Quantifying the Effects of Prior Knowledge and Interpretational Methodology from the Creation of Structural Models*

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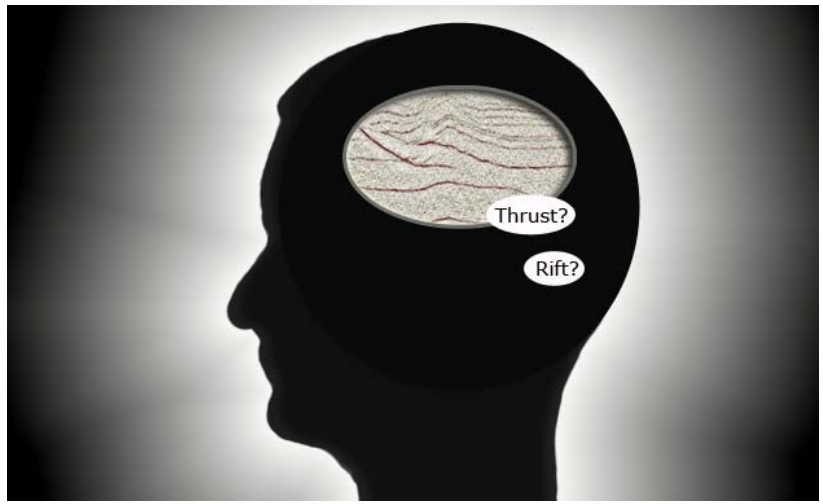
Abstract

The prior knowledge that individuals apply to datasets has an impact on interpretation and model creation, but the nature of the impact is uncertain. A key question is what factors of a person's prior knowledge are most influential? Here we have quantified some of the effects of prior knowledge and interpretational methodology on structural model creation for a dataset that supports multiple conceptual models.

Geoscientists often work with inherently uncertain data. In resource exploration datasets of different certainties are combined to build a picture of the subsurface by data interpretation and model construction. The concepts used in making interpretation choices are based on prior knowledge. During the interpretation the geoscientist will attempt to validate each concept, often subconsciously sometimes consciously against previous knowledge. Some concepts will be disregarded quickly, others considered more carefully.

In this paper we assess the factors which influenced concept choice during a seismic interpretation exercise by comparing expertise, prior experience, training and discipline with the concepts applied to the interpretation exercise. Rather than considering the impact of each variable in isolation, we have used polytomous regression analysis to assess relative impacts. Our statistical analysis of these data show that two key variables are statistically significant; level of expertise in structural geology and the type of interpretational technique employed. These results are the first to quantifiably demonstrate that interpretational methodologies and conscious use of validation techniques may have more impact on positive interpretational outcome and model creation than prior knowledge. The results show that focused training of staff in particular techniques would have a positive impact on reducing the risk inherent in seismic interpretation.

Quantifying the effects of prior knowledge and interpretational methodology on structural models



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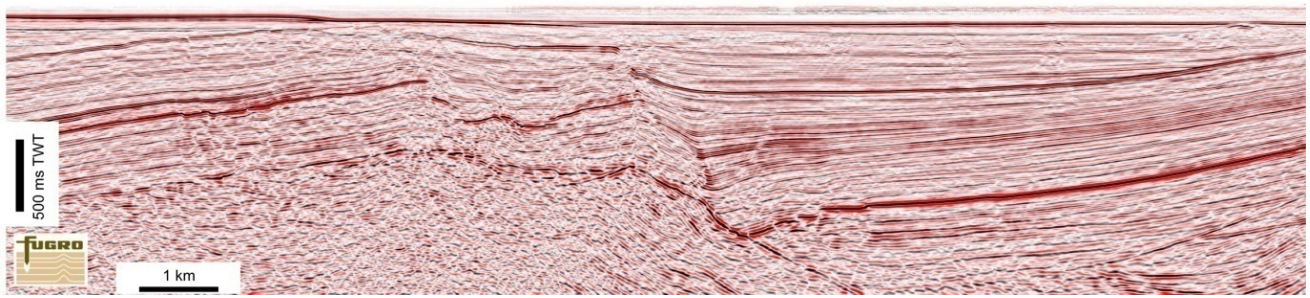
Multiple Solutions

Geological Datasets - spatially limited data

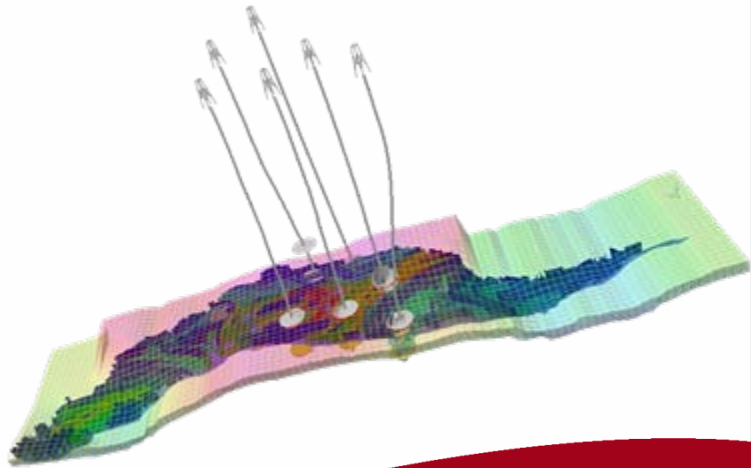
Often data is collected
by remote sensing



Multiple Solutions

Interpretation - data collection and data processing stage – interpretation of geological data has an inherent uncertainty

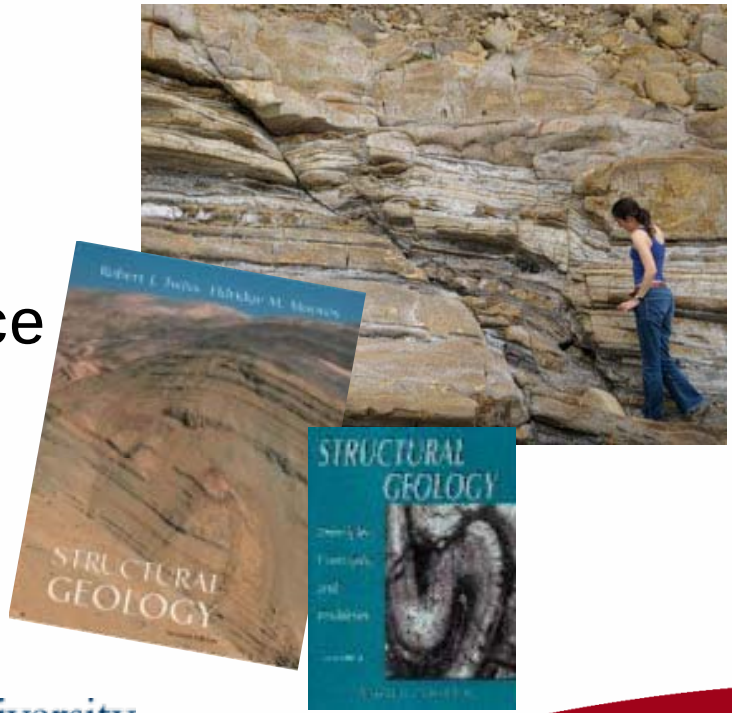
Hard data and soft data is combined and used to make predictions and interpretations



Concepts

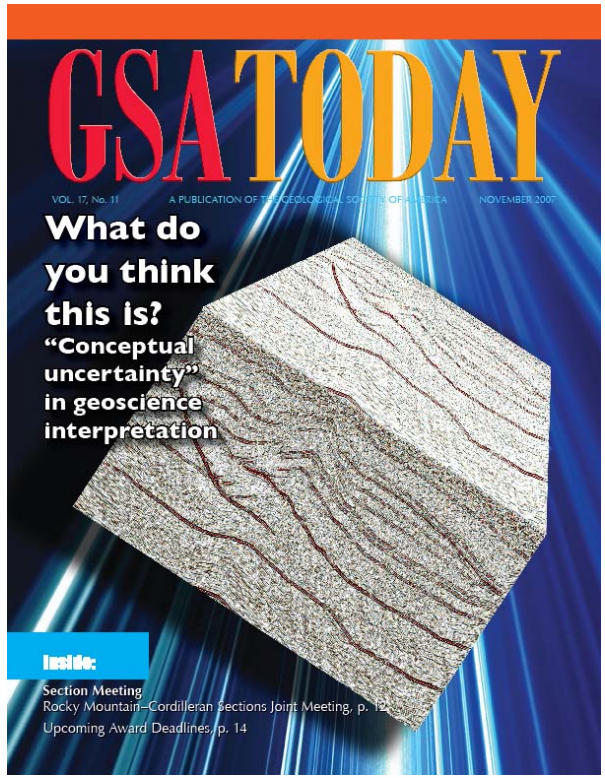
Concepts - are applied to data during interpretation.

Concepts are based on analogues formed from previous experience: direct personal experience and indirect gained from others



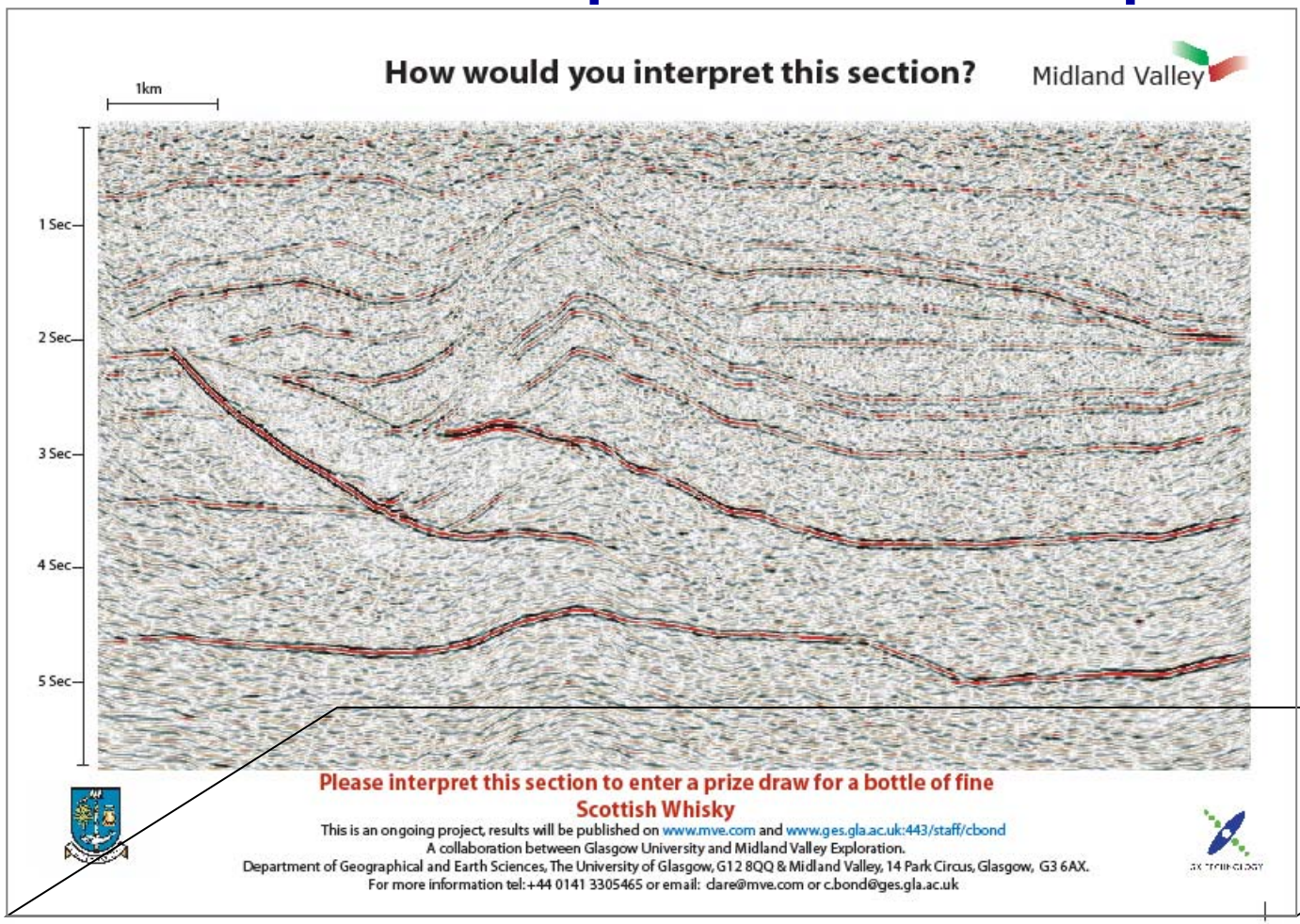
What concept to use?

Statistics presented here are based on a seismic interpretation experiment published in GSA Today



(Bond *et al.*, 2007)

Seismic Interpretation Experiment



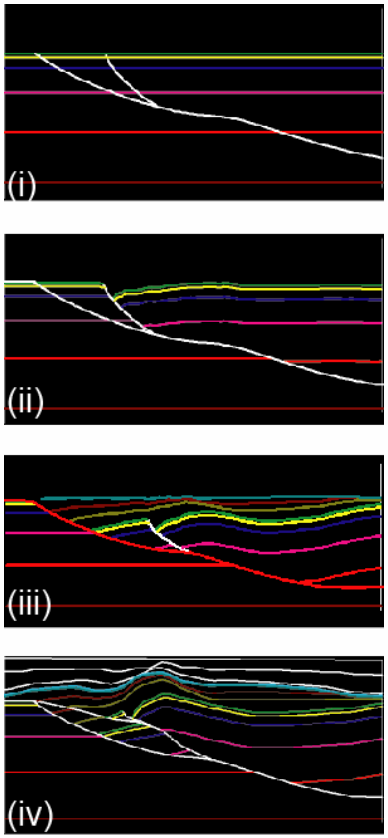
GX TECHNOLOGY

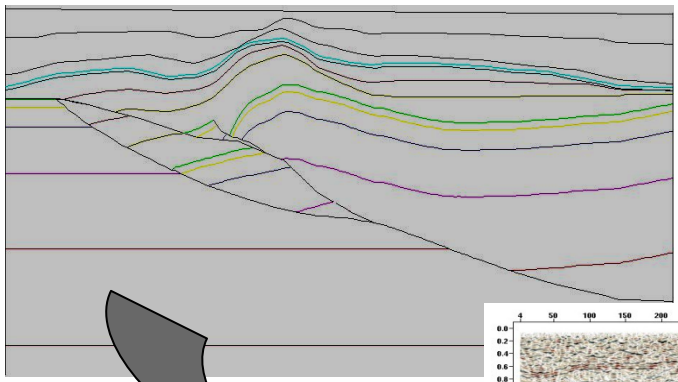
Midland Valley

University of Strathclyde Glasgow

University of Glasgow

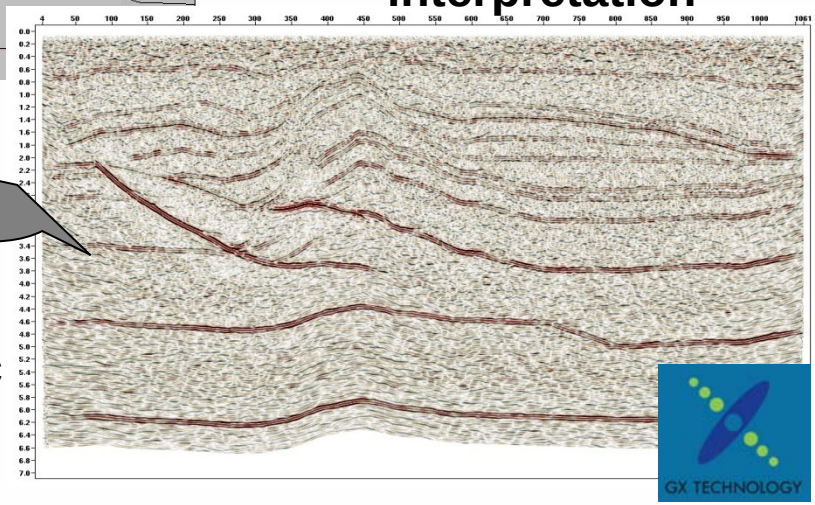
Seismic created from known model



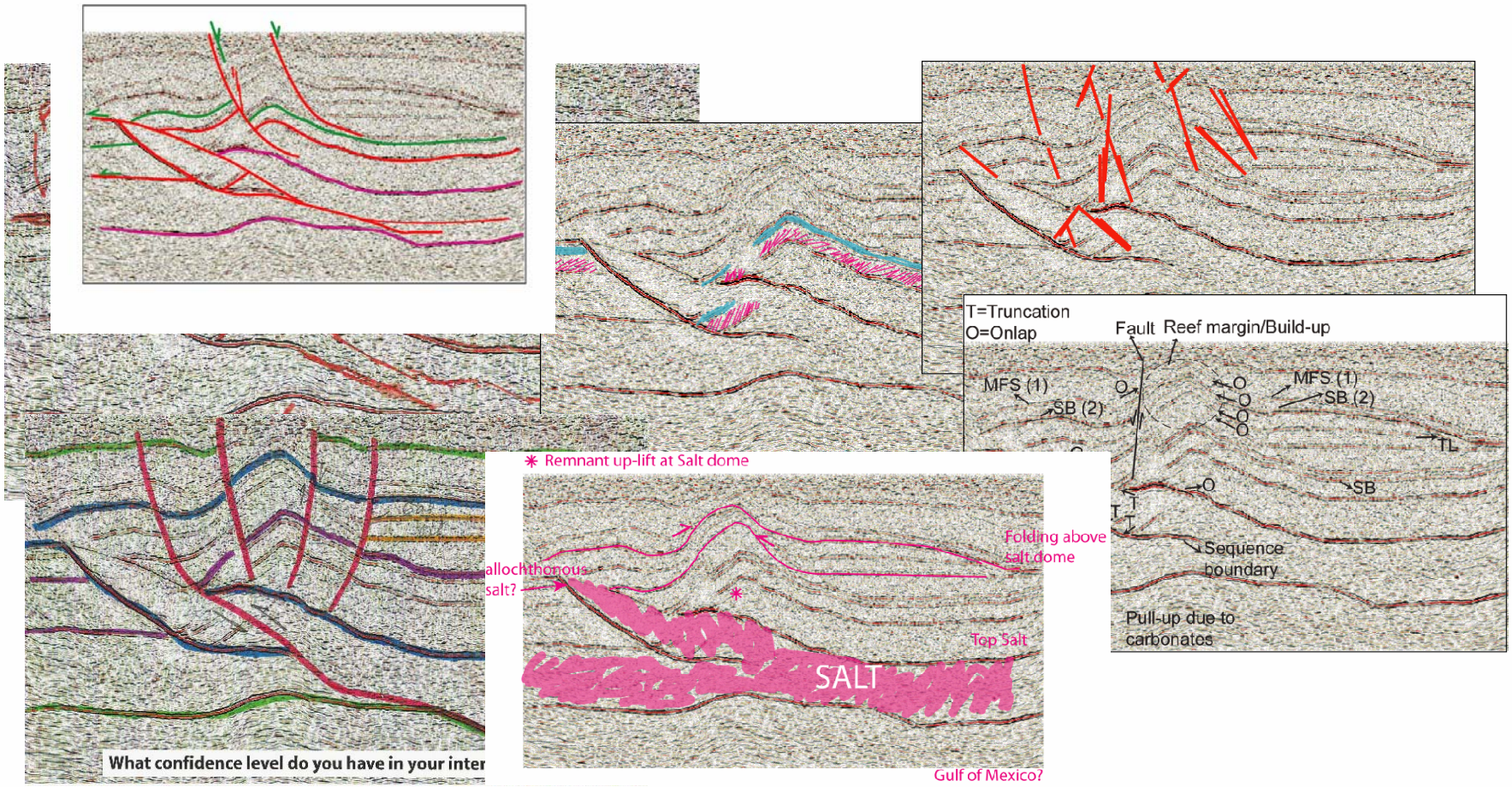


Odin project used synthetic seismic based on a structural model created by forward modelling to test subjective spread in interpretation

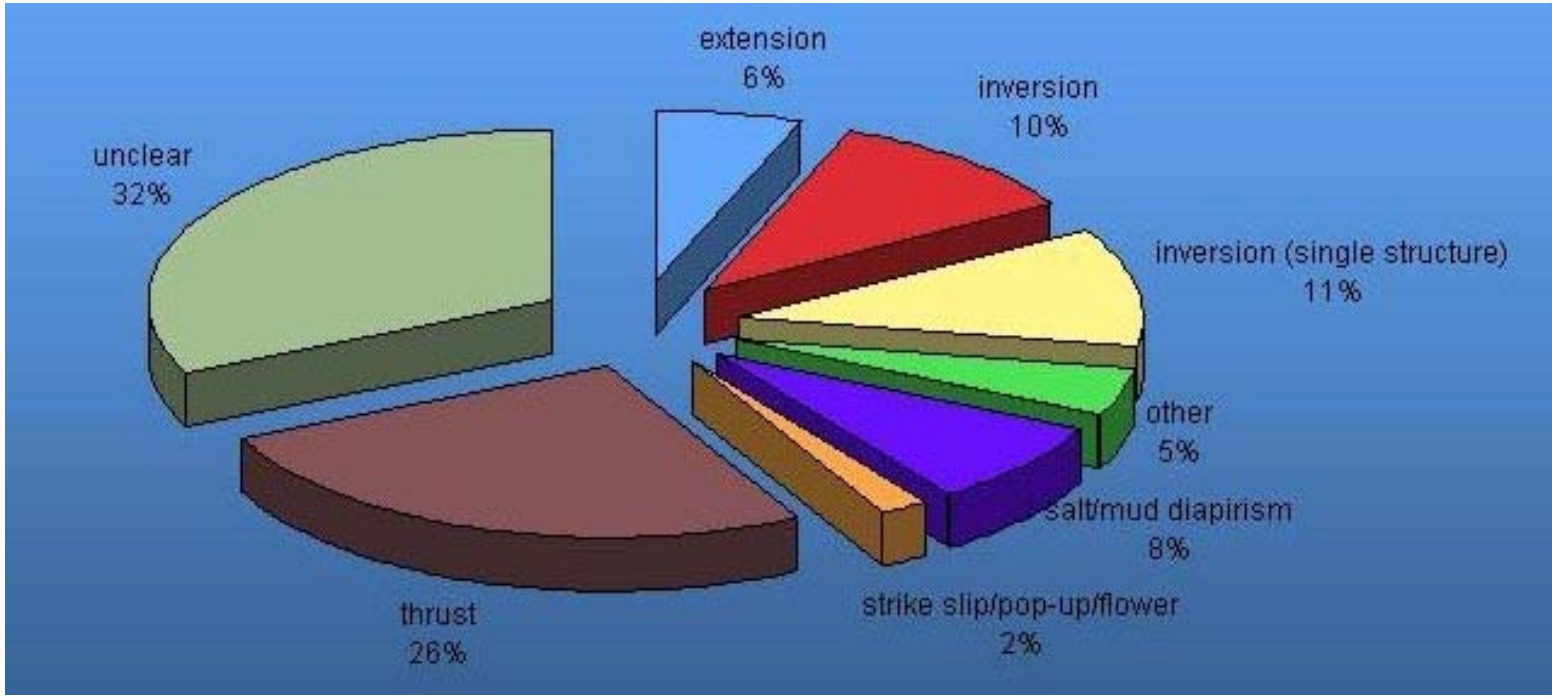
Synthetic seismic



One dataset – many concepts



Many structural models



Non-unique solutions?

Prior Knowledge

Heuristics and biases:

- **Heuristics – rules of thumb**
- **Biases – how we are influenced**

Classic prior knowledge studies:

- **Tverskey and Kaheman (1974) Science**
- **Krueger and Funder (2004) - Bias not always negative**

Prior Knowledge

Studies:

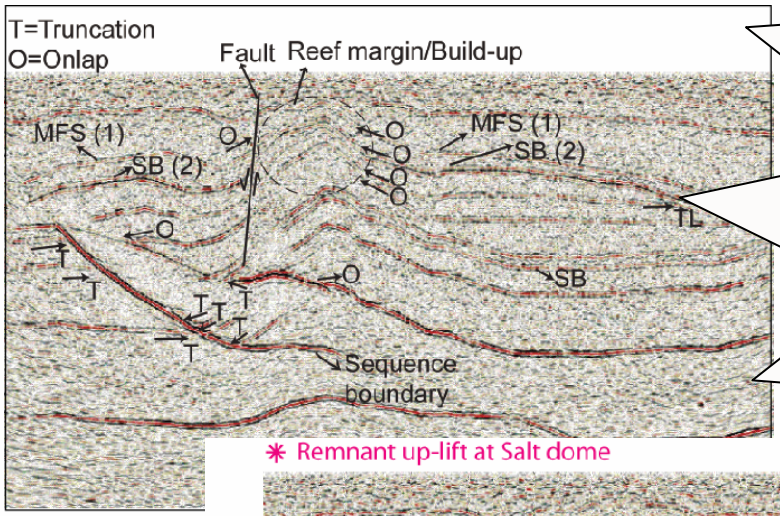
Based in cognitive psychology and economics

Geological focused studies:

Rankey & Mitchell (2003) First Break

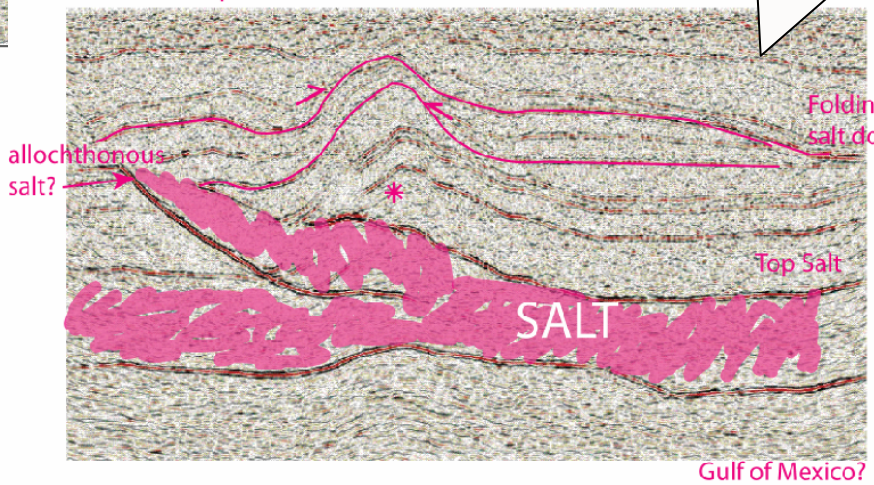
“That’s why it’s called interpretation”

Bias



Anecdotal – evidence from the results....

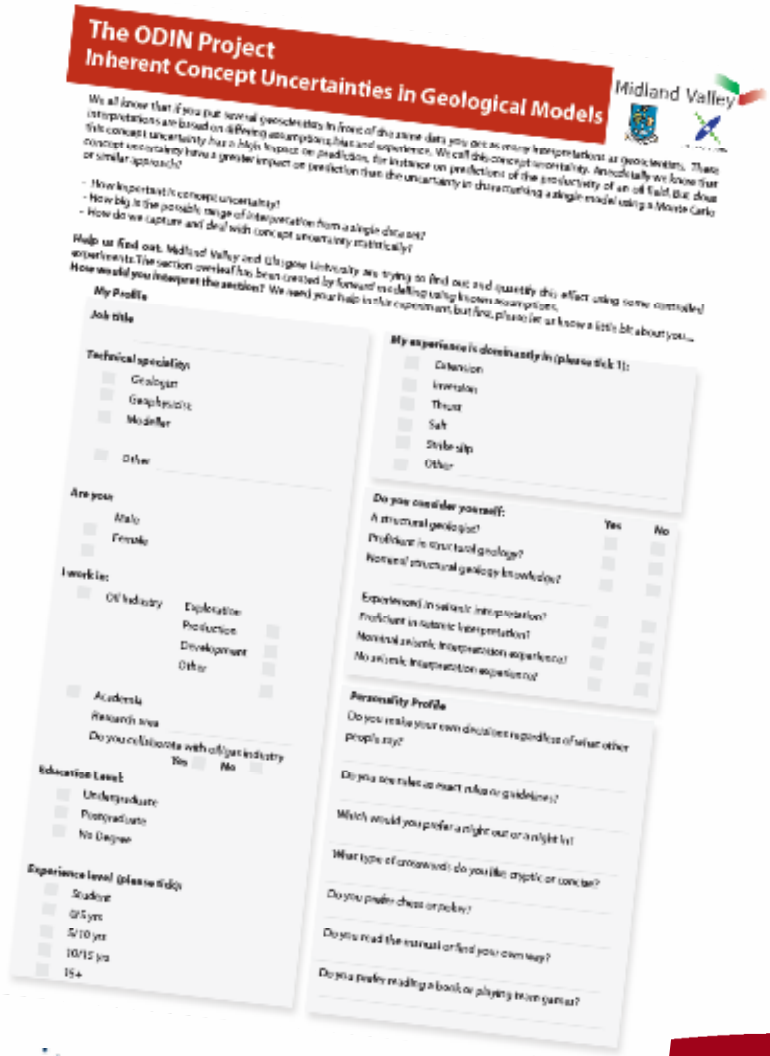
But what about statistically?



Student – PhD salt tectonics

Questionnaire

When completing the interpretation, participants were asked to fill in questions about their previous experience and background.


The ODIN Project
Inherent Concept Uncertainties in Geological Models
Midland Valley
My Profile
Job title
Technical specialty
Geologist
Geophysicist
Modeller
Other
Are you
Male
Female
I work in:
Oil Industry
Exploration
Production
Development
Other
Academia
Research area
Do you collaborate with oil/gas industry
Yes
No
Education Level
Undergraduate
Postgraduate
No Degree
Experience level (please tick)
Student
0/5 yrs
5/10 yrs
10/15 yrs
15+
My experience is dominantly in (please tick 1):
Extension
Inversion
Thrust
Salt
Strike slip
Other
Do you consider yourself:
Yes
No
A structural geologist
Proficient in structural geology
Normal structural geology knowledge
Experienced in seismic interpretation
Proficient in seismic interpretation
Minimal seismic interpretation experience
No seismic interpretation experience
Personality Profile
Do you make your own decisions regardless of what other people say?
Do you see rules as exact rules or guidelines?
Which would you prefer a night out or a night in?
What type of crossword do you like: cryptic or concise?
Do you prefer chess or poker?
Do you read the manual or find your own way?
Do you prefer reading a book or playing team sports?

What did we ask?

In total 16 questions were asked:

~~Q1. Job title,~~

Q2. technical speciality,

Q3. gender,

Q4. work area,

Q5. education level,

Q6. experience (years),

Q7. experience (tectonic setting),

Q8. personal assessment of ability as a structural geologist and as a seismic interpreter (Q9),

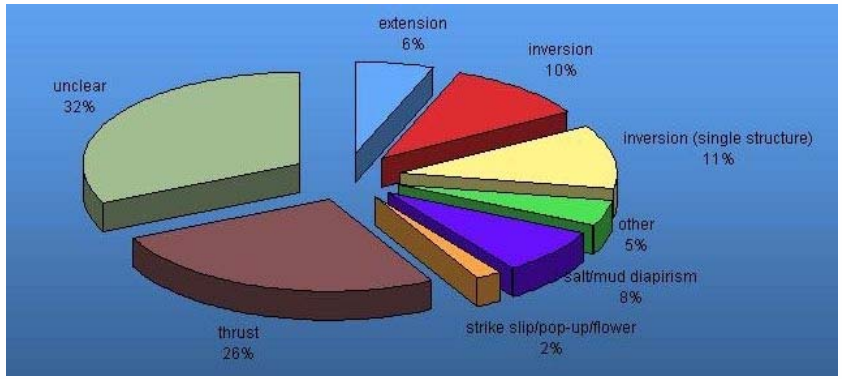
~~and a personality profile (Q10-16).~~

Statistical Analysis

The remaining 8 questions resulted in 34 variables, which were combined for statistical analysis with...

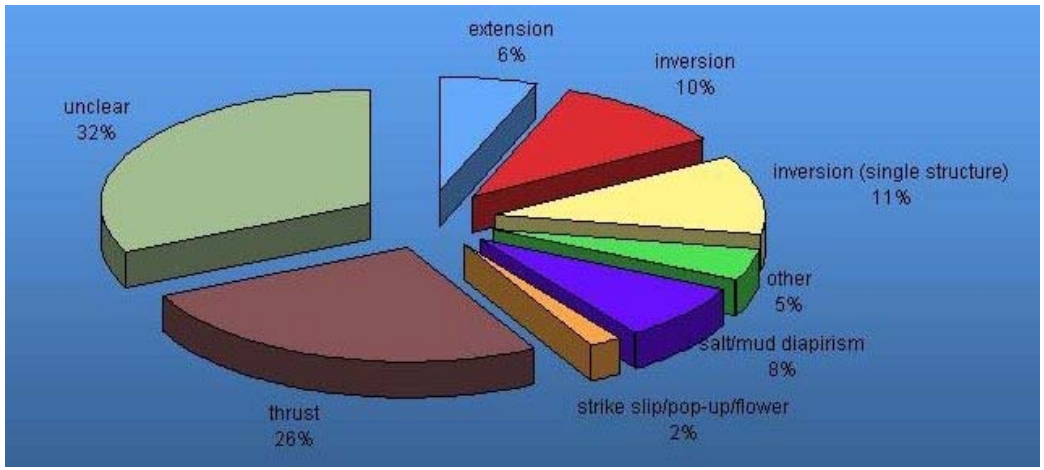
Interpretational outcome

(thrust, inversion, extension, strike-slip, diapirism, other and unclear).



Original dataset

- Thrust was the most dominant answer
- People with 15+ years experience did no "better" than students.

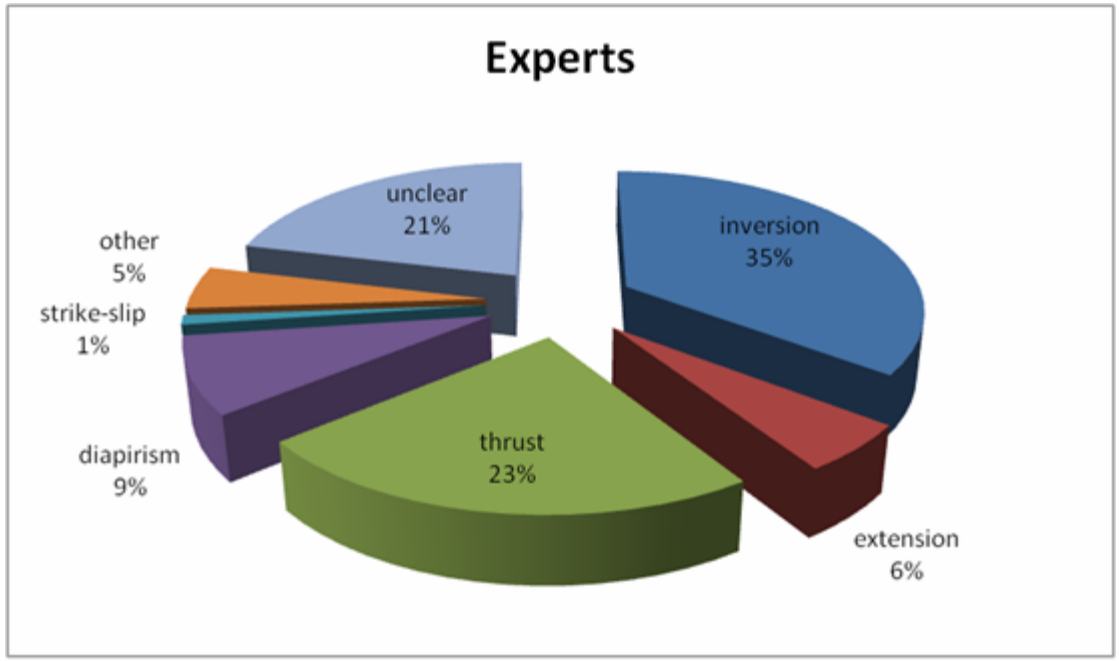


Experts

Experts those that described themselves as Structural Geologists or Proficient in Structural geology.

184 subjects

of the original 467



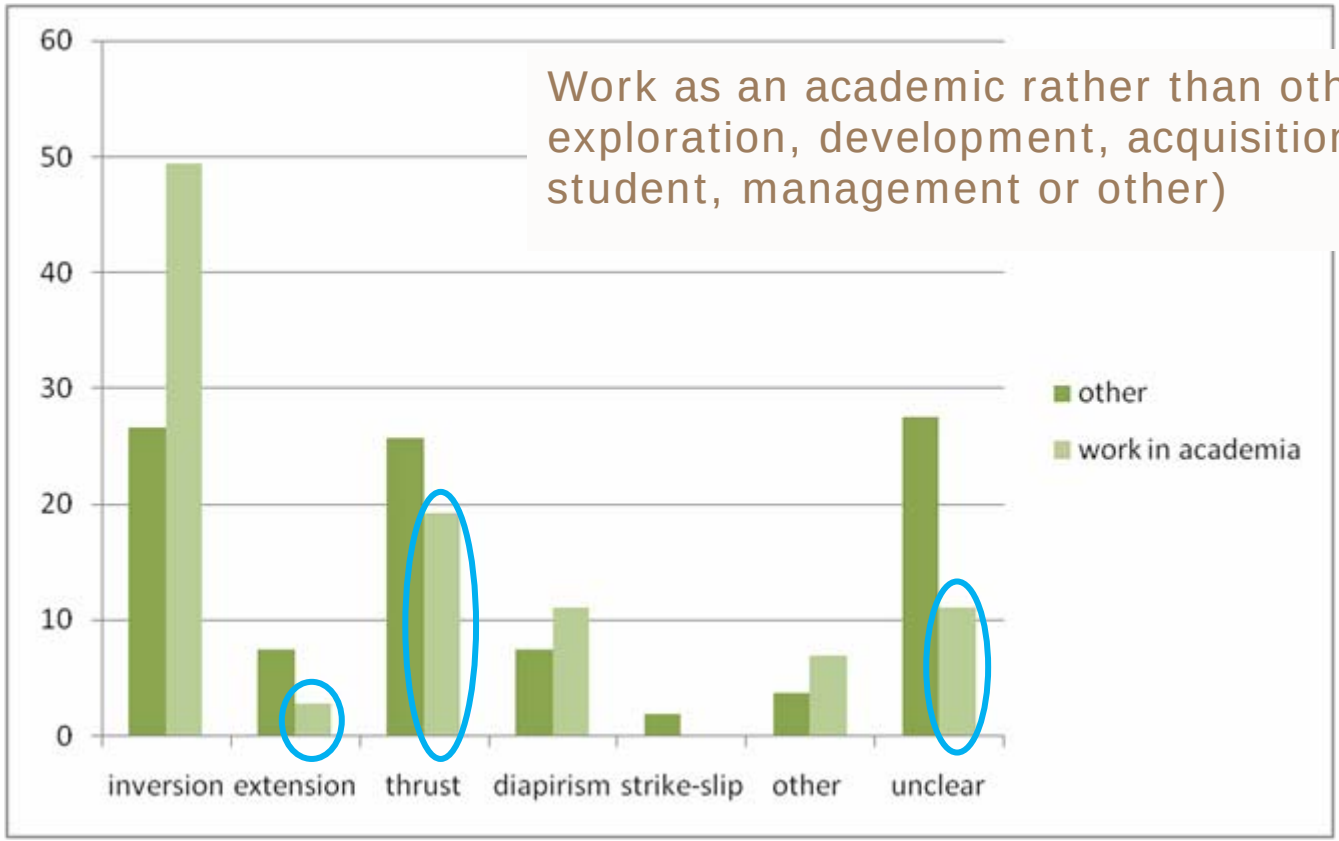
Regression Analysis - Experts

Polytomous Regression Analysis compares affects of all variables against a normal (inversion)

Only two significant variables

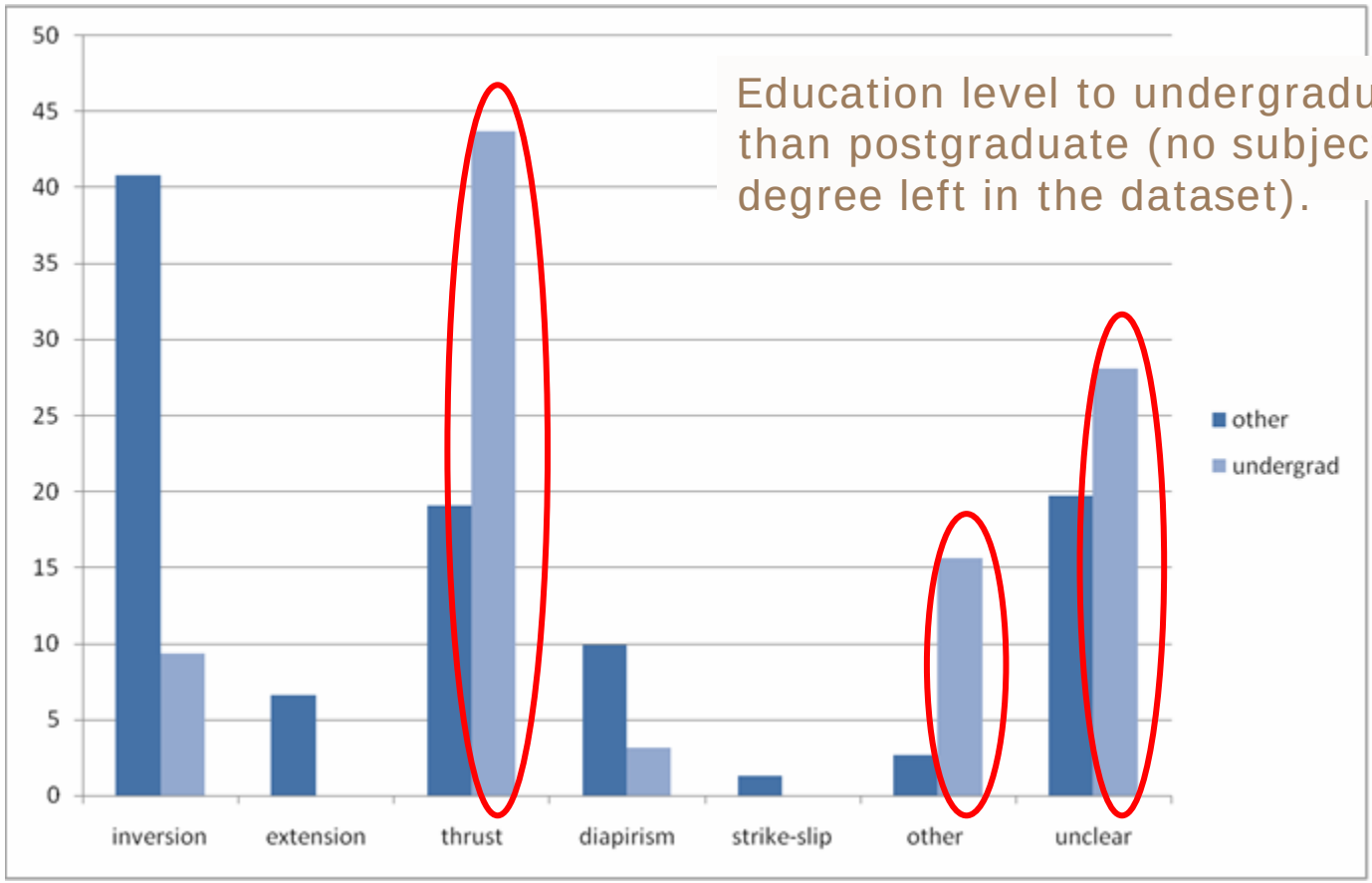
- Academic
- Under-graduate degree

Regression Analysis - Experts



Work as an academic rather than other (production, exploration, development, acquisition and processing, student, management or other)

Regression Analysis - Experts



Education level to undergraduate, rather than postgraduate (no subjects with no degree left in the dataset).

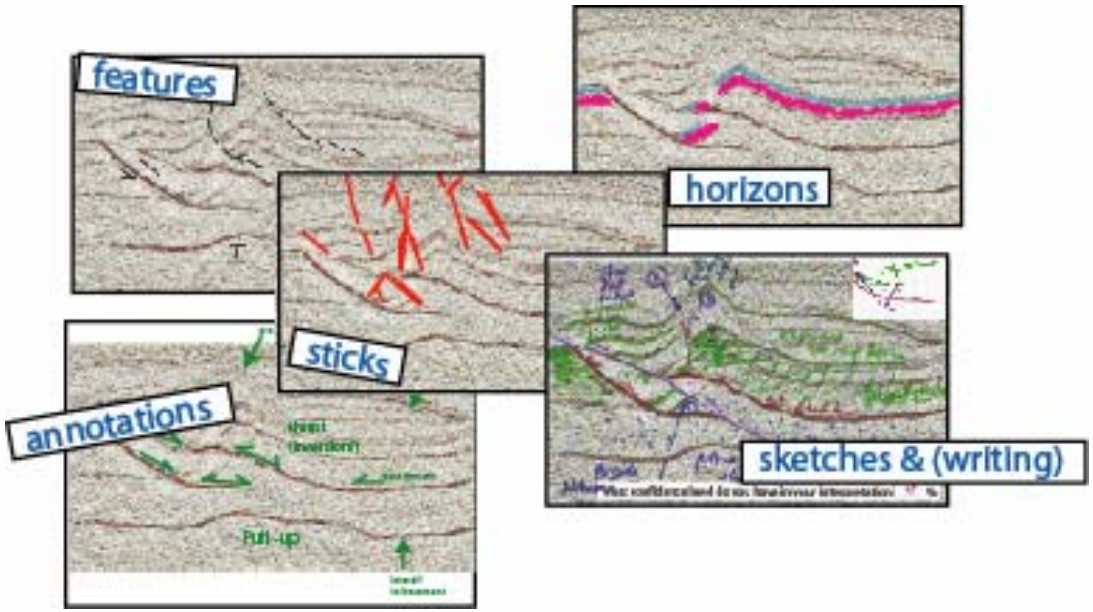
Regression Analysis - Experts

Conclusions

Don’t write off academics or education yet!

…other thing considered

Interpretational style and techniques (features, horizons, sticks, writing (descriptive), sketches and writing (evolution) and annotation)).



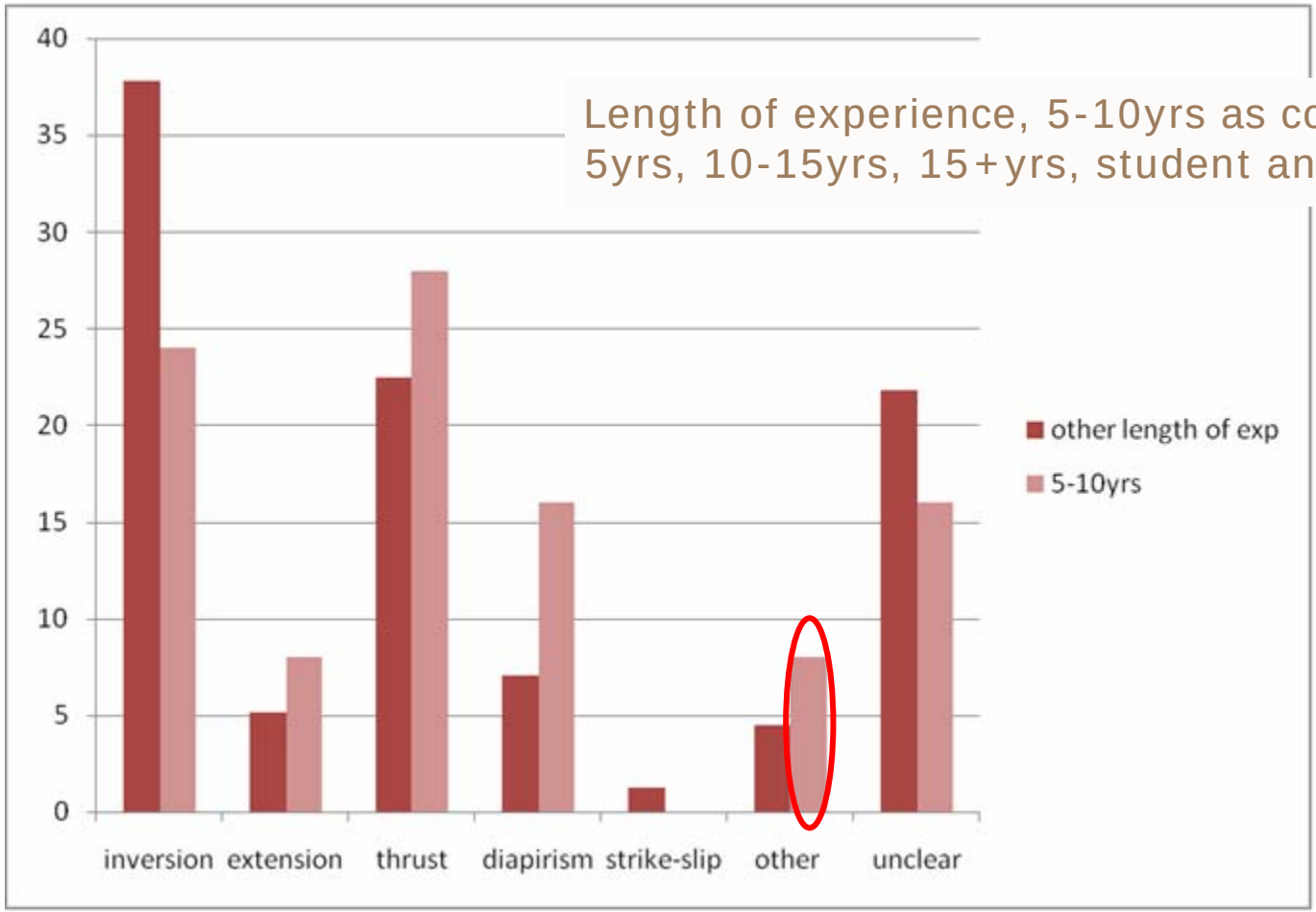
Total no. of interpretational techniques used.

Technique influences - Experts

Techniques used included in the analysis as a total number:

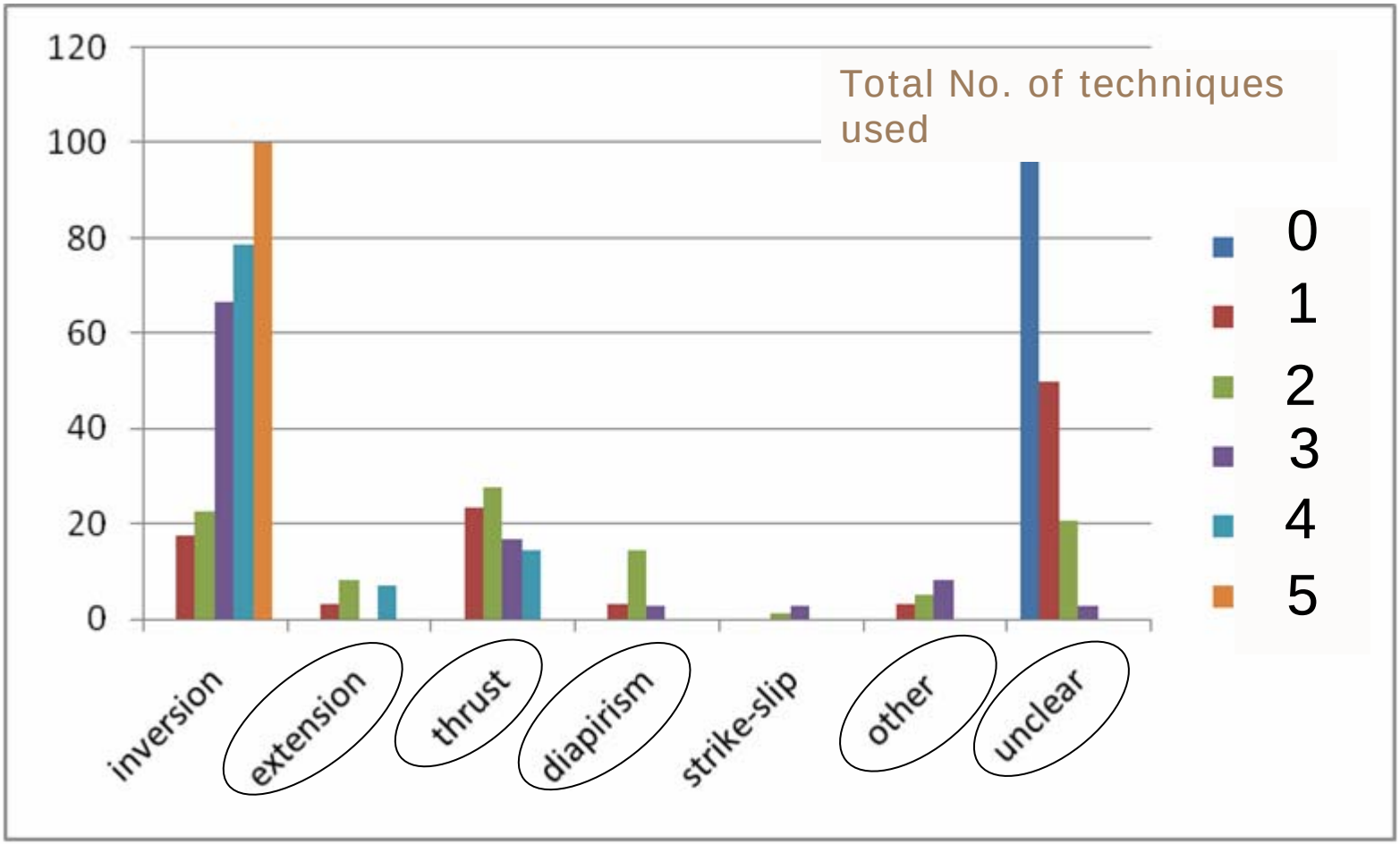
- Under-graduate degree NO CHANGE
- 5-10 yrs experience
- Number of techniques
- ACADEMIA no longer important

Technique influences - Experts



Length of experience, 5-10yrs as compared to 0-5yrs, 10-15yrs, 15+yrs, student and none.

Technique influences - Experts

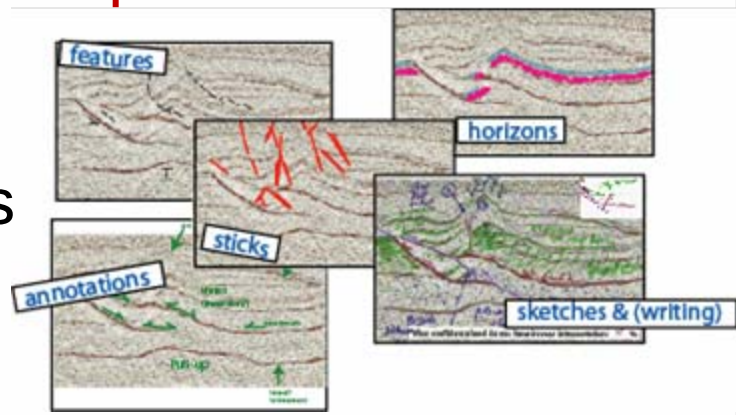


Individual Techniques - Experts

Techniques used included in the analysis as individual parameters:

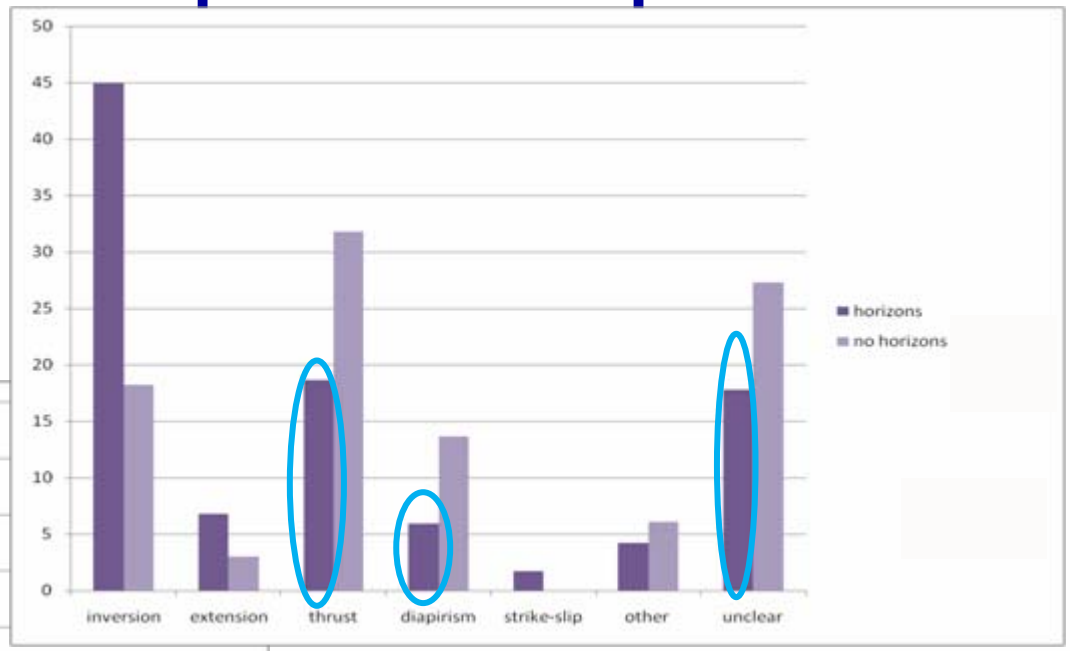
- Under-graduate degree Thrust and Other
- 5-10 yrs experience -no longer important
- ACADEMIA still not important
- Horizons, annotations, features

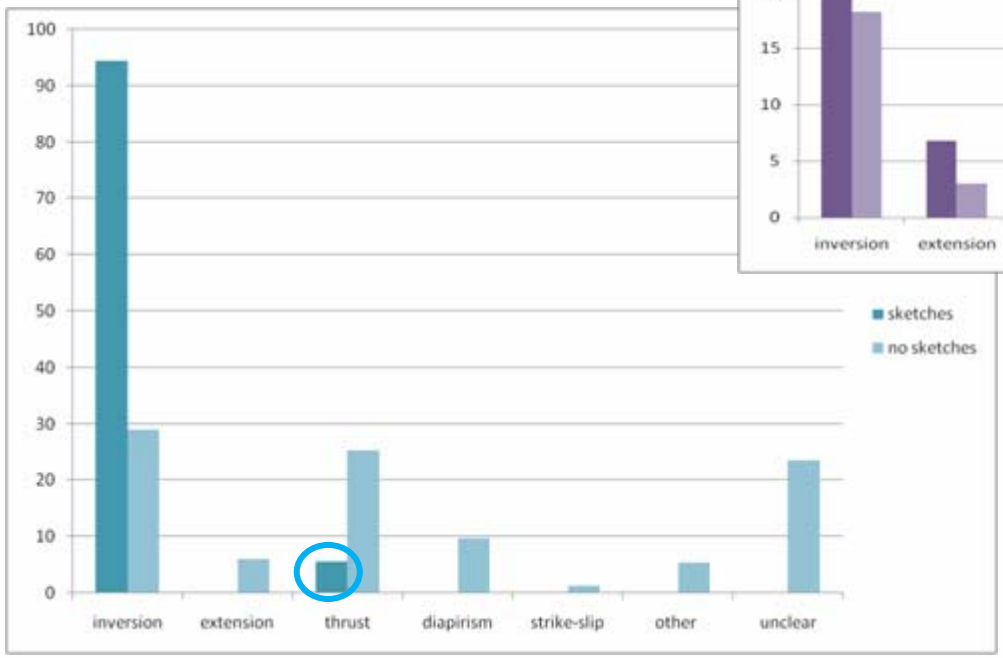
separate writing and sketches



Individual Techniques - Experts

Features highlighted, annotations and writing – less likely to produce an unclear interpretation





Evolutionary thought – does it work through time?

Conclusions

Experts – if defined by structural geology more likely to get the correct answer than any other, but only 35%.

Those without a postgraduate degree – still more likely to give a thrust interpretation.

Academics – do better than others but… is it because they have the techniques?

Techniques have a strong influence both in the number of ways the data is queried and the specific technique used.