface.

- Borehole coding (including observations and interpretations) was captured in a corporate database before the commencement of modelling and any lithostratigraphic interpretations may have been re-interpreted in the context of other evidence during cross-section drawing and modelling, resulting in a mismatch between BGS databases and modelled interpretations

9 Model QA

In order for a geological model to be approved for publication or delivery to a client a series of quality assurance checks are carried out. This includes visual examination of the modelled cross-sections to ensure that they match each other at cross-section intersections and fit the borehole and geological map data used. The model calculation is checked to ensure that all units calculate to their full extent within the area of interest and the modelled geological surfaces are checked for artefacts such as spikes and thickness anomalies. The naming convention of the modelled geological units is checked to ensure that recognised entries in the BGS Lexicon of Named Rock Units (http://www.bgs.ac.uk/lexicon/home.html) and the BGS Rock Classification Scheme (http://www.bgs.ac.uk/bgsrcs/) are used as far as possible. Geological models are accompanied by a standard metadata report, such as the London Basin superficial and bedrock Lithoframe 50 model metadata report (Burke et al., 2014), which describes the datasets used in the model and records any geological decisions made during the model construction process.

Any issues found in the QA checking process are recorded and addressed before delivery/publication of the model.

10 Model Uncertainty

No attempt has been made to establish uncertainty up to the point of the model and metadata report being published. However, as a general rule with cross-section based models, uncertainty increases with distance away from boreholes used in the cross-sections. The drilled depth of the boreholes also affects uncertainty, with the deepest boreholes providing the most detail on the deepest modelled units.

11 Model Images

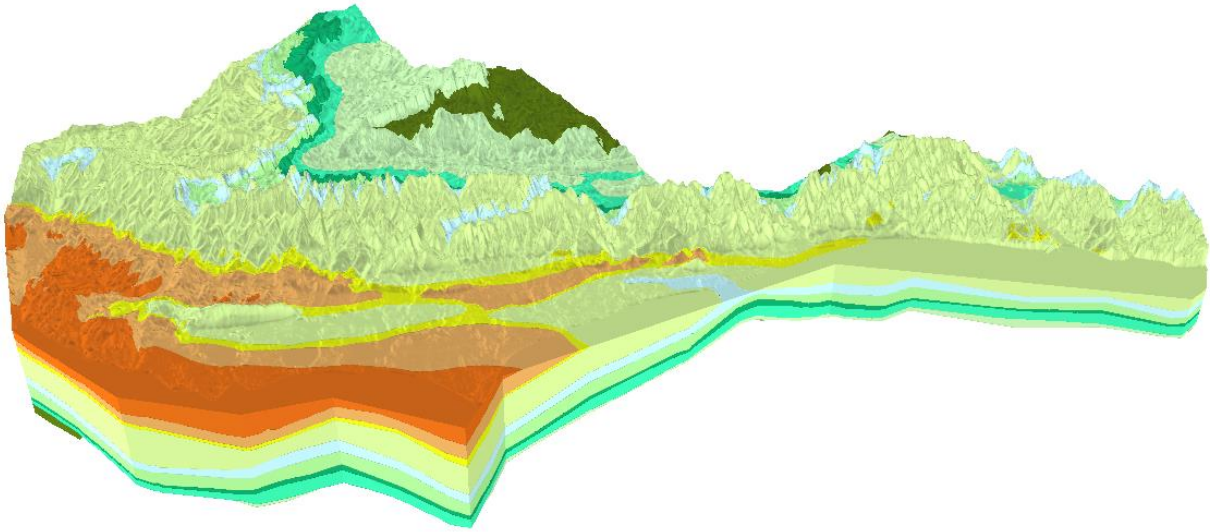

Figure 3 3D view of the model, looking from the south, with all units shown. Vertical exaggeration x20.

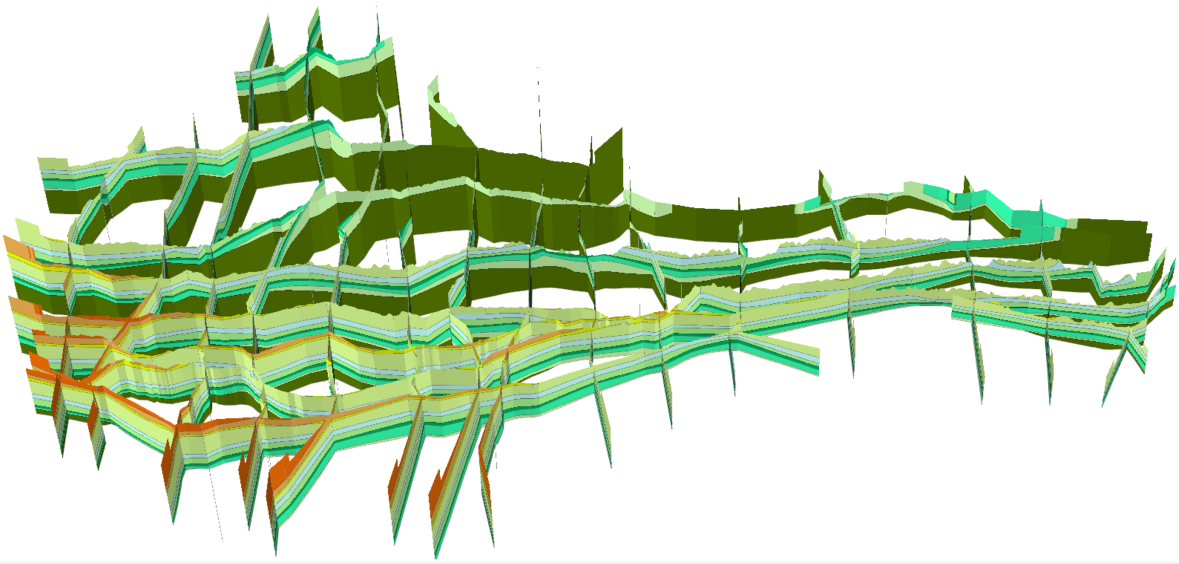

Figure 4 3D view of the cross-sections constructed to constrain the model (UK3D sections not shown). Vertical exaggeration x20.

12 References

British Geological Survey holds most of the references listed below, and copies may be obtained via the library service subject to copyright legislation (contact libuser@bgs.ac.uk for details). The library catalogue is available at: http://geolib.bgs.ac.uk.

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