Teaching Geoscience to Non-Geologists: Petroleum-Engineering Geology Field Camp at Colorado School of Mines (Abstract #75555, Session T124)

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Introduction

The petroleum-engineering (PE) geology field camp at Colorado School of Mines is a cross-disciplinary outdoor geology laboratory at a field station near Rangely, Colorado. Twenty to 40 students participate annually. The field camp has existed for over 35 years, and the curriculum has evolved accordingly. Presently, two professors (authors of this poster), a geologist and a petroleum engineer, and two geology TA's, team-teach the course, resulting in a high student-teacher ratio. The instructors also have extensive petroleum-industry experience. The two geology TA's are recruited for strong backgrounds in sedimentary and structural geology.

The camp is strongly supported by a PE industry advisory committee and PE alumni, because geology is an essential component of petroleum engineering.

Context

Students in the course:

1. Have just completed the junior year in the PE major: average age is 21.

2. Have *mastered* basic physics, chemistry, and basic petroleum engineering topics such as petroleum fluids, drilling, and rock properties.

3. Have been *exposed* to basic sedimentary and structural geology in lab-based courses the previous two semesters (Fall and Spring).

The two previous geology courses, in addition to basic geology required of all CSM undergraduates:

a. Are applied courses taught for non-majors: emphasis varies depending on instructor.

b. Are variably field-based, depending on instructor.

c. Retention and transfer of knowledge is an issue.

d. Efforts are being made to link the previous courses to the objectives of field camp by working with instructors.

4. Field camp is likely the last academic exposure to geology for many of the students.

5 Bridge to a capstone senior-level integrated design course where

PE, geologic and geophysical engineering students work together on cross-disciplinary petroleum geoscience projects.

Learning Goals

Goals for the camp include:

1. 3-D visualization and how to link surface to subsurface,

2. How to gather and analyze multiscalar data,

3. Relate petroleum engineering to geologic workflows, and

4. Integrate engineering, geologic and geophysical technology.

Materials, Data, Tools, and Logistics

Specialized tools, equipment and software are NOT required. Tools/equipment consist of common geologic material: Brunton compasses, tape measures, Jacob staffs (1.5 m sticks), and field notebooks.

Data sets are donated by petroleum-industry supporters and/or downloaded from public-domain sources: digital elevation models, geophysical logs, specialized image logs, and seismic reflection lines.

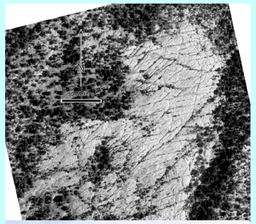
Important logistics include the following:

1. Because the Rangely area is in the middle of active oil and gas development, industry operators in nearby fields commonly host the group for facility tours. Prior to visiting fields, geologic exercises are conducted on outcrops of the producing reservoir intervals to link surface to subsurface.

2. Camp facilities are minimalist, consisting of plywood-sided cabins, well water, and porta-potties. Electricity was added in the mid-1980s.

Activities

Activities consist of daily outcrop-based labs related to nearby oil and gas fields. Labs use mapping, measuring section, sketching, and note-taking to promote geologic thought processes: geophysical data link the outcrop to the subsurface. Two labs emphasize 3-D visualization of stratigraphic pinchouts and folds, which for many students is the first time they actually " see it." Another lab relates student-gathered data from an outcrop fracture pavement to subsurface strain patterns. In a day long " Acquisition Game" teams analyze oil and gas properties based on the geologic and engineering data analyzed over the two weeks.



Fracture Analysis

In groups of three, students analyze fracture length, orientation, and spacing on a well-exposed "pavement" at the crest of an anticline that they have mapped in a previous exercise. Frisbees are used as sampling devices: where a frisbee lands on the pavement, is where data are gathered. "Null" throws (no fractures intersected) are counted to illustrate the probability of encountering fractures in an 8" borehole.

Thirty fractures per student group are plotted on a rose diagram and compared to regional stress-strain and borehole-image data. Students are also required to analyze how fluid would flow from N to S across the field area.

Instructors give a mini-lecture on stress-strain analysis.

Fluid-Flow in Apparently Homogeneous Eolian Deposits

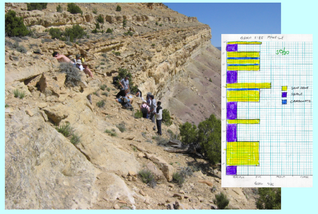
In a series of exercises along the Weber Sandstone outcrop belt at Dinosaur National Park, students analyze small to large scale heterogeneities in otherwise homogeneous-appearing eolian sandstone. Sketching the outcrop forces students to observe bedding surfaces and small-offset faults. They are required to divide the cliff face exposure into possible flow units.

Acquisition Game: Tying the Experience Together

In instructor-assigned groups of 3-4, students spend the last full day of field camp analyzing 12 "properties" that include oil and gas fields studied during the two weeks of camp. Each property has a series of geologic data sheets and questions that must be answered, using the geologic tools gained during field camp. These tools illustrate the "geologic workflow" commonly used in the petroleum industry. Each team selects five fields for bidding and then selects final bids constrained by the amount of budget available. Geology topics lead to answering engineering questions: recoverable reserves (hydrocarbon volumes) and economic value. Each team writes a final report that includes an analysis of bidding strategy.

Reservoir Continuity in Lacustrine Shoreface Deposits

In groups of 3, students measure 100 feet of section through stacked lake shoreface deposits. Using the measurements to calculate net-gross sandstone, the students also have to correlate their sections to a suite of gamma ray logs along the outcrop belt. The exercise is followed by a visit to an oil field 13 miles west and downdip of the outcrop, where the same rocks are producing oil.



Stratigraphic Pinchouts & Visualizing in 3-D

An excellent outcrop of crevasse channel, splay, and fluvial meanderbelt bodies provides an opportunity for students to physically touch stratigraphic pinchouts in three dimensions. Teams of students are assigned to different bodies beginning at different horizons on the cliff face below. As they walk around the outcrop, they make notes and take sketches to answer various questions about flow continuity. Around the back of the outcrop where everyone finishes, the teams then present their observations and interpretations to the rest of the group. For many students, this is the first time they actually visualize in 3-D.

Challenges

Teaching non-majors presents several challenges because love of subject matter cannot be assumed. Challenges related to maintaining an interest in geoscience include:

1) fostering an applied science approach; and

2) maintaining a positive attitude toward geology and the outdoors.

Presently, we attempt to overcome these challenges by integrating pure engineering into the curriculum on several days and by breaking up the session with a geology field trip that consists of a rafting excursion on the Green River through the Split Mountain anticline. Geology, however, is NOT discussed by the instructor during the trip. Inquiry is left to curiosity.

In addition, "normal" challenges include:

1) teaching iterative thought processes; 2) creating 3D visualization exercises; 3) creating linked exercises that build on each other; 4) retention of material taught.

Assessment

Assessment during the field session consists of

1. Daily journals,
2. Written lab reports,
3. Results from "Acquisition Game,"
4. A comprehensive final exam that also includes a questionnaire about the field experience: logistical (living) and learning.
5. Instructors and teaching assistants also make inquiries and provide "listening posts" during the field session and make on-the-spot changes as needed.
6. Instructors make notes during each session and revise and create new exercises continually.

As a hindsight process, feedback is solicited continually from alumni who are practicing professionals.