Finding Fault: Laboratory Experiments and Classroom Studies on Identifying Faults in Images

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Research Questions

- How do geoscientists develop the ability to distinguish geologically salient features, such as faults, from visually distracting features?

- What techniques can we use in the classroom to help students develop that ability?

Research Approach

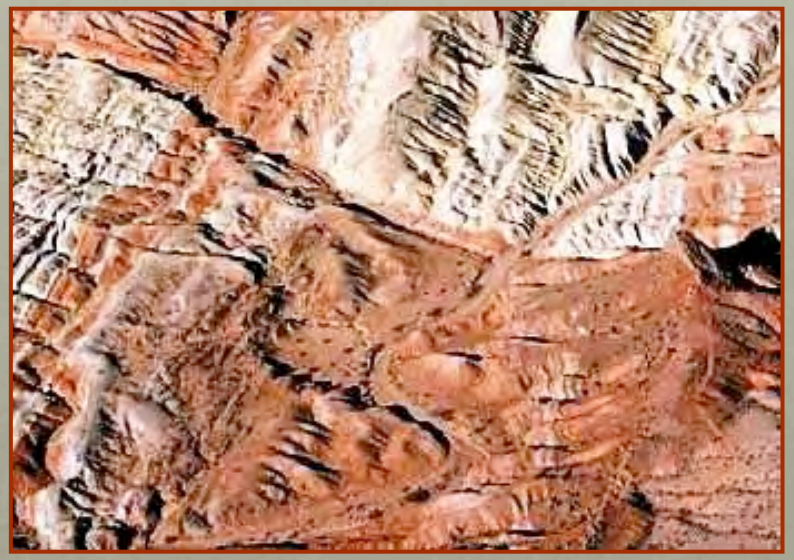
- Collaboration of geoscience educators and cognitive psychologists
- Both laboratory experiments and classroom studies
- Initial focus on identifying faults in outcrop photos

Classroom Studies

- Two introductory geology classes at Carleton College
- Pre-instruction questionnaire about prior geoscience experience and knowledge about faults
- Pre- and post-test: shown a set of outcrop photographs, asked whether a fault was present in each image. If so, asked to circle it on the image.

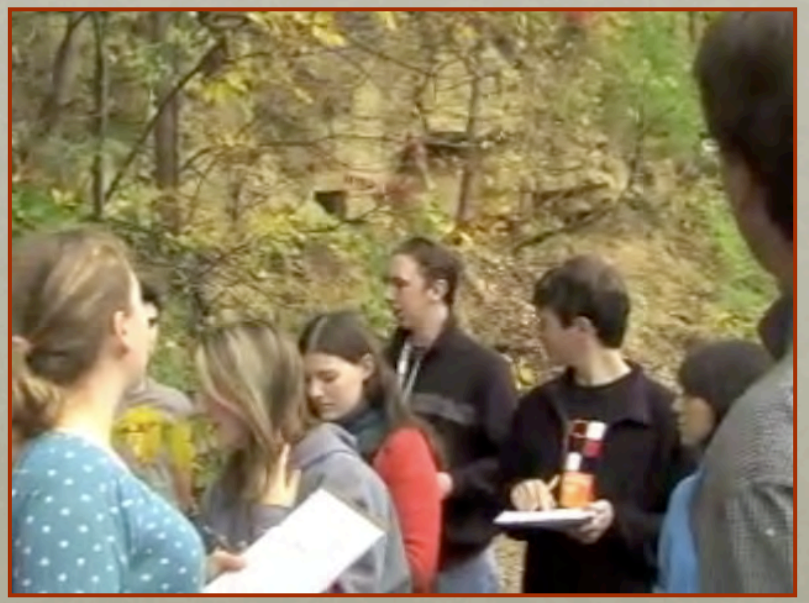
Classroom Studies

- Over the course of the term, instructors documented class time and activities related to faults
  - One field-based class; students saw a fault once
  - One survey class in physical geology; faults came up many times, in many contexts



Classroom Study Results

- Students' abilities to distinguish faults from distractors improved in both classes
  - 67% → 77% in field-based course
  - 59% → 84% in survey course
- Students who could define "fault" prior to taking the pre-test performed better (on average) on the pre-test, but not on the post-test



Item Analysis: "Easy" Images

- Classroom students found these images easy to decipher, even on the pre-test

Item Analysis: Challenging Images

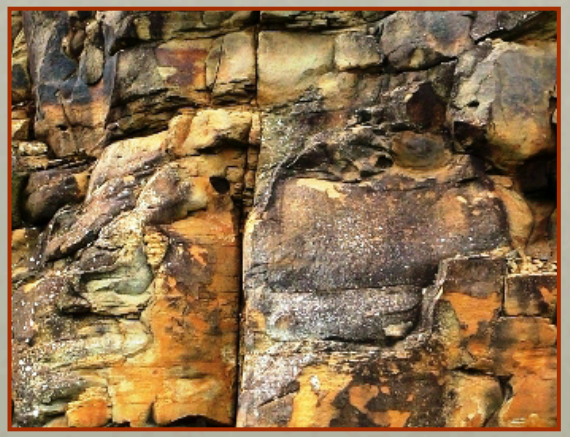
- Classroom instruction made a significant difference in students' ability to identify faults in these images, or to correctly identify them as lacking faults





Item Analysis: Very Challenging Images

- These images were challenging, even for classroom students on the post-test



Classroom Study Results

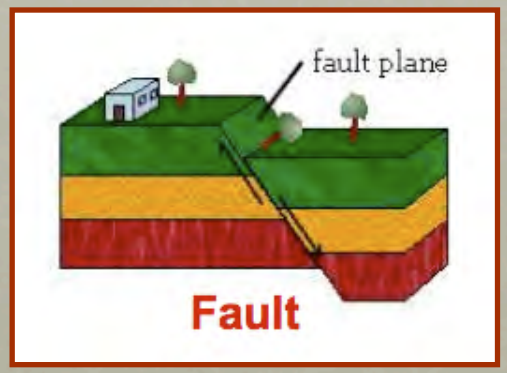
- Based on item analysis, students appear to be learning
  - That not all fractures are faults
  - To look for offset, even where layering is subtle or the offset is not eroded

Laboratory Experiments

- Common to all:
  - Non-geoscience (psychology) students at Northwestern University
  - Survey of prior geoscience knowledge/experience
- Experimental sequence: participants
  - Read a definition of faults (instruction)
  - Practiced finding faults in images (training task)
  - Were tested on their ability to identify faults in the same images as were used in the classroom pre- & post-test (transfer task)
- Differences between experimental conditions:
  - Level of detail in fault definitions
  - Sequence of practice images

Instructions

- Verbal definition only: "A fault is a fracture in a rock that shows some evidence of movement or displacement."
- Verbal definition with fault diagram:



- Verbal definition with paired diagrams of fracture & fault:

Training Task (=Practice)

- Paired images
  - Similar first
  - Dissimilar first
  - (Same 18 pairs)
- Single images (same 36 images)
- No practice
- In every case: no feedback on responses




Hypotheses

- Instruction:
  - Schematic diagrams will enhance participants' understanding of the verbal definition of fault
  - Paired schematic diagrams of faulted and unfaulted layers will be more effective than a single diagram of faulted layers
- Training:
  - Participants will be more successful at identifying a fault when they can compare two outcrop images, where one includes a fault and the other does not.

Laboratory Experiment Results

- *Best results:* instructions with paired diagrams (faulted and unfaulted layers) followed by practice comparing image pairs

Laboratory Experiment Results

- Otherwise, participant performance was (statistically) similar, regardless of instruction and training conditions:

Instructions	Training	N	D'
Verbal only	Image pairs	72	0.84 (1.39)
Verbal + single fault diagram	Image pairs	28	1.13 (1.20)
Verbal + single fault diagram	Single images	29	1.10 (1.45)
Verbal + single fault diagram	None	17	0.76 (1.11)
Verbal + paired diagrams	Image pairs	35	**1.47** (1.20)

- D' is the difference between the z-transforms of the hit rate and the false alarm rate. A perfect score on this test would result in a score of D'=3.26.

Informal Comparisons of Classroom Studies to Laboratory Experiments

- ***Caution! These two studies involve different student populations!***

- Experimental participants at NU who were given verbal fault definitions or who were shown the verbal definition with a single diagram of faulted layers perform similarly (D' = 0.94) to CC introductory geology students on the classroom pre-test (D' = 0.68)

- Exception: experiment participants who saw paired diagrams in the instructions and practiced on paired images performed comparably (D' = 1.47) to Carleton students taking the post-test (D' = 1.94)

Implications

- Paired diagrams of faulted and unfaulted layers, such as this one, appear to be particularly effective in helping novices understand faults:

- ***Note:*** Showing only the diagram on the right is not as instructive as showing both of these diagrams together.

Implications

- Novices seem to particularly struggle to distinguish fractures from faults and to recognize faults where layering is subtle or where the fault surface is not eroded. It may be helpful to address these points explicitly in the classroom.

Questions Arising From This Study

- Carleton students vs. Northwestern students: how comparable are these two sets of results?
  - For how long do experimental subjects retain their ability to recognize faults?
- Would the use of paired diagrams and images be helpful in developing expertise in other perceptual geoscience tasks (distinguishing salient features from distractors)?