Development of a national geophysical log data archive: legacy data as a national asset

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Preserving and protecting your geological assets in a time of crisis?

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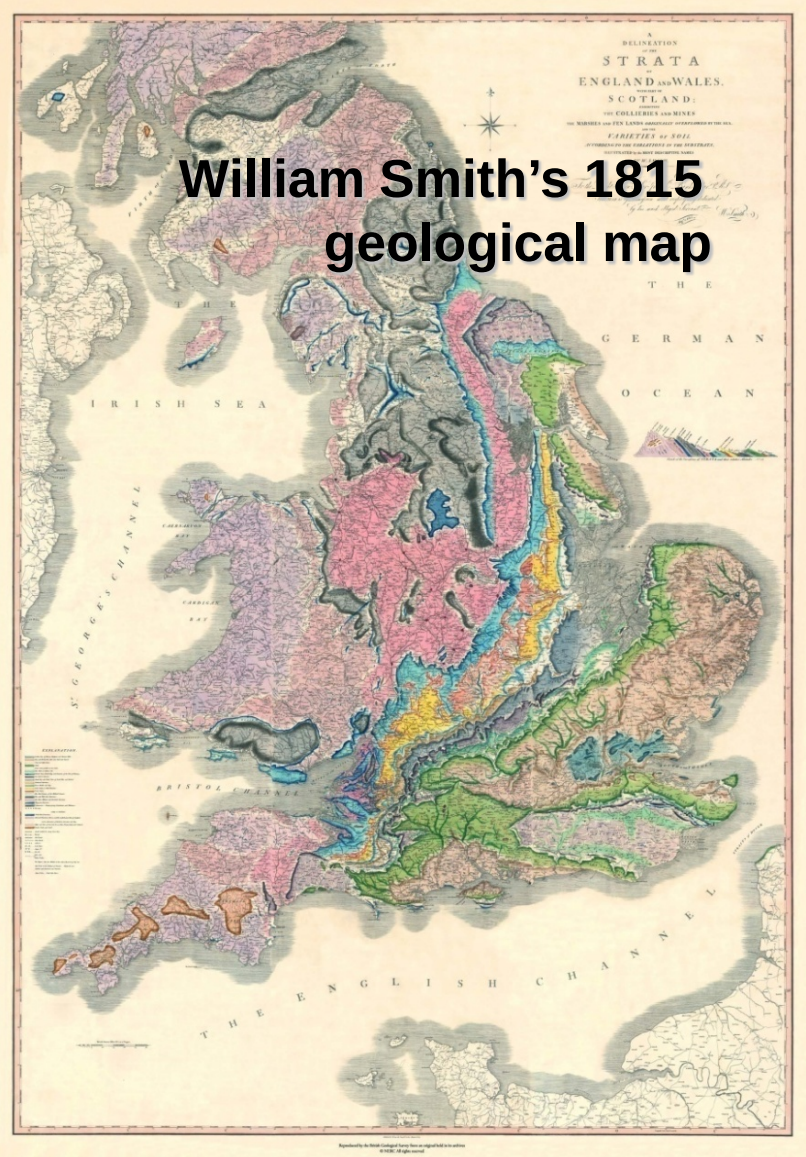
Nature of problem

- UK faces major challenges (no not that one)
- Geological issues arise quickly and unexpectedly
- Geological information a key component of decision making
  - Rapid aggregation of data is part of the solution
- Ensuring continuity of geological data is important for supporting the UK economy

BGS role for UK: past and present



William Smith's 1815 geological map

- Crises needing geological input are not new
  - Energy security
- 1815: End of Napoleonic wars kick-started Industrial Revolution.
- 1835: BGS setup to map UK coalfields for Industrial Revolution
- Today: Continuity of geological information essential for UK economy
- Future needs for subsurface information are unpredictable

Additional Pressures

- Financial pressures
  - Need to reduce cost of software licensing
  - Moving from: data storage within proprietary software
  - To: archival in universally accessible format
- Succession planning
  - Retirements of longstanding staff
  - Loss of domain knowledge
- Data Management Rationale
  - not just data preservation
  - Organising of data in most accessible way for future (as yet unknown) uses
  - Managed use allowing scoring data on appropriateness

Question 1: What do we know?

- Need to aggregate all information about a location
- Need all data together so relevance can be assessed
- Need quality attributes so data value can be assessed
- Need to ensure relevant stratigraphy can be sampled
- Is data digital or analogue?
- Can we understand uncertainty and defend interpretations against robust scrutiny

Geophysical logs

- Geophysical logs describe subsurface properties and stratigraphy

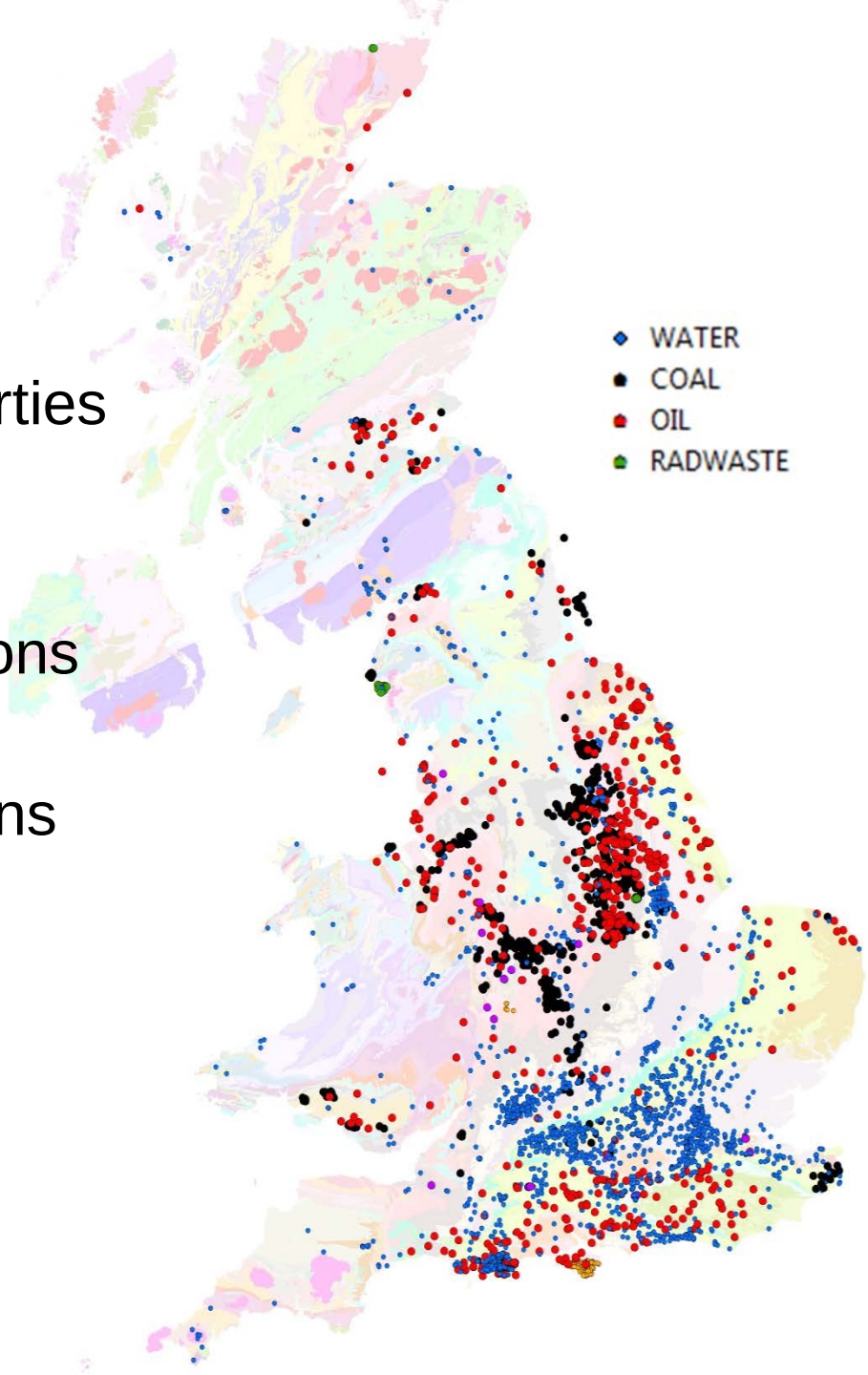
- UK have maintained database of geophysical logs for 30 years to underpin regional geological interpretations

- BGS collects datasets for our own science
  - But gives capacity to answer questions when asked

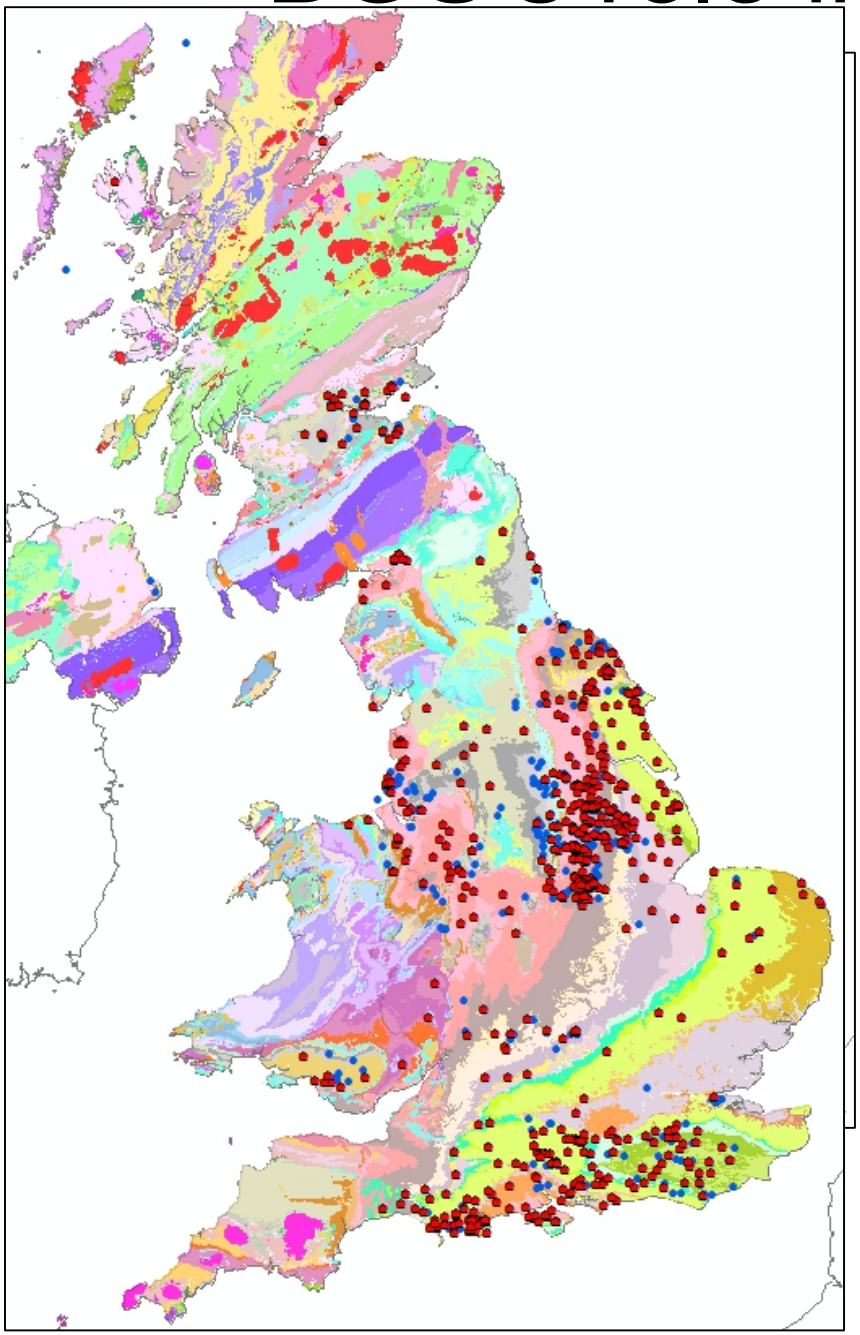
- Digital essential for use
  - Original digital data always preferred
  - Analogues data requires expensive conditioning

UK Onshore Digital Geophysical Log Database

- Logs describe subsurface properties & stratigraphy
- BGS collects for own science
- Gives capacity to answer questions
- Geophysical logs for 30 years to underpin geological interpretations
- BGS collates deep digital data geophysical log for UK wells
- Increasing onshore data:
  - 2006: 3150 wells, 12000 curves
  - 2016: 4580 wells, 192000 curves



BGS's role in digital log data



- UK Coal data: variable coverage
  - Acquired 1950-1995
  - Non-standard suite
  - Units, tools quality standardised with time
- Metadata quality:
  - very poor
- Data Quality
  - Some poor data, most suboptimal
  - Later data high quality
- UK Oil deep geophysical log data
  - BGS now integrated into DECC system
  - Systematic collection of original digital data
  - Acquired WW2-today
  - Units, tools quality standardised with time
- Metadata quality
  - very good
- Data Quality
  - Most recent wells have excellent logs
  - High quality imaging

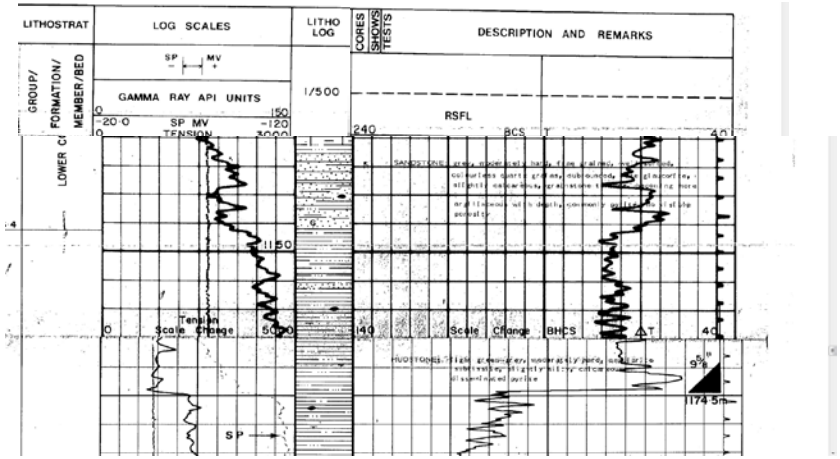
Log Data quality and lifecycle

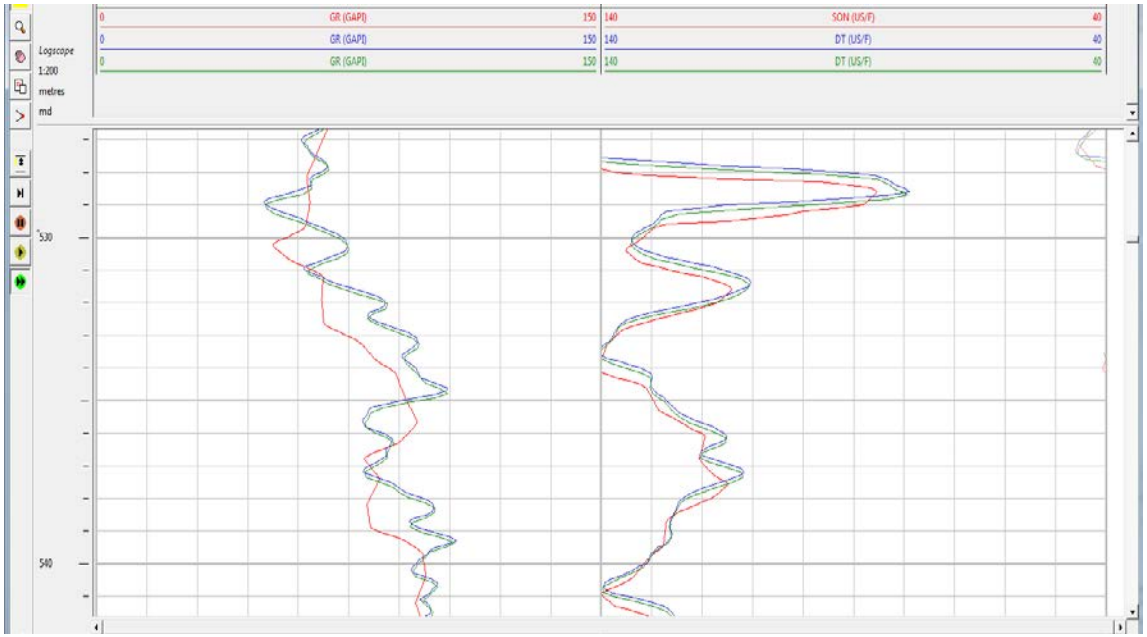
- Log data has long lifespan
- Industry data management is of highly variable quality
  - Correlation between bad data management & bad data
- Good data management saves time & good for UK PLC
- Useful data and metadata in composite plots and reports
- Data scoring for quality and completeness

Example 1: UK Shale gas reserves

- UK Carboniferous equivalent to US shales gas units
  - Poorly sampled and heterogeneous
- ~2010 BGS quantifying UK shale gas resources
- After Blackpool tremors high public scrutiny …
- Assessment of highly uncertain reserves demanded
  - Wells sampling shales in-situ limited, even
  - Wells sampling overlying strata are often old.
- Geophysical logs allowed calculation of reserves
  - Despite poor data, metadata allowed clear statements of uncertainty
  - Data improved for Weald report leading to higher certainty
  - not been challenged by either side

Best and worst practise with UK well data management



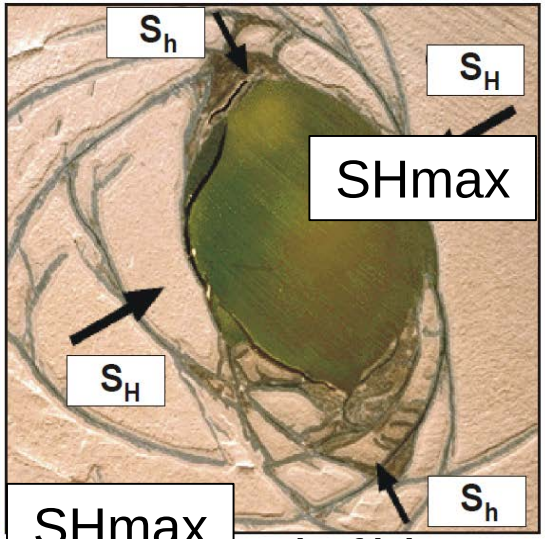


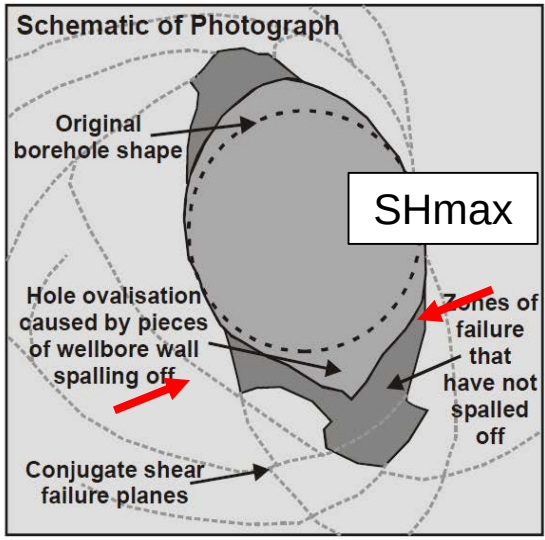
Case Study 2: understanding in-situ stress orientation

- **Royal Society & Royal Academy of Engineering, 2012, Shale gas extraction in the UK: a review of hydraulic fracturing**

- "BGS or other appropriate bodies should carry out national surveys to characterise stresses and identify faults in UK shales"

- Breakouts: stress-induced enlargements of the cross section of the well
- Breakouts form perpendicular to the direction of maximum horizontal stress (SHmax).





raph of laboratory simulated borehole breakout

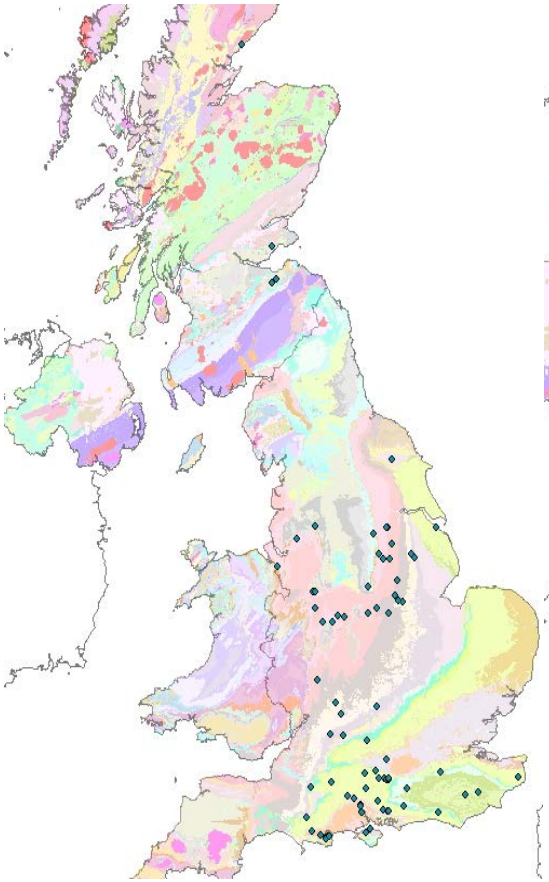
S_h: minimum and maximum of horizontal stress directions

Right: Diagram identifying the main features

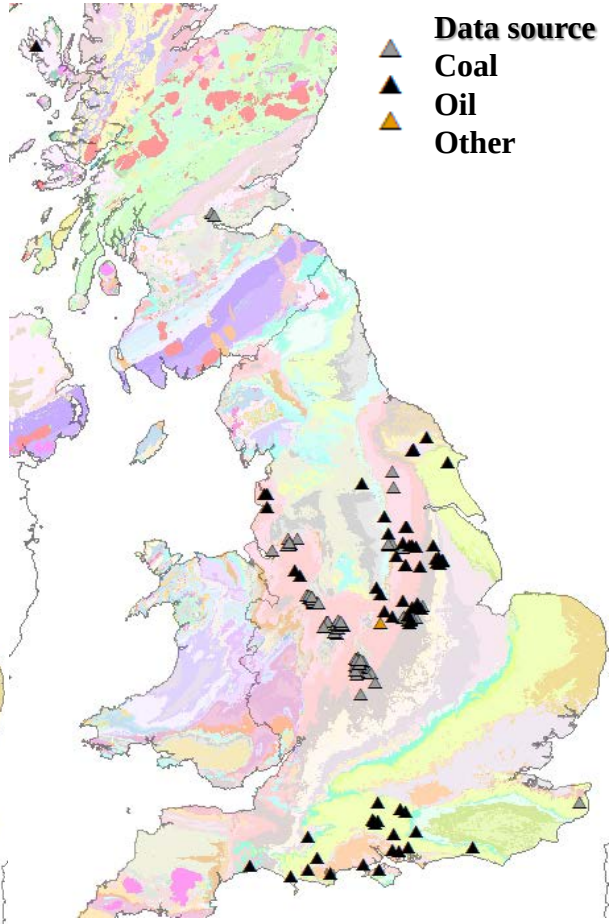
From Reinecker et al (2003)

Availability of new data

1990
Caliper Data



2015
Caliper Data



2015
Image Data

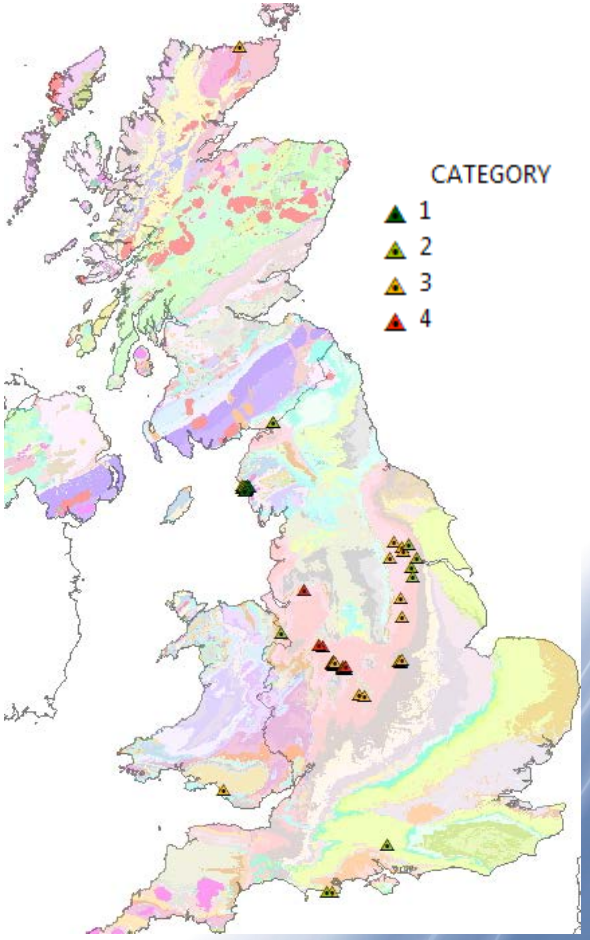
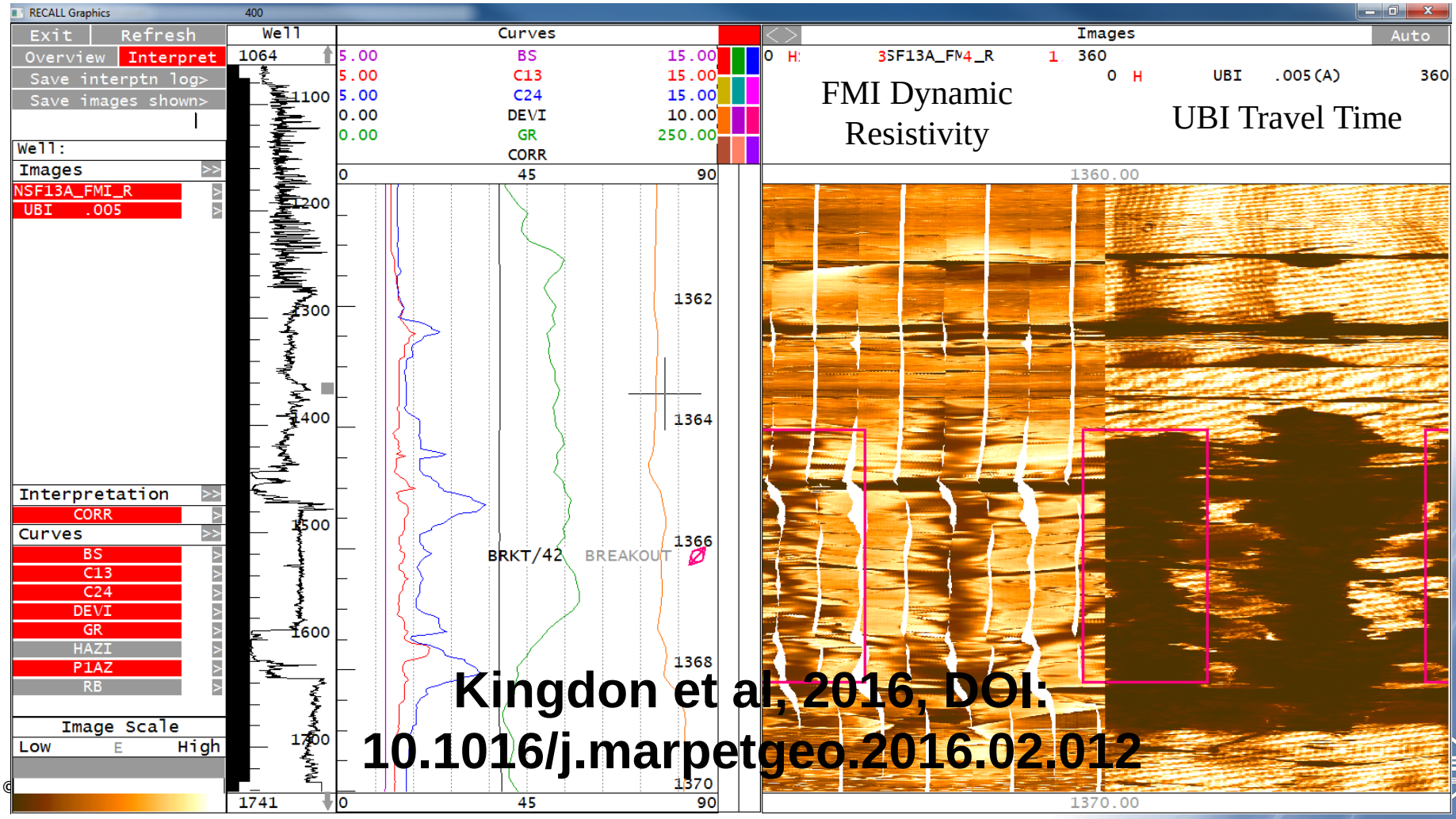


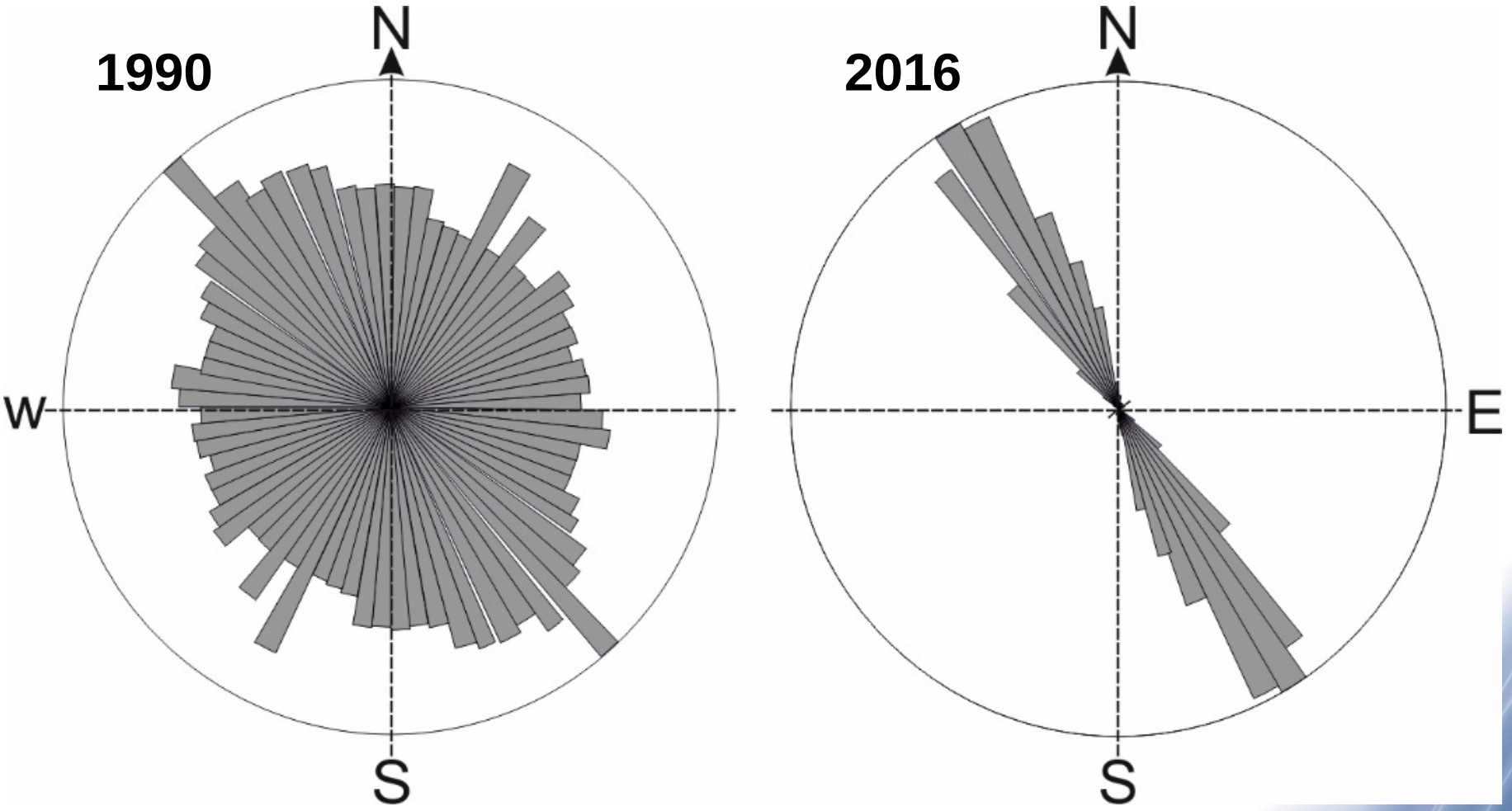
Image logging of breakouts

- Image logs provide much higher vertical resolution
- 2.5 mm vs. 5-15 cm
- Borehole wall coverage: 25% - 90%



Kingdon et al, 2016, DOI: 10.1016/j.marpetgeo.2016.02.012

Recalculated UK stress orientation

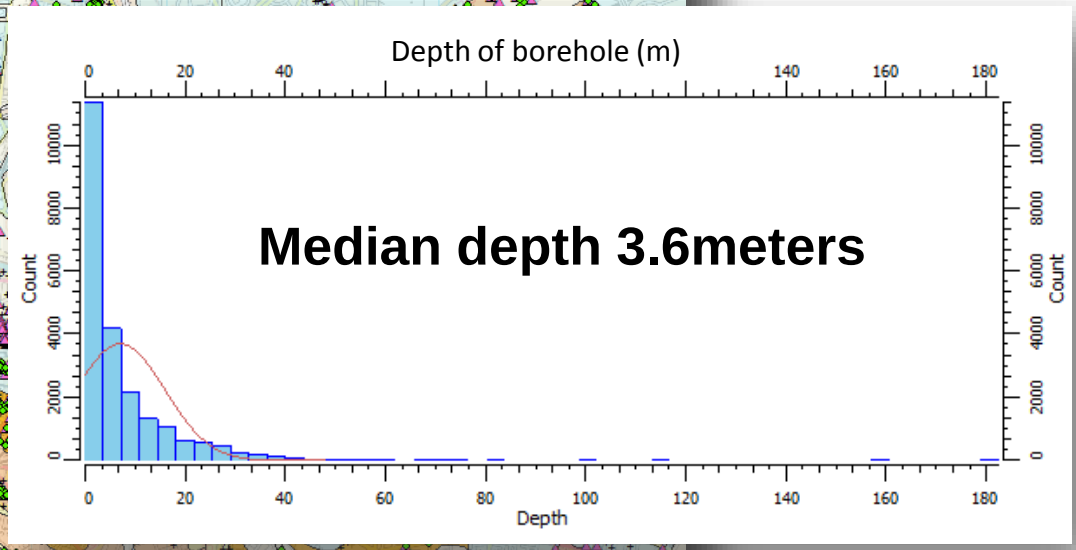


Kingdon et al, 2016, DOI: 10.1016/j.marpetgeo.2016.02.012

Case Study 3: PropBase Simplifying digital data conditioning & access

- BGS has previously prioritised data security
  - data stored securely and atomised
  - Taken precedence over need for data access
  - Data access requires new tools
- PropBase: Dynamic denormalised data structure
  - Procedural automated data conditioning
  - Transforms complex data into standardised outputs for use in multiple software packages
    - Webservices
    - GIS formats
    - CSV,TSV etc
  - Data available for immediate use

Digital borehole data in Glasgow



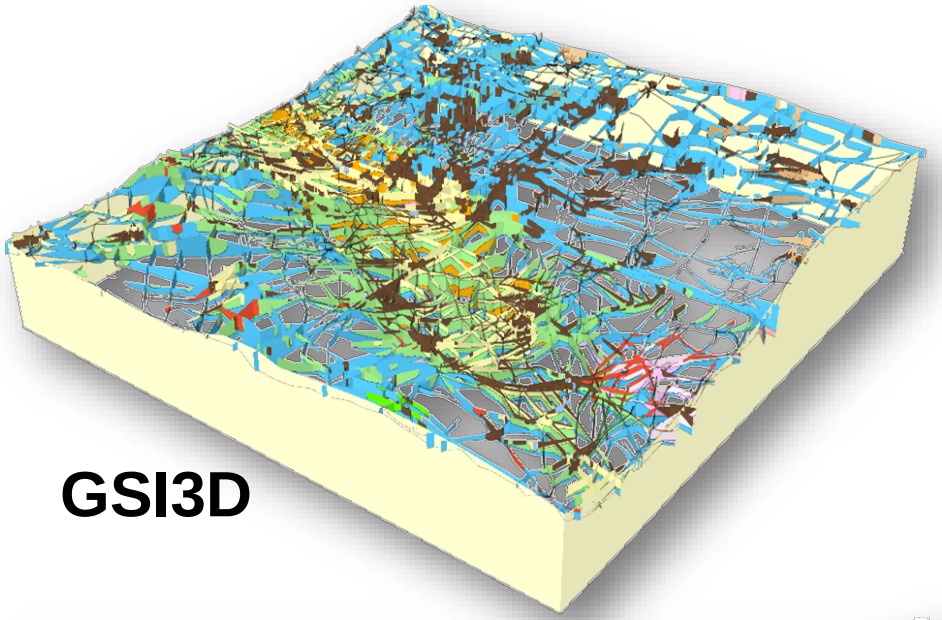
10,342
Boreholes/Trial Pits

Kearsey et 2015,
DOI: 10.1016/j.enggeo.2014.12.017

Glasgow 3D geological modelling

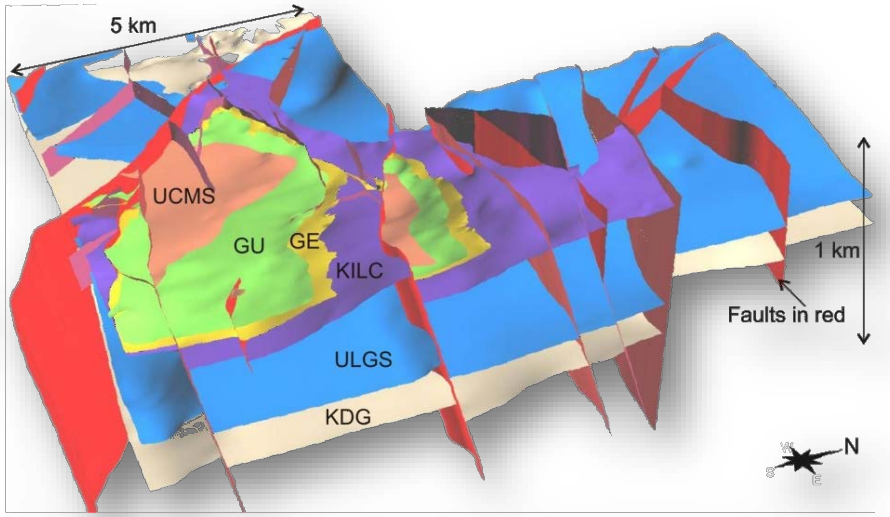
Variety of methods and software (inc. combined workflows) depending on local geology and data available

- **QA**
- **Metadata**
- **Uncertainty**
- **Delivery**

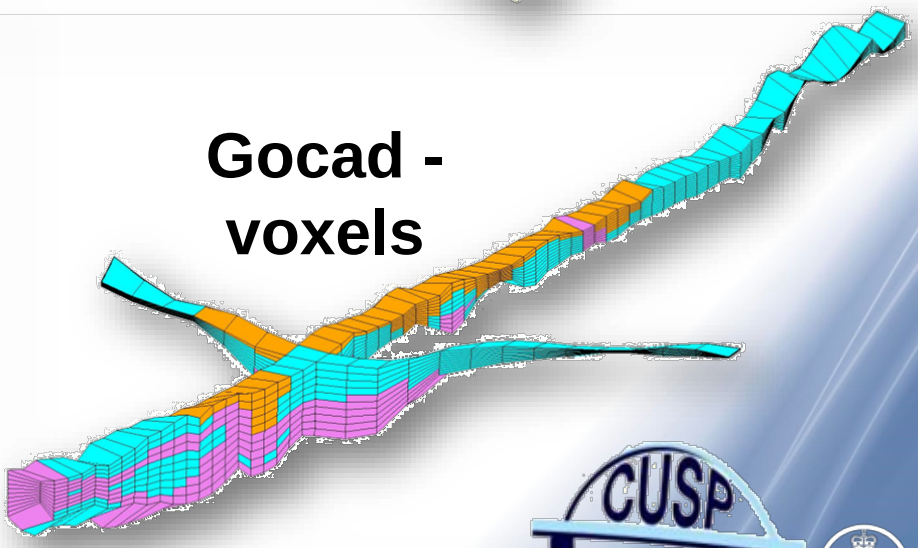


GSI3D

Gocad - surfaces



Gocad - voxels



Case Study Conclusions

- UK government, regulators and public need impartial information to support better decisions
- Geophysical log data allows BGS to inform real world decisions
- BGS needs to hold, manipulate and interpret these data
- Data MUST be quality assured
- Full metadata vital for assessing value of data
- Data and metadata ensures reliability of its interpretation

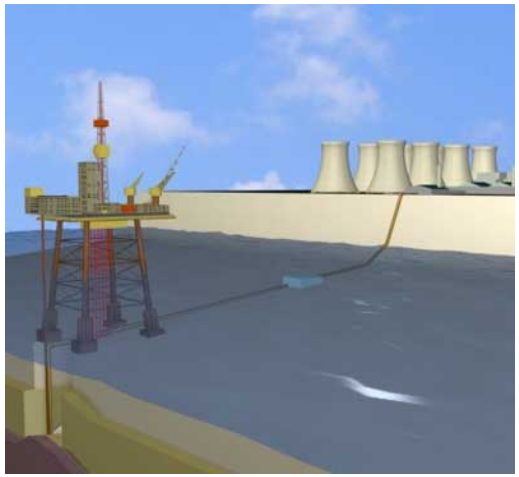
Conclusions: Data Management, Standards & formats

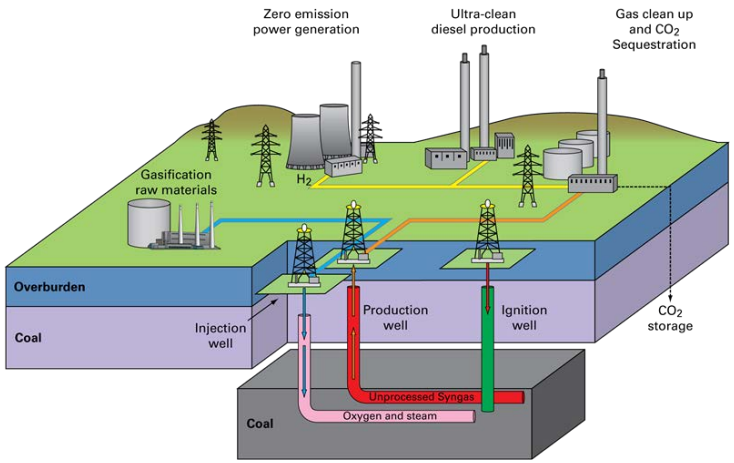
- Projects only possible because of
  - tightly constrained digital data
  - recent advances in data management procedures
- Changing from “collect everything” and hold forever
- To: Prioritising digital over analogue
  - Minimises space & expensive data conditioning
- Scrape all metadata from record even if not immediately useful
- Hold archive in original digital formats
  - can always return to this if serious problems
- Convert data to simplest format for most uses
  - ASCII, CSV, LAS
- Data management means engaging with users to maximise value
- Effective data management facilitates new science

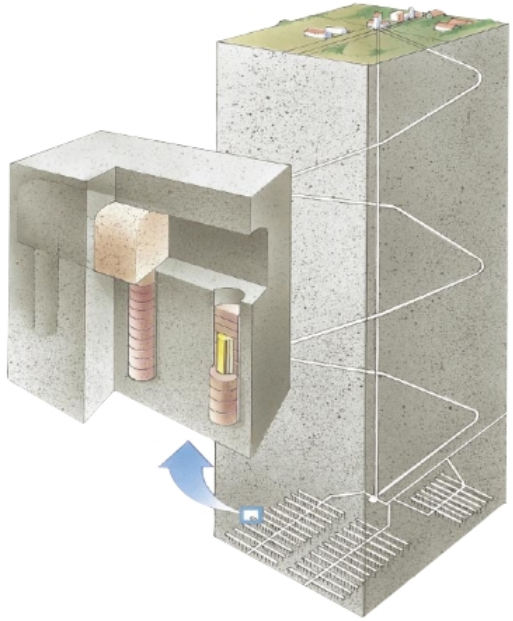
Data driving innovation

- Controls on formation of individual deformation features
- Tailored decision-support service
- Subsurface understanding for UK public

Some potential future uses of data







- The challenges of the future are complex and uncertain
- The subsurface will have a huge role in providing energy, managing environmental change and disposing of waste
- Costs will be high so prior knowledge is essential
- High quality data is vital for understanding the subsurface to meet such challenges