British Geological Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

Workshop on 3D geological modelling methodologies: an overview of activities in BGS

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Andy Kingdon
Team Leader: Parameterisation and Statistics
British Geological Survey
aki@bgs.ac.uk
+44 115 936 3415

BGS and 3D modelling

- This is a brief overview of the multiple strands of 3D modelling within BGS from ingestion of data to final model delivery
  - Some of these activities are complete and have been delivered to our end-users
  - Some are still research activities undertaken within BGS for our own needs
- The following presentation is complex because so is the role of 3D within our work

BGS representatives at this meeting

Expertise from across BGS modelling science

- **Rachel Dearden – Development of products & delivery**
  - Knowledge exchange for model outputs

- **Holger Kessler –Team Leader: Geological Modelling Systems**
  - Delivery of 3D modelling technology and methodology

- **Andy Kingdon – Team Leader: Parameterisation & Statistics**
  - Stochastic modelling / subsurface property attribution

- **Murray Lark – Environmental Statistician**
  - Model uncertainty / statistical variability of property

- **Bruce Napier –Team Leader: Visualisation Systems**
  - Visualising geological information in 3D

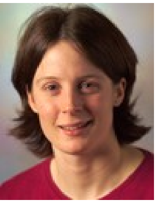
- **Martin Nayembil – Data Architect / Oracle developer**
  - Tools and infrastructures for manipulating geodata

- **Paul Williamson – GOCAD & statistical modeller**
  - Creation of 3D property models, algorithm development

BGS representatives at this meeting

Expertise from across BGS modelling science

- **Diarmad Campbell**
  - Chief Geologist Scotland / project leader “Clyde Urban Super Project”



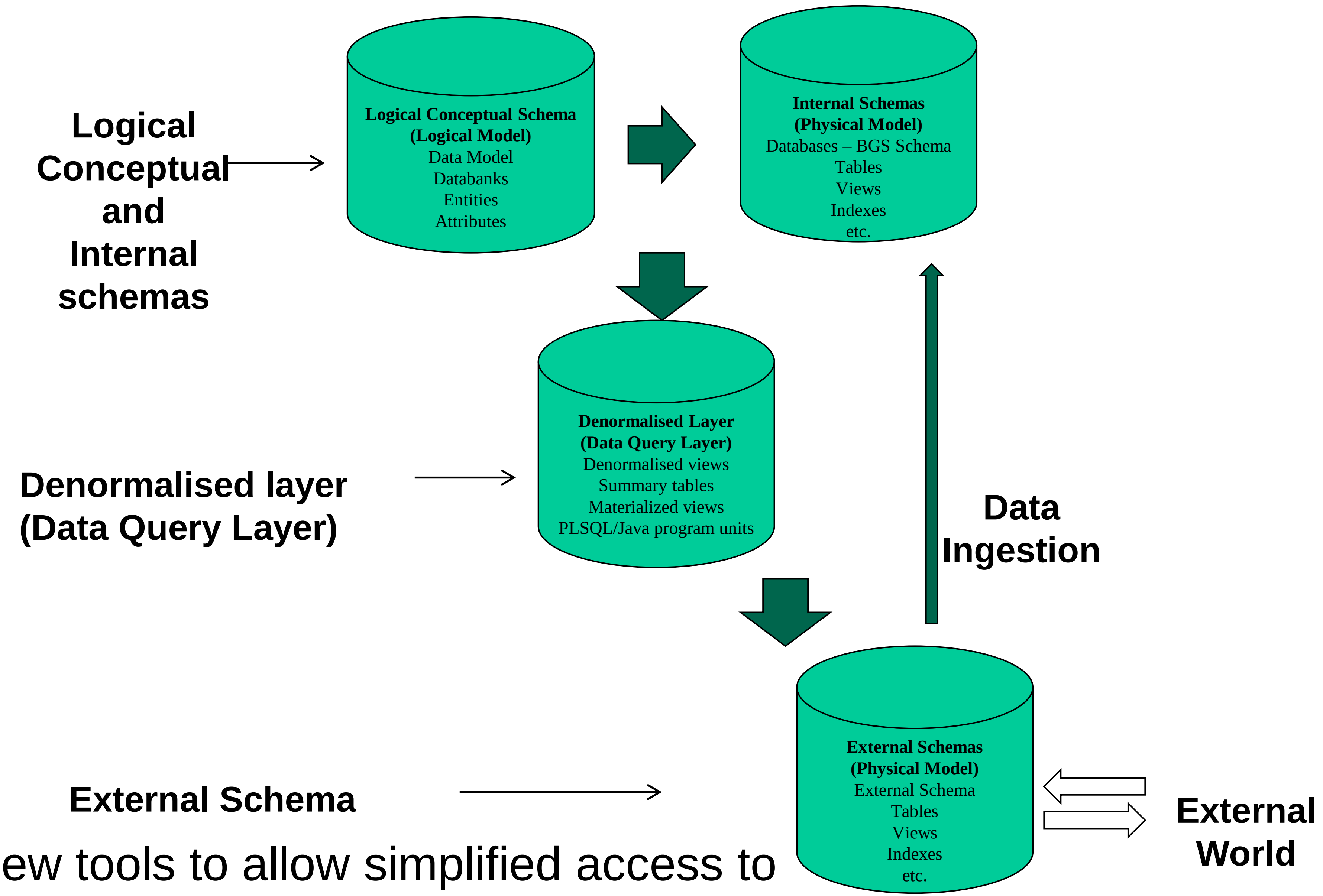
- **Katie Whitbeard**
  - Geological mapping and 3D modelling in Scotland and Northern England

Glasgow in Scotland is increasingly an exemplar of the application of 3D modelling to the study of complex urban geology

Data tools & Architecture

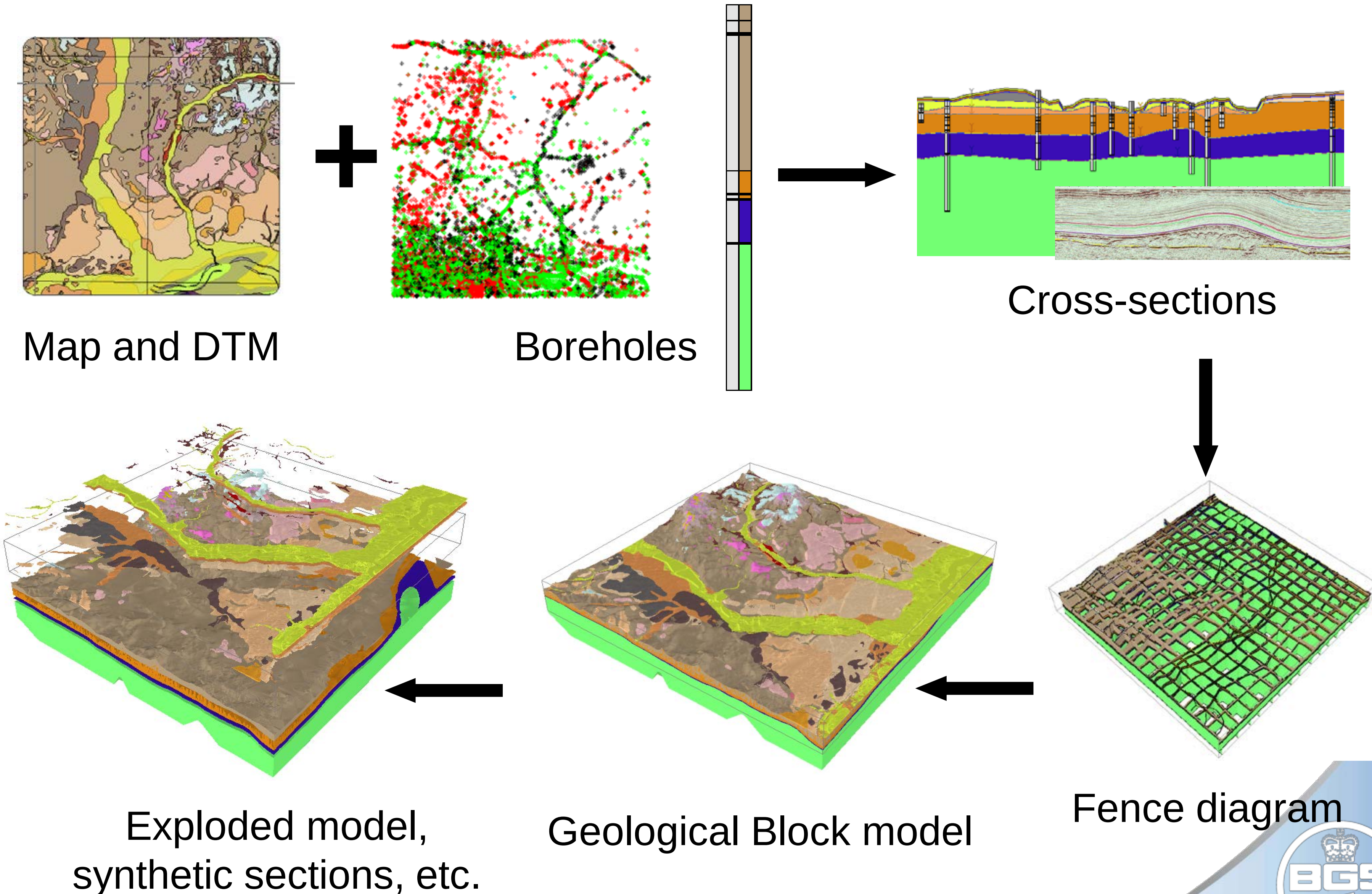
- Planned SAN storage for specialised datasets **or**
- Data holdings stored either within a RDBMS (Oracle 10g®)
- Maintain the integrity of the database designs and data held within them using business rules, standards, dictionaries and good design practices.
  - Ensures co-ordinated data management and data consistency
  - Data centralised for concurrent access by all
  - Structured data for querying
  - Uniqueness / security / auditing / traceability
- Issues: But also project datasets distributed across project websites requiring a corporate solution
- **New Requirement:** Denormalisation tables/tools provide simplified access for users to provide data within BGS from parameterised 3D models and ultimately to users outside BGS

Data Architecture: Component Parts



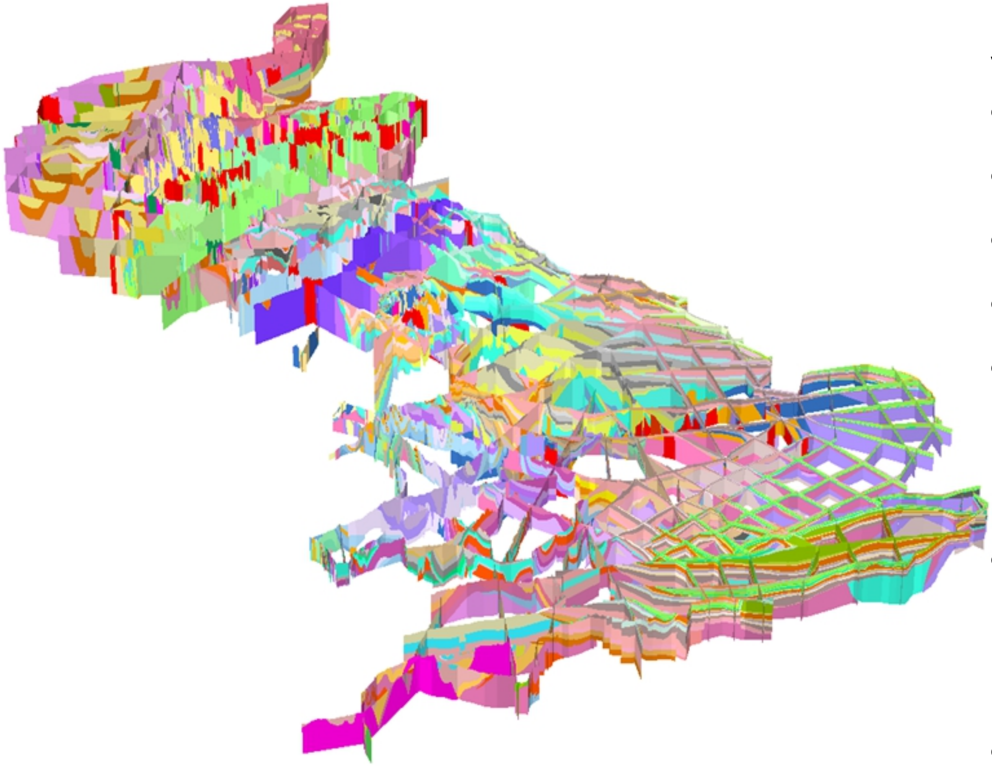
New tools to allow simplified access to data within BGS and soon outside too

Geological Models ("3D maps")



Kessler, H., Mathers, S.J. & H.-G. Sobisch. 2009. The capture and dissemination of integrated 3D geospatial knowledge at the British Geological Survey using GSI3D software and methodology. Computers & Geosciences, 35, 1311–1321

GB3D National Bedrock Model 2009-13



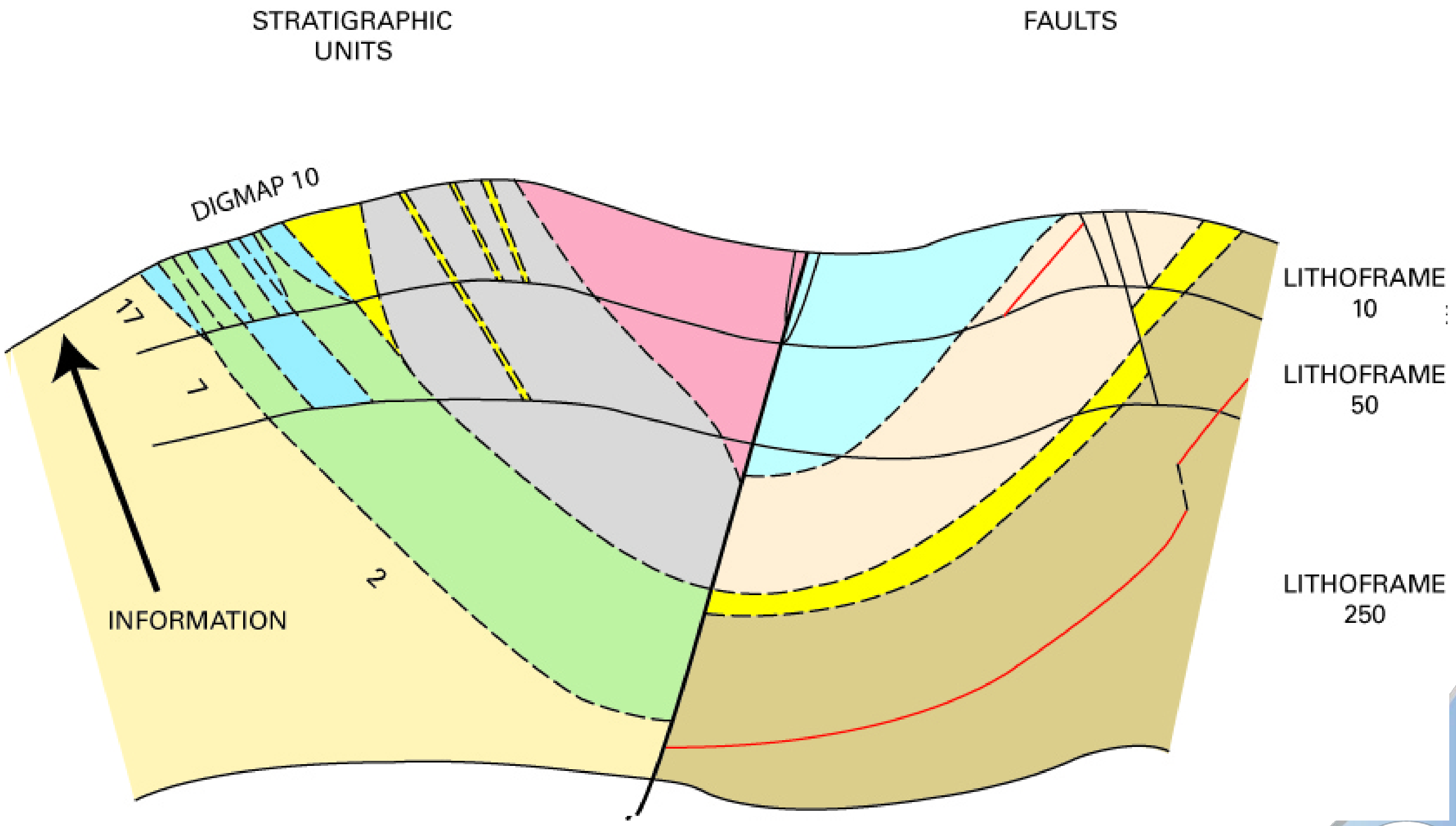
Statistics

- Funded by EA (£150K) plus BGS
- 121 sections,
- 22,000 line km
- Sections 1.5-5.5 km depth
- Built in GSI3D by 15 regional geologists supported by data managers
- Released on BGS website in 6 formats **incl Petrel and GOCAD/Skua** to base Pridoli
- Accompanied by a metadata report,
- DOI has been minted
- Methodology paper is in press with the open access Geoscience Data Journal

Uses:

- Public understanding of science by DECC
- EA risk to aquifers from shale gas
- BGS regional guide
- Thames catchment groundwater model

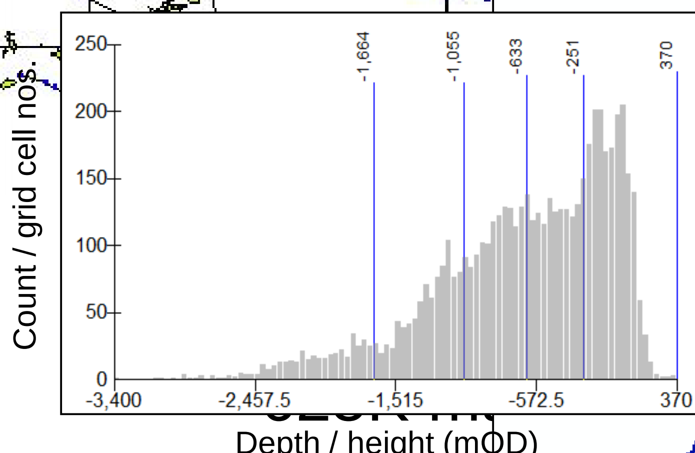
GB3D: Multi-scale modelling

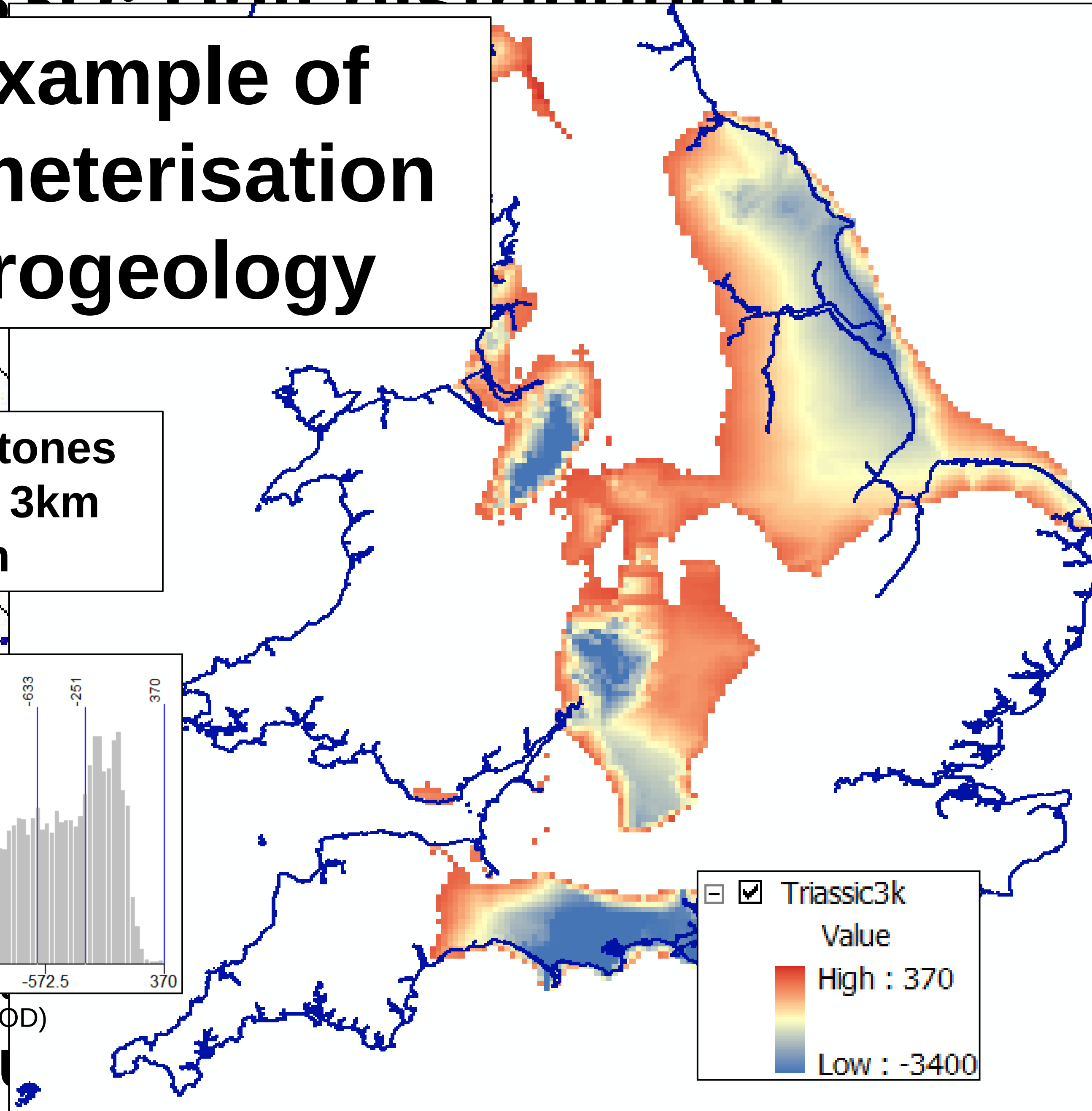


GB3D: Unit distribution

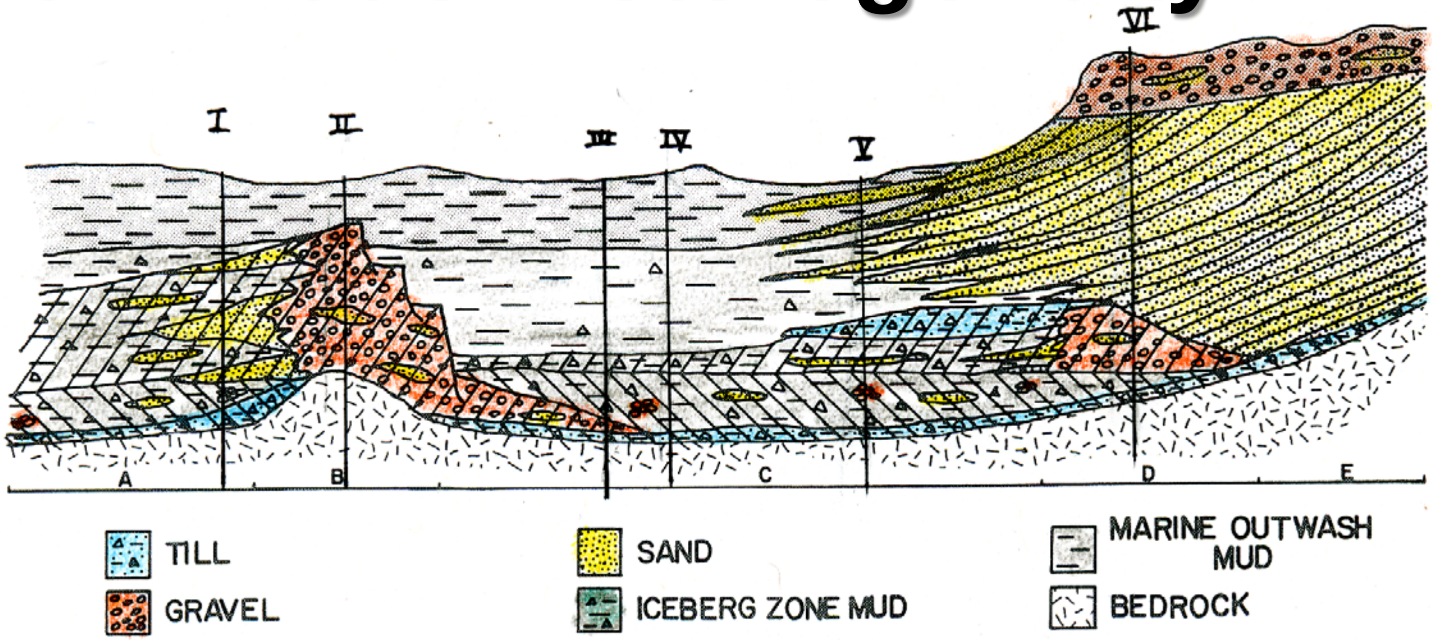
GB3D: Example of bulk parameterisation EA iHydrogeology

Triassic sandstones (base) crop at 3km resolution

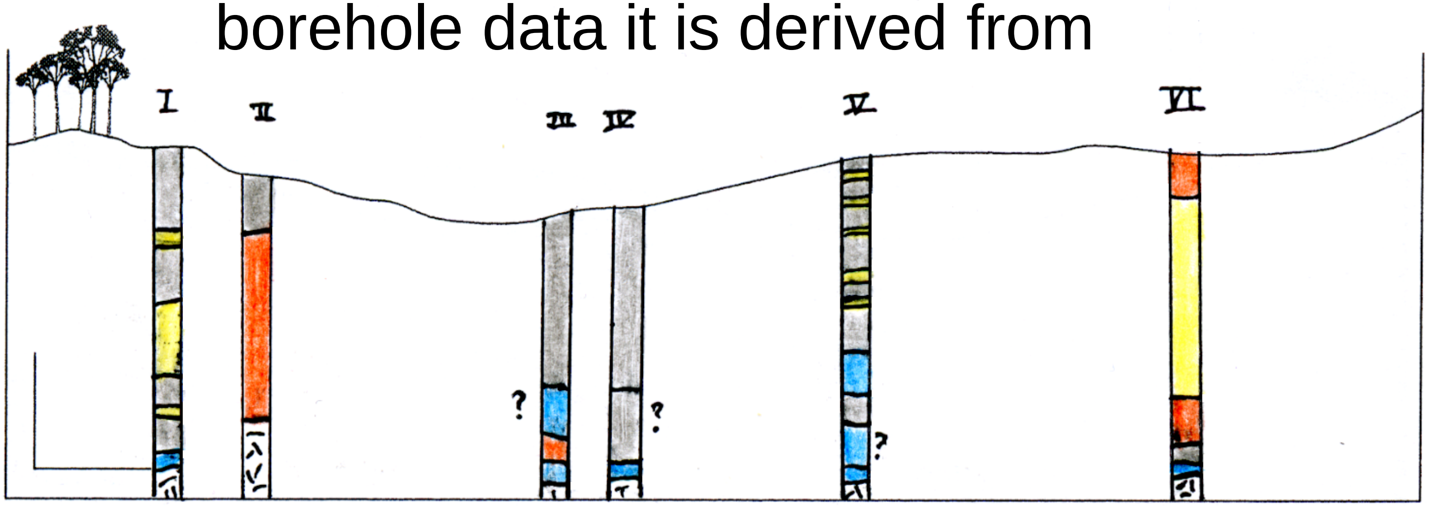




3D model heterogeneity

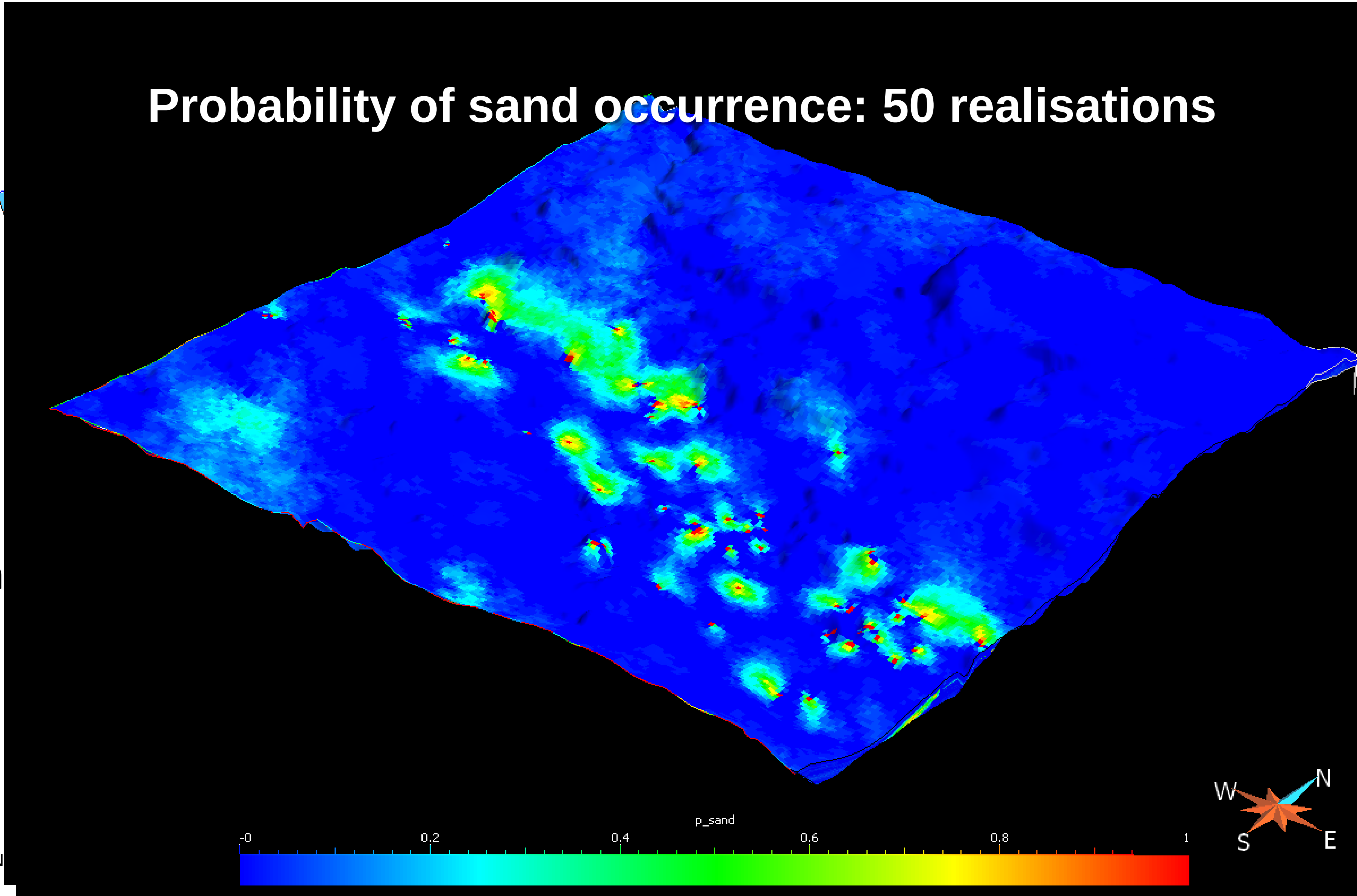


Comparison of cross-sections of glacial materials and the borehole data it is derived from



Glasgow Modelling:

Deterministic vs. Stochastic



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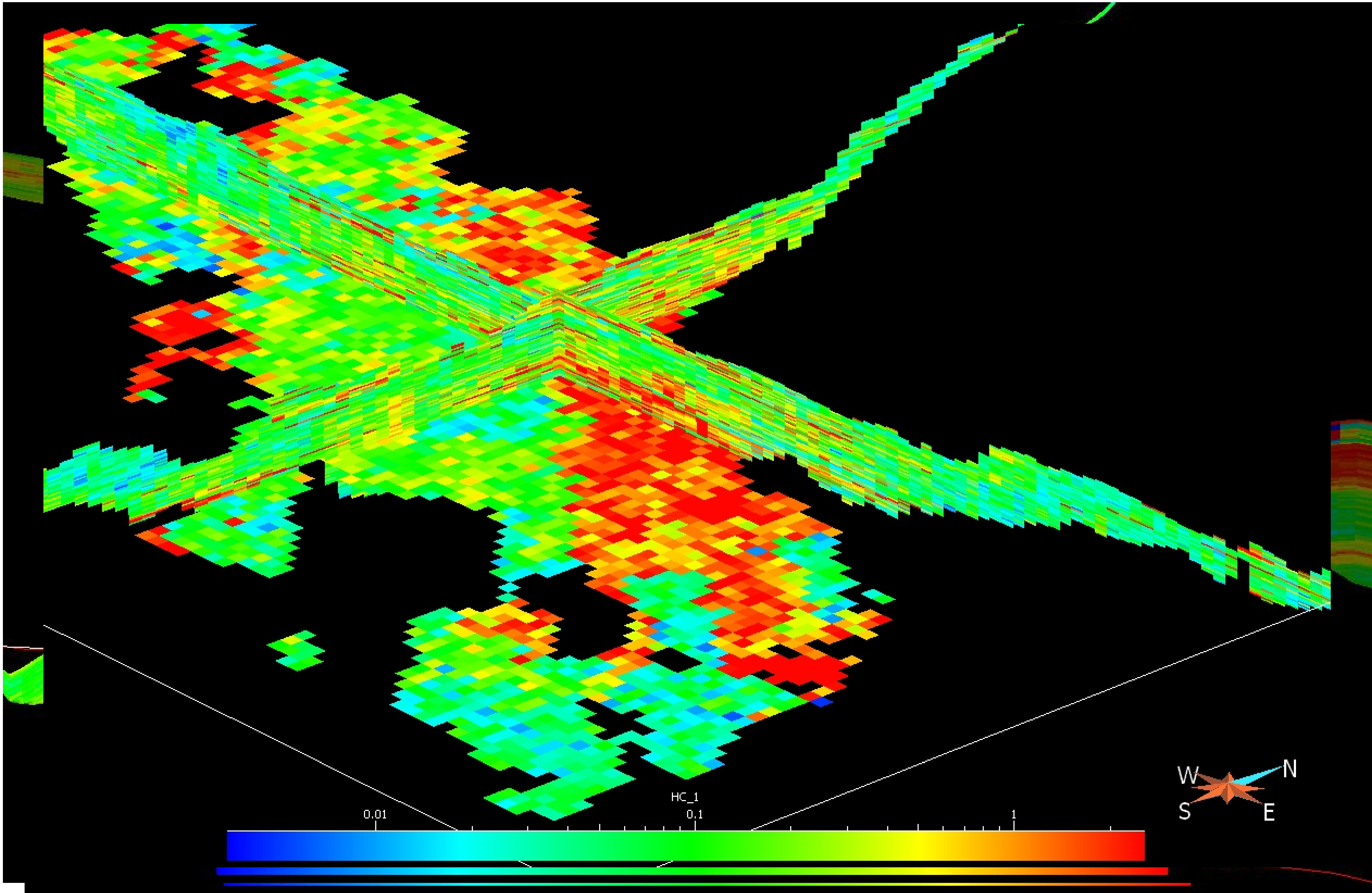
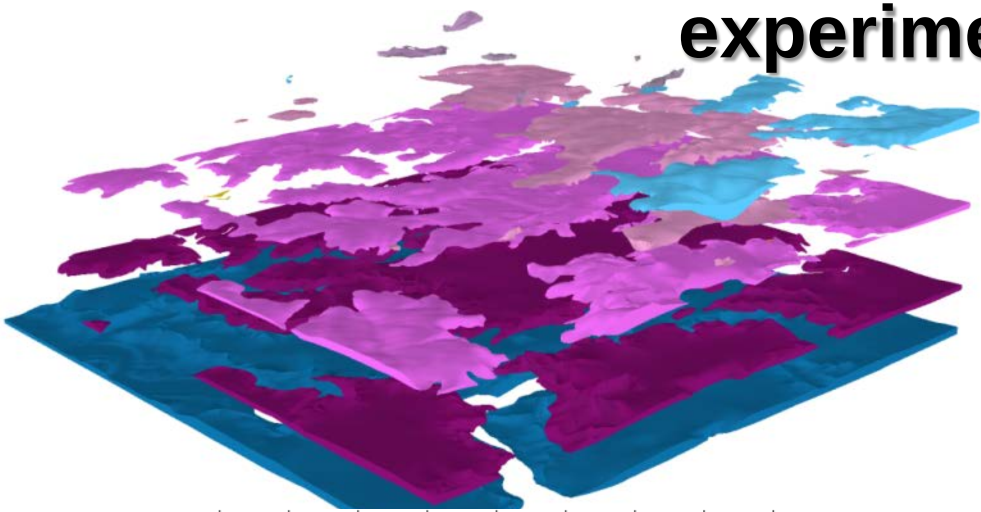
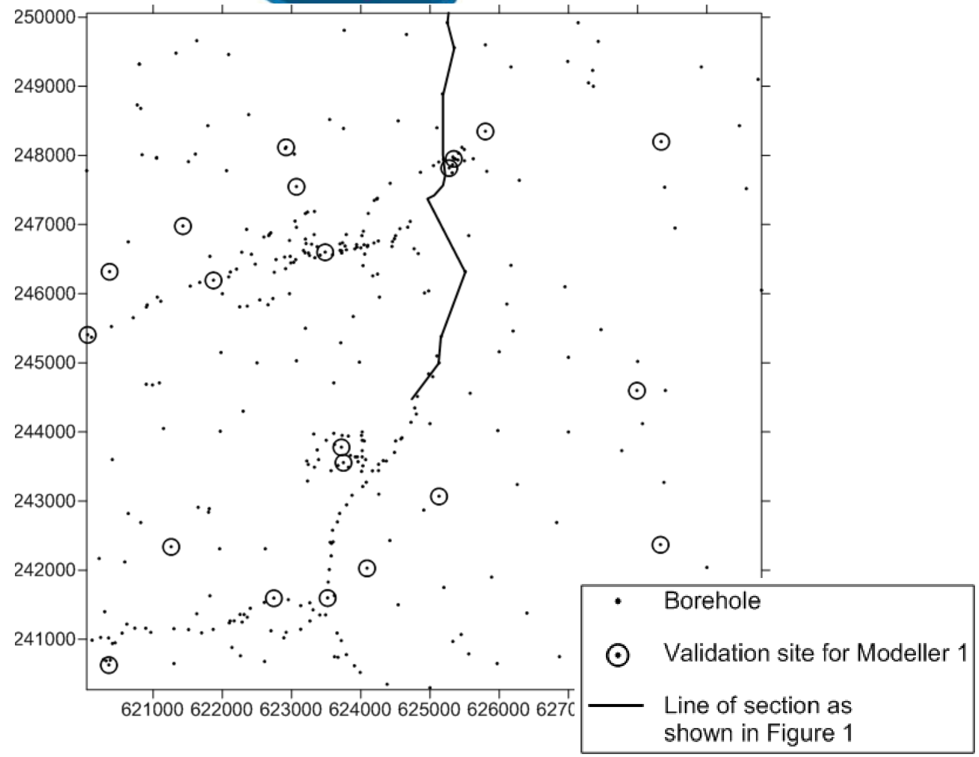
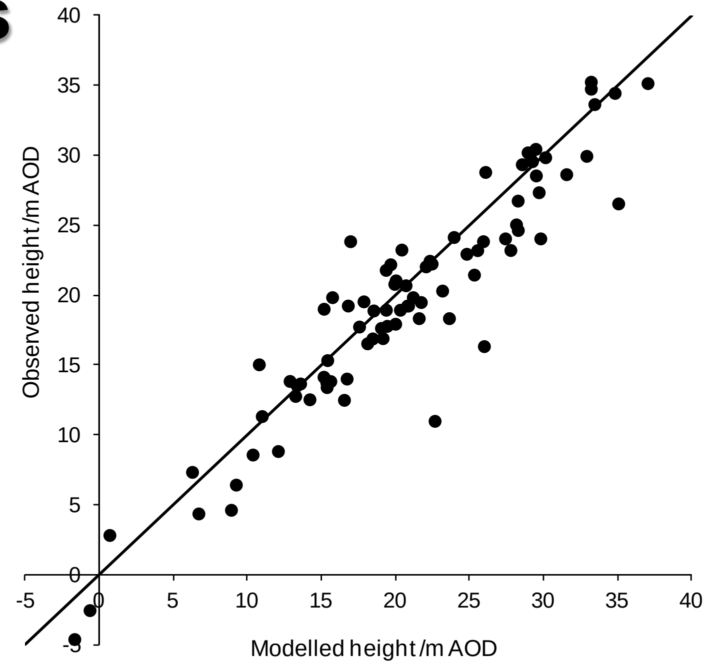
Property Modelling: Bulk density

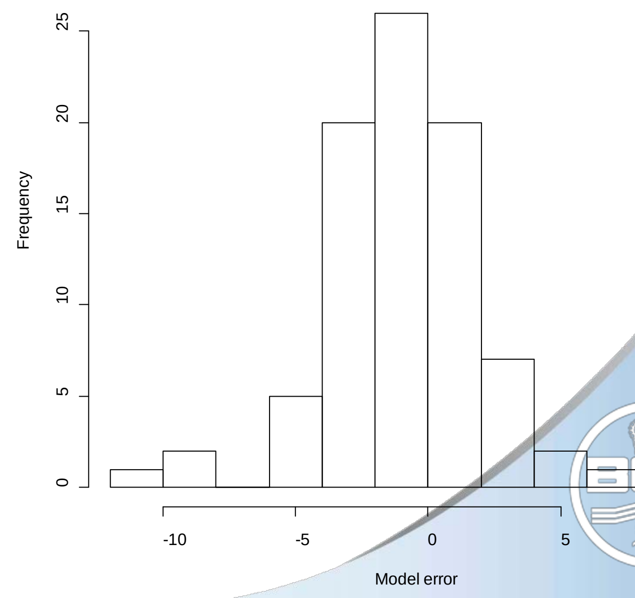


Statistical assessment of model error: designed experiments

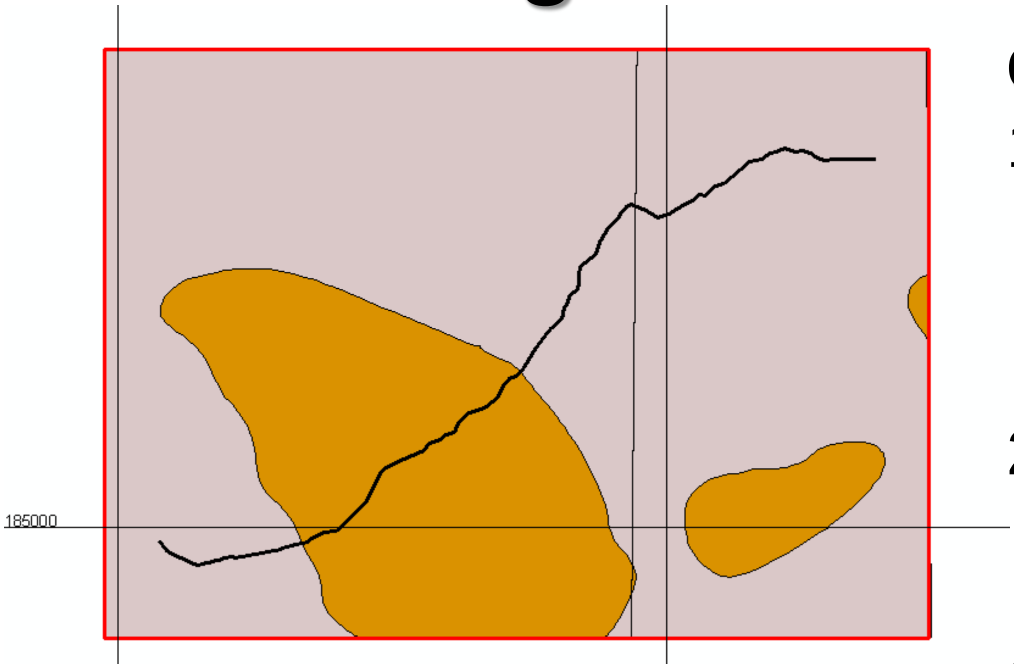


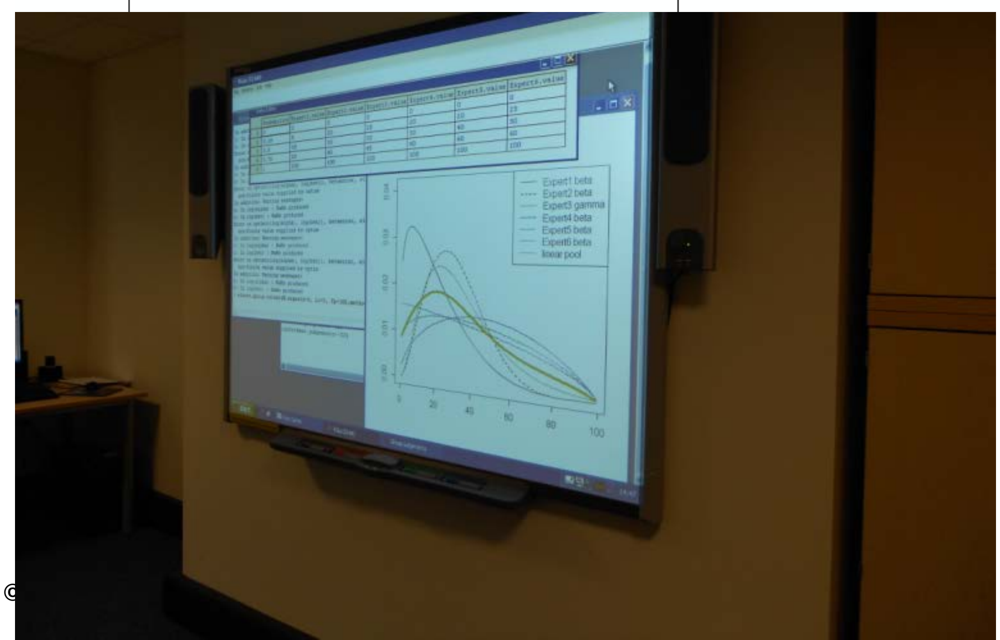






Modelling Uncertainty Assessment

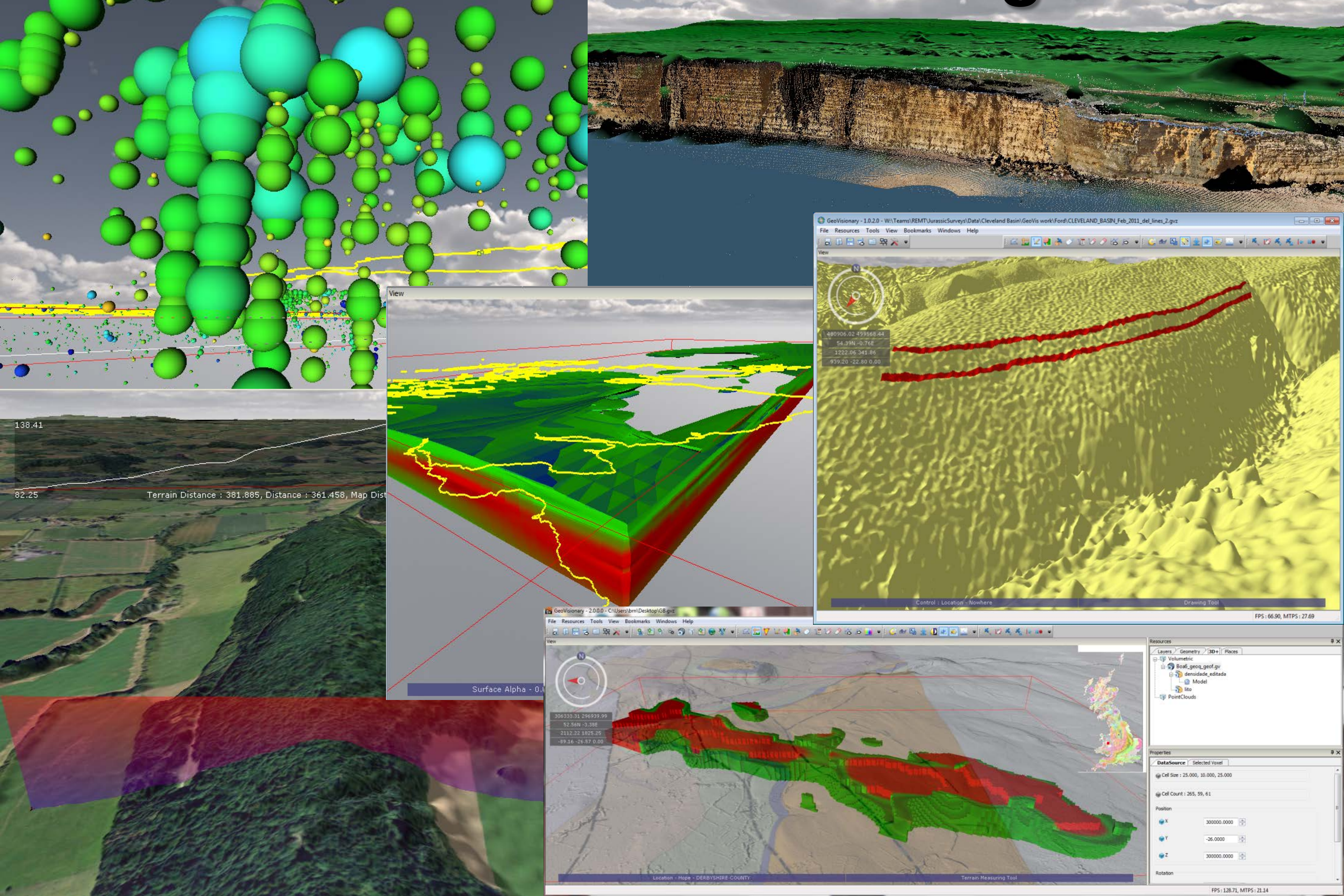




Current questions:

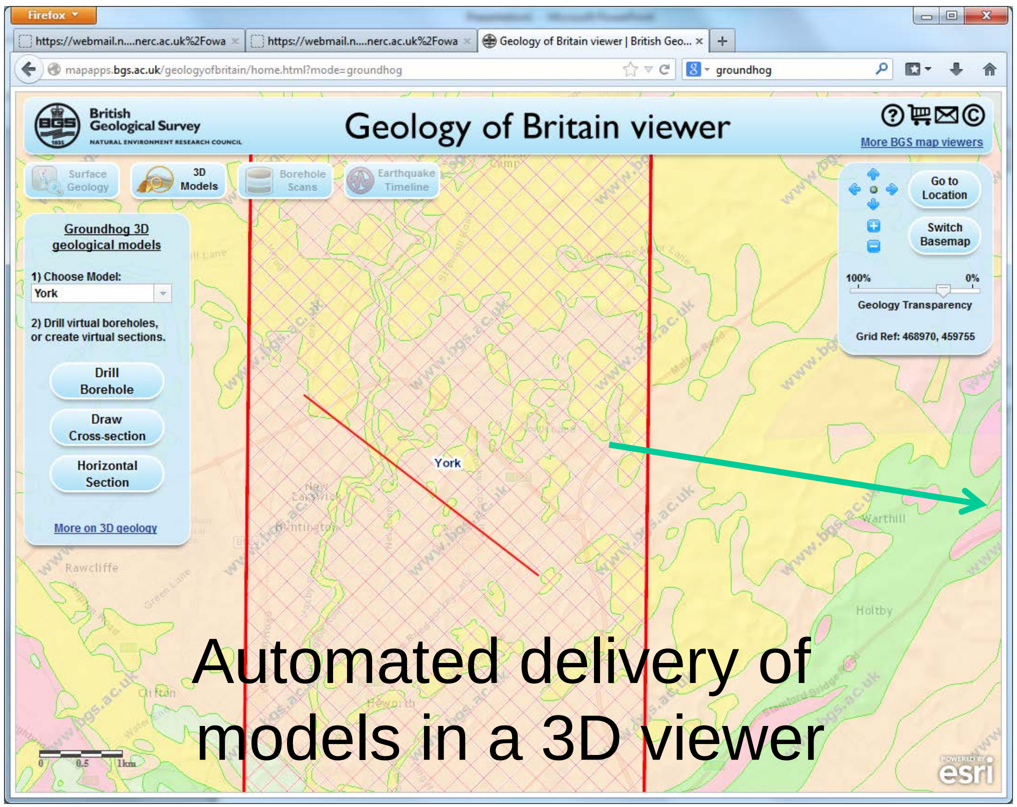
1. What controls the uncertainty of interpretations along cross-sections?
2. How does this uncertainty propagate on interpolation to 3-D volumes?
3. Can expert elicitation provide meaningful quantitative information where data are sparse?

Visualisation Technologies

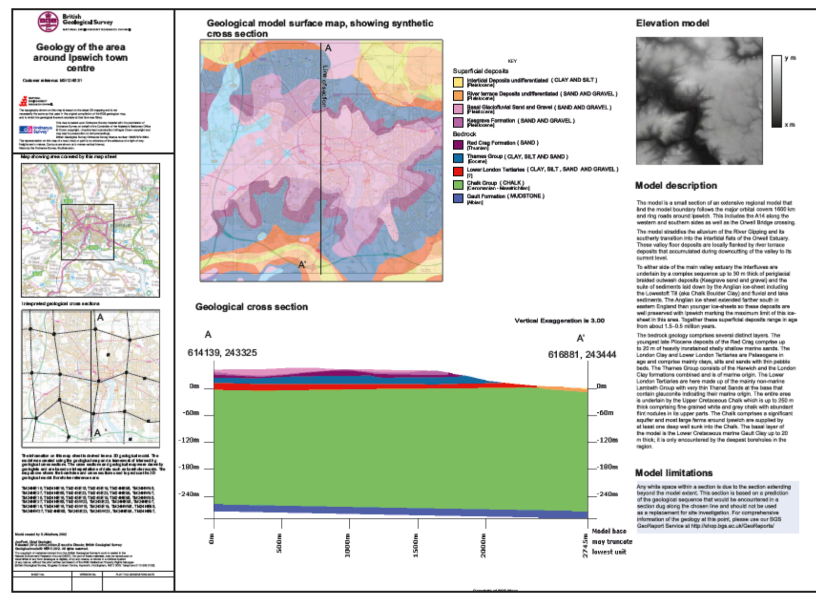


3D model data delivery

- **Short-term aims**
- Commercialise web delivery of *approved* 3D geological models:
  - Using Groundhog for synthetic boreholes & vertical & horizontal cross sections
  - Via 2D grids for top and base surfaces and thicknesses



Automated delivery of models in a 3D viewer



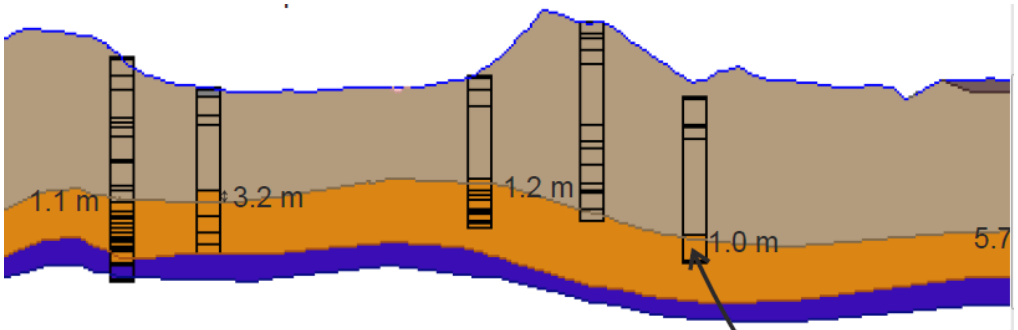
Look and feel of a traditional map

Long-term aims in model provision

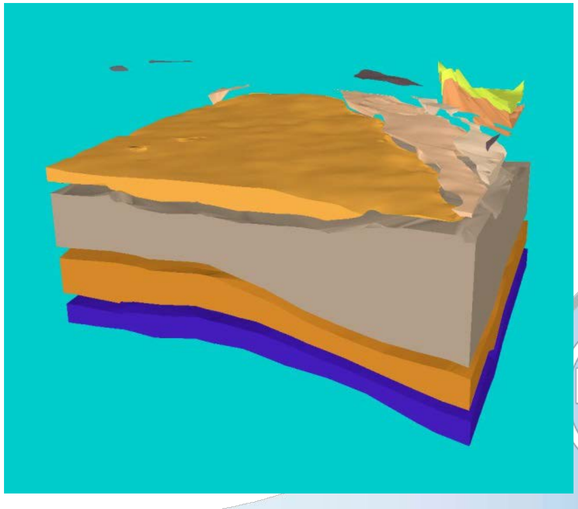
- Provision of 3D geological models within which users can:
    - Add data
    - Edit surfaces (via modifications to cross sections for example)
- Aspiration to enable external model users to submit revised interpretations to BGS
- BGS role to quality assurance and check externally generated line work.

Issues to resolve

- Solving the confidential data problem, so that models can be delivered with raw (borehole) data?
- Educating end-users about how to use and update models
- Indicating model uncertainty in a meaningful way
- Maps and models: keep them in sync. or let them diverge?



External borehole data imported to an existing geological model



Issues:

- Model Management:
  - Versioning, reproducibility and storing models
- Data capture and serving input data
- Modelling type to be used?
  - When is data sufficient to allow stochastic modelling?
  - When to use deterministic / stochastic / stochastic with layers?
- Managing uncertainty
  - Calculating and expressing uncertainty studies
- Availability of skills
- Integration of all of these activities as a coherent whole
- Delivering meaningful, usable outputs within and outside BGS
- Making models repeatable and defendable