

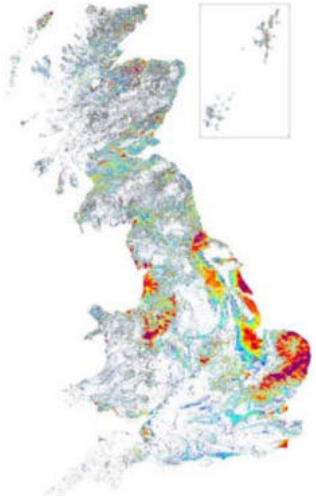
RICKY TERRINGTON, TIM KEARSEY AND STEVE THORPE

25 years of national 3D geological modelling in the UK: Key experiences, challenges and lessons learned

Towards a 3D Geomodel of Europe
GSEU Workshop - 12 & 13 October 2026

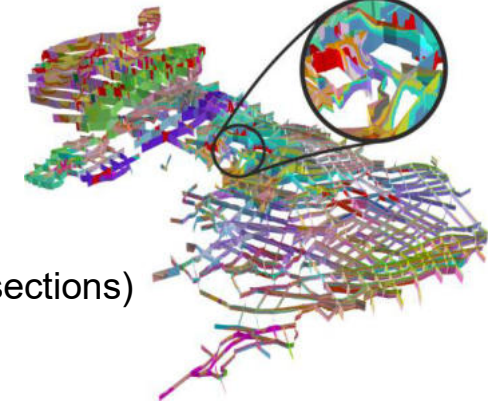
BGS British Geological Survey

National Superficial Deposits Thickness Model



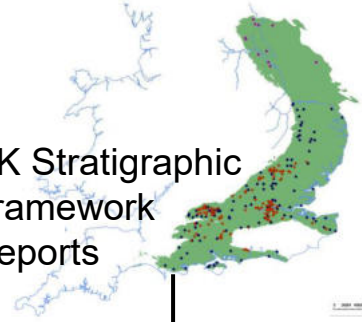
2003

UK3D (Cross-sections)



2013-2014

UK Stratigraphic Framework Reports

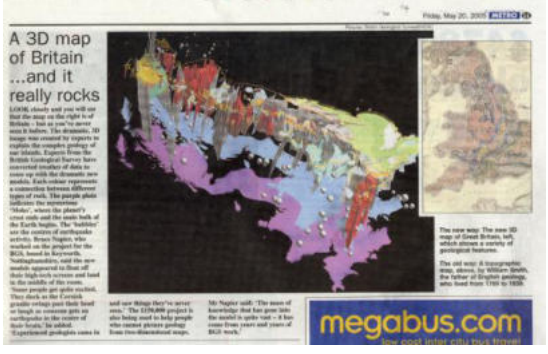




2019-2024

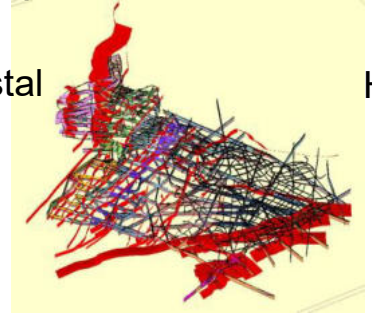
2001 to present day

Lithoframe 1 Million model



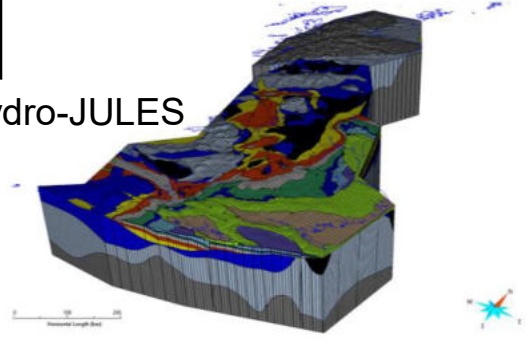
2010-2015

UK Crustal model



2015-2026

Hydro-JULES



Technology advances – impact on 3D geological modelling

Decade	Key Technologies	Typical Software/Tools	Impact
1950s-1960s	Paper mapping, cross-sections, contouring	Hand-drawn maps, drafting tables, early mainframes	Geologists visualised the subsurface using maps, and cross-sections
1970s	Computer contouring, geophysical interpretation	SYMAP, GRID, early seismic interpretation systems	First computer-assisted subsurface mapping and structural surface generation.
1980s	Digital geophysics, workstation computing,	Landmark, GeoQuest, Intergraph, Kingdom	Oil and gas industry develops the first practical 3D subsurface models.
1990s	GIS, 3D visualisation, database systems, CAD revolution	ArcInfo, EarthVision, GOCAD, Geoscience Analyst , Petrel (late 1990s), Bentley MicroStation and Autocad, Vulcan	Transition from isolated surfaces to integrated 3D geological frameworks.
2000s	Geological survey 3D modelling, digital boreholes, DTM integration	GSI3D, GOCAD, EarthVision, Petrel, ArcGIS, GeoModeller.	Systematic 3D geological modelling adopted by geological surveys,
2010s	National models, voxel modelling, web delivery, property modelling	Leapfrog, Petrel, ArcGIS Pro, SKUA-GOCAD, Mira GeoScience	National-scale frameworks such as UK3D and GeoTop emerge; models become reusable assets.
2020s	Cloud computing, automation, digital twins, APIs, Open-source	Leapfrog Works, MOVE, Loop3D, GemPy, Georeka	Shift from static models to dynamic subsurface platforms and knowledge systems.
2030s?	AI-assisted interpretation, automated updates, federated models	AI/ML workflows, knowledge graphs, digital twin platforms, live updates	Continuously maintained national and multinational geological knowledge frameworks.

Advances in technology have progressively reduced the effort required to build models while increasing their scale, resolution, accessibility, updateability, and usefulness.

Strategic Foundations for a National Geological Model

Each endpoint has requirements and challenges

- Interoperability and openness.
- Scalability from regional to national coverage.
- Support for future technologies and applications.

Software

Stakeholder Requirements

- Who will use the model?
- What decisions will it support?
- National, regional, or site-specific applications?

- Provenance of interpretations.
- Data lineage and dependencies.

Metadata



Data

- Availability, quality, consistency, and coverage.
- Integration of legacy and new datasets.
- Data gaps and uneven spatial distribution.
- Long-term stewardship and accessibility.

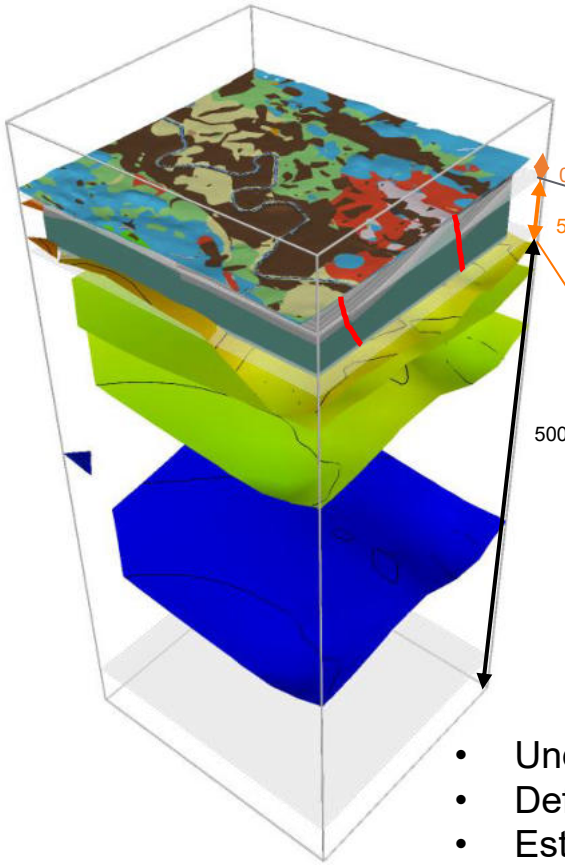
- Consistent modelling methodologies.
- Clear governance and version control.
- Reproducible workflows.

Standards & Workflows

Knowledge

- Capture geological expertise, assumptions, and interpretations.
- Preserve institutional knowledge.
- Recognise multiple competing interpretations.

Are we building a model of the subsurface, or a national system for managing geological knowledge?



	User communities	Input data users expect to be used:	Approximate average vertical accuracy of model:
0 – 50 m	• Infrastructure & engineering • Brownfield • Shallow Groundwater • Groundwater flooding	• Boreholes / geological maps • Often sub-formational heterogeneity is more important than formations	• ± 1 to 10 metres
50 – 500 m	• Drinking water • Mine Working Geothermal • Deep geological radioactive waste storage • Hydrogen storage • Tunnelling	• Boreholes / geological maps/ mine plans/ local geophysics • Users may expect 'traditional' Lithostrat, and/or lithological units	• ± 2 to 50 metres
500 m – 5 km	• Conventional and unconventional hydrocarbons • CCS • Deep Geothermal	• Seismic and wells expected inputs • Often inter-basin interpretations important • May insist on sequence strat / seismo strat	• ± 50 to 500 metres

- Understand why you are building it.
- Define who will use it.
- Establish what resolution is needed and where its limits lie.
- Avoid misuse and over-interpretation.
- Design for multiple applications and future reuse.

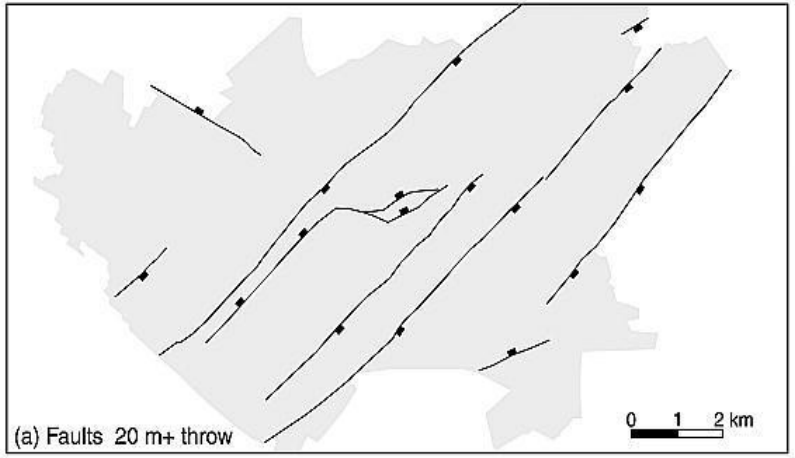
Resolution and scale

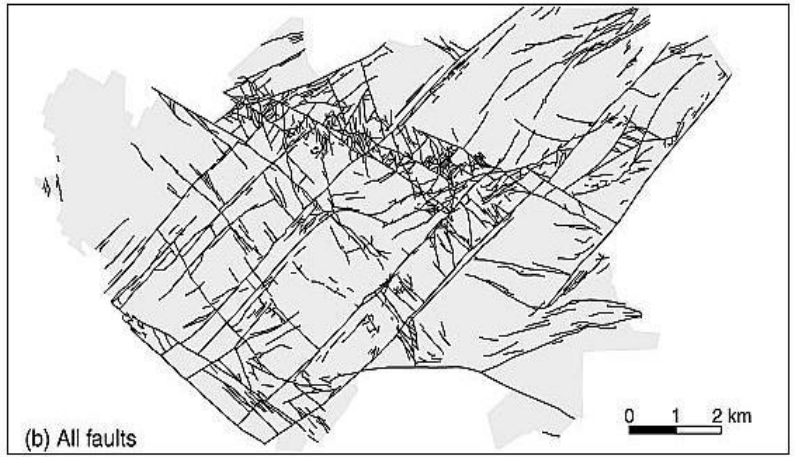
- Resolution
  - Sub-seismic faults
  - Fault-tips and Fault connectivity

- Scale
  - What scale do we need to map structure for National Geological Model?
  - At a prospect scale, detail is essential, but for a national scale model, what's required?

At what scale does additional geological detail cease to add value for national-scale decision making?

Watterson et al., 1996





Subseismic Faulting in Map View

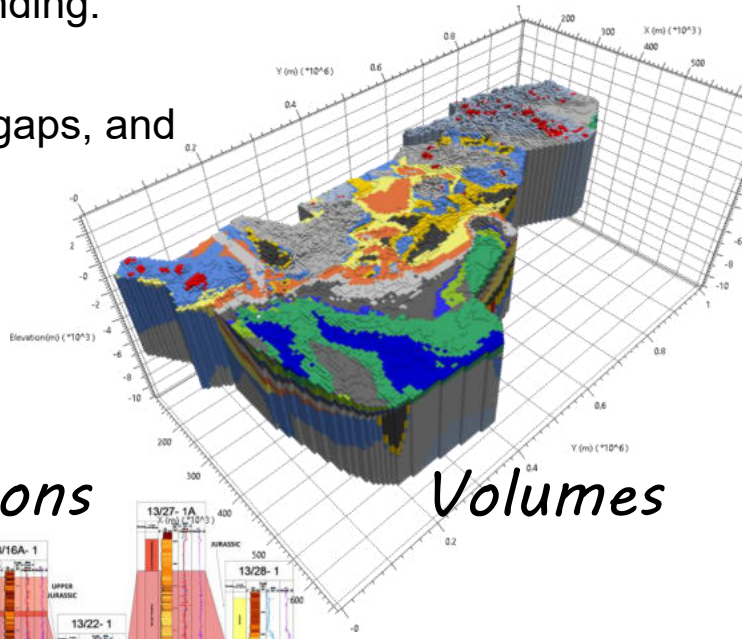
It is not necessarily the model that is important….

- It is the knowledge gained - new insights and understanding.
- Re-examine existing interpretations and assumptions.
- Bringing datasets together can reveal inconsistencies, gaps, and previously unrecognised geological relationships.

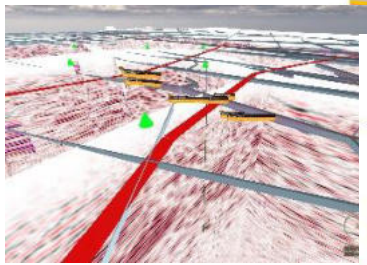
Framework (faults and horizons)

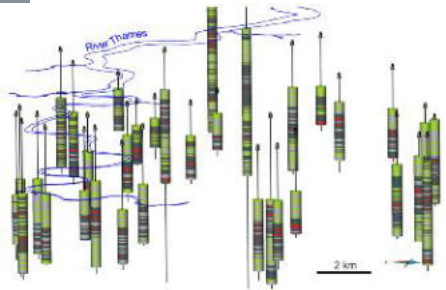


Volumes



Observations





Interpretations

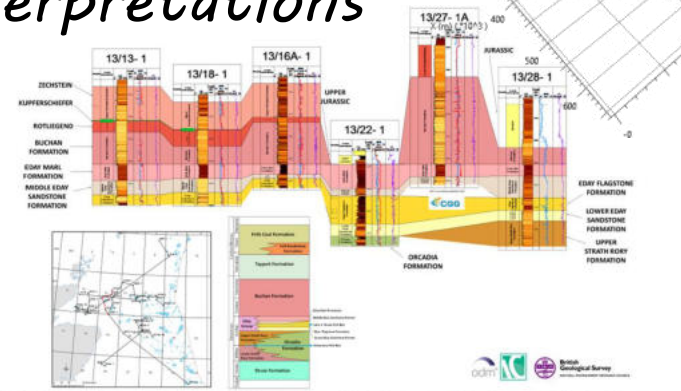


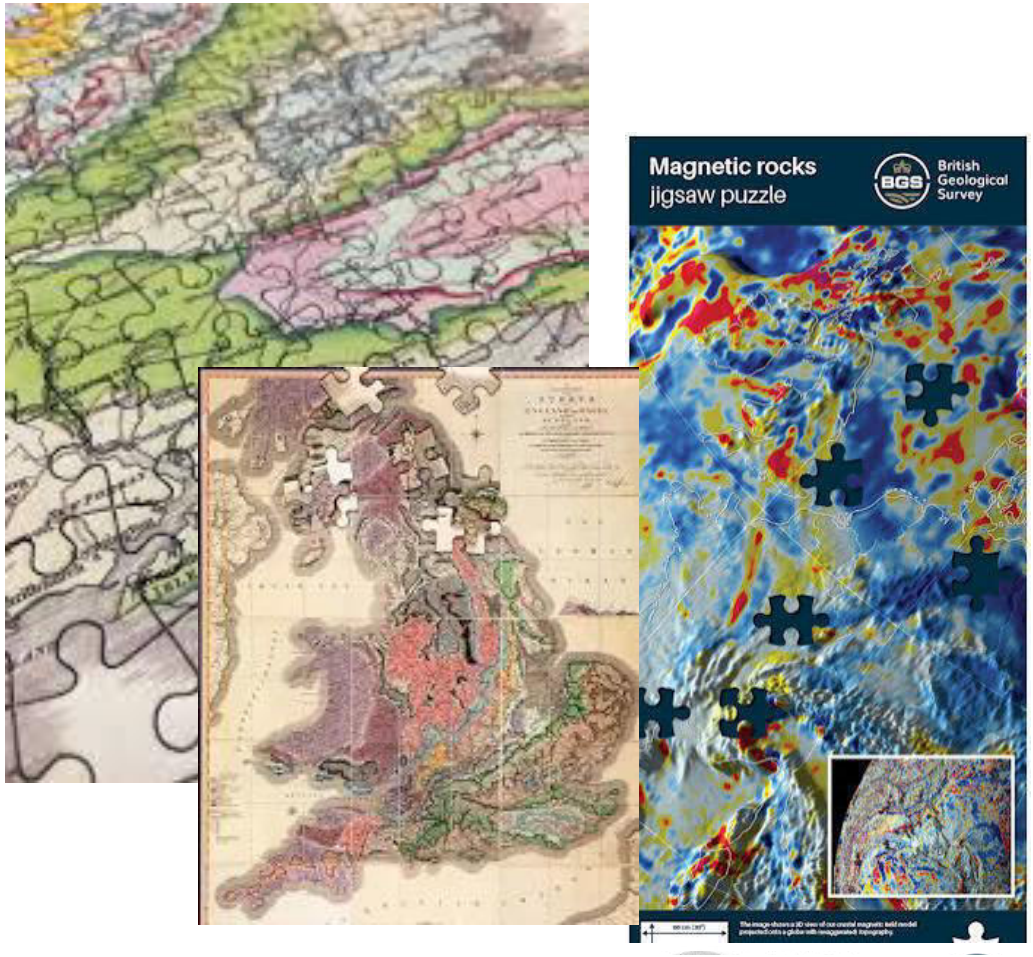
Figure 20 – Panel 2: Middle to Late Devonian strata of the Eday Group to Buchan Formation in Quadrant 13, showing the stratigraphic relationships of formations within the Eday Group. These strata were formerly considered to be part of the Rotliegend Group but were assigned to the Middle Devonian Eday Group by Marshall and Hewett (2003).

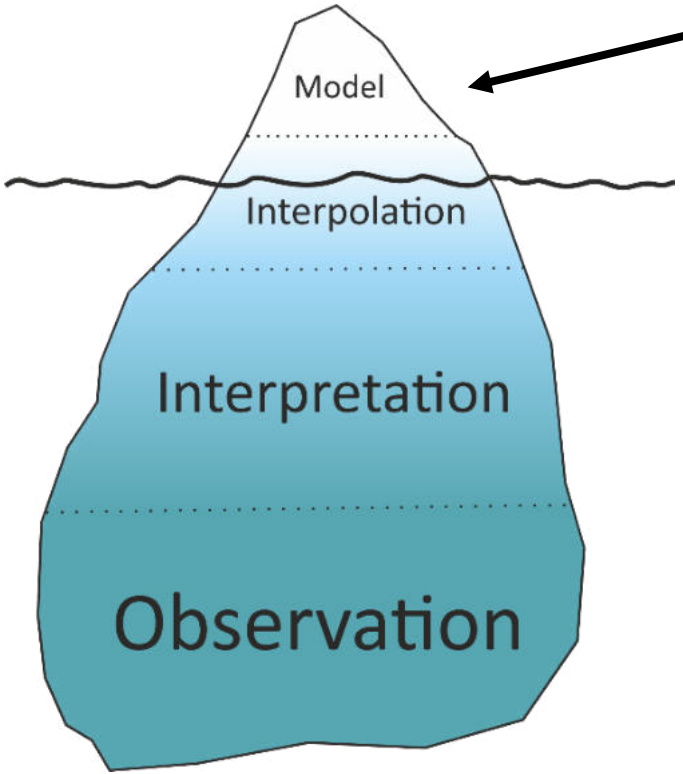
Filling in the gaps…

National coverage inevitably requires geological extrapolation beyond data-rich areas.

Forces the modeller to extrapolate their knowledge beyond local/regional interpretations to a nationally consistent framework.

….. but also presents an opportunity to develop a nationally consistent understanding of the subsurface.





Pinnacle of value 1835 – c. 2019
= Map (/model)

Pinnacle of value c. 2019 onwards
= “geological framework” datasets

Sustaining a National Geological Model - **Keeping the model 'alive'**

- Capture not only model outputs, but the geological reasoning behind them.
- Preserve interpretations, assumptions, uncertainties, and decision-making processes.

→ Maintaining the knowledge base

- A national model requires collaboration across regions, disciplines, and organisations.
- Balance local geological expertise with the need for national consistency.

→ Collaboration with **Challenges**

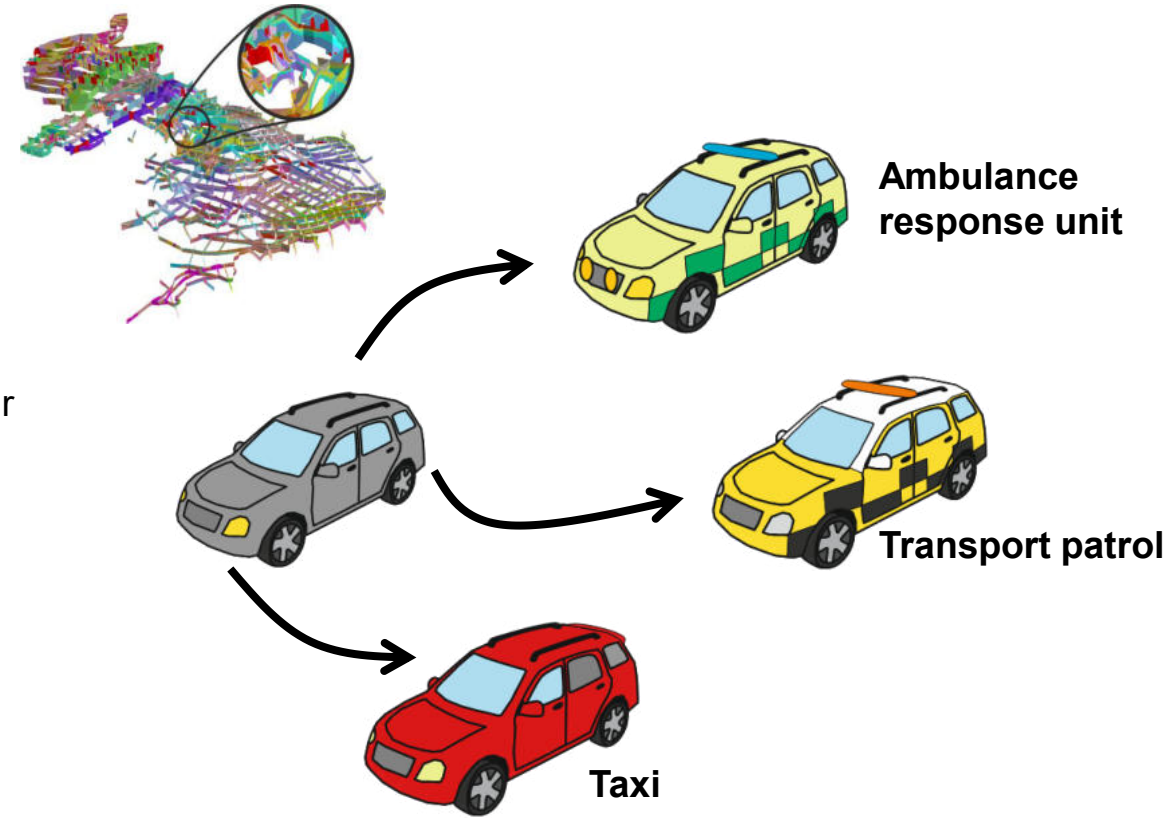
- Develop systems that support rapid updates and model regeneration.
- Ensure source data, interpretations, and model outputs are linked and easily accessible.

→ Efficient **Digital** systems

The long-term value of a National Geological Model lies not only in the model itself, but in the ability to efficiently update, regenerate, and trace the geological interpretations that underpin it.

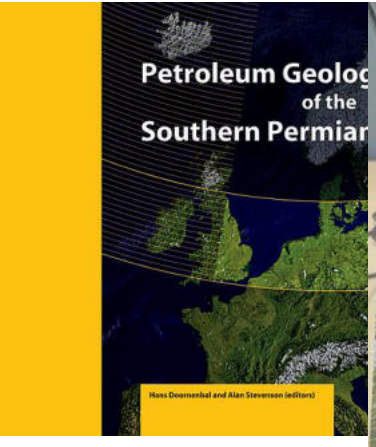
One Model, Many Applications

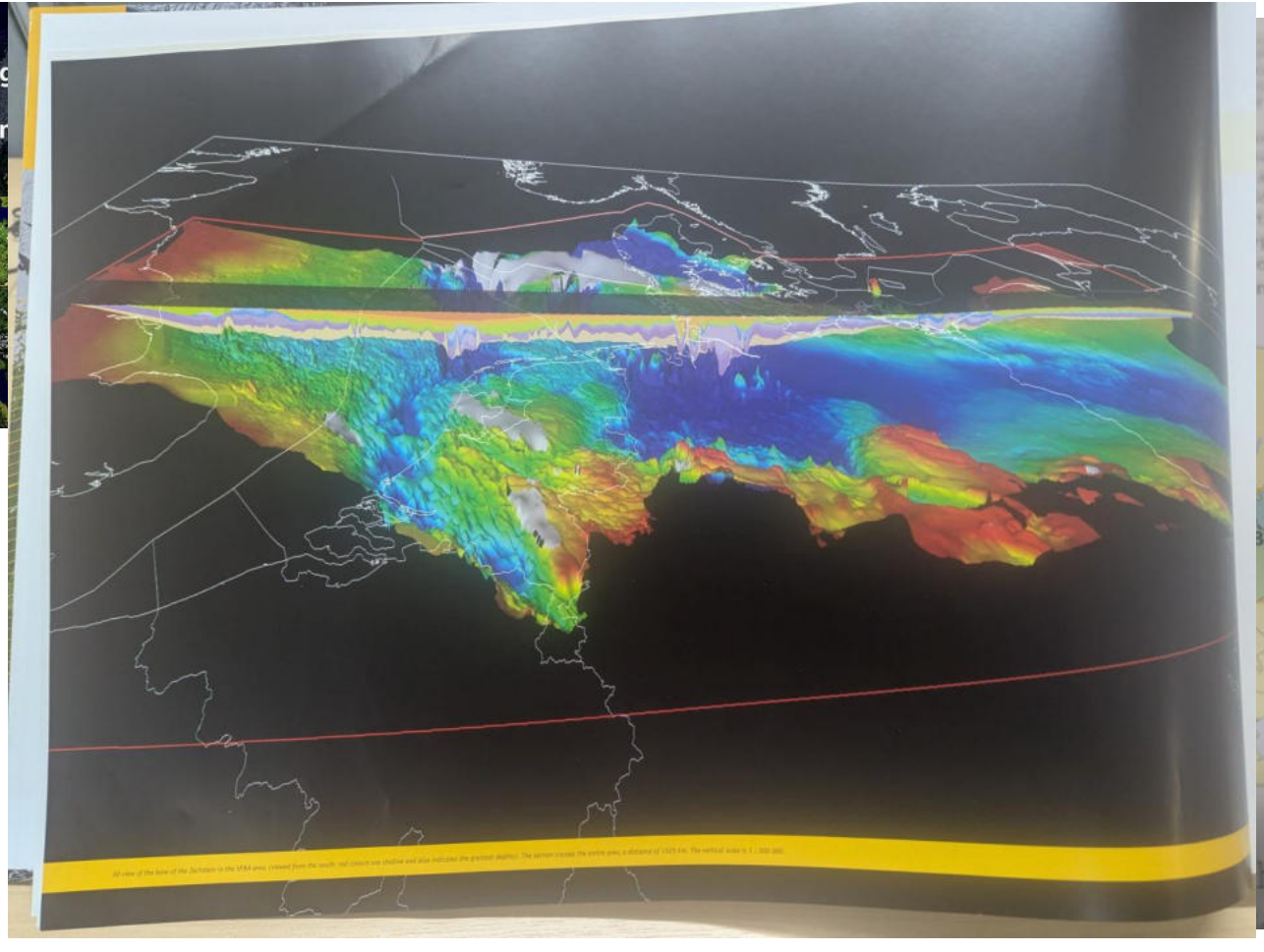
- To be useful, models need to be configured so they are relevant to the task.
- UK3D was re-purposed three different times:
  - Aquifer management and understanding of groundwater systems.
  - Shale gas prospectivity and groundwater vulnerability assessments.
  - Screening for the geological disposal of radioactive waste



Are we building a model for a specific purpose, or a geological platform that can be repeatedly repurposed to address future challenges?

Southern Permian Basin Atlas – learn from past projects







Some things to consider before embarking on the national/multi-national 3D geological model journey

Should the focus be on delivering a single model, or on creating an authoritative subsurface platform that supports multiple applications?

> e.g. can the same framework underpin groundwater, geothermal, carbon storage, mineral resource, engineering geology, and hazard assessments?

Should a national geological model be viewed as a one-off publication/dataset, or as continuously maintained national/multi-national dataset?

A national geological model assumes a coherent understanding of the geology for the whole of the country – how do we convey that this is not the case?!

Should a national geological model aim to represent all known geology, or only the geology that matters for national applications?

