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Fault fictions: Systematic biases in the conceptualization of fault-zone architecture

FAFF

Faults and Fluid Flow
Research Group

Zoe Shipton¹, Jen Roberts¹, Emma Comrie^{2,3}, Yannick Kremer¹, Rebecca Lunn¹, and Jonathan Caine³

1. Department of Civil and Environmental Engineering, University of Strathclyde
2. Department of Management Science, University of Strathclyde
3. Leverhulme Research Centre for Forensic Science, University of Dundee.
4. US Geological Survey, Denver, Colorado (USA)

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Fault fictions: Introduction

A '**mental model**' is an internal cognitive representation of something in the real world

- We rely on **mental models** to make sense of the world around us.
- Mental models are...:
 - **the basis** for how a conceptual or numerical model of a system is defined and parameterised
 - constructed on the basis of **experience** of the external system
 - **subject to bias**.
For example, experience is incomplete and partial when compared to real world complexity = availability bias.

Example: Mental models of geologists

What do ***you*** think of when you think of a geologist?

What might other people think of?

SAGE PUBLICATIONS (www.sagepublications.com)

PUBLIC UNDERSTANDING OF SCIENCE

Public Understand. Sci. 12 (2003) 279–287

Of power maniacs and unethical geniuses: science and scientists in fiction film

Peter Weingart, with assistance from **Claudia Muhl** and Petra **Pansegrau**¹

Weingart et al. (2003) studied depictions of scientists in 222 Hollywood films and found:

- Movie scientists are predominantly white (96%), male (82%), American (49%) and middle aged.
- Medics, physicists, chemists, psychologists likely to be 'mad'
- Anthropologists, zoologists and **geologists** likely to be 'good'

Fault fictions: Introduction

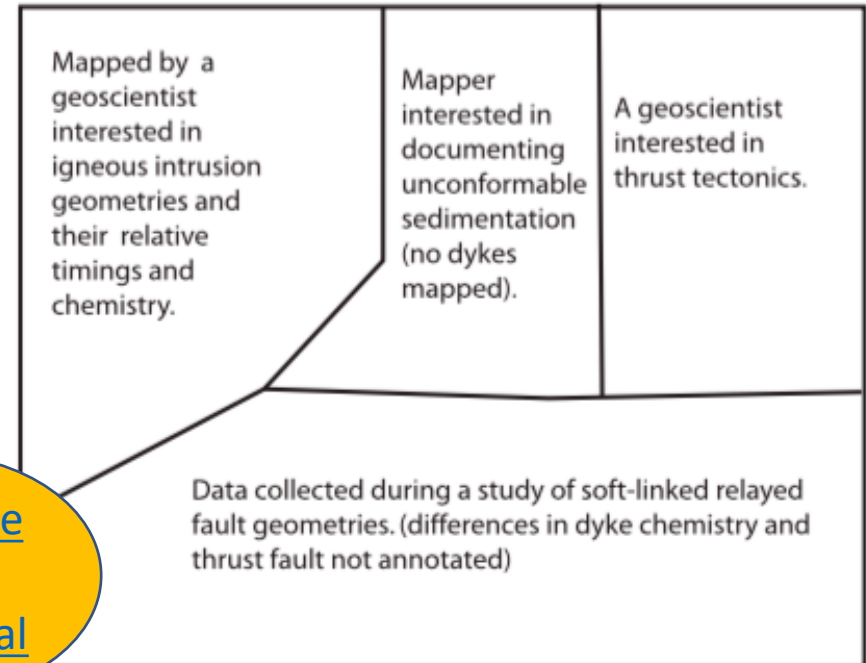
Data provenance matters:

Your mental model is dependent on **what you intend to use that model for.**

Figure on right from Bond et al. (2007) shows schematic geological map compiled from the work of **four** hypothetical geoscientists, each interested in **different aspects of the geology** of the mapped area.

→ **Outcome:** they map **different data!**

In our work, we explore biases that affect our understanding of fault zones, and consider approaches to reduce bias



[Click here to read Bond et al](#)

Fault fictions: Key messages

- Systematic biases can affect **any** geological investigation
- We identify biases that affect our understanding of **fault zones**, and propose approaches to '**de-bias**' the data we gather
- These biases may be **cognitive**, or **physical**
Both relate to being a human studying the physical environment.
Both affect our 'mental models' of fault zones, and so how we gather and interpret data
- We examine effect of bias on predicting the physical properties of fault zones
-> findings are **relevant across the geosciences**
- We cannot eliminate all bias, but must acknowledge and account for it
geoscientists should **identify** and be **open about managing** biases

Fault fictions: Examples of sources of bias

1. Scale: outcrop v. human

- Humans are small compared to (many) geological fault systems.
- We tend to (by necessity) examine a small outcrop of a much larger and very heterogeneous system.
- outcrops are made available by natural and human-made exposures. **i.e. physical selection bias.**
 - Are small exposures 'representative' or is there something special led to them being available for us to study?

2. Our interests:

- Which faults we study is affected by the processes and applications we are interested in
 - Our mental models may be biased toward such processes/applications
- We only pay attention to features relevant to our interest: a form of selection bias.
 - you *observe* loads of pseudotachylytes at a field site but you are studying the rocks they cut so don't report them

3. Language & communication:

- Using ambiguous terms affects our ability to communicate our mental model
- We use the same term to describe different things:
 - In fault studies there are two distinct usages of the term *membrane seal*.
- Some geological phrases derive from - or have come to be associated with - specific geological processes.

4. Individuals come with 'baggage'

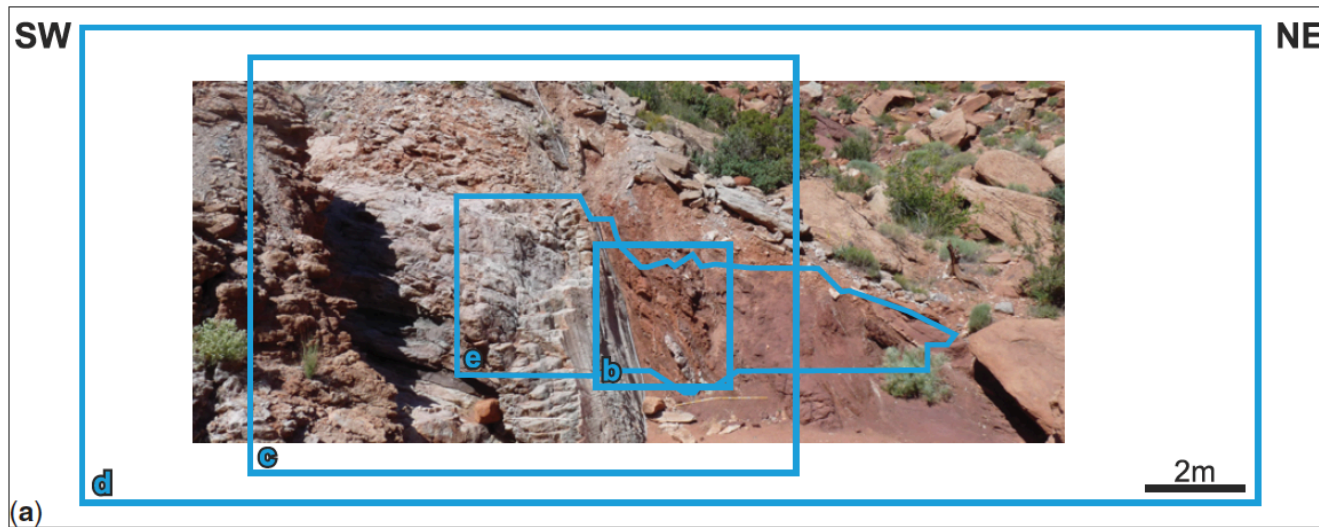
- How we approach and collect data from an outcrop is a product of personal characteristics, interest, training
- Different people collect different data from the same outcrops (see Andrews, this session, and published paper).

[Click here to read Andrews et al](#)

Fault fictions: An example – Moab fault

On the next slide are 4 interpretations of **the same exposure** of the Moab fault, Utah. **Note how different they are.**

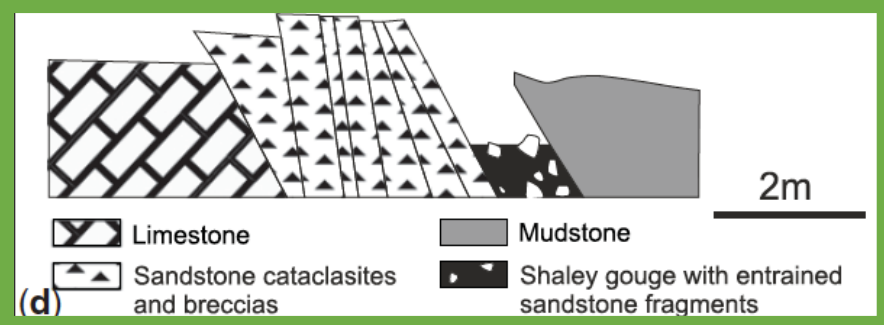
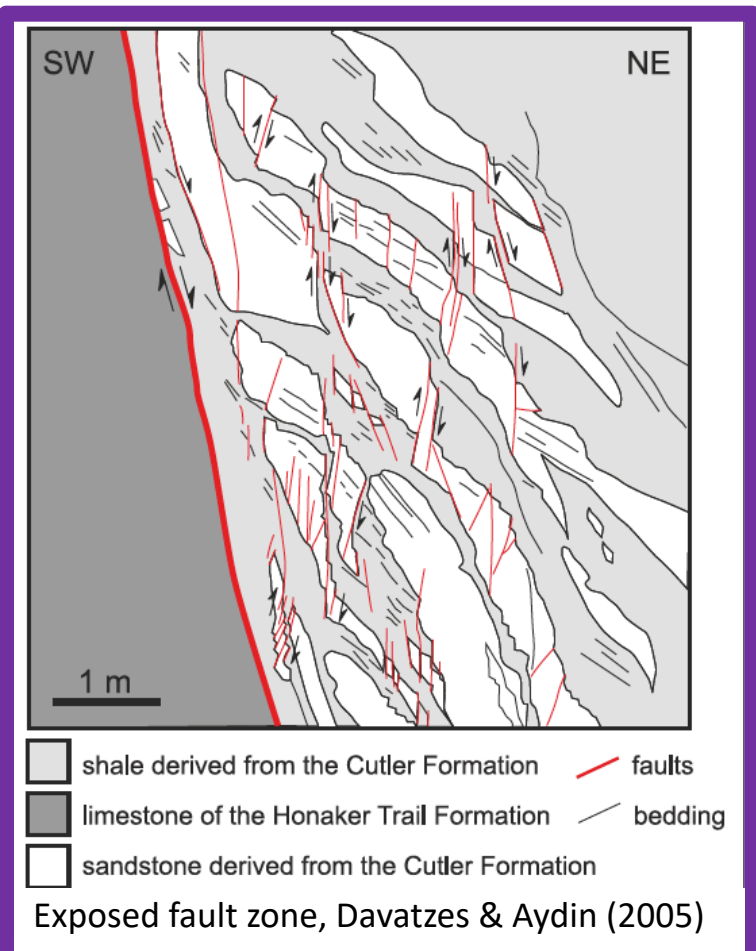
To help you to orientate the 4 interpretations, below (a) is an outcrop photograph of the exposure showing outlines of the 4 fault maps (there is a smaller, colour-coded version of this on the next slide)



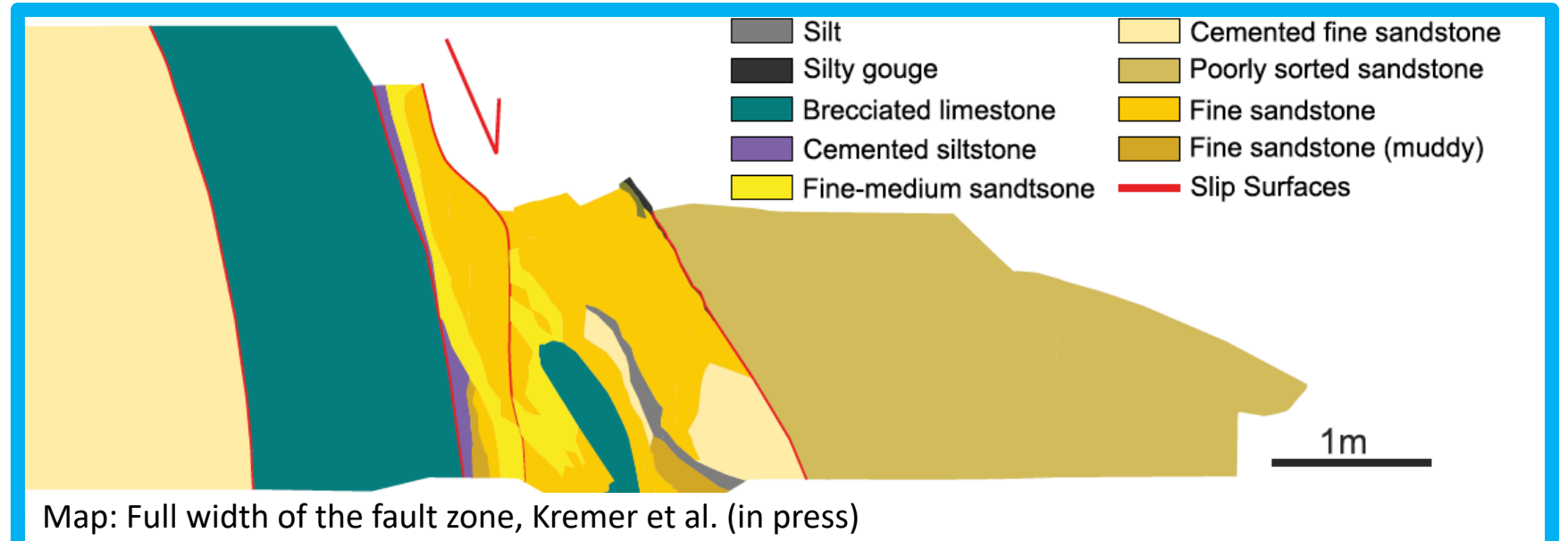
By the way, this beautiful outcrop is on the other side of the road



4 interpretations of the same exposure of the Moab fault, Utah



Structural log, modified from Foxford et al. (1998)



Fault fictions: Approaches to 'de-bias'

The first step is to **raise awareness of biases**. Then consider how to de-bias.

3 key de-bias approaches:

training, **research approach**, **reporting**

Physical bias

Training: Consider how *unrepresentative* the outcrop you are studying might be!

Think, how might the study outcrop may:

...affect the sample size?

...correlate to fault physical properties?

...be affected by factors such as accessibility or field budget?

Approach

- Where possible, **seek different outcrop types**.
- Complement with other data sources (e.g. remote sensing)
- Encourage and support **data pooling** (provided that uncertainties that limit data comparison are accounted for).

Cognitive conscious bias

a) Selection bias:

- **Reporting**: Selection bias cannot (should not?) be eliminated, but should be **reported**. Support the practice of **reporting field methodology** stating what you record and what you don't.
- **Approach**: The bias will be reduced by **data pooling** / synthesizing metadata from the same field site.

b) Language and communication bias

- **Training** developing communication best practice
- **Reporting**: Clearly define terminology and methodology

Cognitive unconscious bias:

Training & Approach 'Think out loud'!

- Forces articulation and thus introspection of one's own thought process.
- Decomposing logic helps to identify and tackle assumptions and logic leaps.

Approach: Working in **groups** reduces personal bias and encourages thinking out loud.

- Groups should preferably be a **mix** of training and backgrounds
- Encouraged to **supportively question and challenge** each other.

Fault fictions: References

Our paper!

Shipton, Z. K., J. J. Roberts, E. L. Comrie, Y. Kremer, R. J. Lunn and J. S. Caine (2019). Fault fictions: systematic biases in the conceptualization of fault-zone architecture. Geological Society, London, Special Publications 496: SP496-2018-2161.

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