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

Created by:
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with help from:
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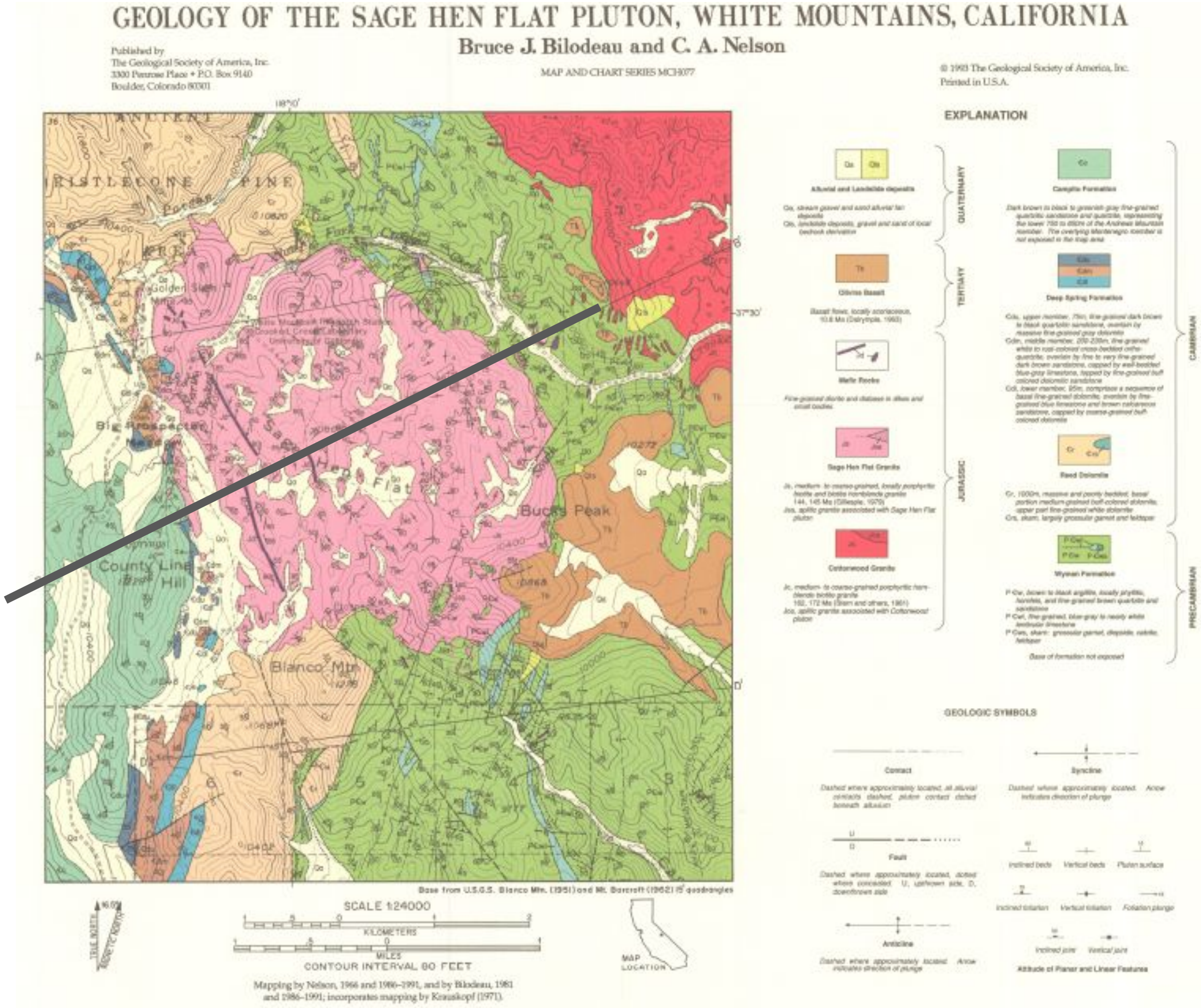
A. Glazner (University of North Carolina)
J.L. Vigneresse (University of Nancy & CREGU, France)

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.

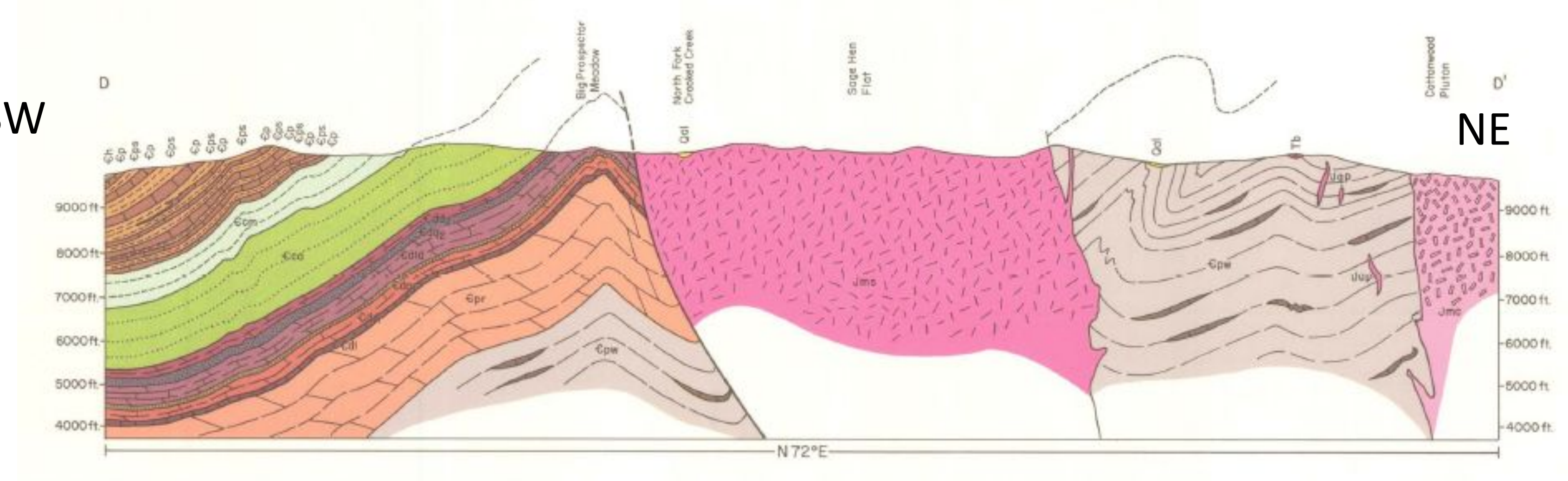
This map is located at the black square in eastern California



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.

SW

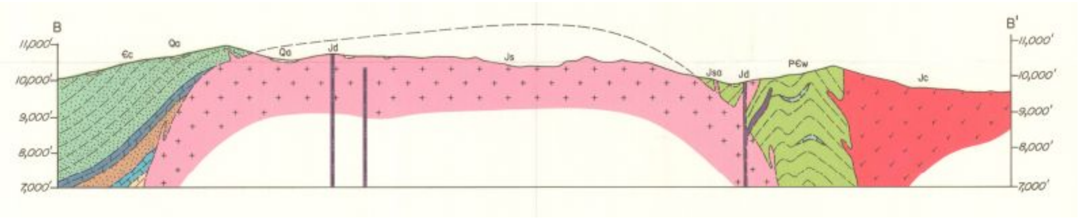
NE



Hall & Ernst, 1987

SW

NE



Note: Cross-sections are shown at approximately the same spatial scale.

Bilodeau & Nelson, 1993

As you might expect, the difference in interpretation results from a difference in observations.

Zoomed-in area in Figure 2

Bilodeau & Nelson (1993)

Hall & Ernst (1987)

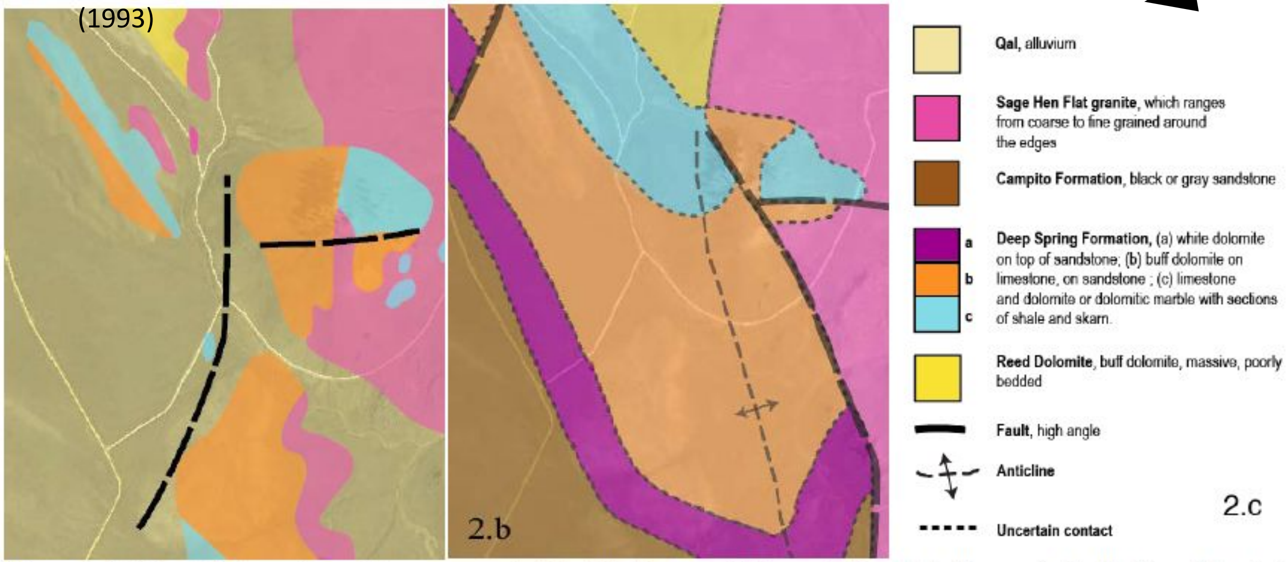
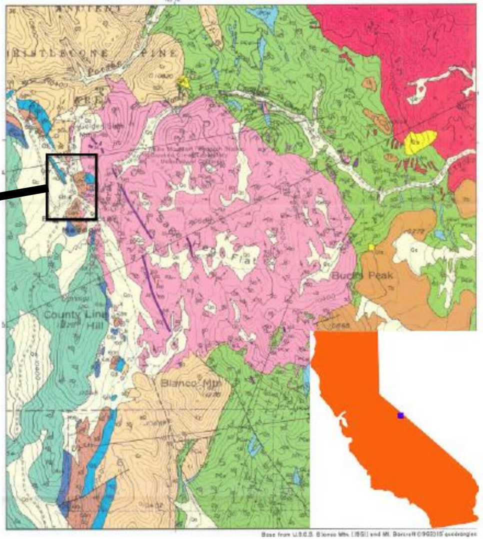


Figure 2. (a) Simplified version of the map created by Bilodeau and Nelson (a) in which the contact with the pluton is intrusive (Bilodeau and Nelson 1993). (b) Simplified version of the map created by Ernst and Hall in which the contact is a simple straight fault rather than an intrusion (Ernst and Hall 1987). (c) Composite stratigraphic key to the two maps above.

Data from student project by L.D. Wison, J.D. Higdon, and J.A. Davidson; Courtesy of A. Glazner



Pink shows extent of Sage Hen pluton
Bilodeau & Nelson (1993) map

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).

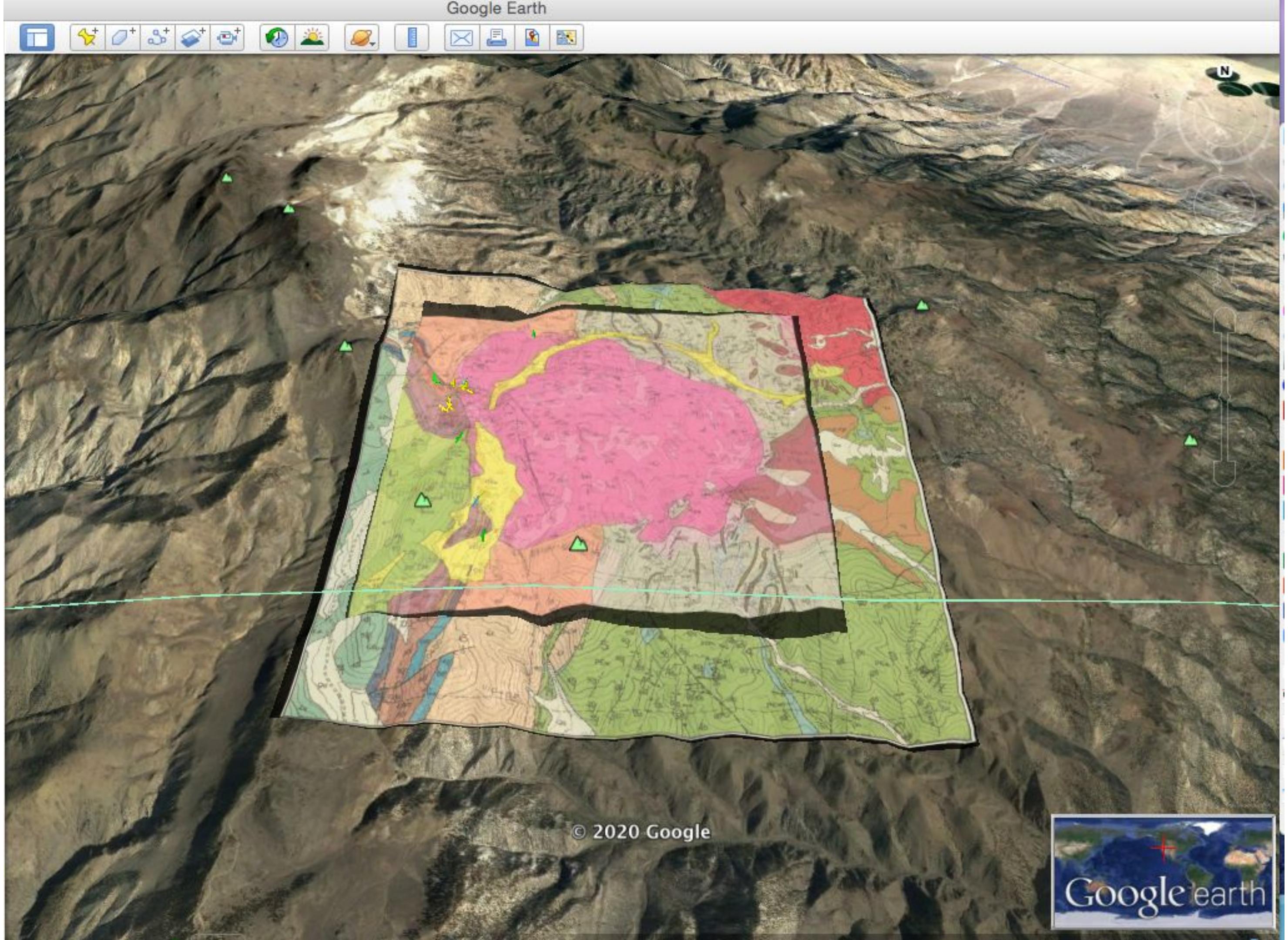
Overview of Sage Hen Flat exercise

- 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.


Google Earth
© 2020 Google
Google earth

Day 2

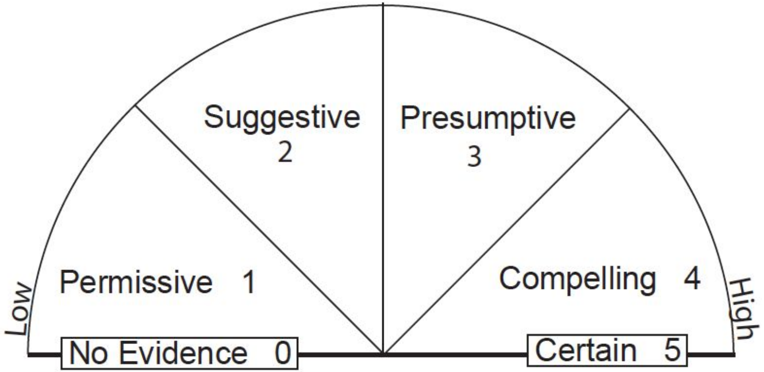
- Day 2 has an data uncertainty module developed by geologists and cognitive scientists. This has embedded videos of geologists working in the field. **Introduction of the "Evidence Meter".**
- There is a powerpoint about fabrics in plutons. Day 2 introduces magnetic fabrics from the Sage Hen flat pluton, 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)

Evidence meter

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".

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.



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

No evidence indicates there is no information that constrains an inference in any way.

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

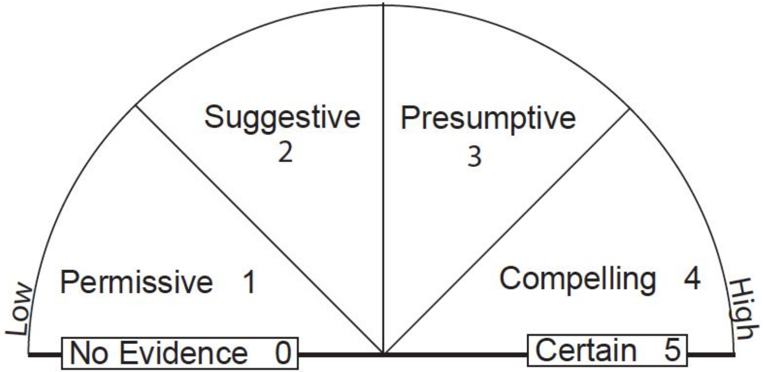
The middle four categories – Permissive, Suggestive, Presumptive, Compelling – have a range of possible values.

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

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?

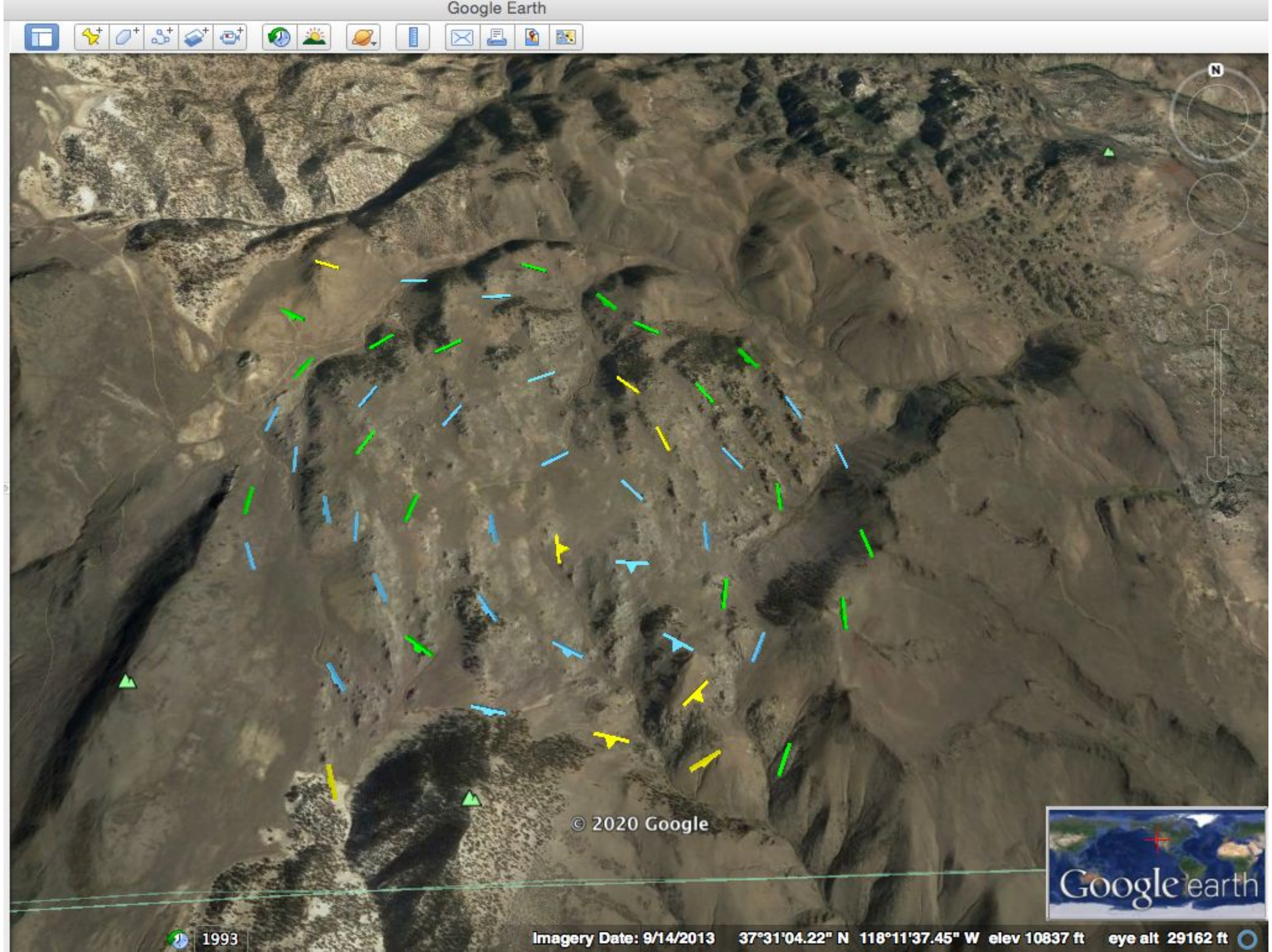


A

Slickenlines. Corona Beach, CA. Jackson

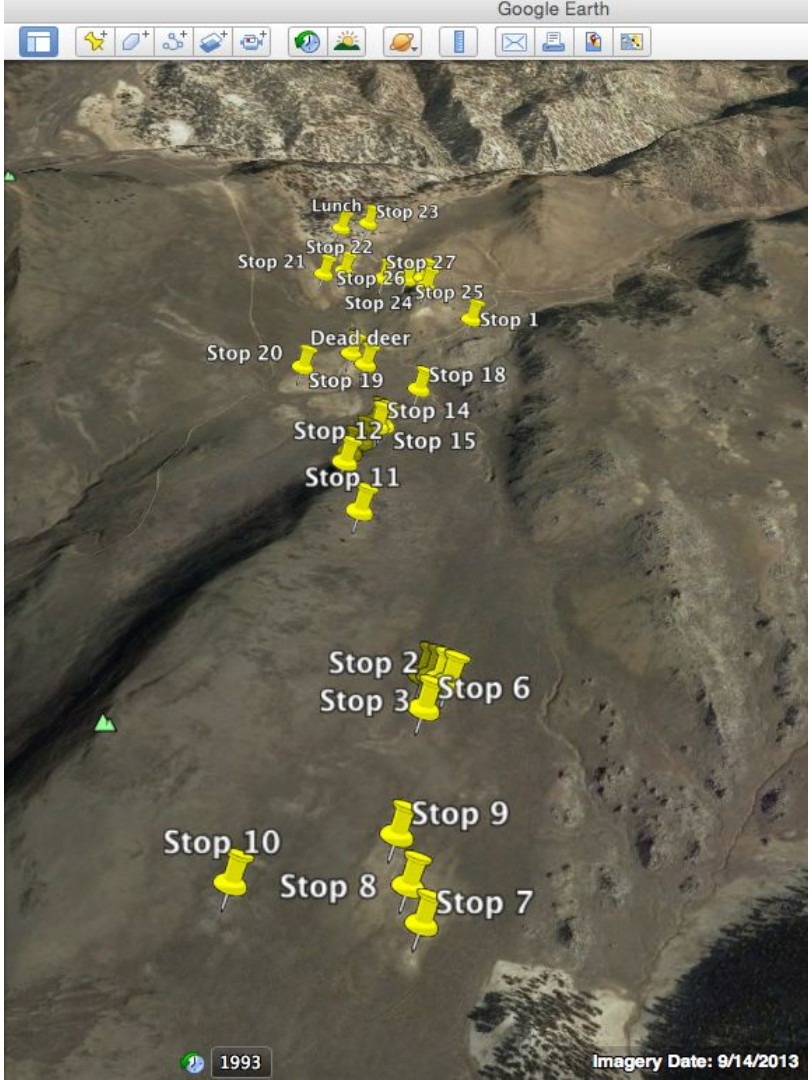
B

Faults in volcanic layers. El Salvador. C. DeMets


Google Earth
© 2020 Google
1993
Imagery Date: 9/14/2013
37°31'04.22" N 118°11'37.45" W elev 10837 ft
eye alt 29162 ft
Google earth

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.


Google Earth
Lunch
Stop 23
Stop 22
Stop 21
Stop 27
Stop 26
Stop 25
Stop 24
Stop 1
Dead deer
Stop 20
Stop 19
Stop 18
Stop 14
Stop 12
Stop 15
Stop 11
Stop 2
Stop 6
Stop 3
Stop 9
Stop 10
Stop 8
Stop 7
1993
Imagery Date: 9/14/2013

The uncertainty associated with a model relates to the data and the uncertainty of that data

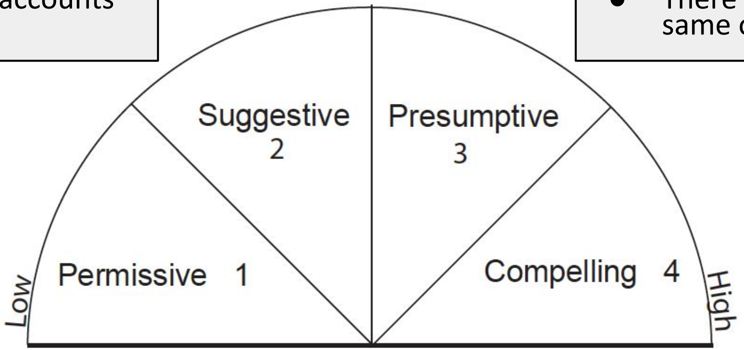
General considerations for ranking model uncertainty:

- 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?

Suggestive
- Consistent with some suggestive and permissive data
- Inconsistent with only permissive (or very small number of suggestive) data
- Makes some predictions that are verifiable
- There may be other models that accounts for the same data

Presumptive
- Consistent with some presumptive data or a lot of suggestive data
- Inconsistent with only some suggestive or permissive data
- Makes some predictions that are verifiable
- There is no other model that accounts for the same or more data

Permissive
- Consistent with some permissive data
- Inconsistent with less permissive data
- Makes a few predictions that are verifiable
- There may be other models that accounts for the same data



Note that Certainty is not possible with a model

Compelling
- Consistent with some compelling & presumptive data
- Inconsistent with only suggestive and permissive data
- Makes many predictions that are verifiable
- There is no model that accounts for the same or more data

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 part
- ➔ Agreement with best available data (and data of different type
- ➔ Suggests verifiable causes that explain and/or predict
- ➔ Advanced comparisons - e.g., Occam’s razor: The best soluti generally the simplest solution
- ➔ Balanced tradeoff between generality (making many testable predictions)and specificity (agreeing with available data)

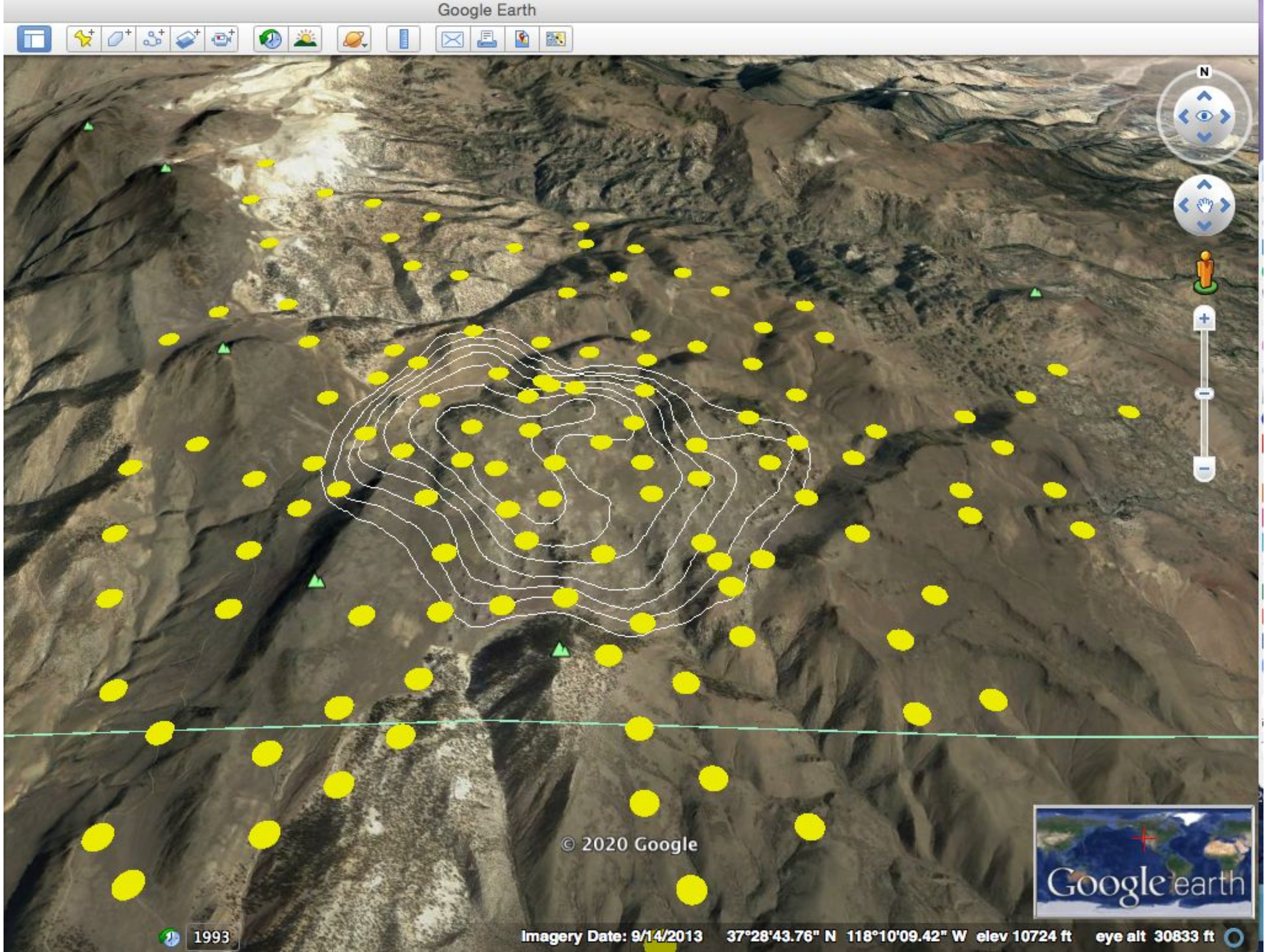
G.E. Box

All models are wrong; some models are useful

From p.240 in
A conversation with statistician George Box, *Statistical Science*, **2** (1987), 239-258.

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.


Google Earth
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© 2020 Google
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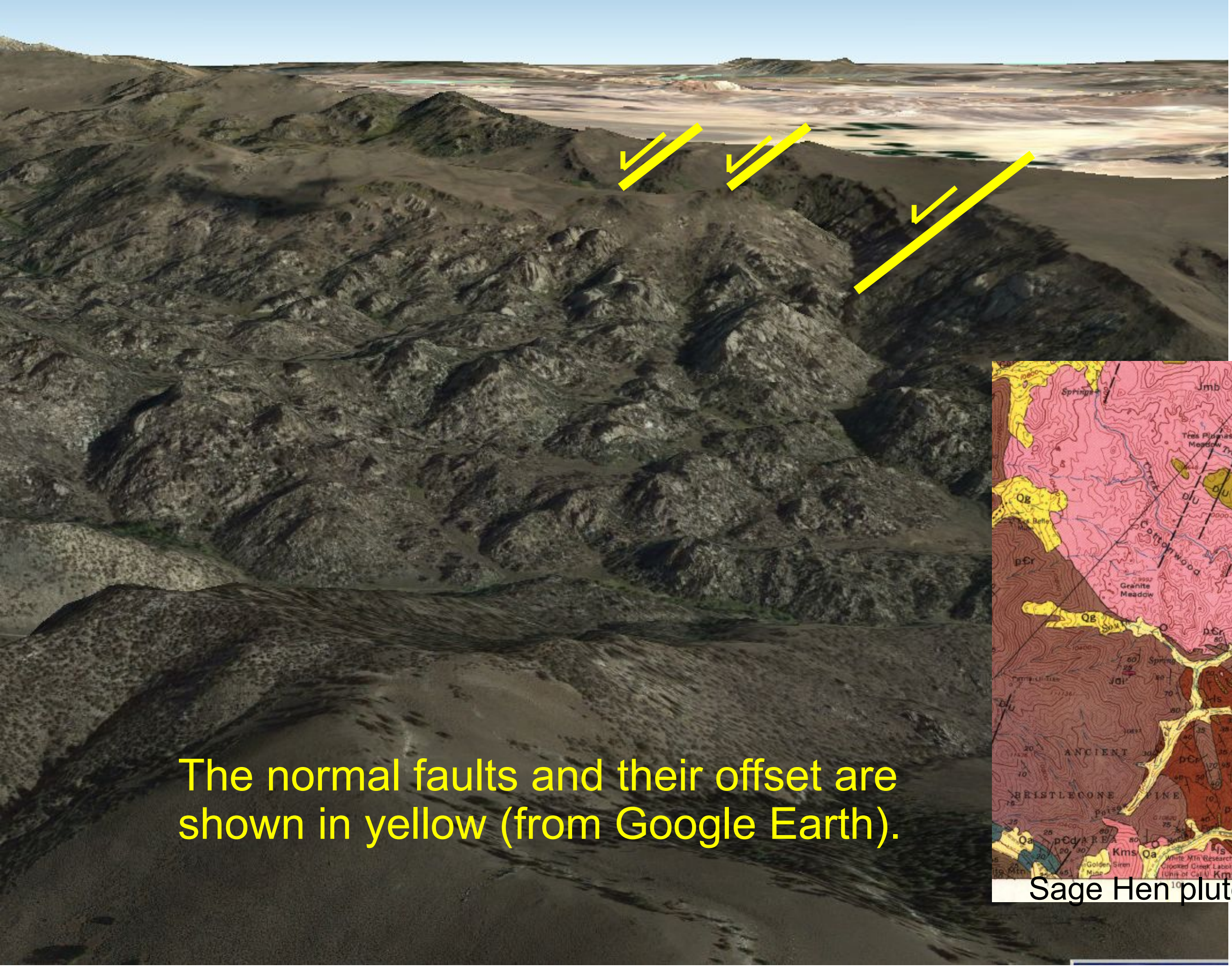
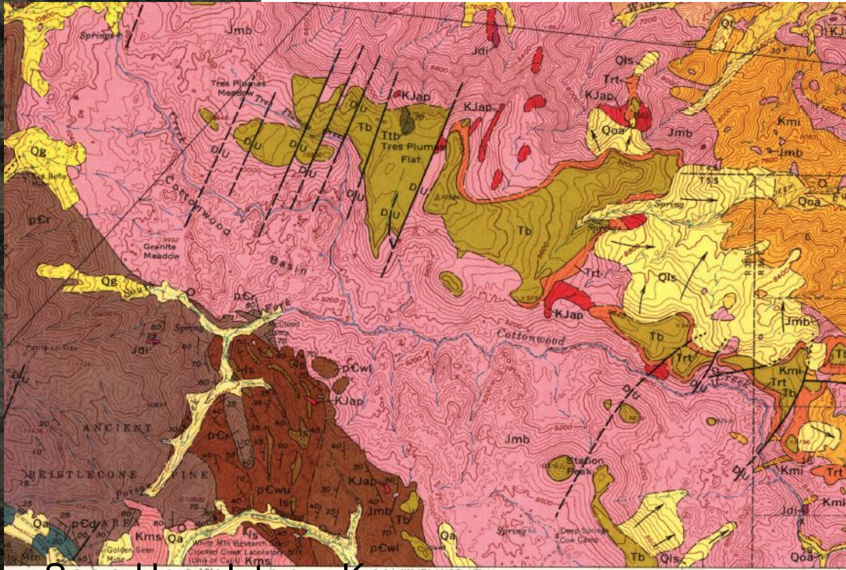
Imagery Date: 9/14/2013 37°28'43.76" N 118°10'09.42" W elev 10724 ft eye alt 30833 ft

Day 5

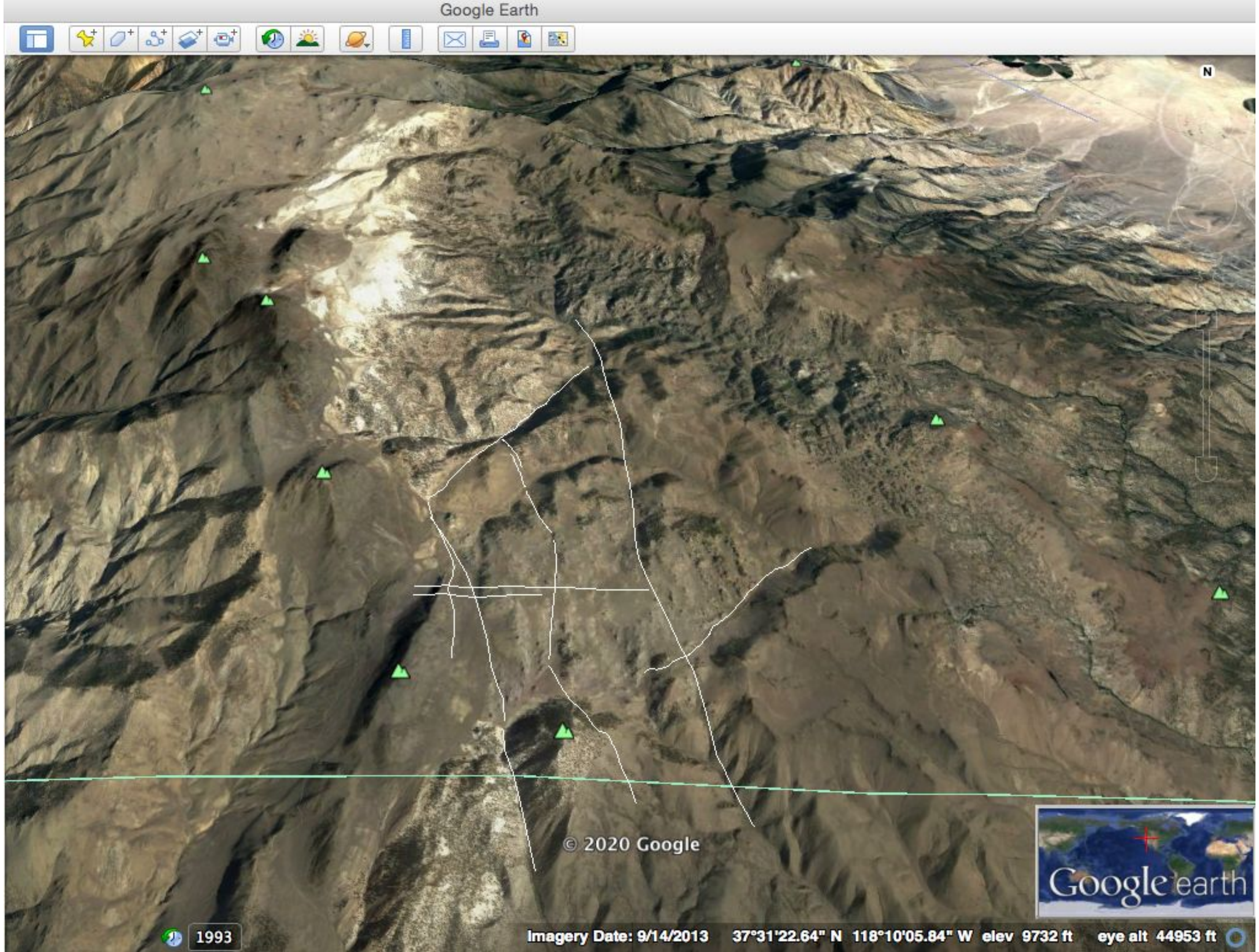
- Day 5 introduces the concept of normal faults in the area, which are not displayed prominently on either geological map.
- The realization of normal faults cutting the pluton explains some of the disparities between the two maps.
- Students use a guided assignment to evaluate the fault data.
- The 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).



Sage Hen pluton = Kms


Google Earth
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© 2020 Google
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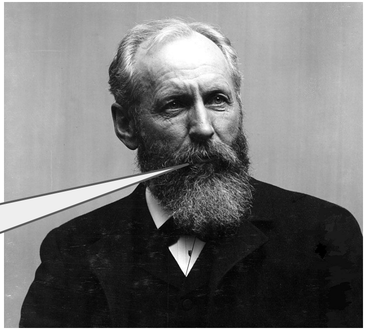
Imagery Date: 9/14/2013 37°31'22.64" N 118°10'05.84" W elev 9732 ft eye alt 44953 ft

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.



By Unknown author - USGS Denver Library Photographic Collection

- 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