Abstract

Outcrop analogues provide crucial insights into fracture networks that are difficult to attain from borehole data alone, especially in exploration areas where wells are sparse, and knowledge of the reservoir is minimal. However, the interpretation of geological data almost invariably involves human input, which introduces interpreter bias into the workflow. To reduce the uncertainty that is inherent in data derived from analogue outcrop studies, the degree to which different interpreters may affect the resultant outputs must be understood, and non-geological variations need to be constrained and mitigated. We apply this approach to quantify the variability in fracture network interpretations derived from satellite imagery, using a population of geologists of varying levels of expertise and experience.

In this study we asked all participants to pick fractures from the same satellite image, at the same scale, under the same conditions, and then compared their results. We selected examples of different fractured carbonate units with varying degrees of image quality. Our analysis of the results focuses on the variations in topology, orientation, intensity and length within the resultant fracture network picked by each participant. We illustrate the implications of the variability with respect to DFN modeling and suggest strategies to standardize fracture interpretations to reduce picker-bias, by post-processing the picks using a topological correction and linkage algorithm.

As expected, we see significant variability in the interpretative picks from different geologists. The effect of this variability on fracture modelling is addressed with respect to orientation, connectivity, and length-intensity scaling. The biggest variations were in how different people digitized closely spaced fractures (fracture arrays), and which fractures people chose to pick. End-member styles in the picking were either to pick many segmented co-aligned fractures, or to pick a single fracture spanning long distances. Different styles have a profound effect on inferred size-intensity scaling relations and can result in a three-fold range in picked fracture intensity within an area.

By applying a topological and linkage correction to the picked data the variance in the measured parameters decreased. However, significant variations in bulk fracture properties still existed in the post-processed interpretations. Variability can be further mitigated by improved training of inexperienced pickers by fracture experts, or by expert-led implementation of machine learning algorithms. Understanding the use-case for a
specific fracture study is important: the human aspect of uncertainty in fracture modelling can and should be minimized at all stages in the interpretation process.

References Cited


1. Introduction: The “Outcrop Analogue to Fracture Model” Workflow

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### 1. Introduction: The “Outcrop Analogue to Fracture Model” Workflow

[Diagram of workflow]

- **Conceptual Fracture Network Model**
- **Geological Data**
- **User Input**
- **User Outputs**
- **Data Processing**
- **Final Results**

### 2. Introduction: Sources of Uncertainty/Variation

- **Sources of variation in fracture data collected from outcrop analogues**

### 3. Methodology

- **Participants were asked to pick two circular AOIs with varying amounts of vegetation cover**
- **Images were interpreted at a fixed scale with straight line drawing tools**
- **Post-processing of the fracture picks is done to try and reduce the variance in the sample results**

### 4. Results: Variations in Orientation & Intensity

- **AOI A**
  - Orientation: 0.29
  - Intensity: 0.63
  - Length: 0.68
  - Connectivity: 0.23

- **AOI B**
  - Orientation: 0.60
  - Intensity: 0.68
  - Length: 0.55
  - Connectivity: 0.67

### 5. Results: Questionnaire

- **Survey results showed a significant spread in inferred length distributions within satellite datasets**

### 6. Post-Processing

- **Clearing the topography manually shifts the data along the Y-axis but does not remove the large spread in the planar connectivity (Fig. 5)**
- **AOI A has the greatest range of values but both AOIs still span all three of the PFI plots: Region 1: null; Region 2: orientation cluster systems become connected; Region 3: density clustered systems are connected (Fig. 6)**
- **Applying the linkage post-processing reduces some of the outliers in the length-intensity data (Fig. 8) in cases where people chose to pick co-aligned fractures**

### 7. Comparison of Raw and Post-Processed Results

- **Fig. 9 Upscaling Length and Intensity**

### 8. Conclusions

- **Fracture network models and their associated uncertainties**
- **Changes in outcrop quality within an AOI caused a variation in the measured fracture parameters**

### 9. References