School of Science

GEOL 208

Structural Geology

Fall 2022

3 credits

Course Outline

INSTRUCTOR: Dr. Joel Cubley
E-MAIL: jcubley@yukonu.ca
PHONE: (867) 456-8605
OFFICE LOCATION: M107 (CNIM Building)
OFFICE HOURS: Mondays, 1-3 pm

CLASSROOMS: A2603 (lecture); T1090 (laboratory)
DATES: September 7, 2022 to December 20, 2022

COURSE DESCRIPTION

This course addresses the fundamental techniques in structural geology, including the mechanics of rock deformation, classification of tectonic structures in stratified and non-stratified rocks, and manipulation of structural data and its predictive use. The links between geological structures, mineral deposits, and exploration and mining practices are examined throughout the course, as is the interplay between deformation and plate tectonics. Students will spend considerable time learning how to understand structural data presented in geological maps and cross sections, as well as eventually developing those materials from their own data.

COURSE REQUIREMENTS

Successful completion of GEOL105 (Physical Geology) and/or permission from the instructor.

EQUIVALENCY OR TRANSFERABILITY

Receiving institutions determine course transferability. Find further information at:
https://www.yukonu.ca/admissions/transfer-credit

Geology 208 has established equivalency with the following institutions:

Simon Fraser University: EASC 204 (3)
University of British Columbia: EOSC 323 (3)
University of British Columbia – Okanagan: EESC 1xx (3)
University of Victoria: EOS 202 (1.5)
Vancouver Island University: GEOL 202 (3)

YUKON FIRST NATIONS CORE COMPETENCY

Students who successfully complete this course will have achieved core competency in knowledge of Yukon First Nations. By the end of this course, students will have greater understanding and awareness of Yukon First Nations history, culture, and journey towards self-determination. For details, please see www.yukonu.ca/yfnccr.

LEARNING OUTCOMES

Upon successful completion of the course, students will have demonstrated the ability to

- Accurately describe all types of common structures exposed at the earth's surface.
- Measure a variety of geologic structures in the field (planes, lineations, fold axes, etc.).
- Analyze the geometry of structures using stereographic and orthographic projections.
- Interpret geological maps in 3D using cross sections and block diagrams.
- Make informed interpretations of structural evolution, based on structural geometry, kinematics and mechanical principles.
- Correlate small scale structures with the regional tectonic framework.

COURSE FORMAT

Weekly breakdown of instructional hours

This course consists of two 90-minute lectures and one three-hour lab period per week. The topic outline included in this course outline details the major topics covered and the order in which topics will be presented throughout the course. It is expected that this course will require 3-4 hours/week of homework and additional reading. It is important to note that the time required will vary by individual.

Delivery format

Lectures and laboratory sections for the Fall 2022 offering of this course will be delivered in a face-to-face format. Laboratory exercises will be conducted in both laboratory and field settings. Whereas students will be given after-hours access to the Earth Sciences laboratory (T1090) to complete lab assignments, the course instructor will not necessarily be present to guide learning. It is thus important that students fully engage and participate during the designated lab period. Off-campus field exercises must be completed during the allocated time with the instructor present.

EVALUATION

Weekly lab assignments	32% (4% each)
Lecture midterm exam	15 %
Lecture final exam	25 %
Lecture theory assignments	8 % (4% each)
Takhini assemblage deformation characterization project	10%
Hamilton Boulevard rock mass characterization project	10%
Total	100%

Assignments

Weekly lab exercises will be due at the start of the following lab section. In addition to these exercises, students will be assigned two short theory assignments for the lecture segment of the course. Details regarding these assignments are available on the course Moodle page.

This course has two projects, each based on a specific outcrop near Whitehorse. The Takhini assemblage project focuses on characterizing fold styles and orientations, plus establishing a deformation history, for an outcrop of greenschist-facies schists near Mendenhall subdivision. The Hamilton Boulevard project focuses on completing a full rock mass characterization on roadcuts of Whitehorse batholith granite near the Copper Ridge subdivision, plus completing wedge failure analysis to identify blocks at risk for failure. Both projects are due on the last day of classes.

Late assignments will be graded based on the following scheme: a deduction of 10% per day up until a total deduction of 50% is reached, following that, assignments must be submitted prior to the date that the instructor hands back the graded assignment (set by the instructor).

Tests

Any student who is absent from a test or exam for legitimate reasons will be eligible to write a deferred exam. Please note that excuses such as car trouble, vacation travel, oversleeping, and misreading the test schedule are not considered legitimate reasons and do not qualify the student for a deferred exam. For missed exams, the student must contact the instructor within 48 hours of the missed exam by phone or email. For missed final exams, students must contact the instructor to discuss an appropriate course of action. Any deferred exams will be scheduled by the Chair of the School of Science.

COURSE WITHDRAWAL INFORMATION

Refer to the YukonU website for important dates.

TEXTBOOKS & LEARNING MATERIALS

Davis, G.H., Reynolds, S.J. and Kluth, C.F. 2012. Structural Geology of Rocks and Regions (3rd ed.). Wiley, Mississauga, ON. 864 p.

Additional resources (available on reserve in the Yukon University library)

Fossen, H. 2010. Structural Geology (1st ed.). Cambridge University Press, New York. 463 p.

ACADEMIC INTEGRITY

Students are expected to contribute toward a positive and supportive environment and are required to conduct themselves in a responsible manner. Academic misconduct includes all forms of academic dishonesty such as cheating, plagiarism, fabrication, fraud, deceit, using the work of others without their permission, aiding other students in committing academic offences, misrepresenting academic assignments prepared by others as one's own, or any other forms of academic dishonesty including falsification of any information on any Yukon University document.

Please refer to Academic Regulations & Procedures for further details about academic standing and student rights and responsibilities.

ACADEMIC ACCOMMODATION

Reasonable accommodations are available for students requiring an academic accommodation to fully participate in this class. These accommodations are available for students with a documented disability, chronic condition or any other grounds specified in section 8.0 of the Yukon University Academic Regulations (available on the Yukon University website). It is the student's responsibility to seek these accommodations by contacting the Learning Assistance Centre (LAC): LearningAssistanceCentre@yukonu.ca.

LECTURE TOPIC OUTLINE

Session	Topic (*lab activities in italics)*	Recommended Textbook Readings
1	Course introduction, primary versus deformational structures, types of structural analysis	Davis Ch. 1 (2-33)
2	Transformations, kinematics, displacement vectors, rigid vs. non-rigid body deformation, pure vs. simple shear	Davis Ch. 2 (35-58; 78-81)
3	Strain: strain ellipse, elongation, 1D and 2D strain, Flinn diagrams, introduction to quantification methods	Davis Ch. 2 (59-77), Ch. 9 (520-525); Fossen Ch. 3 (56-61)
4	Introduction to Stress**:** force, tractions; stress notation, normal vs. shear stresses and calculation; mean and deviatoric stress; principal stresses	Davis Ch. 3 (90-116)
5	Mohr stress diagrams, hydrostatic stress, cohesive strength, role of pore fluid pressure	Davis Ch. 3 (118-120); Fossen Ch. 4 (74-75), Ch. 7 (127-129)
6	Deformational behaviour (rheology): elastic, plastic, and viscous behaviour; common laboratory testing techniques, controls on deformational behaviour	Davis Ch. 3 (120-146)
7	Deformation mechanisms and microstructures I: point defects and dislocations, microfracturing and cataclasis, grain boundary rotation, frictional sliding	Davis Ch. 4 (148-162); Fossen Ch. 7 (120-121)
8	Deformation mechanisms and microstructures II: mechanical twinning, diffusion creep, pressure solution (dissolution creep), dislocation creep, recrystallization	Davis Ch. 4 (162 – 181) Fossen Ch. 10 (207-214)
9	Joints: joints vs. shear fractures, fracture modes, initiation and propagation, fracture criteria, deformation bands	Davis Ch. 5 (193 – 212; 236-239)
10	Faults: naming and classification, deformation textures and fault rocks, strain significance of major fault types	Davis Ch. 6 (249-286); Fossen (152-161)
11	Compressional regimes and thrust faulting: regional overthrusting and thrust terminology, critical taper/orogenic wedge models, thrust geometries, fault propagation folds	Davis Ch. 6 (305-320); Fossen Ch. 16 (312-328).
12	Extensional regimes and normal faulting: blind and growth fault propagation, dilationary structures, relay ramps, low-angle	Davis Ch. 6 (321-333); Fossen Ch. 17 (334 - 350)

	detachments, orogenic collapse and core complexes	
13	Strike-slip faulting models: releasing and restraining bends, Riedel shears, flower structures, transpression and transtension	Davis Ch.6 (334-343) Fossen Ch. 18 (356-368)
14	Folds: geometric description, parallel vs. similar folding, anticlines vs. synclines, parasitic folds and Pumpelly's rule, cylindrical vs. conical folds	Davis Ch. 7 (345-365, 375-383)
15	Folding models and secondary related structures: flexural slip vs. flexural flow, passive slip vs. passive flow, kink folding	Davis Ch. 7 (390-403)
16	Cleavage: types (continuous, spaced, crenulation), strain significance, origins (pressure solution; grain rotation), axial planar cleavages	Davis Ch. 9 (463-486); Fossen (244-254)
17	Foliation development: phyllitic texture, schisosity and gneissosity, mylonitization and mylonite classification	Davis Ch. 9 (492-500**)**
18	Lineations: types of lineations (mineral, intersection; crenulation, boudin, mullion), tectonites, kinematics from lineations	Davis Ch. 9 (501-512); Fossen Ch. 13 (260-279)
19	Shear zones I: general characteristics, geometries, types (brittle, ductile, brittle-ductile), softening mechanisms, coaxial and noncoaxial deformation	Davis Ch. 10 (531-555); Fossen Ch. 15 (286-297)
20	Shear zones II: shear sense indicators (e.g. offset markers, foliation patterns, shear bands, S-C fabrics, mica fish, pressure shadows, en echelon veining)	Davis Ch. 10 (555 – 576); Fossen Ch. 15 298-306)
21	Progressive deformation: instantaneous and finite strain ellipses, progressive pure and simple shear, scale dependence	Davis Ch. 10 (586-598); Fossen Ch.2 (44-48)
22	Data processing and interpretation from Hamilton Boulevard field trip	n/a
23	Data processing and interpretation from Takhini Assemblage field trip	n/a

LABORATORY TOPIC OUTLINE

Session	Topic
1	Field Trip: Structural analysis of the Takhini Assemblage, field data collection (September 9)
2	Field Trip: Rock mass characterization at Hamilton Boulevard (September 23)
3	Introduction to orientations of planes and lines, apparent dip and unit thickness
4	Methods of strain quantification
5	Mohr circles, failure envelopes, and pore pressure
6	Introduction to stereonet analysis (plotting planes, lineations, and poles)
7	Stereonets: apparent dips, rotations, and angular relationships
8	Stereonets: joint and fault analyses (contouring, rose diagrams, principal stresses)
9	Stereonets: fold analyses (β-diagrams, π-girdles, fold axes, interlimb angles, axial planar cleavages)
10	Cross sections and fold construction: angular kink fold and busk arc fold models
11	Cross-sections: projection of structural data into line of section, basics of cross-section balancing