Designing and Implementing Field Experiences through Distance Learning

Saturday Seminar
July 11, 2020
Announcements

● Last meeting today
● New activities? We will continue to accept new submissions into the fall
● NSF IUSE - field safety, incident/near-miss data on physical, mental, & emotional traumas
Sage Hen Flat exercise

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Note: This is designed as a capstone experience for a fieldcamp, but could also be used for fall online teaching
Very simply, there are two maps from the Sage Hen flat pluton in the White Mountains in California. The do not agree, and neither do the cross-sections.

This map is located at the black square in eastern California.
Two approximately NE-SE oriented cross sections were made, along the same line, by two different sets of authors. The point of the exercise is for students to evaluate which is more likely correct, or to propose their own model.

Hall & Ernst, 1987

Bilodeau & Nelson, 1993

Note: Cross-sections are shown at approximately the same spatial scale.
As you might expect, the difference in interpretation results from a difference in observations.

The fact that these two maps are so different indicates that:
1) Geological maps are interpretations
2) There is uncertainty of observations even on professional maps.
Overview of Sage Hen Flat exercise

• The approach is to reproduce the process of science in figuring out a problem. The setup of two different interpretations is a compelling one.

• Each day introduces a new data set, that the people who made the original maps didn’t have. This approach requires a daily re-evaluation of what they actually know.
  • Day 2: Fabric data on the pluton;
  • Day 3: Geological data coded for uncertainty on the west edge of pluton;
  • Day 4: Gravity; and
  • Day 5: Regional faulting.

• The central theme of the module is uncertainty. Days 2 & 3 have uncertainty modules about “data” and “models”, respectively. This strongly reinforces the daily re-evaluation of what they know.

• There will be a video of all powerpoint presentation (e.g., fabrics).
Overview of Sage Hen Flat exercise

• Day 1: Gain familiarity with tectonics of the White Mountains, the PC-C stratigraphy intruded by the Jr pluton, and the GoogleEarth images from the area.

• Day 2: Learn about data uncertainty. Work concentrates on magnetic fabrics within the pluton and dispersion of measurements. Create x-section.

• Day 3: Learn about model uncertainty. Explore data from west side of pluton. Create strip map of western side of pluton.

• Day 4: Use gravity data to get subsurface geometry of pluton. Create x-section.

• Day 5: Explore normal faults in field area. Create x-section.

• Day 6: Write up results. Turn in report.
Day 1

Note that individual fieldcamps will have to purchase one copy of each of the geological maps from GSA to share with students (~$20).

- Pre-assessment of module
- Each day has an overview for students, a powerpoint presentation, some resources (lectures, maps), sometimes a powerpoint module on uncertainty, and often an assignment that is due at the end of the day. There is one GoogleEarth .kmz file with all the data for the entire exercise.
- Day 1 has 50 minute video of Prof. S. Morgan explaining the Geology of Sage Hen flat
- Students turn in: 1) Worksheet of using GoogleEarth in White Mountains; and 2) A stratigraphic section of the Precambrian-Cambrian section of the White Mountains.
Day 2

- Day 2 has an data uncertainty module developed by geologists and cognitive scientists. This has embedded videos of geologists working in the field. **Introduction of the “Evidence Meter”**.

- There is a powerpoint about fabrics in plutons. Day 2 introduces magnetic fabrics from the Sage Hen flat pluton, determined using the Anisotropy of Magnetic Susceptibility (AMS) technique. It provides magnetic foliation and lineation. It is real data that is new and unpublished data.

- There is also data on mineralogy and microstructures.

- The uncertainty is evaluated through the dispersion of the AMS fabric data. The GoogleEarth files color codes the data by dispersion (uncertainty).

- Students make a cross section through the pluton (only)
No evidence indicates there is no information that constrains an inference in any way.

Permissive is the least certain form of evidence. Permissive suggests that a particular idea or inference cannot be ruled out, but it is also not the only available solution.

Suggestive indicates that there is positive evidence for a particular inference, but that the evidence also allows the possibility for other inferences.

Presumptive – defined as “presumed in the absence of further information” – indicates that an inference is “more likely right than wrong”.

Compelling indicates that the evidence is strongly supportive of the inference. Compelling evidence for an inference is based on a preponderance of positive evidence.

Certain indicates that there is a direct and resolvable link between the evidence and a particular inference.

“No evidence” and “Certain” are end members, because there is no variability within these categories.

The middle four categories – Permissive, Suggestive, Presumptive, Compelling – have a range of possible values.
Example of Technique 2: Geologic Mapping

Uncertainty in Kinematics

How sure are you the rocks in photo A are part of a strike-slip fault? Photo B? Why?

Slickenlines. Corona Beach, CA. Jackson

Faults in volcanic layers. El Salvador. C. DeMets
Day 3

- Day 3 has a model uncertainty module developed by geologists and cognitive scientists. This includes multiple working hypotheses and criteria for evaluating between different models. This has embedded videos of geologists working in the field. **Introduction of the “Evidence Meter” for models.**

- Day 3 introduces field data from the western margin of the Sage Hen flat pluton. The geologist explicitly evaluated his uncertainty while collecting the data, so the students can evaluate the utility of that approach.

- The students will evaluate the different interpretations of the geological maps, with the data from the geologists.

- Students make a geological map of the western margin of the pluton.
The uncertainty associated with a model relates to the data and the uncertainty of that data

General considerations for ranking model uncertainty:
- What is uncertainty of the data that are consistent with the model?
- What is uncertainty of the data that are inconsistent with the model?
- What is the balance of uncertainty in consistent and inconsistent data? (consistent data should ideally be low uncertainty)
- How well does the model provide predictions?
- Are other models available and better?
Models are never certain

Models are an approximation of reality. Because models “fill in” between available data points, there is always extrapolation and interpretation in a model.

Even models that seem obviously true -- think of Newtonian mechanics -- do not hold under all conditions (e.g., for objects moving at high speeds, one must adopt ideas from Einstein’s relativity). Thus, scientists have adopted the idea that models must be treated only as the best available approximation.

BUT, some models are better than other models, because they come closer to approaching certainty.

“Goodness” in a model is defined by several criteria:

➔ Logical consistency - i.e., parts of it don’t contradict other parts
➔ Agreement with best available data (and data of different types)
➔ Suggests verifiable causes that explain and/or predict
➔ Advanced comparisons - e.g., Occam’s razor: The best solution is generally the simplest solution
➔ Balanced tradeoff between generality (making many testable predictions) and specificity (agreeing with available data)

Day 4

- Day 4 introduces sub-surface data on the pluton from gravity analysis. This is real data.
- Gravity is a coarse tool, but it effectively eliminates one of the two models.
- The students will make a cross-section map of the entire field area, improving upon their earlier cross-section across the Sage Hen Flat pluton.
- Students use a guided assignment to evaluate the gravity data.
- Students will use the gravity data as an isopach map, which is likely a new concept when applied to granite.
Day 5

• Day 5 introduces the concept of normal faults in the area, which are not displayed prominently on either geological map.
• The realization of normal faults cutting the pluton explains some of the disparities between the two maps.
• Students use a guided assignment to evaluate the fault data.
• The students will make a new cross-section map of the entire field area, improving upon their earlier cross-section from the day before.
The normal faults and their offset are shown in yellow (from Google Earth).
What is a new scientist to do?
To start, find a mentor and learn the skills from that person.
We will use G.K. Gilbert, because he is one of the best.

- Be open to new ideas (rich in hypotheses).
- Be fair about how you interpret observations (maintains a judicial attitude).
- Do not be warped by prejudice (judge the hypothesis as an idea, regardless of its source (including yourself)).
- Do not be blind to the faults of any model, even the one you ultimately choose. It isn’t certain; it can’t be certain.

Perhaps the best advice ever given to a new geologist (from Paul Bateman, USGS)

“You don’t have to be right; you do have to be consistent with your data”

A working set of guidelines:

➔ Collect good data and honestly evaluate your uncertainty
➔ Be more skeptical of your models than you are of your data
➔ It might not be possible to ever get to even a presumptive model for any area; you might not have enough data or the right kind of data to evaluate it
➔ Published models are likely to be suggestive or better; however, they are never certain
➔ AND finally, what makes your data and model most useful is an accurate evaluation of the uncertainty associated with each