

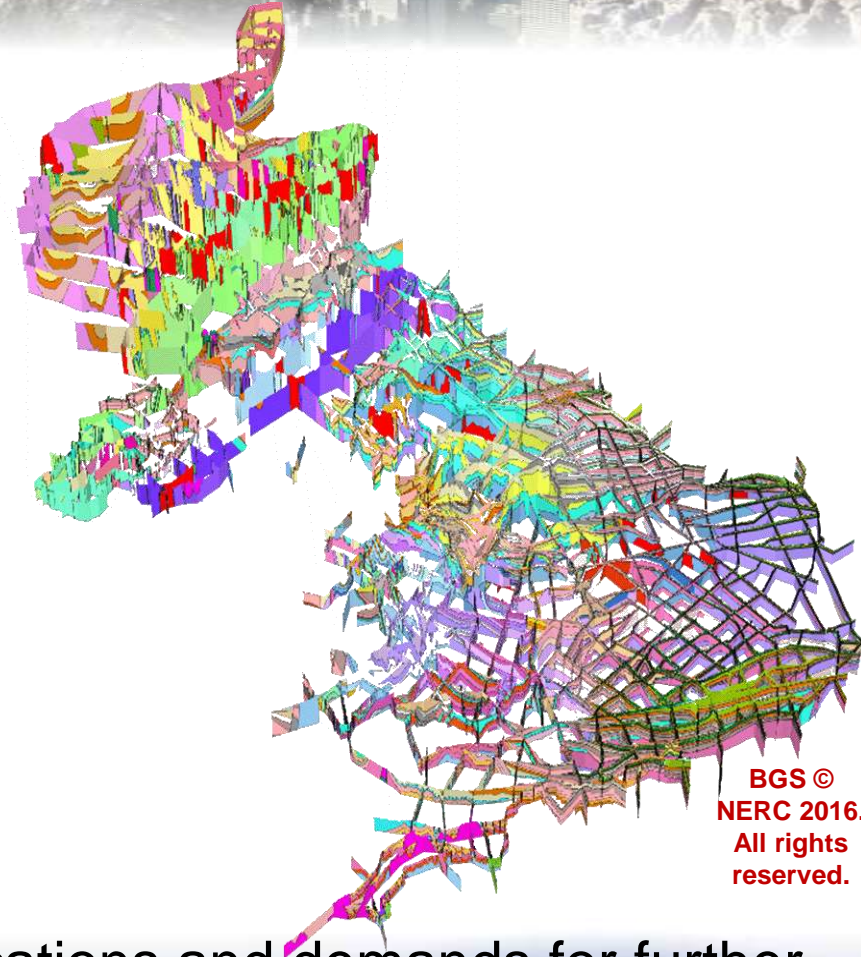


British Geological Survey

NATURAL ENVIRONMENT RESEARCH COUNCIL

Gateway to the Earth

# The UK's 'National Geological Model'



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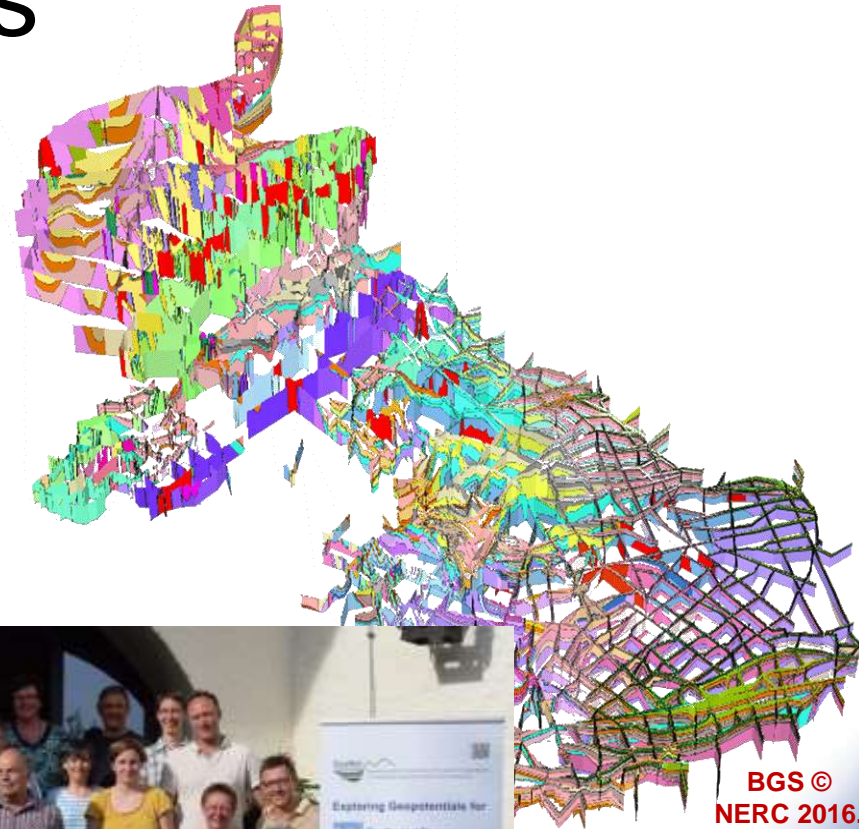
Recent developments, current applications and demands for further enhancement

Jon Ford [jford@bgs.ac.uk](mailto:jford@bgs.ac.uk)

# Acknowledgments

Holger Kessler, Jonathan Lee,  
Graham Leslie, Sian Loveless,  
Alison Monaghan, Tony Myers,  
Steve Thorpe, Ricky Terrington,  
Colin Waters, Ben Wood,  
Mark Woods

Steve Mathers

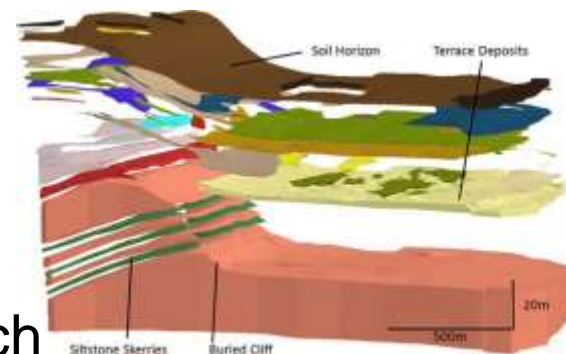
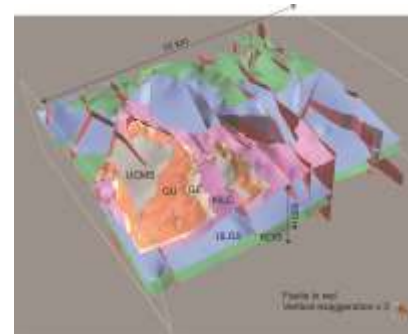


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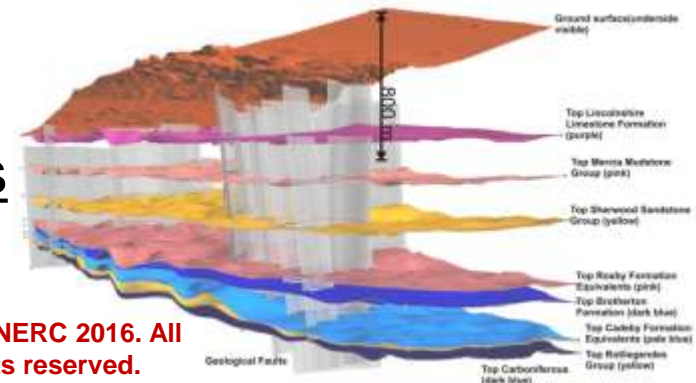


# The National Geological Model

- 3D modelling - major part of BGS portfolio:
  - range of scales, local-regional
  - variety of applications
  - diverse funding
  - sizeable 3D resource
- National Geological Model:
  - “promote a consistent approach to individual models” (recognising the need for these to be different)
  - “develop national-scale syntheses to meet an overarching strategic need for consistent UK-wide coverage”



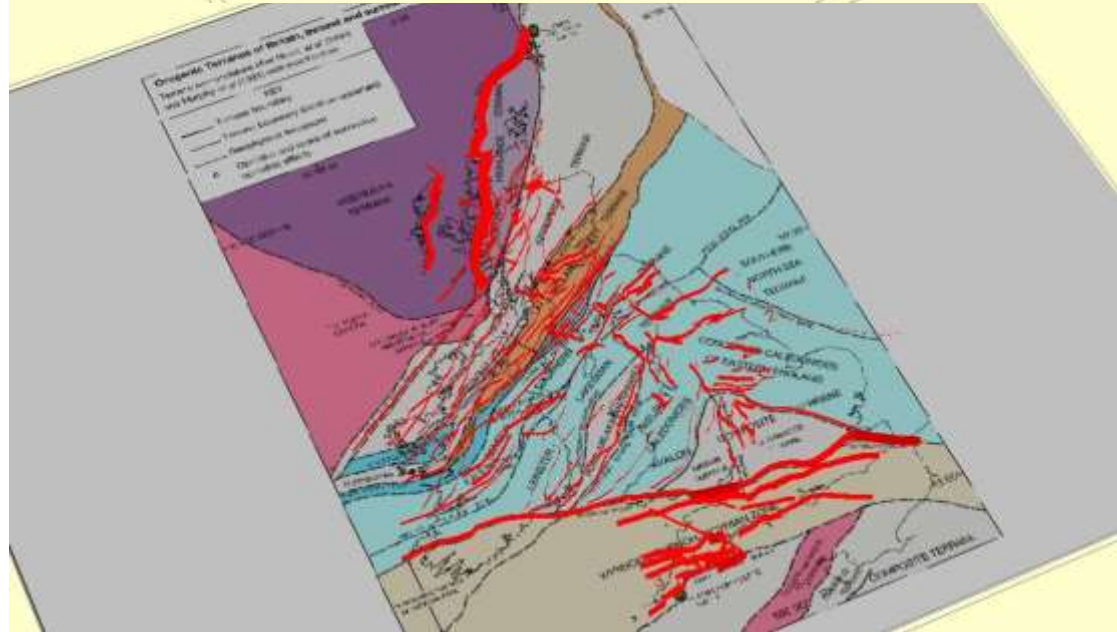
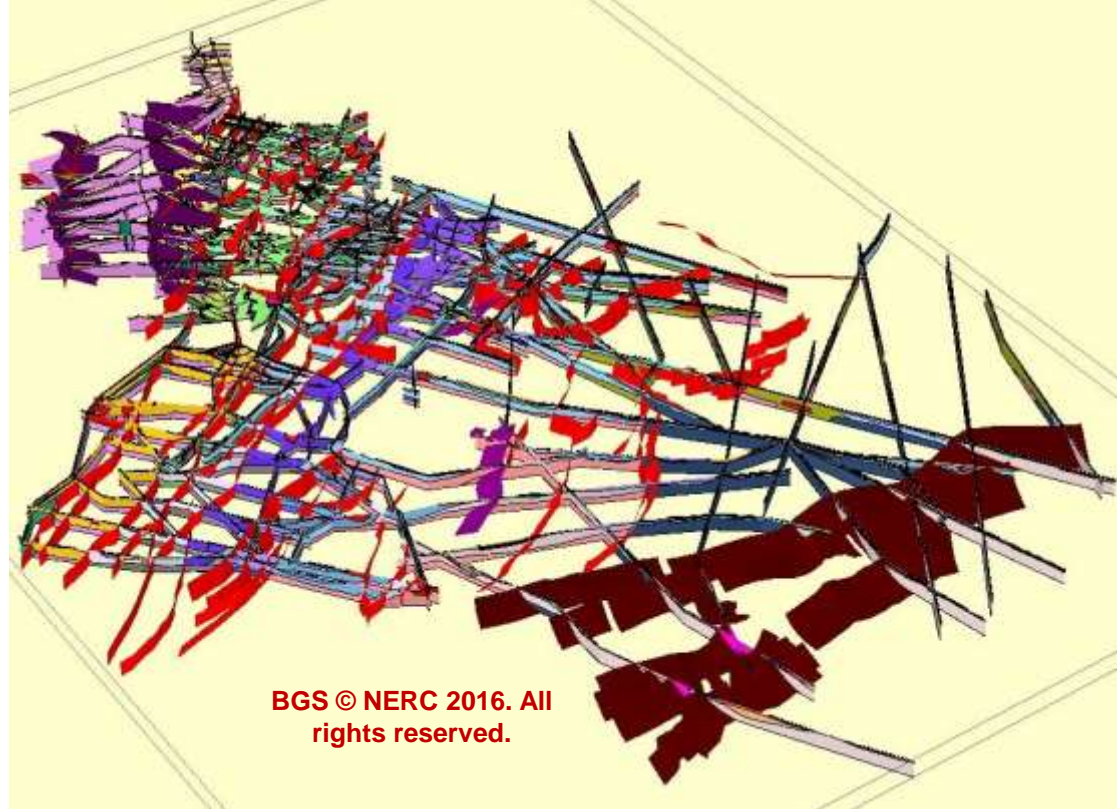
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# UK Crustal Model

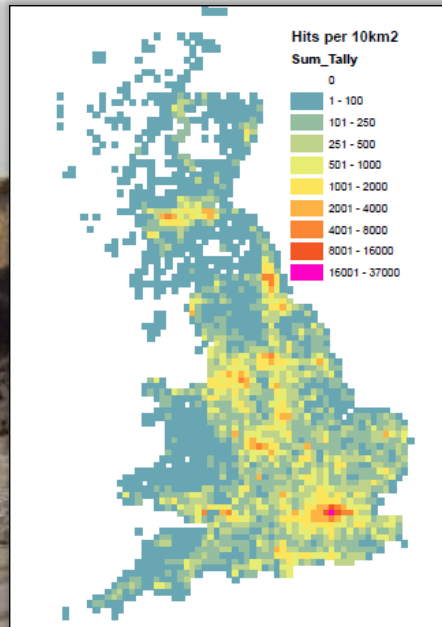
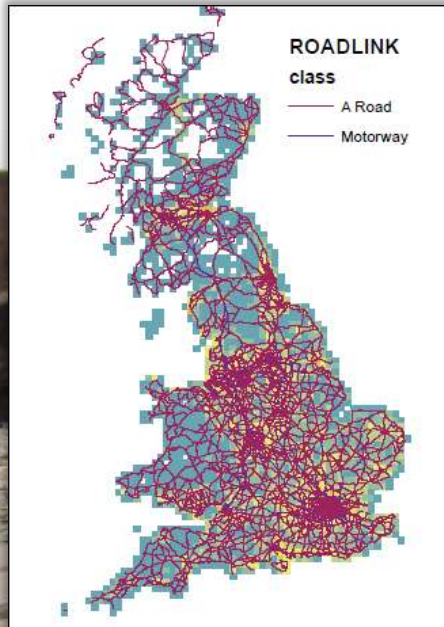
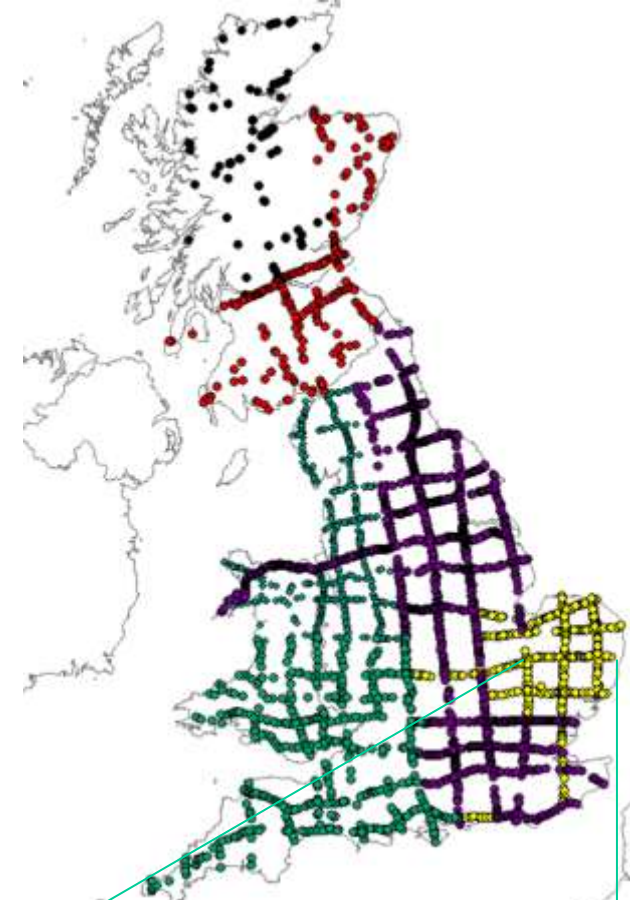
- First crustal-depth (15 km) national-scale fence diagram for the UK and Ireland
- Generalised conceptual understanding of the tectonic framework
- Major faults and Caledonian and Variscan terranes depicted
- “A stating point”
- Intended to visualise the broad-scale architecture, for training and to promote scientific debate by the geoscience community





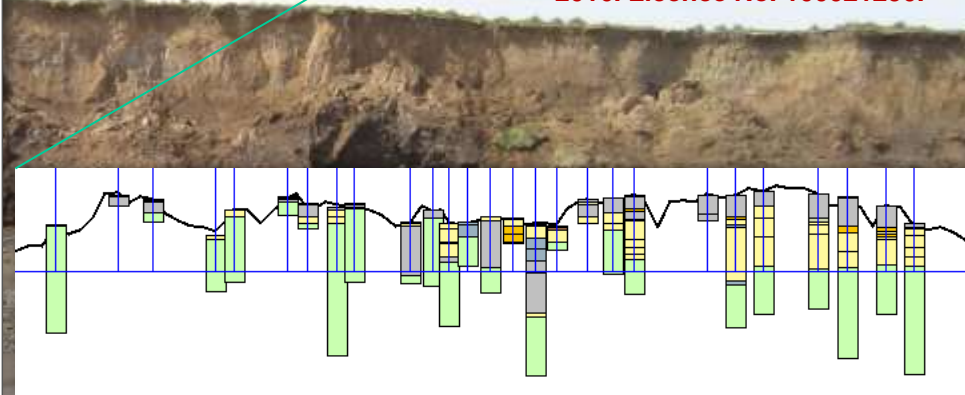
# UK Quaternary Model

- Broad framework linking the major Quaternary basins and existing models
- Reference framework for new-start models
- 3D equivalent to 1:625 000 scale Quaternary map
- Constrained by 6000 boreholes, growing!



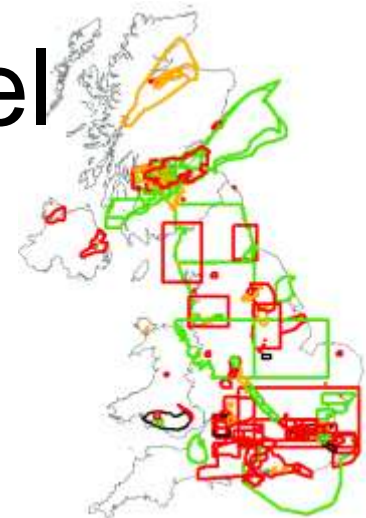
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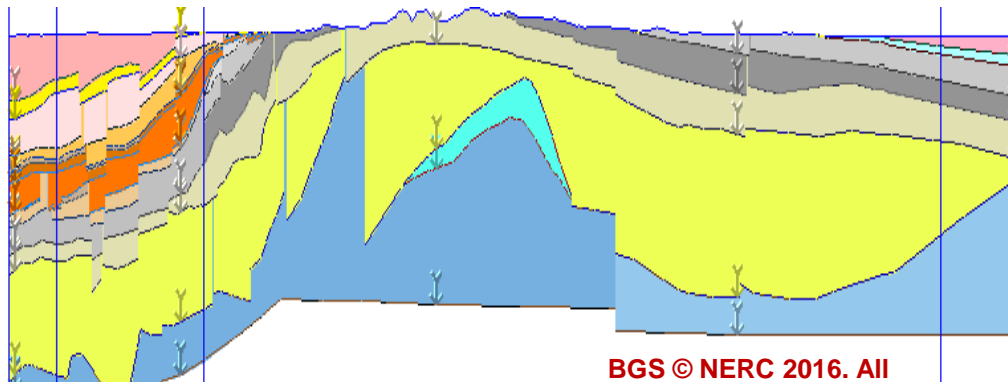
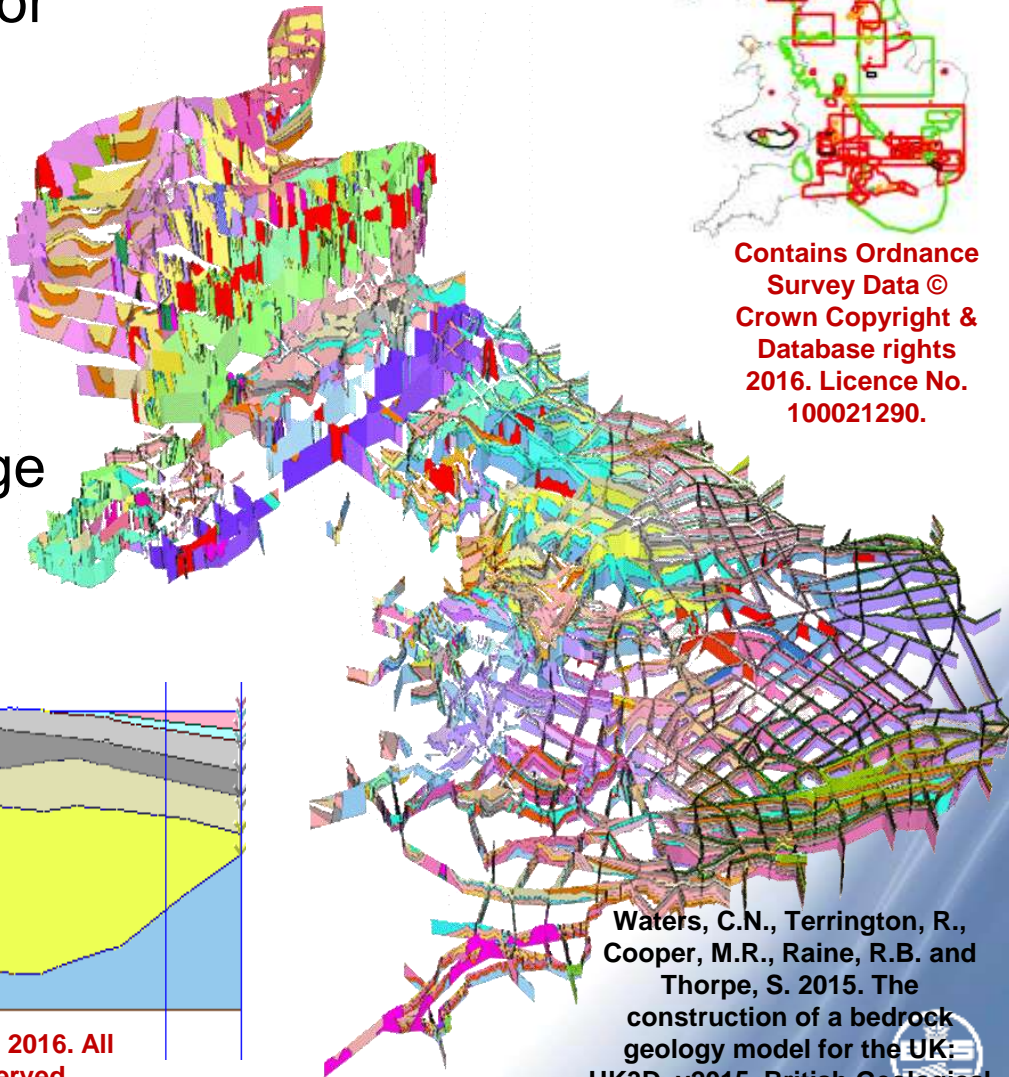


# UK3D - National Bedrock Model

- An impartial reference-frame for the UK subsurface
- Successor to 1:625,000 scale map (lithostratigraphical Gp's)
- Synthesises a wealth of data and interpretation
- Captures geologists' knowledge in a consistent framework
- Peer-reviewed, open dataset



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# UK3D - National Bedrock Model

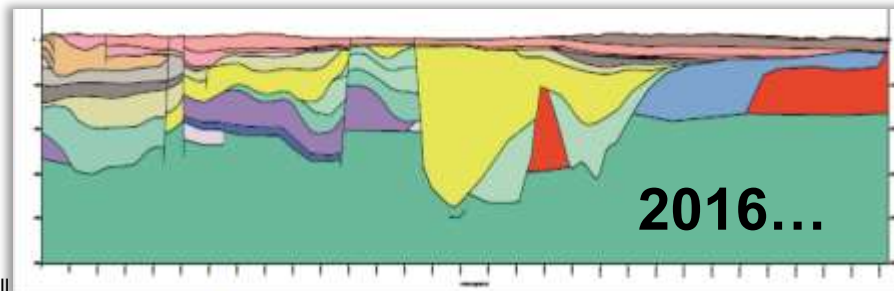
- **2009-10** Initial sections for England & Wales
- **2010-12** Infill sections, coast and Scotland
- **2012** Deepening in sedimentary basins (GB3D)
- **2014** Infill, off-shore extension and key boreholes
- **2015** Northern Ireland extension
- **2016** software migration and structural enhancement

Annotations in the screenshot:

- Source cross-section is automatically recorded (points to 'Cross-section s2')
- Horizon name(s) and fault type are automatically recorded (points to 'CR-LMAS(NORMAL)')
- Citations are user and timestamped to provide metadata audit trail (points to 'BWOOD - 01-06-2016 at 09:13')

**Metadata – software supported**

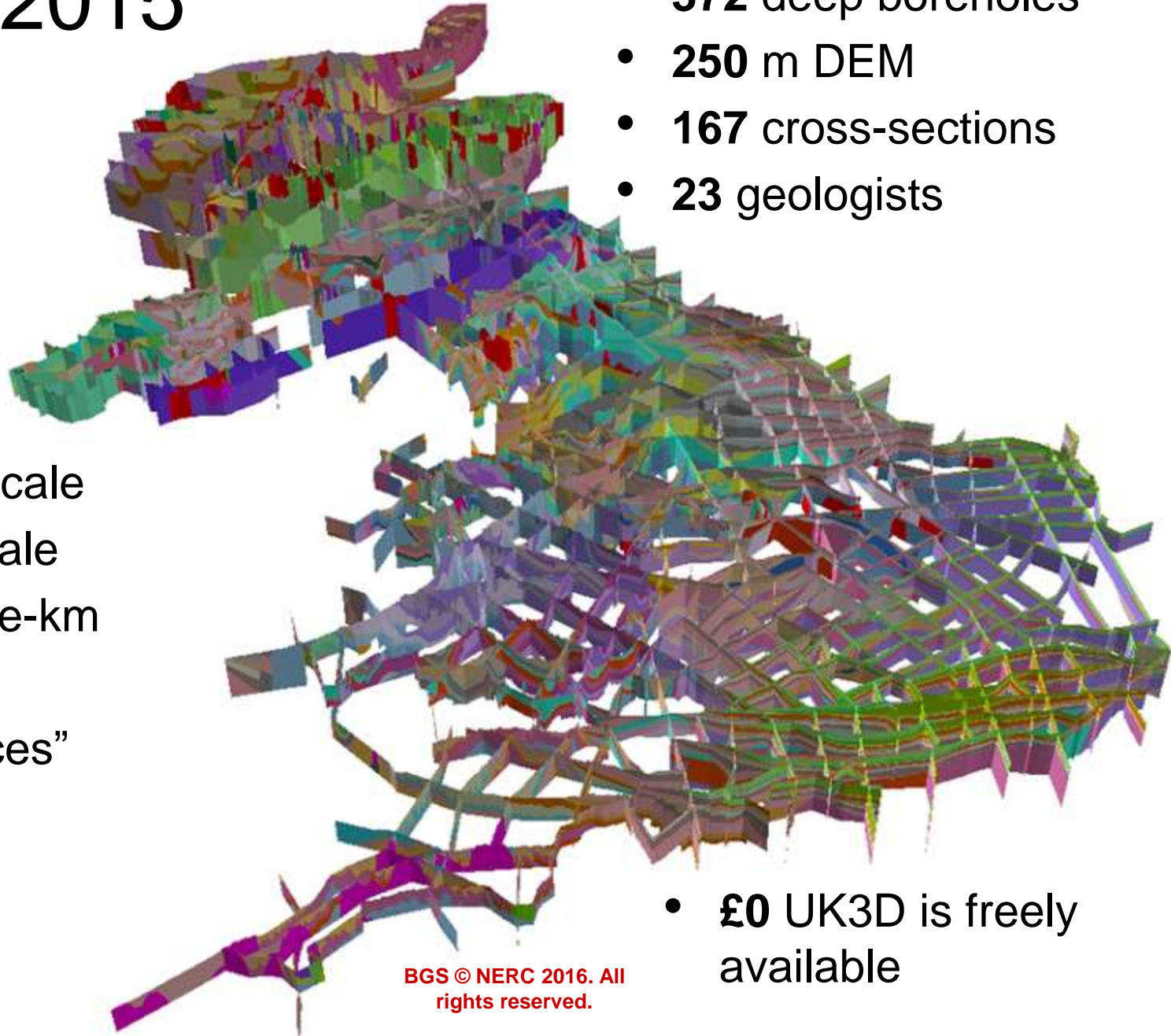
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Staff Name	Date	System Location	Description of Change
Colin Waters	01/04/2014	W:\Team\NW\A\colin\GMS\GSD\DATA\GSD02_Short\GSD02_CMBN\GSD02_NDA_V8_ST_FT_Regions.gp	Extended GSD-4055_1 to 1500m and added 150m wavyline area that section didn't extend to 200m
Ricky Terrington	01/04/2014	W:\Team\NW\A\colin\GMS\GSD\DATA\GSD02_Short\GSD02_CMBN\GSD02_NDA_V8_ST_FT_Regions.gp	Deleted lines errors (e.g. NW line)
Ricky Terrington	20/01/2014	W:\Team\NW\A\colin\GMS\GSD\DATA\GSD02_Short\GSD02_CMBN\GSD02_NDA_V8_ST_FT_Regions.gp	Trimmed off edges of sections where they extend beyond the section edge
Ricky Terrington	01/01/2014	W:\Team\NW\A\colin\GMS\GSD\DATA\GSD02_Short\GSD02_CMBN\GSD02_NDA_V8_ST_FT_Regions.gp	Wavy mapping
Ricky Terrington	01/01/2014	W:\Team\NW\A\colin\GMS\GSD\DATA\GSD02_Short\GSD02_CMBN\GSD02_NDA_V8_ST_FT_Regions.gp	Checked all sections for consistency between sections at ends and crossing points
Colin Waters	01/01/2014	W:\Team\NW\A\colin\GMS\GSD\DATA\GSD02_Short\GSD02_CMBN\GSD02_NDA_V8_ST_FT_Regions.gp	Revised GSD02_NDA with WAVE INC(170) a Repeat Measure, part

**Decision process. 4K entries**

# UK3D v2015



- **372** deep boreholes
- **250** m DEM
- **167** cross-sections
- **23** geologists

- **625 000** scale
- **50 000** scale
- **20,000** line-km
- **6000** m
- **5427** “traces”
- **445** units

- **£0** UK3D is freely available



# UK3D Access and Delivery

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## UK3D — 3D geological model for the United Kingdom

### Downloads

The model is available for free download in a number of formats, including 3D PDF, 3D Shapefiles, KMZ (for Google Earth), in the bespoke BGS Viewer and as files for use in specialist geological modelling packages.

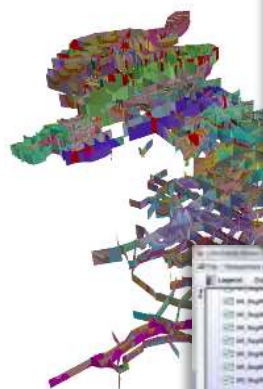
### Terms of use

The UK3D downloads listed here are delivered under the Open Government Licence, subject to the following acknowledgement accompanying the reproduced BGS materials: "Contains British Geological Survey materials © NERC [year]".

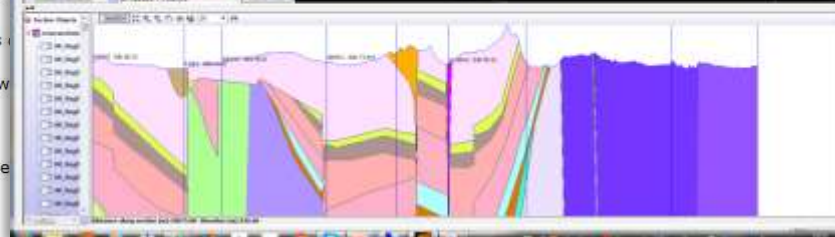
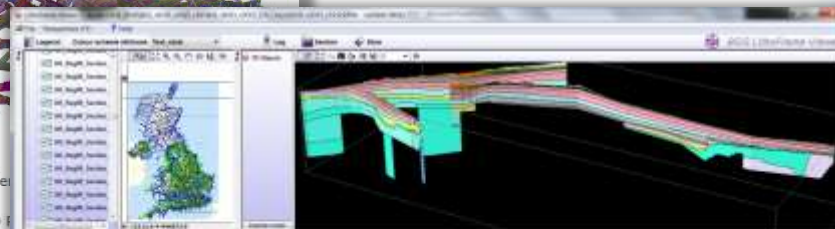
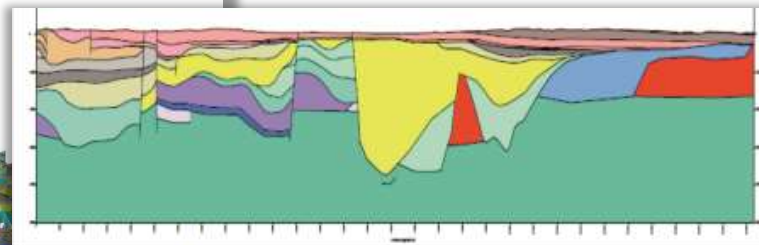
- UK3D Boreholes 2015 (3D Shapefile with layer file) 880 kb, zip
- UK3D Cross sections 2015 (3D Shapefile with layer file) 6.9 MB, zip
- UK3D England North 3D pdf 19.9 MB, zip. Double Sided rendering must be enabled for visualisation – please see ReadMe.txt file with 3D PDF download.
- UK3D England South 3D pdf 17.0 MB, zip. Double Sided rendering must be enabled for visualisation – please see ReadMe.txt file with 3D PDF download.
- UK3D Northern Ireland 3D pdf 4.74 MB, zip. Double Sided rendering must be enabled for visualisation – please see ReadMe.txt file with 3D PDF download.
- UK3D Scotland 3D pdf 13.8 MB, zip. Double Sided rendering must be enabled for visualisation – please see ReadMe.txt file with 3D PDF download.
- UK3D Wales 3D pdf 9.94 MB, zip. Double Sided rendering must be enabled for visualisation – please see ReadMe.txt file with 3D PDF download.
- UK3D individual sections (KMZ format) 9.84 MB — best viewed using Google Earth 7
- UK3D GOCAD Plines (polylines) 2.57 MB (extracted from UK3D cross sections for the base of stratigraphical units down Silurian))
- UK3D Petrel correlation lines 1.7 MB (extracted from UK3D cross sections for the base of stratigraphical units down Silurian))
- UK3D LithoFrame model 96 MB

You will first need to install the LithoFrame Viewer as below: 37.9 MB

1. download the viewer and install (high spec graphics card required; details in the user manual that is included)
2. download the model data from this page and save
3. open the viewer software and use the file menu to open the model \*.gsipre file (this may take 3–5 minutes)



UK3D national bedrock fence







# East Anglia - Geological 3D Model

Geological 3D model prepared by S J Mathers, S Thorpe and R L Terrington  
Interactive 3D PDF by C Ritchie

- 3D PDF's with Flash
- Portability and usability
  - geographic context
  - geological context
  - interactivity (scale!)
- 'control'



Produced by the British Geological Survey, www.bgs.ac.uk

Orfordness, Suffolk from the southwest  
Photograph © Mike Page 2016

This model provides a unique visualisation of the 3D geology of the East Anglia region. It is provided to accompany the new regional guide to the geology of this area produced by BGS. The model shows the subsurface arrangement of the sedimentary rocks and associated igneous intrusions to a depth of 1.5 kilometres.

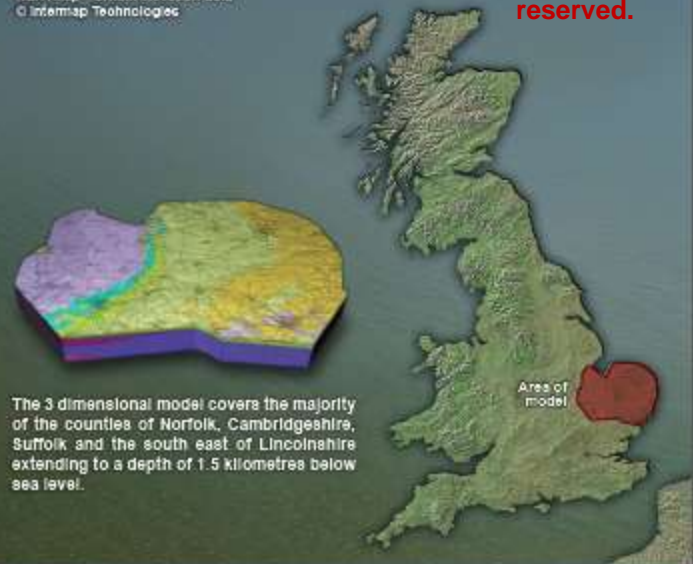
This document is divided into four pages: this introductory page; the 3D geological model with display and interrogation tools; an expanded geological legend for the model and instructions on how to navigate and use the tools with the model. You can navigate quickly between pages using the page links to the right.

- Geological Model ▶
- Detailed Legend ▶
- Instructions ▶

This publication forms part of an ongoing program to improve delivery methods for BGS geological information – we welcome your feedback. Please feel free to send us your comments at the following email address: [imap@bgs.ac.uk](mailto:imap@bgs.ac.uk)

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NEXTMap™ Britain elevation data © Intemap Technologies

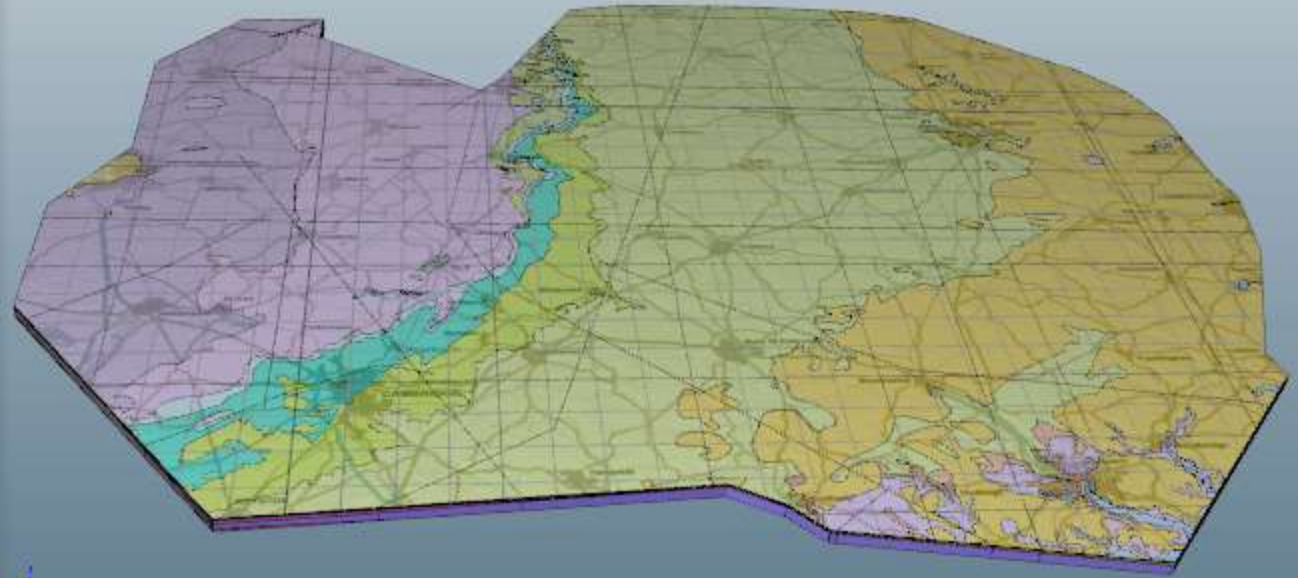
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The 3 dimensional model covers the majority of the counties of Norfolk, Cambridgeshire, Suffolk and the south east of Lincolnshire extending to a depth of 1.5 kilometres below sea level.



- Key to geological units**
- Neogene
    - Crag Group
  - Palaeogene
    - Thames Group (including London Clay)
    - Lambeth Group
    - Thanet Sand Formation
  - Cretaceous
    - White Chalk Subgroup
    - Grey Chalk Subgroup
    - Gault Formation and Upper Greensand Formation
    - Lower Greensand Group
    - Wealden Group (Mudstone, siltstone & sandstone)
    - Wealden Group (Sandstone & siltstone, interbedded)
  - Jurassic
    - West Wakes Formation, Ampthill Clay Formation and Kimmeridge Clay Formation
    - Kilnseye Formation and Oxford Clay Formation
    - Inferior Oolite Group and Great Oolite Group
    - Lias Group
  - Permo-Trias
    - Mercia Mudstone Group
    - Sharwood Sandstone Group
    - Zechstein Group
    - Other Permian Rocks
  - Devonian and Carboniferous
    - Coal Measures Formation
    - Devonian Rocks (Carboniferous Limestone)
    - Devonian Rocks
  - Lower Palaeozoic
    - Intrusive Igneous Rocks
    - Silurian Rocks
    - Ordovician Rocks
    - Cambrian and Ordovician Rocks (Unfossiliferous)
    - Cambrian Rocks
  - Pre-Cambrian
    - Neoproterozoic to Palaeozoic Rocks (Undifferentiated)
    - Neoproterozoic Rocks



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Ground surface

National grid (major 20km, minor 5km)

Topography

Transparency

Bedrock geology

Transparency

**Block display control**

All on  All off

**Selected feature**

Stratigraphy:

Lithology:

Age:

BGS Location code:

**Vertical Exaggeration Factor**

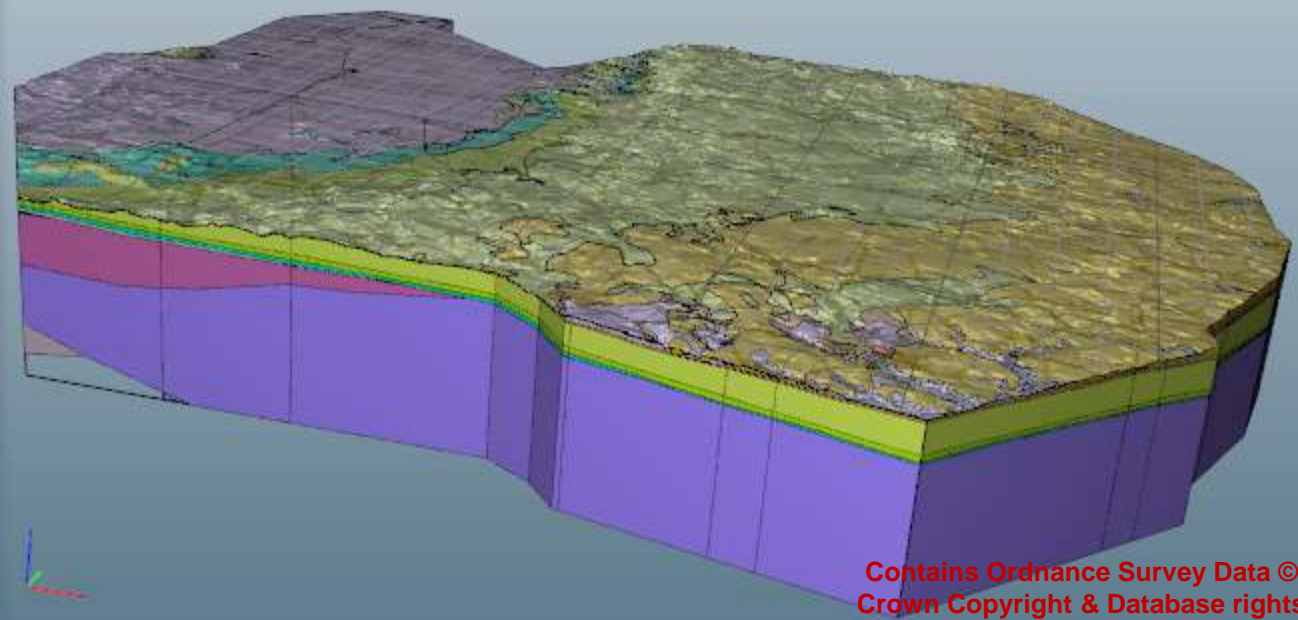
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**Introduction**

**Detailed Legend**

**Instructions**

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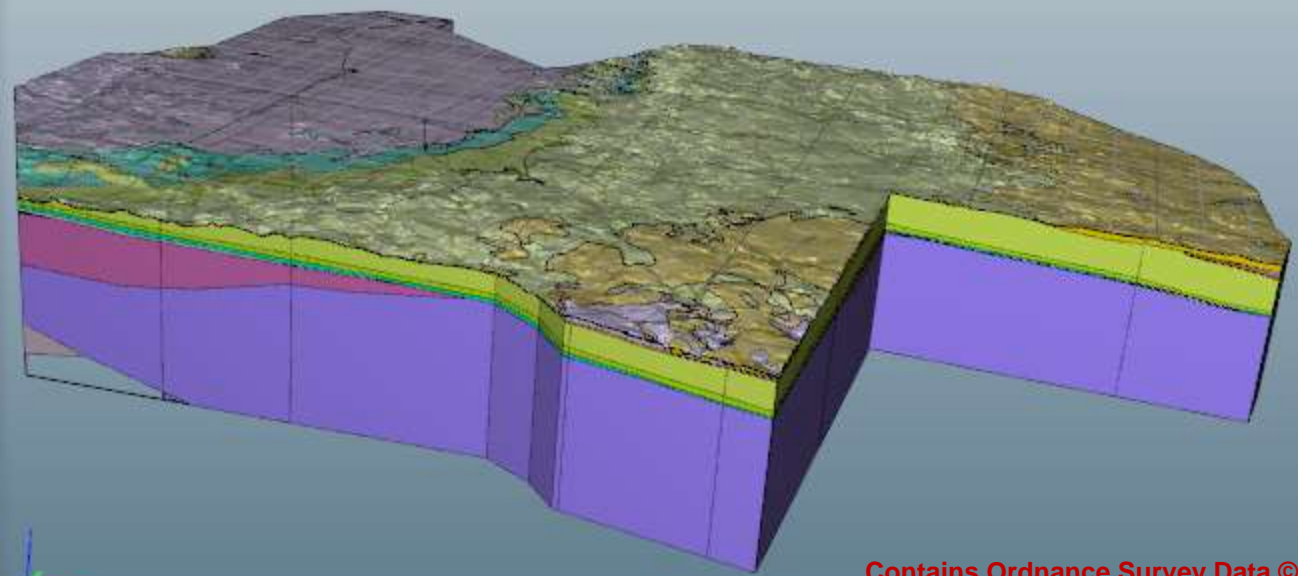
Introduction ▶

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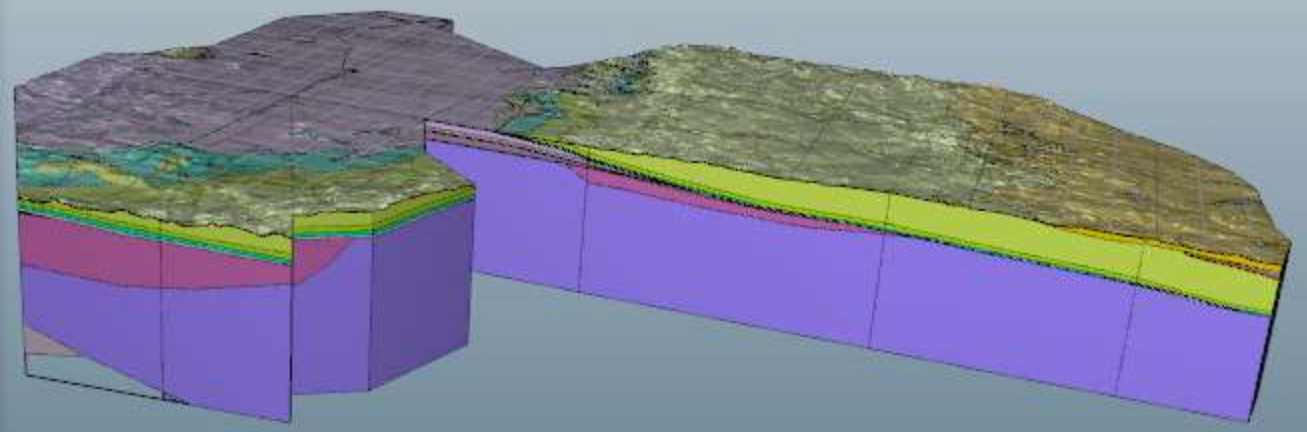
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Introduction

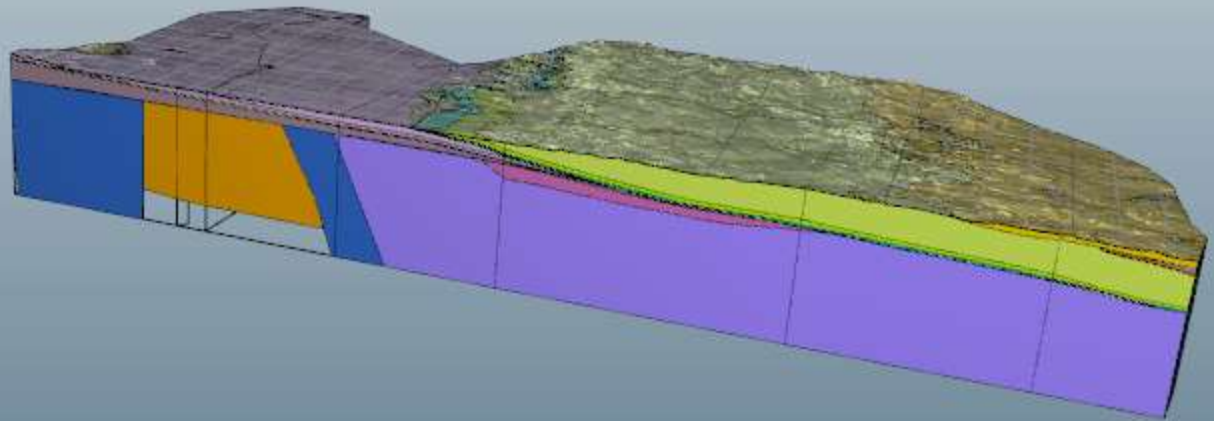
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Age:  
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**Block display control**

Ground surface  
 National grid (major 20km, minor 5km)  
 Topography  
 Transparency  
 Bedrock geology  
 Transparency

All on  All off

**Vertical Exaggeration Factor**

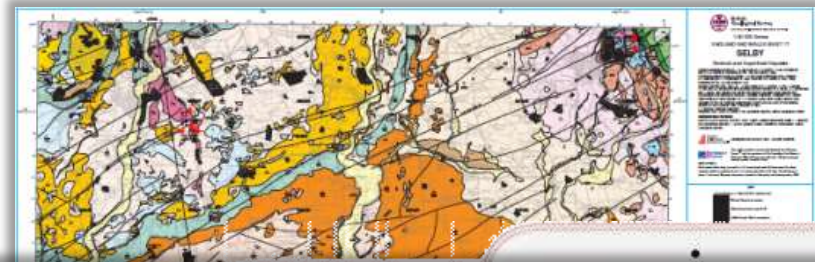
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15  
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Roll: 3°

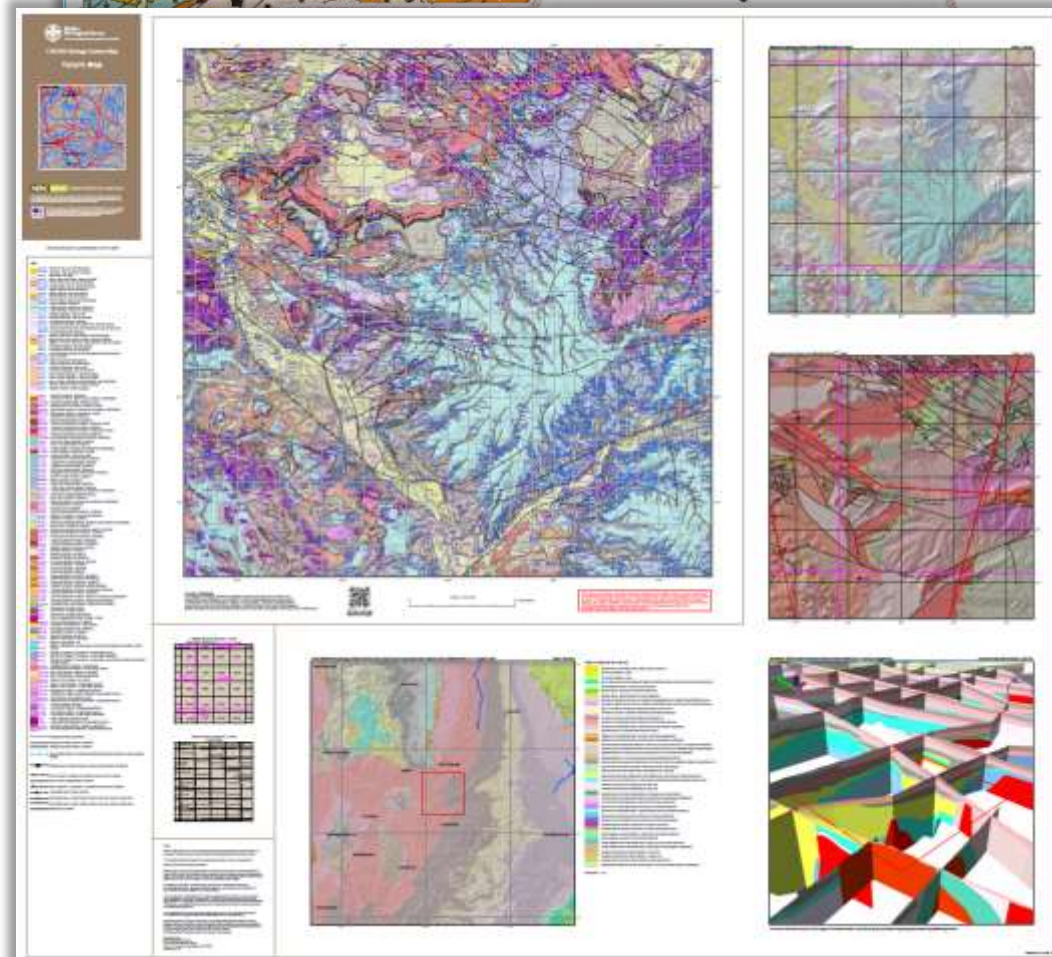
**Introduction** ▶  
**Detailed Legend** ▶  
**Instructions** ▶

# “Print on demand” maps

- Ongoing demand for 2D data and products
- Map marginalia and cross-section enables 3D understanding
- Digital data greatly increases uptake
- Lacks of marginalia limits 3D comprehension
- ‘POD’ under development
- Offers best of both!
- UK3D provides cross-section information



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**Legend**

**Water**

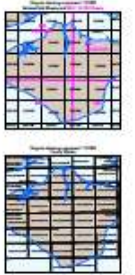
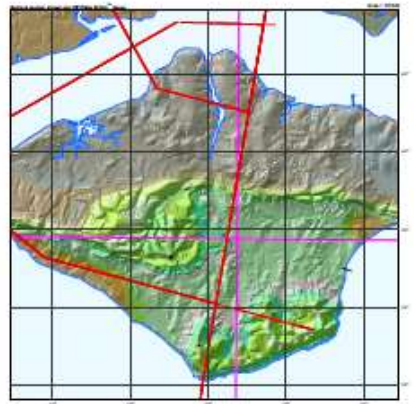
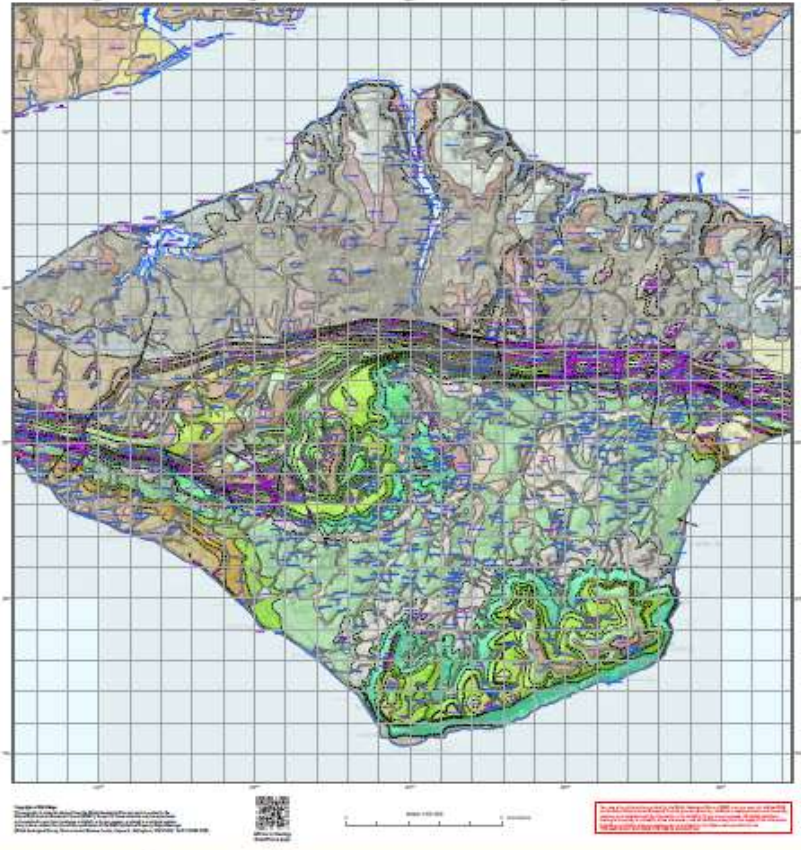
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- Sea level + 100m

**Infrastructure**

- Major roads
- Minor roads
- Roads
- Railways
- Canals
- Watercourses
- Drainage
- Boundaries
- Contours
- Spot heights
- Grid lines
- Grid squares
- Grid intersections
- Grid labels
- Grid numbers
- Grid letters
- Grid coordinates
- Grid reference
- Grid system
- Grid map
- Grid data
- Grid information
- Grid details
- Grid features
- Grid elements
- Grid components
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- Grid sections
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- Grid surfaces
- Grid shapes
- Grid forms
- Grid structures
- Grid objects
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- Grid networks
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- Grid maps
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- Grid text

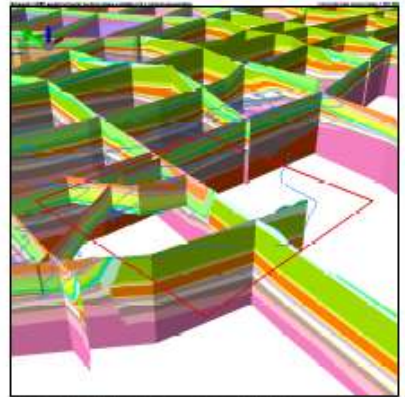


**Legend**

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**100021290.**





**BGS**  
British Geological Survey

1:50 000 Geology Catchment Map  
River Glaven catchment



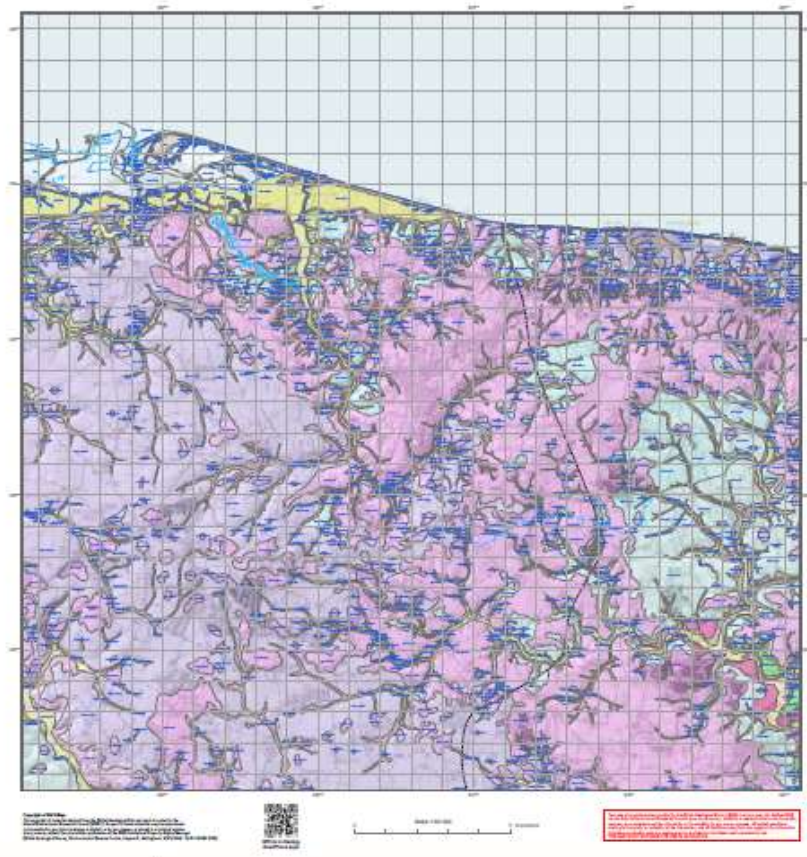
**NERC**

1:50 000 Geology Catchment Map  
River Glaven catchment

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**Legend**

- Major roads (A roads)
- Minor roads (B roads)
- Footpaths
- Water courses
- Water bodies
- Urban areas
- Industrial areas
- Other built-up areas
- Open land
- Grassland
- Arable land
- Woodland
- Other land uses
- Geological features
- Topographic contours
- Spot heights
- Grid lines
- Scale bar



**Index**

1	2	3	4	5
6	7	8	9	10
11	12	13	14	15
16	17	18	19	20

**Inset Map**

**Notes**

1. This map is a reproduction of the original map published by the British Geological Survey in 2016. It is not a substitute for the original map.

2. The map is based on the Ordnance Survey data and is subject to the same conditions of use as the original map.

3. The map is not a substitute for the original map and should not be used for navigation or other purposes where accuracy is essential.

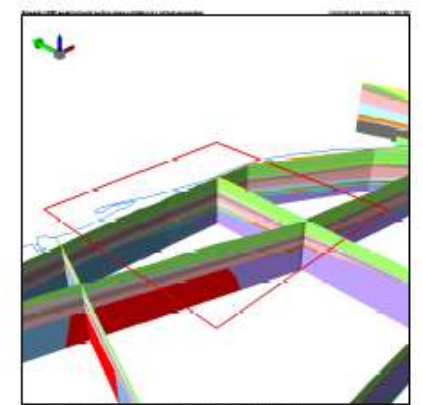
4. The map is not a substitute for the original map and should not be used for navigation or other purposes where accuracy is essential.

5. The map is not a substitute for the original map and should not be used for navigation or other purposes where accuracy is essential.



**Key to symbols in notes**

- 1. This symbol indicates a specific geological feature.
- 2. This symbol indicates a specific geological feature.
- 3. This symbol indicates a specific geological feature.
- 4. This symbol indicates a specific geological feature.
- 5. This symbol indicates a specific geological feature.



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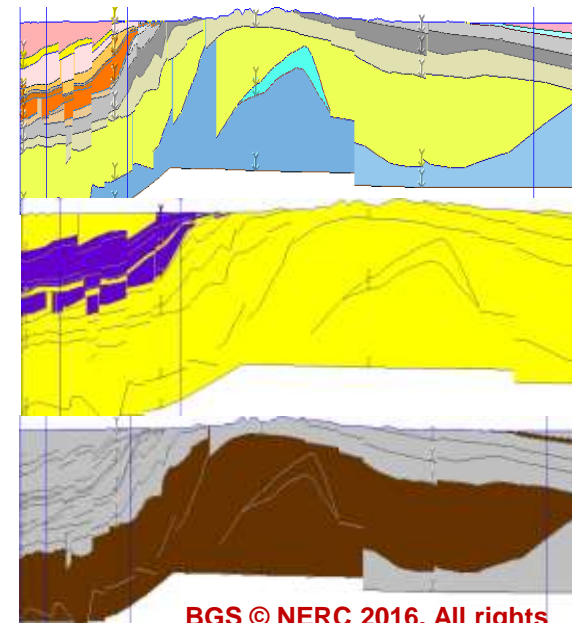
# National Geological Screening

- National screening exercise for geological disposal of radioactive waste (E, W & NI)
- UK Gov't favours a voluntarist approach from communities
- BGS Contributing to the prospectus of information available to inform interested communities
- UK3D used in the process that will identify:
  - rock types of interest
  - major faults
- Ongoing RWM Ltd funded-work



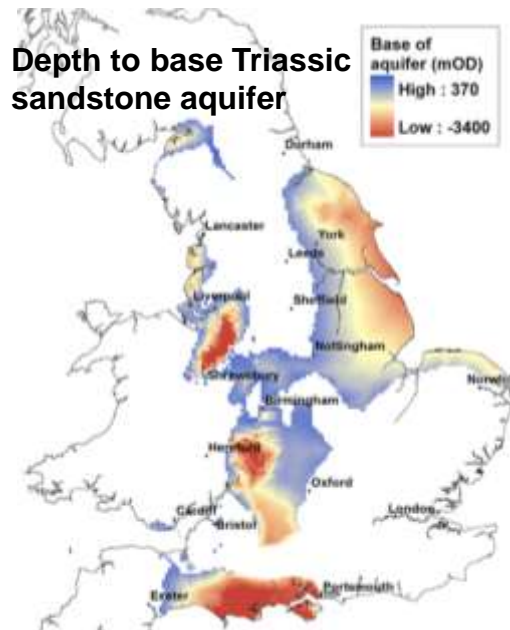
# Aquifer/shale separation

- Unconventional hydrocarbons driving significant interest in the subsurface
- **Assumption: risk of contamination (by any pathway) is greater if aquifers and shales closer together**
- Location of Principal Aquifers and continuation at depth and shale units with the potential for exploitation
- National scale (England and Wales), online resource

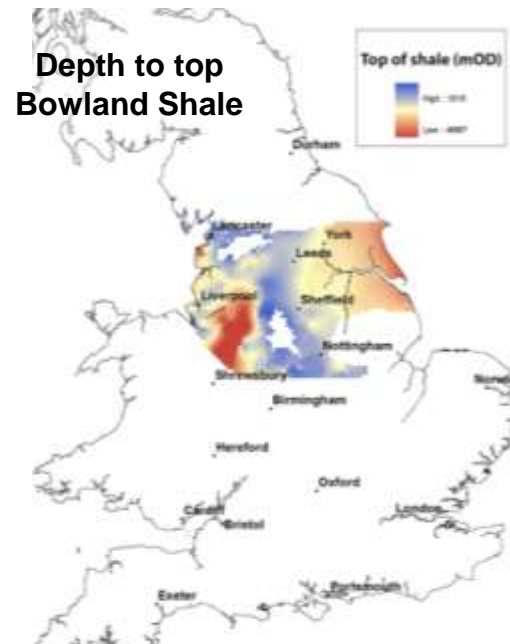


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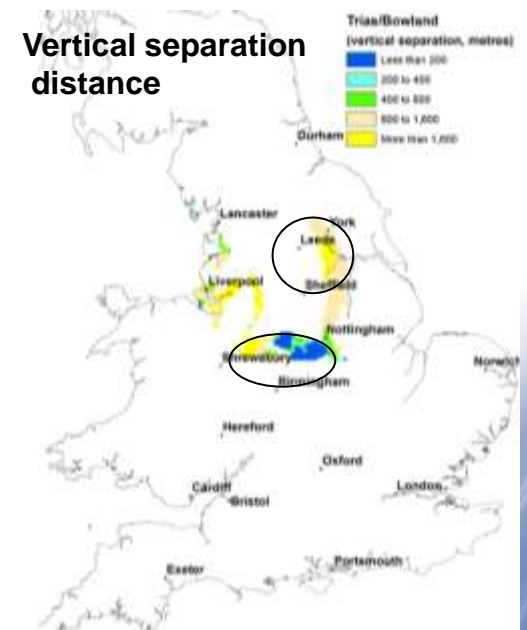
Depth to base Triassic sandstone aquifer



Depth to top Bowland Shale



Vertical separation distance

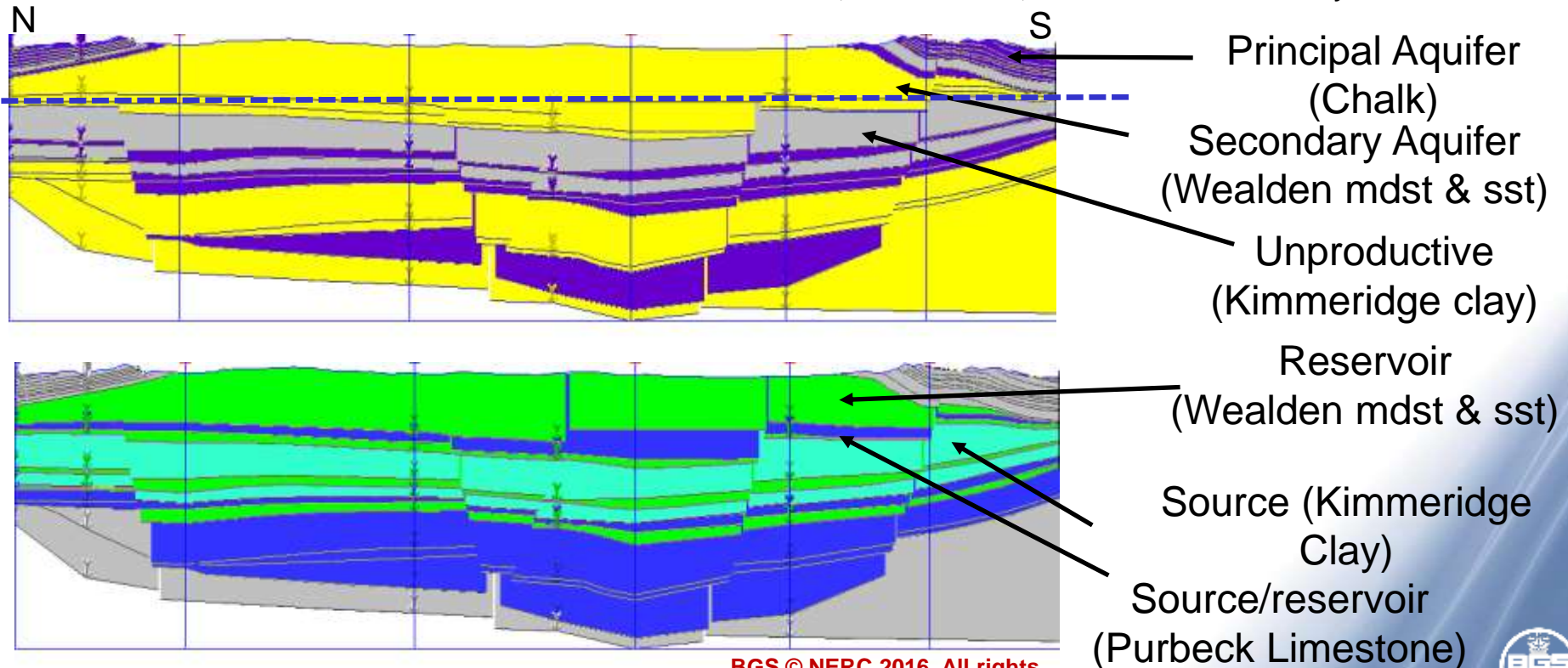


# 3D Groundwater Vulnerability

- Further identification of aquifers and sources
- Geometric understanding of sources/receptor relationships
- Identification of specific possible preferential flow pathways



Loveless S., Bloomfield, J., Ward, R., Davey, I., Hart, A. and Lewis, M. Groundwater vulnerability to onshore hydrocarbon activities in England. Geophysical Research Abstracts. Vol. 18, EGU2016-14540, 2016. EGU General Assembly 2016

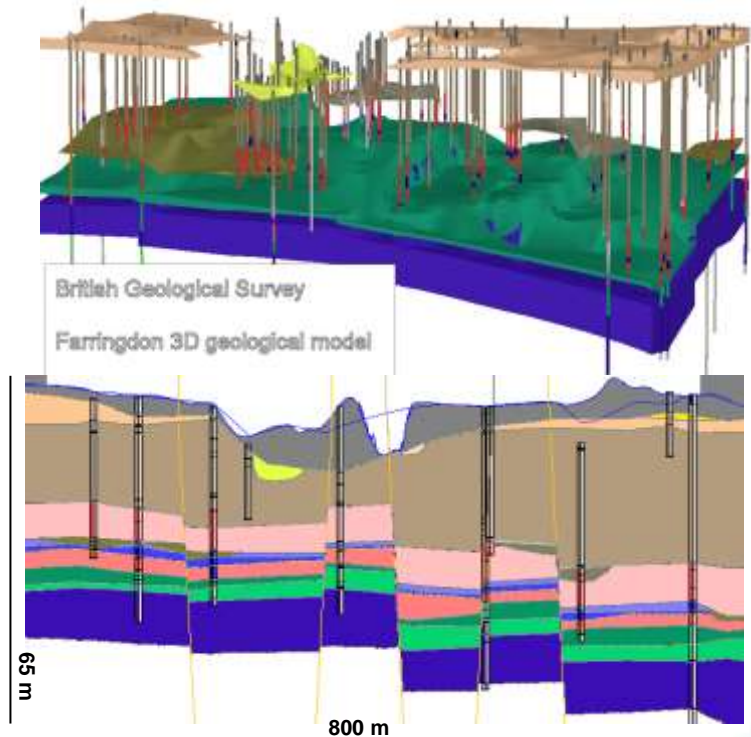




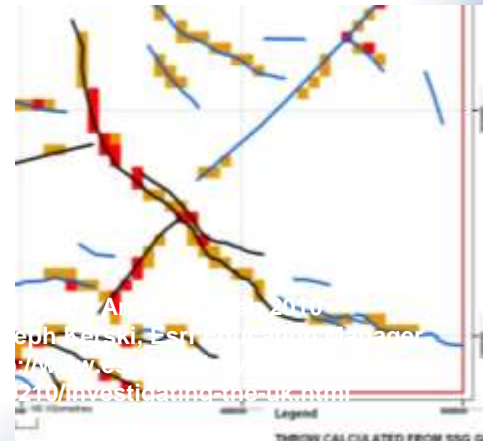
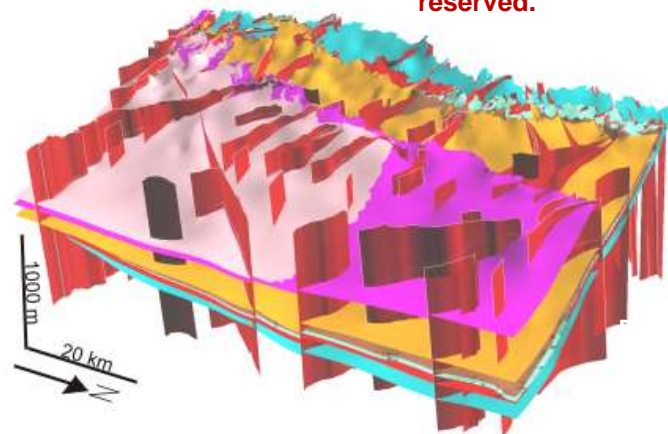
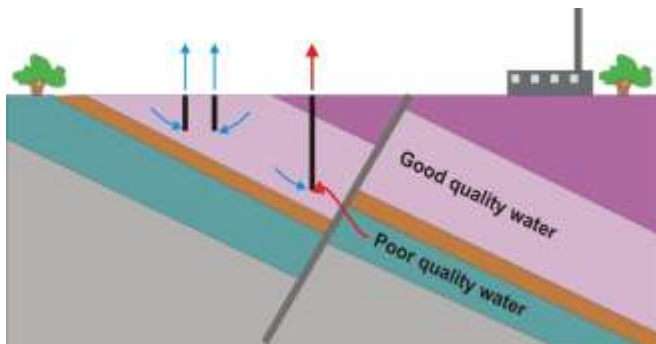
# UK 3D Fault Network

- “Pathways” increasingly significant
- #1 driver for bedrock modelling: fault detection & analysis **across scales**
- Need to go beyond current 2D national datasets:
  - 3D geometry & extent
  - rock properties
  - 4D history
  - Confidence

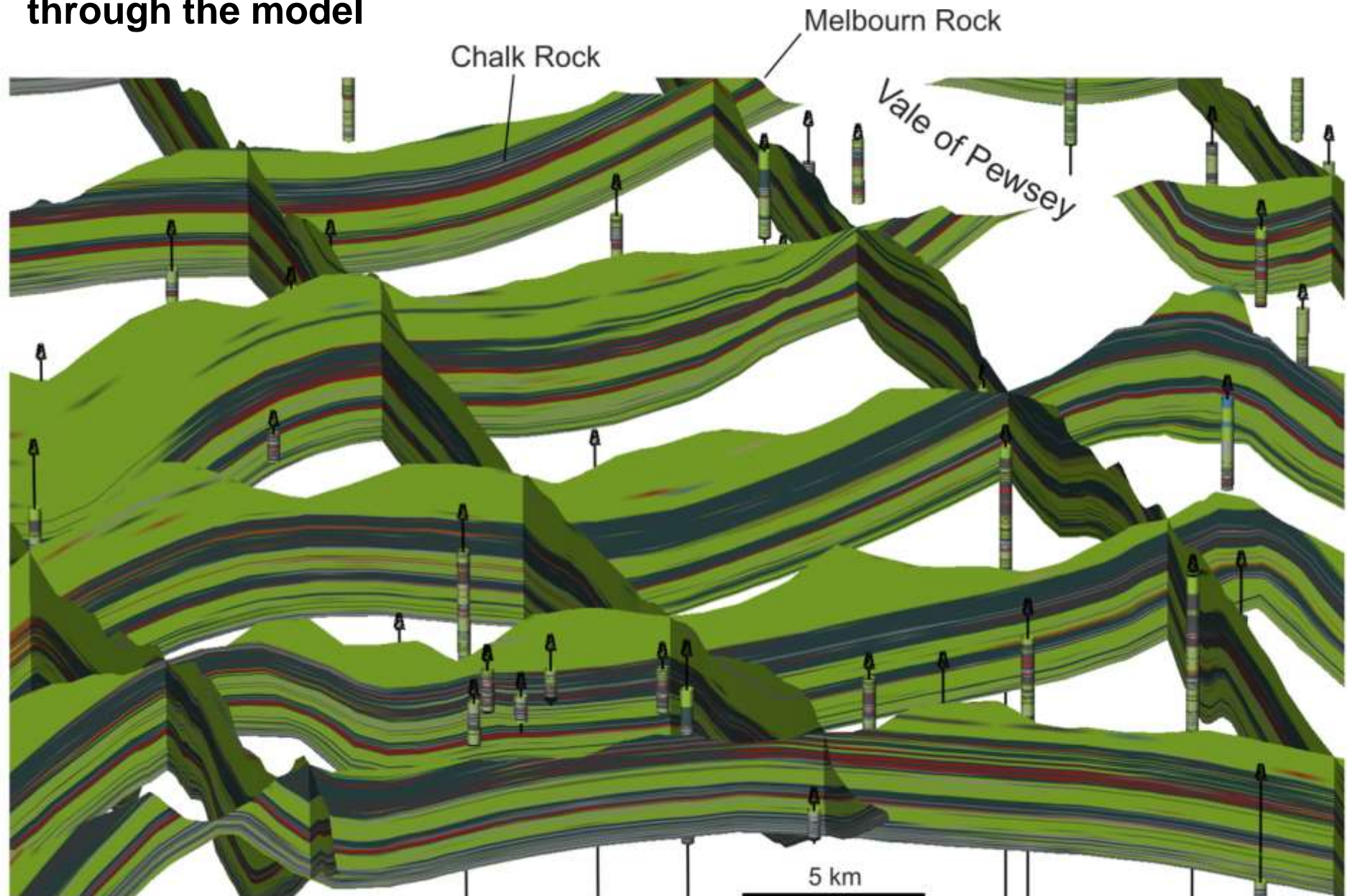
UK3DFN



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# Use geostatistical techniques to extrapolate physical properties through the model



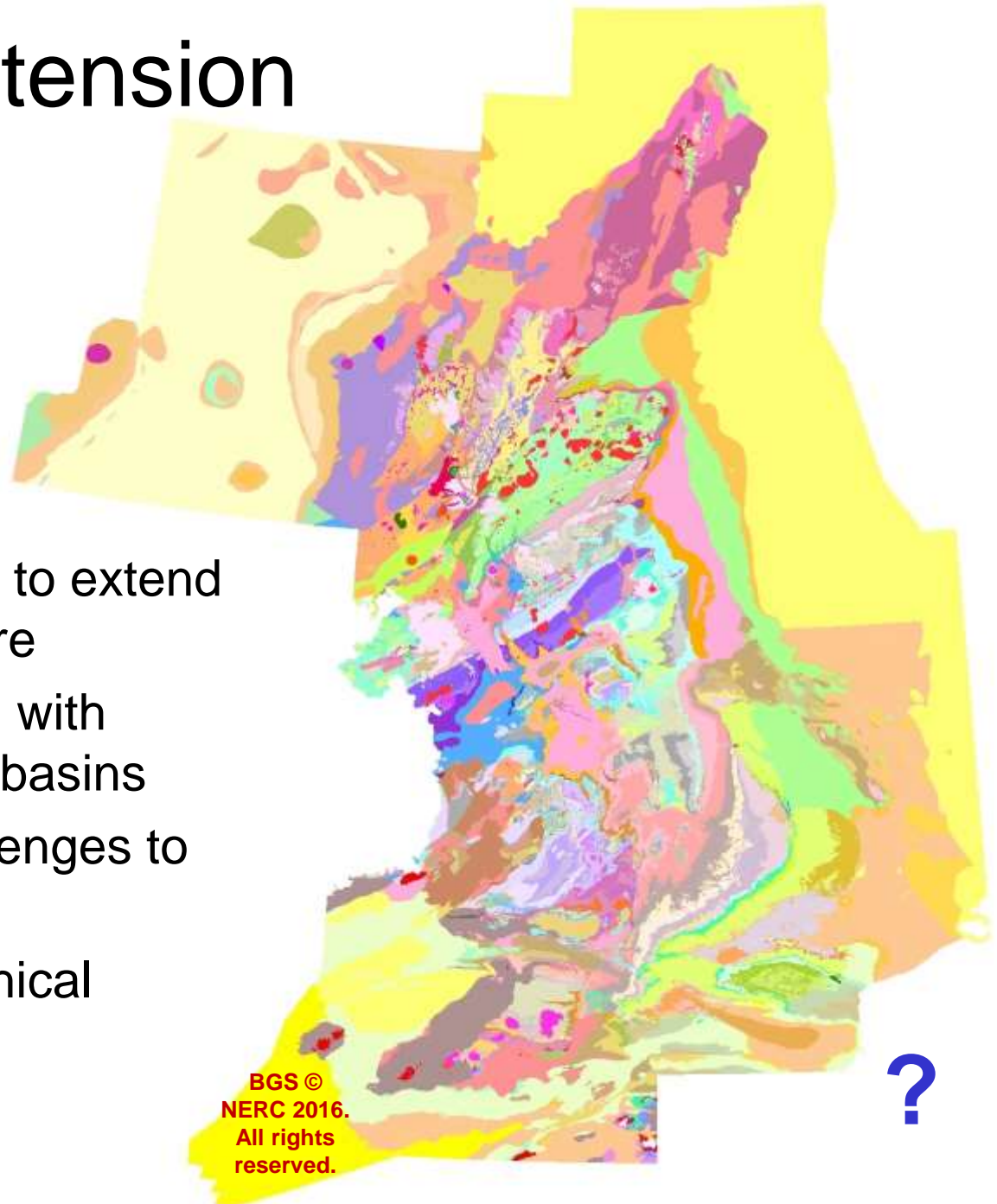
Woods M., Newell, A., Haslam, R.B., Farrant, A.R. and Smith, H. 2016. Predicting the subsurface. *GeoScientist*, vol. 27 no. 4, May 2016. Geological Society of London.

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# Offshore extension

- Strategic aim to extend UK3D offshore
- Commencing with hydrocarbon basins
- Various challenges to overcome:
  - stratigraphical
  - technical
  - cultural





# Summary

- **NGM** – suite of national-scale models of the UK – **continues to evolve**
- **UK3D** – mature model - **recent applications maximise the value / impact**
- 
- **Clear drivers for development of the NGM**  
– emerging uses of the subsurface, new data and technology



**British Geological Survey**  
NATURAL ENVIRONMENT RESEARCH COUNCIL

Data SIO, NOAA, U.S. Navy, NGA, GEBCO  
Image IBCAO

Image Landsat

Google earth