MISKOLCI EGYETEM
MŰSZAKI FÖLD- ÉS KÖRNYEZETTUDOMÁNYI KAR

ENVIRONMENTAL GEOCHEMISTRY

Environmental Engineering MSc

MFFAT730009

2023/24. 1st semester

COURSE COMMUNICATION FOLDER

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

Tartalomjegyzék

1. COURSE DESCRIPTION

Course Title: Environmental geochemistry **Responsible Instructor:** Dr. Ferenc Moricz, associate professor	**Code:** MFFAT730009 **Responsible department/institute:** Institute of Exploration Geosciences
	Type of course: Compulsory
Position in curriculum (which semester):3rd	**Pre-requisites (if any):** -
No. of contact hours per week (lecture + seminar): 2+0	**Type of Assessment (examination/ practical mark / other):** exam
Credits: 2	**Course:** full time

Course Description: The students will be guide into the distribution of the elements and compounds of the different zones of the Earth, with special focus on the uppest zone of the Lithosphere. Near this, the analisys and characterization of the artifically created deposites – such as solid and liquid mining wastes and tailings, the tailings of the coal mines, etc.. – is shown. The different types are characterized and vizualized by the view of environmental load and potential heavy metal mobilization or other harmful effects. The Eh-pH diagram of the most important heavy metals are shown with the geochemical modelling software of HSC Chemistry 7.0. The importance of concentration and effects (both negative and positive) of the different elements and groups of elements in the biosphere, in surface of groundwater are shown. Near this, the possible enrichment of these elements are also decribed. The behaviour of the elements and their most important types of alterations on surface condition are presented.

Competencies to evolve:

Knowledge: T1, T3, T4

Ability: K2, K5, K10

Attitude:

Autonomy and responsibility: F1, F4

The short curriculum of the subject: Basic of geochemistry of the Litosphere. Element groups. Behaviour of hydrogen, alcali and alcaline earth metals. The dominant role of carbon, aluminium and silicon in rock forming. Heavy metals as main source of toxicity. Appearance and roles of rare earth elements and trace element. Roles and importances of nitrogen, oxygen and halogenids. Classification and analysis of the possible contingencies on the different types of waste and tailing deposits (mining waste and tailings, dumps od coal mining, etc.). The visualization of the Eh-pH diagrams of the most common heavy metals, using HSC Chemistry modlling programme. The appearance and toxicity of the different elements in the flora, fauna and human body. Effects of the different elements in surface and ground water. Alteration of the different minerals, rocks, and compounds on surface condition.

Assessment and grading:

The final grade will consist of two part. During the semester two midterm tests are written. The average of them will be the 50% of the final grade. The rest 50% is for the final exam. The total (100%) of them is graded as:

90 -100% 5 (excellent)
80 – 89% 4 (good)
70 - 79% 3 (satisfactory)
60 - 69% 2 (pass)
0 - 59% 1 (failed)

Compulsory or recommended literature resources:

Dill H.G. (2010): The „chessboard" classification schene of mineral deposits. Elsevier, 2010.

Albared, F. (2005): Geochemistry. An introduction. Cambridge Univ. Press.

D. Sarkar, R. Datta, R. Hanningan: Concepts, and applications in environmental geochemistry, Elsevier 2007.

John W. Anthony, Richard A. Bideaux, Kenneth W. Bladh, and Monte C. Nichols, Eds. (2003): Handbook of Mineralogy. Mineralogical Society of America.

Brownlow, A. H. (1996): Geochemistry. Prentice Hall, New Jersey.

Petruk W.: Applied mineralogy int he mining industry, Elsevier, 2000

Rankama, K., Sahama, Th.G.: Geochemistry. Univ. Chicago Press.

White, William M. (2013) Geochemistry. Wiley-Blackwell, 668 p

Raju, R. Dhana (2009) Handbook of Geochemistry: Techniques and Applications in Mineral Exploration. Geological Society of India, 520 p.

Albarede, Francis (2003) Geochemistry: An Introduction. Cambridge University Press, 248 p.

Oweis, I. S. – Khera, R. P. (1998): Geotechnology of Waste Management. PWS Publishig Company, (2nd ed.)

2. CURRICULUM OF THE SUBJECT

Mineralogy and geochemistry
Year 2020/21, semester 1st
Time of lecture: Thursday, 10:00 – 12:00

Week	Topic of the lecture
2020.09.14.	Basic of geochemistry of the Litosphere. Element groups.
2020.09.21.	Behaviour of hydrogen, alcali and alcaline earth metals.
2020.09.28.	The dominant role of carbon, aluminium and silicon in rock forming.
2020.10.05.	Heavy metals as main source of toxicity.
2020.10.12.	Appearance and roles of rare earth elements and trace element.
2020.10.19.	Roles and importances of nitrogen, oxygen and halogenids.
	1st midterm test
	Classification and analysis of the possible contingencies on the different types of waste and tailing deposits (mining waste and tailings, dumps od coal mining, etc.).
2020.11.09.	The visualization of the Eh-pH diagrams of the most common heavy metals, using HSC Chemistry modlling programme.
2020.11.16.	The appearance and toxicity of the different elements in the flora, fauna and human body.
2020.11.23.	Effects of the different elements in surface and ground water.
2020.11.30.	Alteration of the different minerals, rocks, and compounds on surface condition.
2020.12.07.	2nd midterm test
2020.12.14.	Rewriting of unsuccess midterm test(s) / Pre-exam

Seminars:
Through examples, exercises and case studies the students get knowledge, which will be necessary.

3. EXAMPLE FOR MIDTERM TEST:

I, MINERALS (20%)

1, What is cuprite?(5%)
a, Cu_2O b, $CaSO_4$ c, Cu_3AsS_4 d, ReS_2

2, Which is a mercury suphide?(5%)
a, cinnabar b, wurtzite b, realgar d, hematite

3, Which is that mineral, from which 3 highly profitable metal can reach out?(5%)
a, cromite b, sylvanite c, crocoite d, clorargirite

4, Which ion produces reddish-brown colour?(5%)
a, Fe^{2+} b, Fe^{3+} c, Cu^{+} d, Cu^{2+}

II, REPLACING (20%)

1, Which replacing is true? (5%)
a, $Fe^{2+} \rightarrow Mg^{2+}$ b, $Fe^{3+} \rightarrow Mn^{2+}$ c, both of them d, none of them

2, Which element can be replaced by Mn^{2+}? (5%)
a, Fe^{2+} b, Ca c, Mg d, all of them

3, In which mineral the rhenite (ReS_2) could replace? (5%)
a, cassiterite b, pyrolusite c, molybdenite d, cuprite

4, What could Mn-oxide adsorb? (5%)
a, Co and Ni b, Cu and Pb c, REE, U and Th d, all of these

III, ORIGIN (10%)

1, Mainly in which type of rocks the Li can enrich significantly? (5%)
a, gabbros and basalts b, no significant difference between rock types
c, granites and nefelin sienties d, quartz sandstones

2, Mainly in which type of rocks the Co and Ni can reach the highest concentration? (5%)
a, sediments, mainly in quartz sandtones b, pegmatites of granite and nefelinesienite
c, mainly in ultrabasic and basic rocks d, evaporites of arid climates

IV, SHORT ESSAY (50%)

1, How can you describe the "Environmental geochemistry". On which scientific are it is important? (10%)

2, Shortly describe how much the silicon content (in form of SiO_2) of the four main rock type. (10%)

3, Write down the 5 main types of classification of the elements, with examples (20%)

4, If there are 2 mines with the same orebody volume, the first is with 2.0% of Cu in form of tetrahedrite, the second mine is with the same ratio of Cu, but in tennantite. Which one would you choose (2%)? Explain by chemical formulas (2-2%), and describe from point of environmental (2%) and economical (2%) view your chosen mine? (total: 10%)

4. EXAMPLE FOR MIDTERM TEST ANSWERS:

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2, Which is a mercury sulphide?(5%)
a, cinnabar b, wurtzite b, realgar d, hematite

3, What is not a copper mineral?(5%)
a, chalcanthite b, chalcopyrite c, chlorargirite d, cuprite

4, Which ion produces reddish-brown colour?(5%)
a, Fe^{2+} b, Fe^{3+} c, Cu^{+} d, Cu^{2+}

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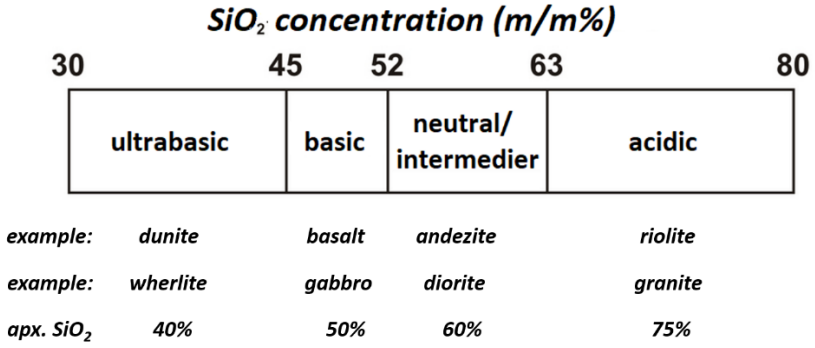
IV, ESSAYS (50%)

1, Geochemstry is a special mixture of the scientific area of geology and chemistry, where the focus is on the geological and mineralogical systems, but from point of chemical aspects. That

thin layer of geochemistry, which works and includes the environmental aspects, morover the focus moves toward it, called as environmental geochemistry.

2,



3,

Classiciation type	**Groups**	**Exaples**
Nuclearic properties	stable	^{1}H, ^{2}H, ^{16}O, ^{32}S
	radioactive	^{3}H, ^{14}C, ^{238}U
Temperature of condensation	volatile	Pb, Na, K, P, Mn, Cu
	refractorical	W, Zr, Hf, Al, Ca, Ti
Affinity (Goldschmidt's type)	siderophil	Mn, Fe, Co, Ni, Pt
	chalcophile	Cu, Zn, Hg, As, S
	litophile	Si, Al, Ca, K, Na, Ti
	atmophile	N, He, Ne, Ar, Kr
Compatibility (magmatic)	compatible	Co, Ni
	incompatable	La, Eu
Prevalence (Earth's crust)	main element	Si, Al, Ti, Fe, Mn, Ca
	trace element	Ni, Rb, Sr, Zr, Hf, Y

4, tetrahedrite: $Cu_{12}Sb_4S_{13}$ and tennantite: $Cu_{12}As_4S_{13}$

I would choose the mine, where the copper is in tetrahedrite, because:
- From point of environmentally the arsenic in the structure of tennantite decrease the profit, because this heavily toxic element needs to be win out and store, not to let any pathway toward nature or living bodies.
- From point of economy from the tetrahedrite near the copper, antimony can be win put, which is a good price metal on the global market. So near the profit of copper, extra profit can be produced from the antimony.

5. EXAMPLE FOR FINAL TEST:

I, MINERALS (5%)

1, Which mineral is usually radioactive?(1%)
a, actinolite b, celestine c, uvarovite d, cheralite-(Ce)

2, Which mineral has Sn content?(1%)
a, enargite b, cassiterite c, pyrite d, cuprite

3, Which is not a sulphate?(1%)
a, glauberite b, anglesite c, andradite d, bassanite

4, Which mineral has no TiO_2 chemical formula?(1%)
a, perovskite b, rutil c, anatas d, brookite

5, Which element cannot built in larger amount into the monazite mineral?(1%)
a, La b, Ce c, Y d, Nd

II, REPLACING (5%)

2, What can be replaced by Hf? (1%)
a, Zr b, Zn c, both of them d, none of them

1, Which element can be replaced by Mg? (1%)
a, Ca b, Fe^{3+} c, both of them d, none of them

5, Which element can be replaced by Sr? (1%)
a, Fe b, Na c, Ca d, none of them

4, Which element can be replaced by Rb? (1%)
a, Ca b, K c, Zn d, none of them

3, What can be replaced by Mn^{2+} in magmatic rocks? (1%)
a, Fe^{2+} b, Mg c, Ca d, all of them

III, ORIGIN (5%)

1, Mainly in which type of rocks the Mo and W can enrich? (1%)
a, Hawaiian type basalt b, andesite and intermedier rocks
c, late differenciates d, gabbros and dunite

2, In which rock type has the highest Be content? (1%)
a, basalt b, andesite c, granite d, pegmatites

3, Mainly in which type of rocks the Cr and Ta can enrich? (1%)

a, early differenciates
b, late differenciates
c, sandstones and quartzite
d, don't enrich in the same type of rocks

4, Mainly in which type of rocks the U can enrich? (1%)

a, Hawaiian type basalt
b, salts of evaporites
c, low temperature hydrothermal system
d, sediments with high organic content

5, Mainly in which type of rocks the Nb and Ta can enrich? (1%)

a, Hawaiian type basalt
b, granites
c, sandstones with low clay content
d, gabbros and dunite

IV, ESSAYS (35%)

1, Draw down a cross section of the Earth. Name its layers. (5%) What effect any why creates the magnetic field around the Earth? (2%)

2, Write down the coal order (at least 4 member) and explain the changes of the concentration of C and the pollutions. (5%)

3, Describe the 5 phases (mineral names + chemical compositions; sharp or/and approximately Ca:Mg ratio) of the pure calcium carbonate metasomatism to pure magnesium carbonate. (5%)

4, There is a high sulphate containing fluid, which flows through a sediment zone. This zone theoretically contains all elements (in dissolved phase) of the periodic chart. Write down 5 mineral (at least 2 with heavy metals) which can be formed theoretically (5 mineral names and 5 chemical compositions). (5%)

5, Draw down the orthoclase-albite-anorthite triangular. Write down the names' criteria. (6%)

6, Write down in 1-2 sentence and describe with (stochiometrically correct) equation as the dissolved ferric ion precipitate from solution as hydroxide and transform to goethite and later to hematite by water loss. (7%)

6. EXAMPLE FOR FINAL TEST ANSWERS:

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4, Which mineral has no TiO_2 chemical formula?(1%)
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5, Which element cannot built in larger amount into the monazite mineral?(1%)
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2, In which rock type has the highest Be content? (1%)
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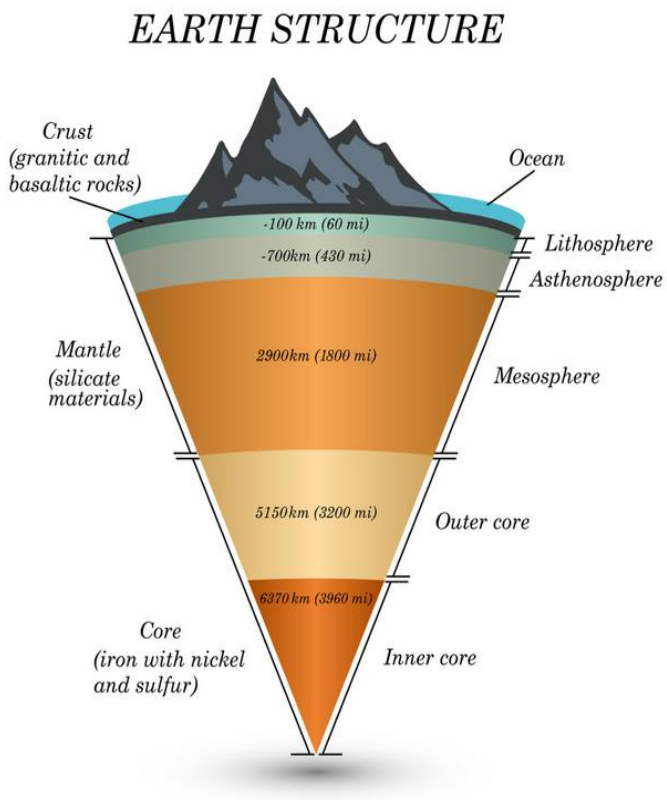
5, Mainly in which type of rocks the Nb and Ta can enrich? (1%)

a, Hawaiian type basalt
b, granites
c, sandstones with low clay content
d, gabbros and dunite

IV, ESSAYS (35%)

1, The "dinamo effect" creates the magnetic field around the Earth, because the core consist of Fe and Ni, but it has significantly different rotating speed than the outer layers.



2, The coal order is the following: peat => lignite => brown coal => hard coal => antracite. As it goes forward the carbon (C) content continuously increasing, from the apx. 60% of the peat to the apx. 99% of the antracite. The amount of the contaminants, such as sulphur (S), nitrogen (N), hydrogen (H) and oxygen (O), continuously decreasing, as the material goes forward the higher maturity.

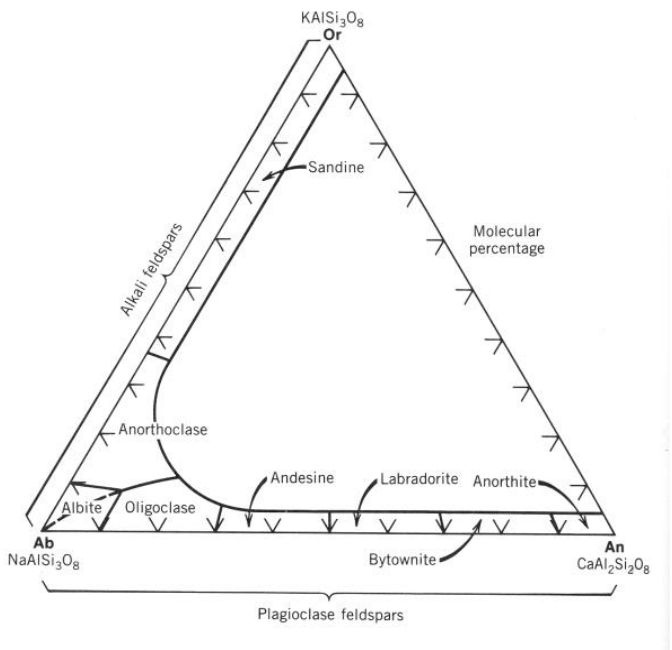
3, The calcium carbonate (calcite) metasomatism to pure magnesium carbonate (magnesite) is the folowing:

name	formula	Ca/Mg ratio
calcite	$CaCO_3$	Ca=1; Mg=0
magnesium containing calcite	eg: $Ca_{0.8}Mg_{0.2}CO_3$	Ca≠1;Mg≠0, Ca>>Mg
dolomite	$CaMg(CO_3)_2$	Ca=Mg=1
calcium containing magnesite	eg: $Ca_{0.2}Mg_{0.8}CO_3$	Ca≠0;Mg≠1, Ca<<Mg
magnesite	$MgCO_3$	Ca=0; Mg=1

4, The four sulphate mineral are the followings:

gypsum	$CaSO_4*2H_2O$
anhydrite	$CaSO_4$
melanterite	$FeSO_4*7H_2O$
chalcanthite	$CuSO_4*5H_2O$ (heavy metal containing)
barite	$BaSO_4$ (heavy metal containing)

5, Albit-anorthite name criteria:
Albite: min. 90% albite mineral, so Na:Ca ratio is min. 90%:10%)
Anorthite: min. 90% anorthite mineral, so Ca:Na ratio is min. 90%:10%)



6, From the dissolved ferric ion ferric-hydroxide ($Fe(OH)_3$) forms first, later by dehydration (loosing water) thermodynamically more stable goethite ($FeO(OH)$) is formed, which is further transforms to hematite (Fe_2O_3) by water loss.

$Fe^{3+} + 3H_2O \Rightarrow Fe(OH)_3 + 3H^+$

$Fe(OH)_3 \Rightarrow FeOOH + H_2O$

$2FeOOH \Rightarrow Fe_2O_3 + H_2O$

7. FURTHER REQUIREMENTS

The presents for the students both on lecture is compulsory. The ratio of the absence cannot exceed the 30%, which equal with 4 times during the semester. The higher ratio automatically resulted as denial of the signature.

Miskolc, 31. 08. 2023.

Dr. Ferenc Móricz
associate professor