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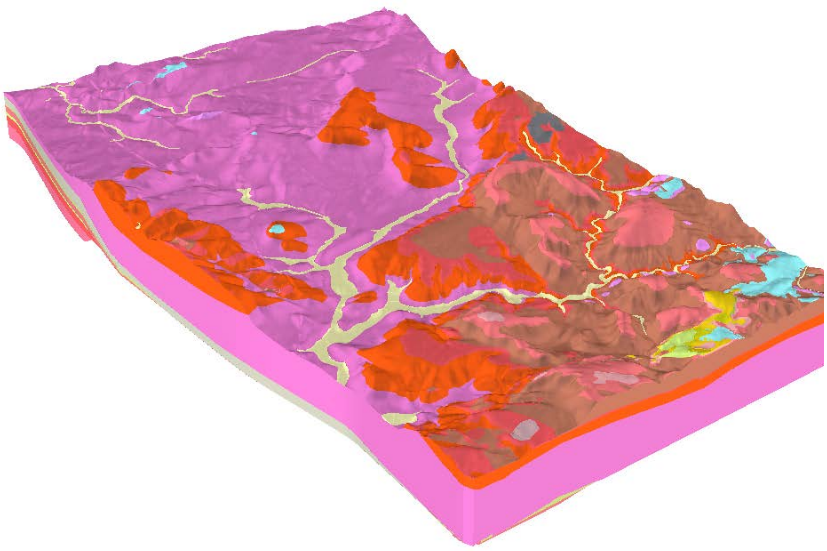
GSI3D model metadata report for HS2 Area 4 (Thorpe Mandeville to Ladbroke)

Geology and Regional Geophysics Programme

Open Report OR/15/035



BRITISH GEOLOGICAL SURVEY

GEOLOGY AND REGIONAL GEOPHYSICS PROGRAMME

OPEN REPORT OR/15/035

GSI3D model metadata report for HS2 Area 4 (Thorpe Mandeville to Ladbroke)

J Thompson

Edits by H. V. Gow, H. Burke & S. Thorpe

Keywords

GSI3D, 3D modelling, Geological Model, HS2.

National Grid Reference

SW corner 450072,241758
NE corner 447441,260924

Map

Sheet 94, 114 and 115, 1:50 000 scale, Warwick, Banbury and Towcester

Front cover

3D View of modelled volumes.

Bibliographical reference

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Summary

This report describes the 3D geological model of HS2 (High Speed 2 rail link) Area 4 (Thorpe Mandeville to Ladbroke), created by Jo Thompson with support from Steve Thorpe. The model was created as part of a set of nine geological models that cover the proposed HS2 rail route from the end of the HS2 London model to Birmingham and the West Coast Main Line near Lichfield. The models were funded from the NERC/BGS Science Budget to promote BGS modelling and geological interpretation services to this important infrastructure project and to test methodologies and procedures for creating geological models by multiple compilers.

The report describes the model construction and purpose, with spatial limits and scale, sources of information, data processing, workflow, decisions, assumptions, rules and limitations, together with images of the model.

1 Modelled Volume, Purpose and Scale

This model is of the bedrock and superficial geology of an area along the proposed route of the High Speed Rail link between London and Birmingham (HS2). It covers the section of the HS2 route between Thorpe Mandeville in Northamptonshire and Ladbroke in Warwickshire. The bedrock geology of this section of the route comprises Triassic to Middle Jurassic strata, together with superficial deposits of glacigenic and fluvial origin. This is one of nine models along the proposed route. It is suitable for use at scales between 1:100,000-1:10,000, down to a depth of 30 m below OD.

Prior to the modelling work, an assessment of the quality and availability of the digital geological linework and existing 3D models of the whole HS2 route between London and Birmingham was undertaken (Barron *et al.*, 2012). As a of this review, the geological mapping of this sector was deemed to be adequate, dating from the 1950s to the 2000s. Thus this 3D model is based on geological line work from existing 1:50 000 scale DiGMapGB data.

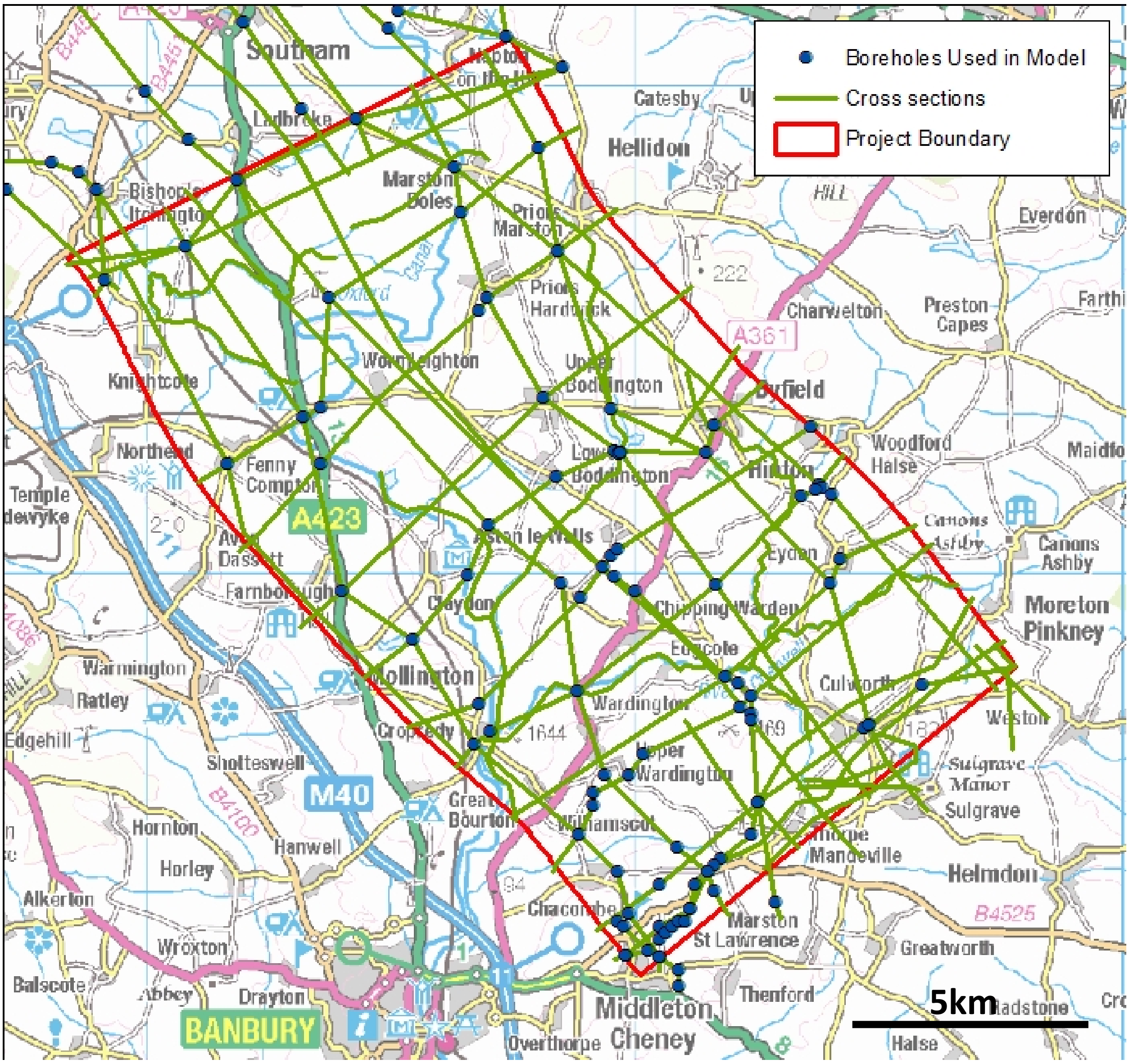

Figure 1: Map of model area showing boreholes used and cross sections (Contains Ordnance Survey data © Crown Copyright and database rights 2015).

2 Modelled Surfaces/Volumes

The modelled bedrock, superficial and artificial deposits are listed in Table 1 in the relative stratigraphic order used in the model. Brief descriptions of the geological units are given here, but more detail can be found in the BGS Lexicon of Named Rock Units. The level of detail and extent of the natural geology in the model may differ from that shown in other BGS datasets. Artificial ground was modelled according to the corresponding 1:50,000 scale geological maps. Table 1 should be used as the legend for viewing images of the model in this report.

Table 1: List of modelled units

Geological unit	Age	Model Name	Comments
Worked Ground	Quaternary	WGR-VOID	
Alluvium	Quaternary	ALV-XCZSV	
Head	Quaternary	HEAD-XCZSV	
Glaciofluvial deposits (Mid Pleistocene)	Mid Pleistocene	GFDMP-XSV	
Till (Mid Pleistocene)	Mid Pleistocene	TILMP-DMTN	
White Limestone Formation	Mid Jurassic	WHL-LMST	Includes Blisworth Limestone Formation on Towcester sheet
Rutland Formation	Mid Jurassic	RLD1-MDST	Upper division of Rutland Formation. Includes Blisworth Limestone Formation.
Taynton Limestone Formation	Mid Jurassic	TY-LMOOL	Lateral equivalent of Wellingborough Limestone Member
Wellingborough Limestone Member	Mid Jurassic	WBRO-LMST	Lateral equivalent of Taynton Limestone Formation
Sharp's Hill Formation	Mid Jurassic	SHHB-ARSL	Lateral equivalent of Rutland Formation
Rutland Formation	Mid Jurassic	RLD-MDST	Lower division of Rutland Formation mudstone beds in area where WBRO is present above. Lateral equivalent of Sharp's Hill formation
Stamford Member	Mid Jurassic	STAM-SDSL	Lateral equivalent of Horsehay Sand Formation
Horsehay Sand Formation	Mid Jurassic	HYSA-SDST	Lateral equivalent of Stamford Member
Northampton Sand Formation	Mid Jurassic	NS-SDLI	
Whitby Mudstone Formation	Early Jurassic	WHM-MDST	
Marlstone Rock Formation	Early Jurassic	MRB-FLIR	
Dyrham Formation	Early Jurassic	DYS-SIMD	
Charmouth Mudstone Formation	Early Jurassic	CHAM-MDST	
Rugby Limestone Member	Early Jurassic	RLS-MDLM	*
Saltford Shale Member	Late Triassic to Early Jurassic	SASH-MDST	
Langport Member	Late Triassic	LPMB-LMST	**
Penarth Group	Late Triassic	PNG-AROCLS	
Blue Anchor Formation	Late Triassic	BAN-MDSI	
Branscombe Mudstone Formation	Late Triassic	BCMU-MDST	
Sidmouth Mudstone Formation	Early to Late Triassic	SIM-MDST	

* The RLS has been correlated in Area 4. This equates to base of CHAM in Area 3, but no envelope has been constructed or surface calculated in Area 3 for this unit as there is not enough information.

**The LPMB has been correlated in Area 4. This equates to PNG in Area 3, but no envelope has been constructed or surface calculated in Area 3 for this unit as there is not enough information.

Area 4 lies in the transition area where the East Midlands Great Oolite Group succession passes into that of the Cotswolds (Sumbler, 2002, pp 8-13, fig. 5). Therefore some of the modelled units are laterally equivalent to each other, as shown in Table 1.

The Rutland Formation is divided into an upper and lower unit (RLD1-MDST and RLD-MDST respectively) to accommodate the Wellingborough Limestone Member, which occurs in the middle of the Rutland Formation.

3 Modelled Faults

Several small faults, most with throws of less than 10 m were modelled, dipping 65 degrees for drawing guidance, based on mapped surface faults. These were modelled as 'steps' in the geological surfaces rather than as discrete fault blocks. No major faults occur in the modelled area.

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

5.1 GVS AND GLEG FILES

The generalised vertical section (.gvs) and geological legend (.gleg) files were assembled using Notepad or Excel and iterated as the model expanded and new units were encountered. The GVS was based on DiGMapGB-50 data by identifying all those geological units that are within a 5km area of the HS2 route. However some units occur only in subcrop, so additional units in the GVS had to be appended as modelling progressed. The GLEG files were created using the standard BGS colours from DigMap-50. Overall GVS and GLEG files were created for the whole HS2 route, rather than for each individual model area. Thus the units used in this model are only a subset of those available in the overall HS2 GVS file.

5.2 GEOLOGICAL LINEWORK

Bedrock, superficial and artificial geological DiGMapGB-50 (1:50 000) data and geological linework from sheets 184 (Warwick), 201 (Banbury) and 202 (Towcester) was used in the model.

5.3 DIGITAL TERRAIN MODEL

The terrain model used in this model was the BGS Bald Earth 20 m DTM obtained from the BaldEarth model and trimmed to the project area (5 km buffer of the route shape file). A NextMap DTM was also considered, but not used for modelling.

5.4 BOREHOLE DATA

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). After borehole coding was completed, the boreholes were extracted from the BGS *Single Onshore Borehole Index* (SOBI) database for use in the 3D modelling software using a set of queries. The borehole log file (.blg) needed to be deduplicated and a borehole filter tool was used to address this

A set of priorities was applied to borehole records that were coded by more than one project. The records at the top of this list have a higher priority and the filter tool keeps these records and discards other matching records. This left a total of 162 boreholes coded out of a total borehole count of 634.

5.5 CROSS-SECTIONS

All cross sections from Areas 3 and 5 were loaded in to the model in order to edge match, these were then trimmed and used to help calculate the model.

5.6 ISOPACHYTE MAP

The isopachytes from Figure 15 of the Chipping Norton Memoir (Horton *et al.,* 1987) were used to inform the model (Base Lower Lias).

6 Model Development Log

During the course of the modelling, the modeller kept a running log of the development, changes and decisions made for their designated modelling areas (Figure 2). These records are kept as part of the model storage and metadata (QA) process and can be accessed as needed.

03/04/2014

HS2_Area4_NWSE_Section2

03 April 2014

13:53

Surface geology suggests folding within the DYS-MRB-WHM although this is not marked on the map (around Cropredy Lawn/Beecham's cottages), this may fit in with localised faulting. It is unclear from the fieldslip what evidence was used - there is a borehole (#88 on field slip, SP44NE73, 331590) which has 2' soil, 3' yellow clay, 85' blue clay/lmst). This would suggest possibly a valley head overlying CHAM. Fieldslips illegible! But the hand drawn contours suggest that the geologist was fitting the outcrop to the contours which aren't quite correct. WHM outcrop possibly should be on top of the small hill instead?

Figure 2: Example of Development Log Text

7 Model Assumptions, Geological Rules Used etc.

7.1 OUTCROP CHANGES

In light of borehole interpretation, it was necessary to make some small changes to the outcrop of some units. This is illustrated in Figure 3 (the original DiGMapGB extract) and Figure 4 (the geological units used in model calculation).

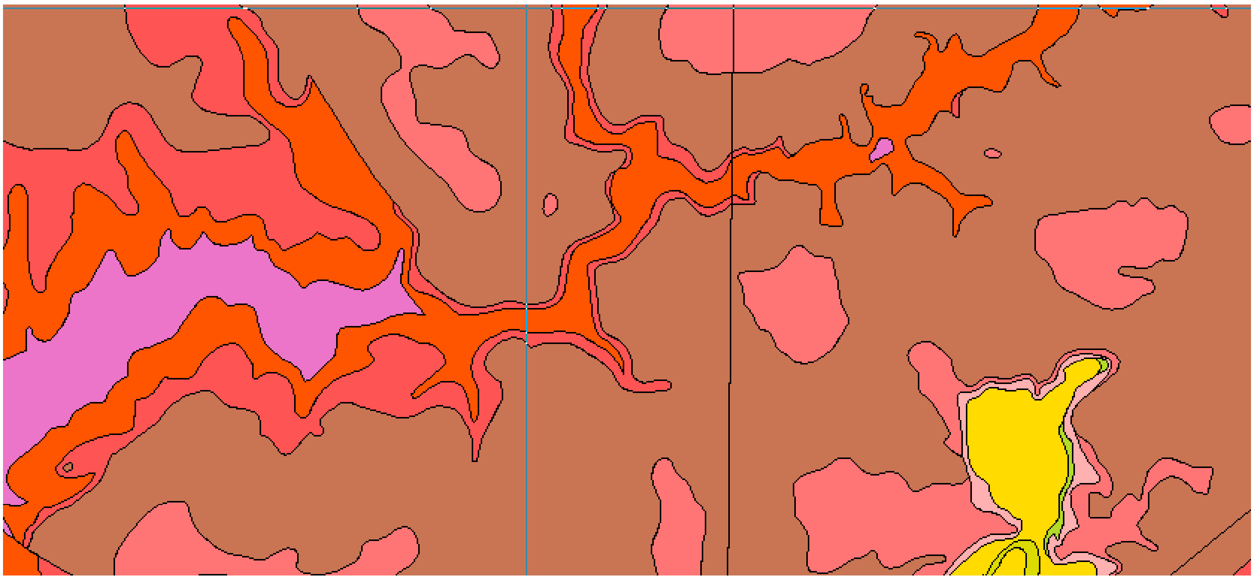

Figure 3: Example of small changes to outcrop, DiGMapGB extract. Key as per Table 1.

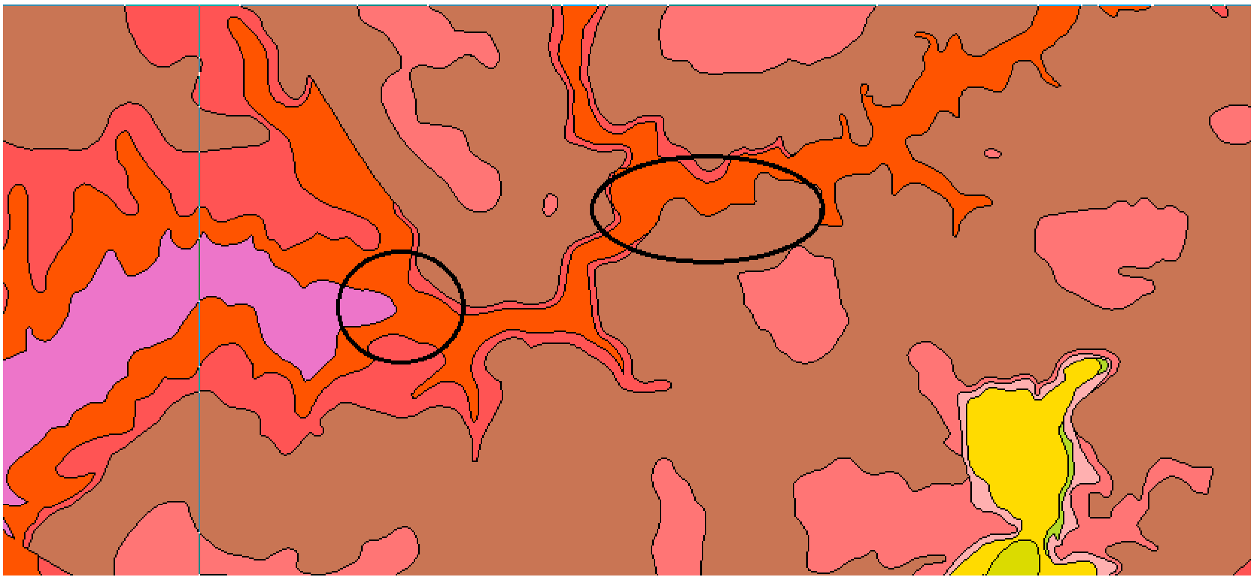

Figure 4: Example of small changes to outcrop, geological units as used in the model calculation. Key as per Table 1.

7.2 MARLSTONE ROCK FORMATION

In the southwest of the model, around Middleton Cheney (SP44SE, SP54SW) there is a dense grid of bores for ironstone, into the Marlstone Rock Formation. Base of MRB was taken at the base of the lowest significant ironstone bed (>0.15 m thick) (also agreed with Mark Barron who modelled Area 3).

8 Model Limitations

8.1 MODEL SPECIFIC LIMITATIONS

- Borehole data within the model is limited in many areas, particularly the north. This was improved by importing the cross sections of the adjacent models (Area 3 to the south and Area 5 to the North).

- Faults were not expressly modelled as fault planes in GSI3D, but instead modelled as stepped profiles in the individual cross sections.

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 a subset of the available data; 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.

- 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 mismatches between BGS databases and modelled interpretations.

- 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. Worked Ground – WGR, 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.

9 Model QA

In order for a geological model to be approved for publication or delivery to a client a series of QA checks is 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.

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

10 Model Images

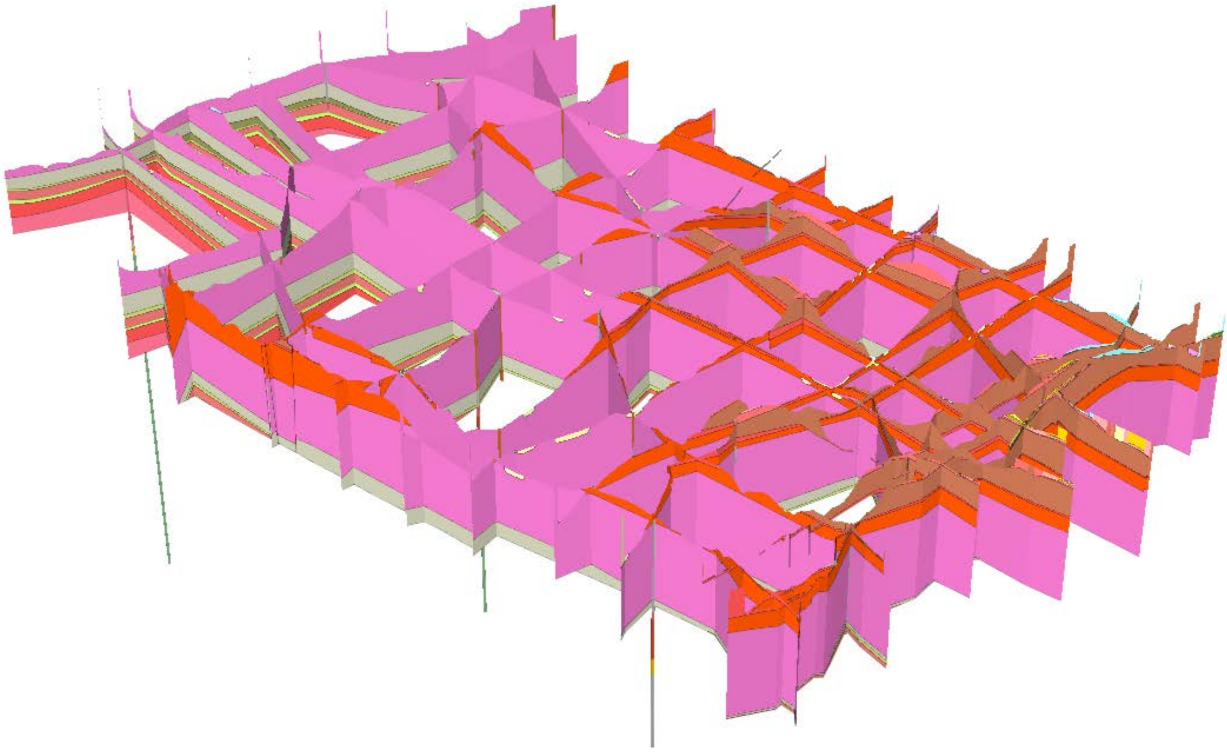

Figure 5: Cross-sections that are used in the model calculation. Shown at x10 exaggeration. Key as per Table 1.

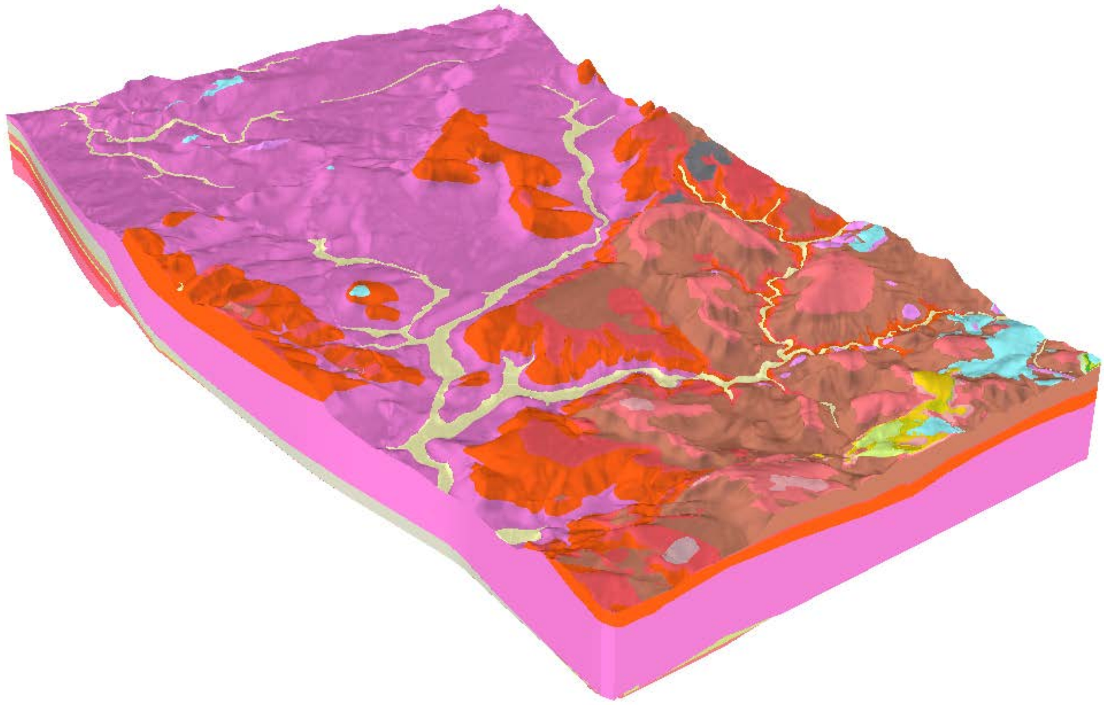

Figure 6 View of fully calculated volume model. Shown at x10 exaggeration. Key as per Table 1.

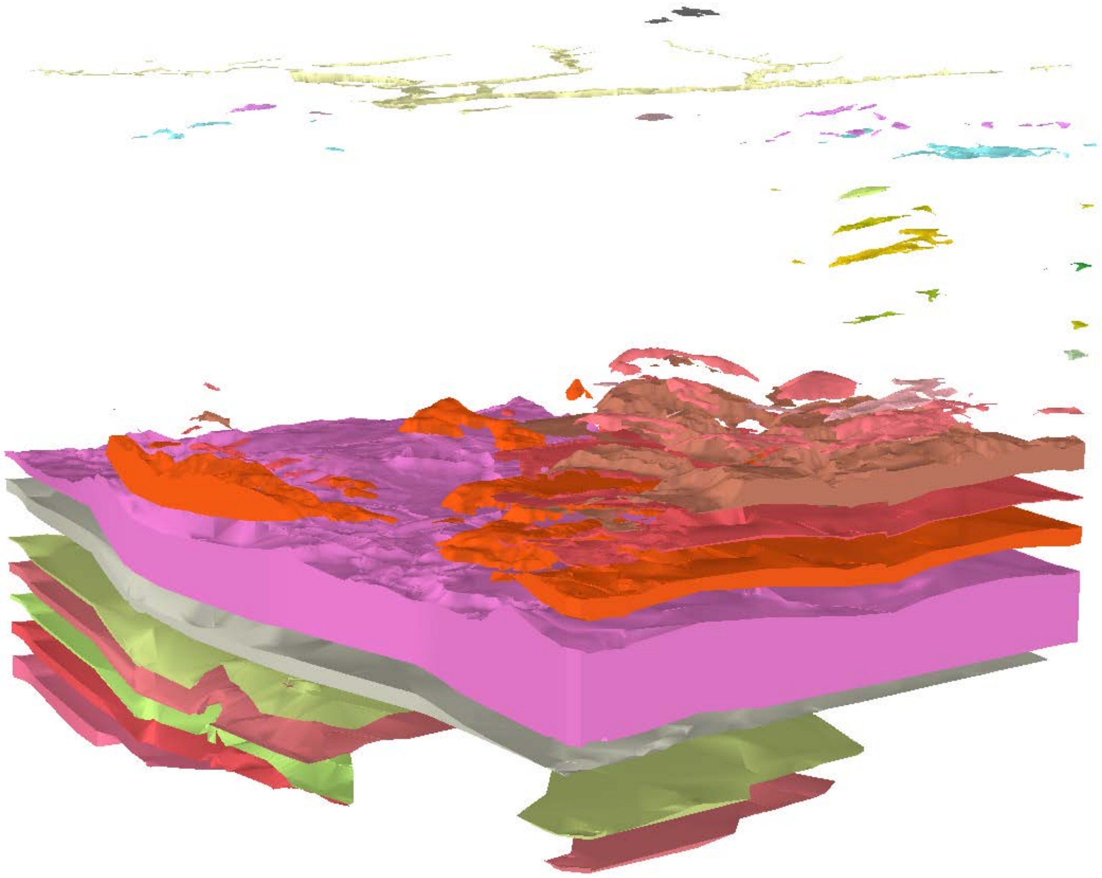

Figure 7: Exploded view of HS2 Area 4 Model. Shown at x10 exaggeration. Key as per Table 1.

11 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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