Structural Geology (GE 231) Syllabus
Fall, 2007

1. Instructor
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2. Texts and required materials
Additional materials: You will also need high-quality mechanical pencils (0.5-mm lead or smaller) and a scientific calculator.

3. Course objectives
Structural geology is the study of the geometry of geologic structures (such as faults, folds, joints, intrusive bodies, etc.), how these structures form, their significance to the geologic history of an area, and their relationship to plate-tectonic motions. In my opinion, a basic course in structural geology should: 1) enable you to evaluate a suite of geologic structures in order to draw conclusions about their formation and significance to the geologic history of an area, 2) enable you to apply basic structural analysis techniques to solve problems in a variety of geoscience disciplines, and 3) help you develop the three-dimensional thinking skills needed to evaluate subsurface geology in three dimensions using two-dimensional data sets. In addition to these three primary goals, this course also aims to improve your graphical and written communication skills.

4. Course structure
4.1 Lecture periods
The lecture portion of this course will primarily be devoted to covering some of the most important and useful topics in the field structural geology. This will involve me presenting information on these topics orally and graphically using Power Point and illustrations on the board. In order to encourage you to be active learners in the lecture periods, I will frequently pause and have you apply the concepts covered in the lecture and the assigned reading by interpreting maps and photographs of geologic structures or by having you work through simple problems. I encourage you to ASK QUESTIONS AT ANY POINT during the lecture periods. I may also give you short quizzes at the end of lecture periods to assess your comprehension of the topic and to promote retention of the material.

4.2 Laboratory periods
The laboratory part of this course is designed to: 1) have you develop a set of structural analysis skills that you can apply to geologic problems in a variety of disciplines, 2) have you develop good data-recording and geologic-observation skills, 3) improve your three-dimensional thinking skills, and 4) improve your graphical and written communication skills by presenting your data and interpretations in a concise, effective manner. The in-class laboratory exercises
will primarily address items one and three above. The field trips and air-photo mapping exercise will address all of these items by having you collect data, analyze your data using basic structural-analysis techniques, interpret your data, and produce a short geologic report wherein you outline your data and interpretations in writing and illustrations.

When I defended my M.S. thesis, one of my good buddies (a geochemist) circulated an e-mail for the post-defense party. In this e-mail he said “Bill has just defended his Masters in Coloring”. His comment reflects one of the fundamental aspects of structural geology. That is, many of the graphical techniques you will learn in this course such as cross-section construction, block-diagram construction, and geologic-map preparation require careful, precise drafting and, yes, coloring. In many cases, the accuracy of your results in these exercises is dependant on how carefully you can draft the geometric constructions. Therefore, NEATNESS COUNTS!

6. Field trips

There are three in-lab field trips and one all-day field trip. Please show up with all required gear. For the all-day trip you will need to bring lunch. At the end of each trip I will collect your field notebooks, evaluate them, and return them ASAP. I expect to see improvements in your note taking with each trip.

There are no make-up field trips. If you miss one of the trips for an excused absence, I will have to find something else for you to do that requires the same amount of time and effort as the field trip and the geologic report you would have written (probably a really gnarly cross-section and geologic-map interpretation exercise).

6. Assessment

6.1 Student assessment

There are 500 total points possible. Student assessment will be based on:

- Midterm exam (100 points)*
- Final exam (150 points)*
- Six in-class laboratory exercises (total 105 points)
- Four field trips including reports and field notebooks (total 105 points)
  - Written reports, maps, and figures: Trips 1, 3, and 4 = 45 points, Trip 2 = 40 points
  - Field notebooks 5 points x 4 = 20 points
- Two abstracts written for papers discussed in class (total 30 points)
- Mohr-circle homework (10 points)

*Lecture exams may also involve laboratory methods.

For the purposes of a core major’s course, I consider a B to be an average grade. To earn an A in this class you will have to impress me with well-above-average comprehension of the material; efficient, creative implementation of structural analysis methods; and unusual insights and original thinking in your geologic interpretations.

6.2 Instructor assessment

This fall marks the beginning of my 7th year teaching geoscience laboratory classes. However, this course will be my first attempt at teaching a complete lecture/laboratory class. Therefore, I am planning on taking a number of steps to assess my performance and make improvements throughout the semester. Bob Gastaldo will be sitting in on our classes periodically in order to provide constructive criticism. I also plan on asking one or more senior faculty members from outside the Geology Department to sit in on the class. In addition to this, I
am relying on you to provide me constructive feedback on my teaching. I will have you complete informal teaching evaluations once or twice during the semester. If any of you think there is something I am doing that either really helps you learn or is ineffective, please do not hesitate to tell me in person.

7. Attendance and academic dishonesty policies

    Attendance of all lectures, labs, and field trips is required. Don’t cheat. I am really intolerant of academic dishonesty. I will follow College policies on attendance and academic dishonesty. These can be found in the College Catalogue and the Student Handbook.

8. Tentative course schedule

8.1 Lecture Schedule

Note: Class will be canceled October 29–31 (Monday–Wednesday) for the Geol. Soc. of America meeting in Denver.

1. Introduction to structural geology (1 lecture): D&R Preface (vii–ix) and p. 2–37
   • Strike and dip, trend and plunge, rake/pitch
   • Measuring surfaces and lines in the field
   • Introduction to geologic maps
   • Map patterns created by intersections of surfaces and topography
4. Primary structures and facing directions (1 lecture): D&R p. 645–662
   • Geologic contacts
   • Recognizing different geologic contacts in the field
   • Determining facing directions using primary structures
5. Foliations and lineations (1–2 lectures): D&R p. 424–476
   • Types of foliations and their formation
   • Types of lineations and their formation
   • Basic elements of folds
   • Classification of folds: Interlimb angle, dip of axial surface, plunge of fold axis, cylindrical vs. noncylindrical folds, and dip isogons
   • Foliation-bedding intersections and facing directions
   • Geometric techniques using stereo nets
   • Recognizing and interpreting refolded folds
   • Joint formation and morphology
   • Vein formation and morphology
9. Faults, descriptive (4–5 lectures)
   • Basic fault terminology: D&R p. 269–286, 292–303
   • Reverse faults: D&R p. 219–335
   • Normal faults: D&R p. 340–357
   • Strike-slip faults: D&R p. 357–371
• Fault systems and hydrocarbon traps: Harding and Lowell, 1979, AAPG Bulletin — will be handed out in class

**Midterm exam**: Date TBA. Will cover topics 1–9.

10. Stress theory (1 lecture): *D&R* p. 98–122
   • Introduction to force and stress
   • Three principal stress directions and shear stress

11. Fault mechanics (4–5 lectures)
   • Brittle rupture vs. slip on a pre-existing fracture
   • Homework dealing with Mohr-circle analysis. Begin in class
   • Griffith theory: *D&R* p. 252–256
   • Andersonian faulting: *D&R* p. 304–317
   • Exceptions to Andersonian faulting (Hubert and Ruby experiments): *D&R* p. 345–351
   • Fault strength and crustal deformation case study: San Andreas Fault

   • Types of strain
   • The strain ellipsoid
   • Quantifying strain in deformed rocks

13) Rheology theory (2–3 lectures): *D&R* p. 143–148; *Handout from van der Pluijm and Marshak*
   • Relationship between stress, strain, and strain rate
   • Linear rheologies
   • Nonlinear rheologies
   • Rheology and the behavior of the lithosphere
   • Case study: The Homestake shear zone

14) Fold mechanics (1–2 lectures): *D&R* p. 397–423

Optional topics: To be covered if time allows

15) Deformation mechanisms: *D&R Chapter 4*

16) Plastic high-strain zones: *D&R Chapter 9*

Scheduled Lectures: May interrupt topics above

September 24) Preliminaries for Kennebec River field trip

September 28) Preliminaries for Pemaquid Point field trip

November 12) Introduction to geologic cross-section construction

**Final Exam**: Cumulative. Saturday, December 15, 3:30–5:30 PM

8.2 Laboratory schedule

8.2.1 In-class lab exercises

1. (September 11) Planes, lines, and topography — Measuring orientations of planes and lines, planes and topography, apparent dip calculations, and three-point problems. 10 points

2. (September 18) Stereonets-I — Plotting planes, lines, poles to planes, and finding orientation of line in a plane using pitch/rake. 10 points
3. (November 6) Stereonets-II — Rotations, net-slip problems, and bore-hole problems. 15 points
4. (November 13) Structure contours and an introductory cross section. 15 points
5. (November 20) Geologic mapping using air photos — Seminoe Dam area, Wyoming. Will require a written report. 30 points
6. (November 27) Cross sections and cross-section balancing. 15 points
7. (December 4) Block diagram construction. 10 points

8.2.2 Field trips
1. (September 25, during regular lab time) Field trip to Kennebec River outcrops-I — Introduction to the Waterville formation, basic geologic contacts, planes and topography, and collecting and recording data in the field. **Read D&R 626–644 before trip**
2. (September 30, Sunday) All-day field trip to Pemaquid Point — We will: 1) make a large-scale geologic map of these exposures using an air-photo base; 2) measure orientations of bedding/foliation, fold hinges, and fold axial surfaces; 3) use outcrop-scale structures to interpret the relative rheologic strengths of the different rock units; and 4) use cross-cutting relationships to determine the timing of intrusive events.
3. (October 9, during regular lab time) Field trip to Kennebec River outcrops-II — We will focus on interpreting the refolded folds in these rocks.
4. (October 16, during regular lab time) Field trip to Kennebec River outcrops-III — We will focus on interpreting the different vein networks in these rocks.