G323 - Structural Geology (4cr) Spring, 2015

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Lecture times (18077): Monday, 11:15A – 12:05P (room GY447)
Wednesday, 11:15A – 12:05P (room GY447)
Friday, 11:15A – 12:05P (room GY447)

Laboratory times: (18078) Thursday, 1:25P – 3:20P (room GY416)
(18079) Thursday, 3:35P – 5:30P (room GY416)

General Comments

G323 - Structural Geology is intended to provide students with a broadly balanced treatment of structural geology including selected aspects of structural analysis and descriptive analysis (*e.g.* scale, structural elements, geometric elements), kinematic analysis, and dynamic analysis. The latter includes rock deformation (*e.g.* folding, faulting), rock mechanics (*e.g.* stress, strain, deformation) and tectonics (*e.g.* plate tectonics, orogenic belts). Basic geologic concepts and definitions will be assumed (suggested pre-requisites include G221 and G222 or G225 and G334), but reviews will be presented as necessary. Topics will be presented in a manner that intertwines fundamental principles with applications and examples. The material content starts with geometric descriptions, basic definitions of fundamental features such as various types of faults and folds, and global-scale driving forces. This will take up approximately 60% of the semester and provide a working knowledge of the strain or descriptive and kinematic aspects of structural geology (*e.g.* the deformation or structures one can see). The hope is that after this point you will be familiar with what is preserved in nature or created in the laboratory (the end results of unbalanced forces creating the structural features that we wish to understand). We will then consider the dynamic or stress conditions that correspond with the strain record. The discussion of stress will be tied to a general presentation of deformation mechanisms and features that can be used to infer stress conditions. A discussion of regional orogenic belts will be presented at the end of the semester. This organization is a departure from the traditional course organization (one that starts with stress and strain and then progresses on to the general descriptive aspects).

There are two different sets of goals that I hope you will attain this semester. The first set is a mastery of the basic concepts found in structural geology. The second set is for you to be able to take the basic knowledge and apply it to a new structural setting. This would involve evaluating the geologic setting, setting up testable hypotheses, laying out a series of data gathering steps, and then finally drawing conclusions regarding your initial questions.

Instruction will consist of three 55-minute lectures and one 2-hour laboratory per week. Final grades will be based on quizzes, homework, and in-class exercises (10%); laboratory work (35%); two 55-minute written examinations (35%); and a final exam (20%). Quizzes and in-class exercises will be conducted on an as-appropriate schedule and will not be excused. Laboratory reports will be required for each lab and will constitute the basis of the laboratory grade; the Associate Instructor will establish the exact lab turn-in timetable, but in general, materials must be submitted at the following lab meeting (prior to beginning of that week's lab). All labs will be set-up as projects that have individual objectives, although some projects will carry over for several weeks. The lab format will contain aspects that will require the student to work within a problem-solving format. All labs will require a final analysis and the submission of a final set of materials and/or a report. All work in G323 must be conducted in adherence to the academic code of conduct, as stated in *The Code of Student Rights, Responsibilities, and Conduct.*

Texts

A number of good, comprehensive texts cover the topic of structural geology. The text selected for G323 provides a well written, engaging presentation of the material. Additional reading and alternative presentations may be found in the supplementary texts listed below. These supplemental texts will be placed on reserve in the Geology Library.

Required text:

Davis, G.H, Reynolds, S.J., and Kluth, C.F., 2012. Structural Geology of Rocks and Regions, 3rd Edition, *J. Wiley and Sons, Inc*, New York, 839 pp.

Supplementary texts:

Twiss, R.J. and Moores, E.M., 2007. Structural Geology, 2nd Edition, *W.H. Freeman and Company*, New York, 736 pp.

Fossen, H., 2010. Structural Geology, Cambridge University Press, New York, 463 pp.

van der Pluijm, Ben, and Marshak, Stephen, 1997. Earth Structure, An Introduction to Structural Geology and Tectonics, *WCB/McGraw-Hill*, 495 pp.

Hatcher, R.D, Jr., 1995. Structural Geology- Principles, Concepts, and Problems, 2nd Edition, *Prentice Hall*, Englewood Cliff, NJ, 525 pp.

Weekly Schedule – Spring 2015 (subject to future revision)

The following weekly schedule is intended to provide a general framework. A laboratory schedule is also provided. The overall scheduling of topics will be followed as presented, but details may be altered as the course progresses. You should note that the sequencing of topics is non-traditional so that the selection of reading assignments does not follow the required text in a simple fashion. Laboratory material is designed to complement the lecture material and serve to provide an opportunity for the students to investigate specific aspects of the lecture material.

Jan. 12, 14, 16 Lecture: General overview, nontectonic structures, descriptive analysis, kinematic analysis, stress and strain, review of plate tectonics
Reading: D, R,+ K *2-33, 34-66*, 90-104, 706-710
Laboratory 1: Review of topographic maps, strike and dip, simple geologic map patterns and cross sections
Reading: D, R,+ K 684-705

Jan. 21, 23 Lecture: Fractures and joints
Reading: D, R,+ K 193-248
Laboratory 2: Failure envelopes (Mohr diagrams)
Reading: D, R,+ K 118-120, 286-293

Jan. 26, 28, 30 Lecture: Faults
Reading: D, R,+ K 249-304
Laboratory 3: Orthographic and stereographic projections
Reading: D, R,+ K 728-756

Feb. 2, 4, 6 Lecture: Normal faults
Reading: D, R,+ K 321-333
Laboratory 4: Analysis of fault motion through stereographic projections
Reading: D, R,+ K 757-759

Feb. 9, 11, 13 Lecture: Thrust faults
Reading: D, R,+ K 305-320
Laboratory 5: Analog models - sand box and wax tank
Reading: Handout

Feb. 16, 18, 20 Lecture: Strike-slip faults
Reading: D, R,+ K 334-343
Laboratory 6: Cross section construction -general
Reading: D, R,+ K 718-728

Feb. 23, 25, 27 Lecture Exam #1 (Feb. 23)
Lecture: Folding geometries and mechanics
Reading: D, R,+ K 344-404, 405-462
Laboratory 7: Folding: Stereoplots and Structural Contours
Reading: D, R,+ K 735-747

Mar. 2, 4, 6 Lecture: Folding mechanisms cont., cleavage
Reading: D, R,+ K 405-462, 463-491
Laboratory 8: Polyphase deformation in a metamorphic terrane
Reading: D, R,+ K 779-783, hand-out

Mar. 7 Field Trip: (local) - Field description of faults

Mar. 9, 11, 13 Lecture: Kinematic analysis, strain
Reading: D, R,+ K 66-89
Laboratory 9: Strain measurements - micro- and macro-scale observations
Reading: D, R,+ K 66-89

Mar. 16, 18, 20 SPRING BREAK

Mar. 23, 25, Lecture: Dynamic analysis, stress
Reading: D, R,+ K 90-120
Laboratory 10: Strain Associated with Active Faults
Reading: Handout

Mar. 26-29 Field Trip - TN

Mar.30, Lecture: Stress, strain, and deformation mechanisms
Apr. 1, 3 Reading: D, R,+ K 120-147, 148-191
Laboratory 11: Field Trip Write Up

Aprl. 6, 8, 10 Lecture: Deformation mechanisms, rheology
Reading: D, R,+ K 148-191
Lecture Exam #2 (Aprl. 10)
Laboratory 12: Structural analysis of a complex region
Reading: Handout

Aprl. 13, 15, 17 Lecture: Foliation, lineation, shear zones
Reading: D, R,+ K 492-529, 530-598
Laboratory 13: Structural analysis of Active Faulting
Reading: Handouts

Aprl. 20, 22, 24 Lecture: Orogenic belts- Appalachians, Western Cordillera of North America
Reading: D, R,+ K 599-682, *hand-outs*
Laboratory 14: Structural analysis of Active Faulting (cont.)
Reading: Handouts

Aprl. 27, 28 Lecture: Orogenic belts- Appalachians, Western Cordillera of North America
May 1 Reading: D, R,+ K 599-682, *hand-outs*
Laboratory 15: Structural analysis of Active Faulting (cont.)
Reading: Handouts

May 6 Lecture Exam #3 and Final Examination Wed 12:30 P -2:30 P

Field Trips - There are two field trips associated with this course. One field trip takes place on a Saturday in early March; this trip is designed to introduce students to making structural observations and measurements in the field. The students will examine exposures of faults within the Mississippian carbonates, which outcrop south of Bloomington. The goal of the trip is to provide experience in fieldwork with an emphasis on structural geology. The data gathered during this trip serves as a complement to the laboratory exercises that deal with quantitative descriptive analysis (e.g. length scale, magnitude), steronet plotting, and

interpretation of various types of structural data, which have been taking place up until this point in the course. Examples include the orientation of bedding planes, joint surfaces, faults, and lineations and analysis of strain and stress fields responsible for the deformation. A three-day weekend field trip will be scheduled in March to a portion of the Appalachian Mountain Belt in Tennessee. The trip will focus on determining the deformational history of this region. Work will primarily concentrate on descriptions and measurements of the minor structural features such as orientation of primary sedimentary features, bedding, and cleavage/foliation and other deforamation/metamorphic fabrics, minor folds, fault fold interactions, and shear sense indicators at the outcrop scale to determine the regional geometry and overall deformational history of the area.