MISKOLCI EGYETEM

MŰSZAKI FÖLD- ÉS KÖRNYEZETTUDOMÁNYI KAR

STRUCTURAL GEOLOGY

Earth Sciences Engineering MSc course

2022/23 2. Semester

COURSE COMMUNICATION FOLDER

University of Miskolc
Faculty of Earth and Environmental Sciences and Engineering
Institute of Exploration Geosciences

Course datasheet

Course title: Structural geology **Responsible instructor:** Dr. Norbert Németh, associate professor	**Neptun code:** MFFAT720020 **Responsible department/institute:** NyFI **Type of course: C**
Position in Curriculum (which semester): 2	**Pre-requisites:**
Number of Contact Hours per Week (lec.+prac.): 1+2	**Type of Assessment (examination / practical mark / other):** exam
Credits: 4	**Course:** full-time

Course Description: Introduction of the structural features of the rocks, the representation of the sstructures, the deformation of the rock bodies and its physical background.

Competencies to evolve:

Knowledge*:* Differentiates the processes described by the general and specific theories required for the practicising of the fields of earth science engineering, categorizes the internal connections between geological processes, and designs the planning and interpretation procedures. Combines the technical and scientific knowledge required for the high-level integration in earth sciences engineering disciplines, among others in numerical methods, technical physics and their contexts. Categorizes the components of the raw material extraction sector, the technologies used for the extraction and preparation of mineral raw materials, as well as the scope of geo-environmental tasks, their external socio-economic environment and regulatory system. Utilizes the best practices applied to earth science engineering tasks and the long-term development directions that can be expected in this field in the medium term. Chooses the geological and geophysical methods suitable for exploring natural resources. Distinguishes between the methods of exploring mineral deposits. Elaborates a sound application practice on the methods of acquisition and data collection in the applied earth sciences, and on their instrumental measurement and IT data processing procedures.

Ability*:* Applies general and specific scientific theories pf applied earth sciences, systematizes them, solves independent engineering tasks (mainly complex geological prospecting, final report summarizing exploration results, geological-geophysical parts of environmental impact assessments). Composes presentations and written documents in Hungarian or in a foreign language. Performs complex planning, construction, inspection and official licensing tasks (geological-geophysical exploration plans of natural resources, acquisition of environmental geology), innovatively uses the theories and terminology of applied earth science knowledge. Organizes, manages, and supervises complex activities based on or incorporating applied earth science tasks (especially mining, environmental technology investments, operations). Designs prospecting and exploration of geological structures. Contributes to the solution of geological-geophysical tasks arising during the extraction of mineral raw materials (planning, investment, operation, closure) and to analyzes the possible solutions. Identifies the structure of the raw materials extraction sector, the technologies used for the extraction and processing of mineral raw materials, as well as the scope of geo-environmental tasks, their external socio-economic environment and regulatory system. Maximizes the cooperation with related disciplines and manages the (working) group within the framework of larger and more complex activities, based on or incorporating applied earth science tasks.

Attitude*:* Percieves the professional and technological methodological developments in the fields of applied earth sciences, participates in their development. Applies innovative skills

and knowledge in solving professional problems in the fields of earth science engineering. Commits and convincingly demonstrates to knowing and adhering to the professional and ethical values. Maximizes professionalism and professional solidarity. Respects and follows the ethical principles and written rules of work and professional culture in activities, follows them when managing small workgroups. Has a sufficient motivation to carry out activities in often changing working, geographical and cultural circumstances.
Autonomy and responsibility*:* Plans the work independently, and rules on to lead workgroups. Takes responsibility and is accountable for the work processes carried out under his / her control. Makes decisions carefully, in consultation with representatives of other disciplines (primarily legal, economic, and environmental), independently, Takes responsibility for decisions. develops professional decisions in the field of operation entrusted to him/her. Committed to the practice of sustainable natural resource management, occupational health and safety.

The short curriculum of the subject:

1. Representation and data analysis
2. Syngenetic structural elements of the rocks
3. Stress and strain
4. Brittle deformation features
5. Folds, foliations and lineations
6. Deformation mechanisms
7. Inner structure of the Earth and plate tectonics
8. Tectonic position and related structural features

The course includes field practice and working with data recorded there.

Assessment and grading: Attendance at lectures is regulated by the university code of education and examination. Writing a test and constructing a geological profile at least on satisfactory level, respectively during the semester is the requirement of signature.

Exam grading scale: unsatisfactory (0-45%), satisfactory (46-60%), medium (61-70%), good (71-85%), excellent (86-100%).

Compulsory or recommended literature resources:

Compulsory:

Twiss, R. J. & Moores, E. M: Structural Geology. Freeman & Co., New York, 1992, 532 p.

Recommended:

Ramsay, J. G. & Huber, M. I: The techniques of modern structural geology. Vol. 1: Strain Analysis. Academic Press, London, 1983, 1-308 p.

Ramsay, J. G. & Huber, M. I: The techniques of modern structural geology. Vol. 2: Folds and Fractures. Academic Press, London, 1987, 309-700 p.

Ramsay, J. G. & Lisle, R. J: The techniques of modern structural geology. Vol. 3: Applications of continuum mechanics in structural geology. Academic Press, London, 2000, 701-1062 p.

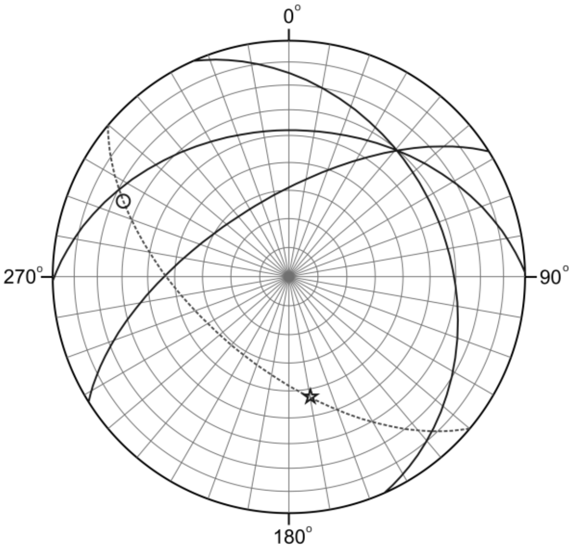
Twiss, R. J. & Moores, E. M: Tectonics. Freeman & Co., New York, 1995, 415 p.

Syllabus of the semester

Week 1: Basic terms; information on the interior of the Earth.
- Practice: use of geological maps; rules and geometrical basis of construction of cross sections.
Week 2: Structural features of the rocks, deformation, description of movements.
- Practice: construction of cross sections.
Week 3: Stresses, mechanics.
- Practice: construction of cross sections.
Week 4: Rheology and failure envelopes.
- Practice: construction of cross sections.
Week 5: Mechanisms and features of brittle deformation.
- Practice: construction of cross sections.
Week 6: Mechanisms and features of ductile deformation.
- Practice: construction of cross sections with drill logs.
Weeks 7-8: Field exercise: structural orientation measurements on folded and faulted rocks.
(The exercise is organised by exchange with the contact hours of another course, in 6 hours)
Week 9: working with orientation data, stereograms.
Week 10: working with orientation data, stereograms.
Week 11: *holiday*
Week 12: construction exercises.
Week 13: construction exercises.
Week 14: *test paper*

Sample for the test paper with answers

1. The continuous great circles on the stereogram represent bedding planes on a cylindrically folded bed, the dashed great circle represents the orientation of a regular set of joints in the same bed.



Equal area projection, lower hemisphere

a. What is the geological meaning of the line defined by the intersection of the great circles representing the bedding? **(1 p)**

fold axis

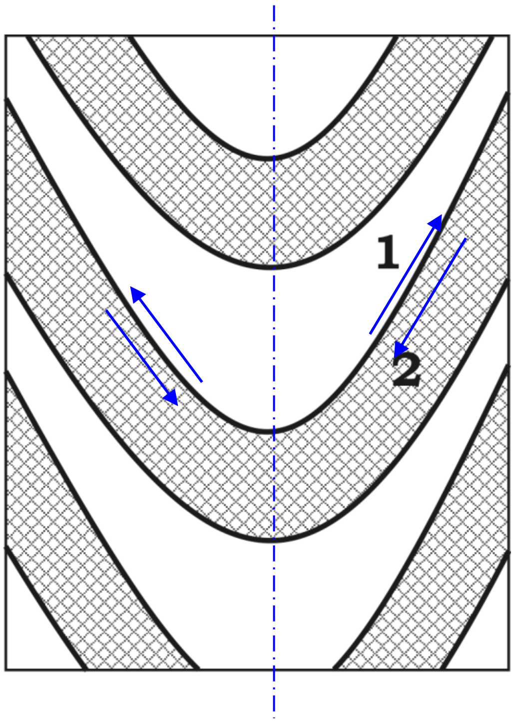
b. Using the polar grid, make a reading of the trend and the plunge of this intersection line in degrees! **(2 p)**

Trend: 40º
Plunge: 30º

c. The intersection and the lines indicated by a circle and a star define the three principal strain orientations of the deformation resulting the folds. What could have been the signs of these principal strains (extension: +, shortening: -)? **(1 p)**

Intersection: +
Circle: -
Star: +

2. The line sketch on the right is the profile view of a cylindrical fold train with alternating beds of lithologies 1 and 2.



a. Indicate with arrow pairs (⇋ or ⇌) the shear sense (during folding) along bedding surfaces on both limbs of the fold! **(1 p)**
b. Indicate with a dash-dot line the axial trace! **(1 p)**
c. Classify the folds according to Ramsay! Put a ring around the correct class code! **(2 p)**

bed 1 (unhatched): 1A 1B 1C (2) 3

bed 2 (hatched): 1A 1B (1C) 2 3

d. How would you describe the competence relation of the beds 1 and 2 based on the fold style? Complete the sentence below! **(1 p)**

Bed 2 is more competent than bed 1

3. Decide whether the following statements are correct or not! **(6 p)**

	true	***false***
Mylonite is a cataclastic rock formed in fault zones.		X
The maximum resolved shear stress on a plane depends on the differential stress and on the orientation of the plane with respect to the principal stress axes.	X	
Normal faults are formed when one of the horizontal principal stresses is tensile.		X
Hydraulic fracturing is made by decreasing the effective stresses and increasing the neutral stresses.	X	
Schistosity is a foliation in coarse grained crystalline rocks.	X	
Crosscutting a reverse fault in a horizontally bedded succession by a vertical borehole will cause omission of some beds in the log.		X

4. Choose the factors from the lists necessary to the definition of the following terms! Be careful, there can be more than one choices which are needed, and some things may occur but are not essential in general! **(5 p)**

a. Ductile deformation

fold formation	
irreversible deformation	X
high temperature	
no loss of cohesion	X

b. Passive shear folding

initially planar structures, layering	X
deformation mechanism allowing ductile flow	X
shear along bedding planes	
continuous cleavage	

c. Principal stress

three mutually perpendicular vectors	X
compressive normal stresses	
vectors normal to planes of no shear stress	X
diameter of the Mohr circle	

d. Tectonic window

topographic depression	
outcrop of older rocks thrust on younger rocks	
outcrop of autochtonous rocks surrounded by allochtonous rocks	X
nappe thrust	X

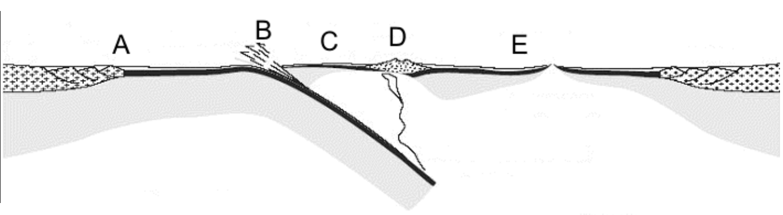
e. Simple shear

plane strain	X
homogeneous strain	X
volume change	
constrictional strain	

5. The sketch on the right shows the generalized profile of an oceanic subduction zone.

a. Give the correct letter to each item of the legends! **(2 p)**

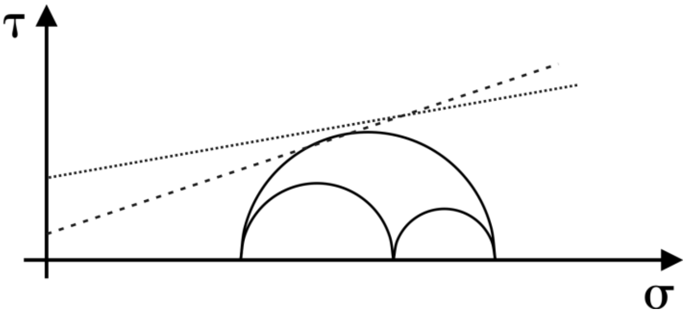
back-arc basin	E
forearc basin	C
island arc	D
oceanic trench	B
passive continental margin	A



b. Which metamorphic facies relates to the subducting plate? **(1 p)**

blueschist

6. The Mohr diagram represents the stress state at the boundary of two different lithologies, sandstone and marl. (Stress quantities are not indicated, but the scale is linear.) Dashed line is a Coulomb envelope for the sandstone, dotted line for the marl.



a. Which of the rocks will fracture in this situation? Underline the correct answer! **(1 p)**

sandstone   *marl*   *both rocks*   *none of the rocks*

b. Which type of structures is expected to form? Underline the correct answer! **(1 p)**

joint sets   *ductile shear zones*   *faults*   *veins*

c. Which changes in the stress state could lead to further brittle deformation in this case? Underline the correct answers (multiple choice)! **(2 p)**

increase of σ_1 with constant σ_2 and σ_3

increase of σ_2 with constant σ_1 and σ_3

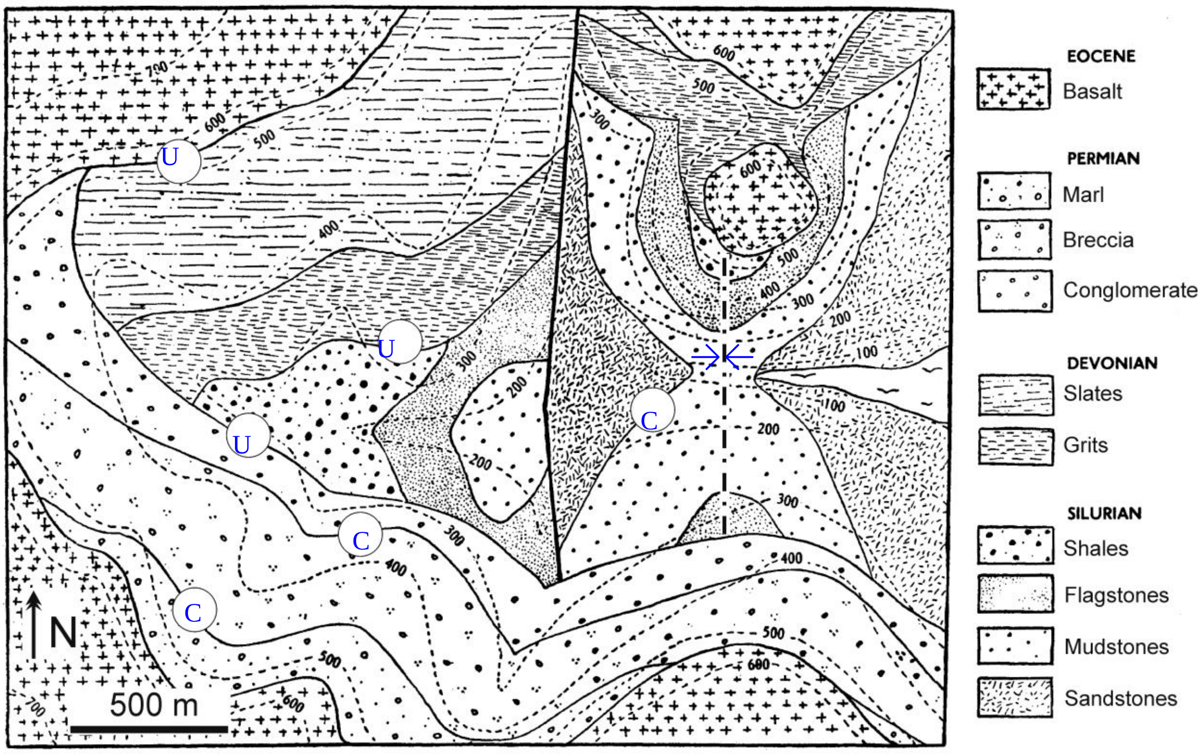
increase of σ_3 with constant σ_1 and σ_2

decrease of σ_1 with constant σ_2 and σ_3

decrease of σ_2 with constant σ_1 and σ_3

decrease of σ_3 with constant σ_1 and σ_2

7. Answer the following questions and tasks using the geological sketch map below!



a. The bold line is the trace of a steeply dipping fault.

Which is the downthrown side of the fault? Underline the correct answer! **(1 p)**

east side *west side*

Give the age of the faulting with the possible accuracy! **(1 p)**

End of Devonian – start of Permian

b. The circles are for identifying some of the contacts of the formations. Indicate the conform bedding contacts with a letter **C** and the unconformities with a letter **U** written in the circles! **(2 p)**

c. The dash-dot line marks the hinge zone of an upright fold. Is it a syncline or an anticline? Apply the correct signs (→← or ↔) on the line to indicate it! **(1 p)**

d. Give an estimation of the dip angle of the base of the Eocene basalt cover! **(1 p)**

horizontal

8. Complete the sentences with the appropriate words! **(7 p)**

If a cleavage comprises cleavage domains and microlithons without preferred orientation it is called a …(1a)… cleavage; if it penetrates the rock completely, it is a …(1b)… cleavage.

The …(2)… can be calculated as the ratio of the actual temperature and the melting point.

In the Newtonian viscous model the increase of the stresses will cause the increase of the …(3)…

The …(4)… can be described as a sum of translation and rotation, without any internal strain.

The …(5a)… is a mineral coating formed on fault planes, where …(5b)… may indicate the direction of displacement.

The orientation of a plane can be defined using three mutually perpendicular lines: the …(6a)…, the …(6b)… and the plane normal.

…(7)… are parts of a competent layer dissected by layer-parallel extension, typical in fold limbs.

1a: spaced____

1b: continuous____

2: homologous temperature_________________________________

3: speed of the deformation_________________________________

4: rigid body movement___________________________________

5a: slickenside____

5b: slickenlines_______________________________________

6a: strike line____

6b: dip line____

7: boudins____

Maximum: 40 points

points	grade
34≤	5
28≤	4
22≤	3
16≤	2
less than 16	1

Exam

Oral exam.

The student draws a number indicating a topic (numbers indicate corresponding chapters from the Twiss-Moores textbook)

1. Techniques of structural geology and tectonics (Chapter 2)
2. Fractures and joints (Chapter 3)
3. Faults (Chapters 4-7)
4. Stress and mechanics of fracturing and faulting (Chapters 8-10)
5. Description of folds and kinematic models of folding (Chapters 11-12)
6. Foliations and lineations (Chapters 13-14)
7. Rheology and deformation mechanisms (Chapters 18-19)
8. Tectonics (Chapters 21-22)

Additionally, she or he has to solve a practical exercise regarding orientational data (like 1st exercise of the sample test).