Structural Geology

Geosciences 241
Spring 2012

Contact information

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Office hours: M 3:00–4:00, Th 2:00–3:00, and by appointment; also feel free to stop by whenever my door is open

Course organization

Schedule: Monday, Wednesday, Friday, 9:00–9:50 am, Sabin-Reed 107
Tuesday, 1:10–4:50 pm, Sabin-Reed 107 (before spring break)
Tuesday, 12:20–4:50 pm, in the field (after spring break)

Monday, Wednesday, and Friday lectures will focus on concepts of structural geology. Before each class, read the lecture assignment, using the reading guide as a suggestion of topics to focus on.

Tuesday lab sessions before spring break will be held indoors and explore fundamental techniques and applications of structural geology. Following spring break, we will be in the field each Tuesday. Note that, in lieu of a weekend field trip, Tuesday field trips will **depart at 12:20 pm**. If you have a conflict with this schedule, please let me know as soon as possible.

Reading:
- An Introduction to Structural Methods by H.R. Burger and T.A. Harms (Tasa Graphic Arts). This is not strictly a textbook but an interactive DVD that provides comprehensive text along with animations to help visualize many concepts. This resource is also available on the Cave computers (no DVD required). Be sure to read the "in-depth comments" you encounter, and take any quizzes associated with the assigned reading to check your knowledge.
- Structural Geology by H. Fossen (Cambridge, ISBN 978-0521516648). One copy will be available in the new Cave (careful — the pages are falling out), one copy is on reserve at Young Science Library, and copies are available for purchase at the Grecourt Bookstore. This book is a superb reference and features helpful complementary online content, accessible at http://www.cambridge.org/fossen.
- Required scientific journal articles will be posted on the course's Moodle site.

Lab equipment:
- Calculator with trigonometric functions
- Clear plastic ruler, marked in 0.1" and/or 1 mm increments

- Protractor (my favorite is the C-Thru W-37 ruler/protractor)
- Several colored pencils
- Hard-lead pencils (example: Staedtler Mars Lumograph 2H or harder), sharpener, and eraser
- Black ink drafting pens
- Pencil compass (for drawing circles)

Field equipment:
- Notebook and/or clipboard for taking notes
- Sturdy footwear
- Clothing appropriate for the weather (keeping in mind that it may be warmer/cooler/rainier/windier at our field sites than on campus)
- A belt on which to wear your Brunton compass (compass issued by me)
- A backpack to hold your belongings

Course goals

Structural geology is the study of Earth's deformation, from atomic to orogenic scale. By using observations of geologic structures — fractures, faults, folds, and fabric — we can make inferences about the deformational history of a region. In addition to gaining insight into plate tectonic processes, structural geology holds great value to society. For example, assessing earthquake hazards require a detailed understanding of a region's structural geology. Additionally, hydrocarbon exploration is fundamentally dependent on knowledge of the subsurface fault and fold architecture. By the end of this course, you will have gained experience in:
- Evaluating the geometry of geologic structures;
- Using concepts of solid mechanics to interpret the kinematics and dynamics of geologic structures;
- Using graphical tools to compile and interpret structural data;
- Evaluating lithologic and structural patterns on geologic maps;
- Making primary observations in the field and using them to construct and test structural hypotheses; and
- Integrating topics in structural geology and plate tectonics through survey of scientific literature.

Grading

Class participation: 5%
Journal article assignments (4): 5% each
Take-home exams (2): 10% each
Lab assignments (8): 2.5% each
Mount Tom concept sketch: 10%
Turners Falls concept sketch: 10%
Cummington concept sketch: 15%

Assignment descriptions

Journal article discussions: We will read four journal articles this semester and spend an entire class discussing them. Two students will be responsible for leading the discussion, and everyone will submit questions in advance to frame the discussion. All articles come from the journal *Geology* and are four pages long. This means that each article is dense but written to be accessible to a broad earth science audience. The papers are:

1. Allmendinger, R.W., R. Smalley, Jr., M. Bevis, H. Caprio, and B. Brooks (2005), Bending the Bolivian orocline in real time, *Geology*, *33*(11), 905–908; doi: 10.1130/G21779.1.
2. Dolan, J.F., D.D. Bowman, and C.G. Sammis (2007), Long-range and long-term fault interactions in Southern California, *Geology*, *35*(9), 855–858; doi: 10.1130/G23789A.1.
3. Suppe, J. (2007), Absolute fault and crustal strength from wedge tapers, *Geology*, *35*(12), 1127–1130; doi: 10.1130/G24053A.1
4. Fagereng, Å and R.H. Sibson (2010), Mélange rheology and seismic style, *Geology*, *38*(8), 751–754, doi: 10.1130/G30868.1.

Take-home exams: There will be two take-home exams during the semester. You will have one week to complete the exams.

Lab assignments: Before spring break, we will spend Tuesday afternoons in the lab. Related assignments are due at the beginning of lab the following week.

Concept sketches: For all but the first field excursion, you will complete a special type of report called a concept sketch. More details will be distributed later in the semester.

Responsibilities

Please arrive on time to class each day and be prepared to discuss the day's lecture topics in small-group and whole-class conversations. We will cover a lot of material in the course, so it is crucial that you keep up with assigned readings. Absences from classes will negatively affect your class participation grade. Labs are an essential complement to lectures, so attendance is mandatory. If you absolutely cannot attend one of the field trips, please let me know as soon as possible so that we don't delay our departure waiting for you.

Honor code

As with all other Smith College courses, the Honor Code is in effect. I encourage you to discuss homework and lab assignments with each other, but any assignments that you hand in must be your own work. Take-home exams are to be completed independently without discussion.

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Day	Date	Topic	Reading	Assignment due
F	1/27	Introduction to structural geology		
M	1/30	Structures in 3D	BH:5–51	
T	1/31	Lab: Lines and planes in structural geology	BH:52–155	
W	2/1	Structures in 3D	BH:156–219	
F	2/3	Strain: Describing deformation	F:2.1–2.6	
M	2/6	Strain: Strain ellipsoid	BH:1252–1318	
T	2/7	Lab: Geologic map patterns	BH:52–219	Lines & planes lab
W	2/8	Strain: Pure vs. simple; finite vs. infinitesimal	BH:1438–1461	
F	2/10	Paper discussion: Strain in the Andes	Allmendinger et al. paper	Discussion preparation
M	2/13	Stress	BH:1048–1076	
T	2/14	Lab: Stereonet analysis		Map patterns lab
W	2/15	Stress	BH:1077–1117	
F	2/17	Stress	BH:1118–1160	
M	2/20	Rheology: Relating stress and strain	F:6.1–6.9	
T	2/21	Lab: Rheology	F:6.1–6.9	Stereonet lab
W	2/22	Deformation mechanisms: Brittle	BH:1161–1238; F:10.1–10.3	
F	2/24	Faults: Description	F:8.1–8.3	
M	2/27	Faults: Geometry	F8.5–8.6	
T	2/28	Lab: Brittle deformation	BH:1161–1238	Rheology lab
W	2/29	Faults; exam review		
F	3/2	Paper discussion: Switching locus of deformation in southern California	Dolan et al. paper	Discussion preparation; exam distributed

*BH: Frame numbers on Burger and Harms DVD; F: sections in Fossen Structural Geology textbook

Day	Date	Topic	Reading	Assignment due
M	3/5	Fault kinematics	F:9.1–9.4	
T	3/6	Lab: Fault map patterns	BH:438–595	Brittle deformation lab
W	3/7	Thrust systems: Architecture	BH:839–882	
F	3/9	Thrust systems: Mechanical analysis	BH:883–907; F: 16.4	Exam I due
M	3/12	Thrust systems & subduction zones		
T	3/13	Lab: Thrust systems	BH:908–938	Fault map patterns lab
W	3/14	Extensional systems	F:17.1–17.12	
F	3/16	Paper discussion: Strength of faults	Suppe paper	Discussion preparation
M	3/19	Spring break — no class		
T	3/20			
W	3/21			
F	3/23			
M	3/26	Strike-slip systems	F:18.1–18.6	
T	3/27	Lab: Brunton practice		Thrust systems lab
W	3/28	Deformation mechanisms: Plasticity	F:10.5–10.6	
F	3/30	Fold geometry	BH:940–993	
M	4/2	Fold geometry	BH:993–1046	
T	4/3	Field: Brittle structures — Mount Tom		Brunton practice lab
W	4/4	Fold kinematics	F:11.2–11.3	
F	4/6	Fold mechanics; exam review	F:11.2–11.3	
M	4/9	Fold map patterns	BH:720–786	
T	4/10	Field: Brittle structures — Turners Falls		Mount Tom concept sketch
W	4/11	Fold map patterns	F:13.1–13.4	
F	4/13	Fold map patterns and exam review	F:12.1–12.5	Exam II distributed
M	4/16	Foliations & Fabrics		
T	4/17	Field: Ductile structures — Cummington		

Day	Date	Topic	Reading	Assignment due
W	4/18	Foliations & Fabrics	F:12.1–12.5	
F	4/20	Ductile shear zones	BH:1461–1493	Exam II due (5 pm)
M	4/23	Ductile shear zones	F:15.1–15.3	
T	4/24	Field: Ductile structures — Cummington		Turners Falls concept sketch
W	4/25	Paper discussion: Deformation zone lithologies and rheology	Fagereng et al. paper	Discussion preparation
F	4/27	Dating deformation	F:21.1–21.6	
M	4/30	Active tectonics		
T	5/1	Field: Ductile structures — Cummington		
W	5/2	Active tectonics		
M	5/7	Last day to turn in Cummington concept sketch		

Please check regularly for updates to the schedule on Moodle!