MINERALOGY AND GEOCHEMISTRY

Earth Scineces Engineering MSc
Hydrogeological Engineering MSc

MFFAT710005

2020/21. I. Semester

COURSE COMMUNICATION FOLDER

University of Miskolc
Faculty of Earth Science and Engineering
Institute of Mineralogy and Geology

Tartalomjegyzék

1. Tantárgyleírás, tárgyjegyző, óraszám, kreditérték
2. Tantárgytematika (órára lebontva)
3. Minta zárthelyi
4. Minta zárthelyi megoldása
5. Minta vizsga
6. Minta vizsga megoldása
7. Egyéb követelmények

1. COURSE DESCRIPTION

Course Title: Mineralogy and geochemistry **Responsible Instructor:** Dr. Zajzon Norbert, associate professor	**Code:** MFFAT710005 **Responsible department/institute:** Department of Geology and Mineral Resources
	Type of course: Compulsory
Position in curriculum (which semester):1st	**Pre-requisites (if any):** -
No. of contact hours per week (lecture + seminar): 2+1	**Type of Assessment (examination/ practical mark / other):** exam
Credits: 4	**Course:** full time

Course Description: Students will get the knowledge of the principals of the distribution of chemical element in the Earth. They will also know the most important thermodynamic processes concerning solid materials, the geochemical classification of elements, the geochemical aspects of the genesis of the most important minerals and mineral assemblages. The geochemistry of isotopes, which explores the chemical evolution of the Earth will also be introduced, as well as the geochemical characteristics of water, organic matter, magmatic, sedimentary and metamorphic rocks by which we can describe the mineral-and rock-forming processes in the crust and mantle.

Competencies to evolve:

Knowledge: T7

Ability: K1, K2

Attitude: A1, A2, A9

Autonomy and responsibility: F2, F5

The short curriculum of the subject: Abundance of chemical elements. Meteorites. Geochemical classification of elements. Chemical composition of Earth. Chemical composition of minerals. Genetic characteristics of mineral parageneses. Isotopes and the Periodic Table. Radioactivity and geochronology. Stable isotopes and geology. Short thermodynamics. Water chemistry. Characteristics of natural water. Geochemistry of soils. Organic geochemistry. Organic geochemistry of freshwater and seawater. Geochemistry of sedimentary rocks. Chemical weathering. Geochemistry of igneous and metamorphic rocks.

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.

2. CURRICULUM OF THE SUBJECT

Mineralogy and geochemistry
Year 2020/21, semester 1st
Time of lecture: Monday, 8:00 – 10:00
Time of seminar: Monday, 10:00 – 11:00

Week	Topic of the lecture
2020.09.07.	Hydrogen and alkaline metals
2020.09.14.	Alkaline earth metals
2020.09.21.	Boron, aluminium, carbon and silicon
2020.09.28.	Rare earth elements, titanium and zirconium
2020.10.05.	Uranium, thorium, vanadium, niobium and tantalum
2020.10.12.	Chromium, molybdenium and tungsten
2020.10.19.	Midterm test (1st)
2020.10.26.	Manganese, iron, cobalt and nickel
2020.11.02.	Copper, gold, silver and platina group elements
2020.11.09.	Zinc, cadmium, mercury, gallium, indium and thallium
2020.11.16.	Tin, lead, arsenic, antimony and bismuth
2020.11.23.	Nitrogen, phosphorus and oxygen
2020.11.30.	Sulphur, selenium, tellurium, haloids and noble gases
2020.12.07.	Midterm test (2nd)

Seminars:
The thematic of the seminars are strongly linked to the topics of the lectures. Through examples, exercises and case studies the students get knowledge, which will be necessary on the area of raw material exploration of mining.
Hand-piece of the most important rock samples are shown, which is linked the individual element enrichments.

3. EXAMPLE FOR MIDTERM TEST:

I, MINERALS (40%)

1, What is acanthite?(5%)
a, AgS b,Ag_2S c, $CaWO_4$ d, AgS_2

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

3, What is nickeline?(5%)
a, NiS b,NiS_2 c, NiAsS d, NiAs

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

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

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

7, Which has the highest chemical resistance among these iron minerals?(5%)
a, siderite b, goethite c, pyrrhotite d, hematite

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

II, REPLACING (20%)

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

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

3, 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

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

III, ORIGIN (10%)

1, Mainly in which type of rocks the Mn can enrich <u>significantly</u>? (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 (30%)

1, Shortly describe how much the Fe content (in form of Fe_2O_3) of the four main (by SiO_2 concentration) rock type. (8%) Write at least 2 other element, which have good correlation with the Fe content of the rocks. (2%)

2, You have mine waste material with Fe-sulphide mineral. It starts oxidize and dissolves. What mineral will be forms, if the dissolved Fe will form mineral with carbonate and sulphate ion? Write down also an iron oxide and oxy-hydroxide. (5 mineral name + 5 chemical composition). (10%)

3, 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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c, mainly in ultrabasic and basic rocks d, evaporites of arid climates

IV, ESSAYS (30%)

1, Based on SiO_2 classification the following four rock types are:
Ultrabasic rock type with apx. 15-25% Fe_2O_3 content
Basic rock type with apx. 8-12% Fe_2O_3 content
Neutral/intermedier rock type with apx. 2-5% Fe_2O_3 content
Acidic rock type with less than 1% Fe_2O_3 content

2, Primer iron-sulphide: pyrite FeS_2
Iron-sulphate melanterite $FeSO_4*7H_2O$
Iron-carbonate siderite $FeCO_3$
Iron-oxy-hydroxide goethite $FeO(OH)$
Iron-oxide hematite Fe_2O_3

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

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

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

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

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

II, REPLACING (5%)

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

2, What can be replaced by Hf? (1%)
a, Zr b, Zn c, both of them 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

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

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

III, ORIGIN (5%)

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

2, 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

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 Nb and Ta can enrich? (1%)

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

5, 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

IV, ESSAYS (35%)

1, 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%)

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

3, Write down the three ways of the calcium carbonate (calcite) appearing from salt water and describe them with 1-1 sentence. Which is dominant in warm and cold sea water? Globally which is dominant?(9%)

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, Write down what is the "REE" abbreviation is used for. Write down the their three appearance mode in bauxite. (4%)

6, Write down the two polymorphs of carbon and described them in 2-3 sentences. (3%)

7, 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. (4%)

6. EXAMPLE FOR FINAL TEST ANSWERS:

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1, Which element cannot built in larger amount into the monazite mineral?(1%)
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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 Nb and Ta can enrich? (1%)

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

5, 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

IV, ESSAYS (35%)

1, 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

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, From salt water (seawater) three ways of the calcium carbonate (calcite) appearing can be possible, like:

1, chemical way: precipitation of $CaCO_3$, as some parameter changes, like: saturation, pH, temperature, partial pressure, etc...
2, physical way: settling down of larger colloid fractions
3, biological way: settling down of calcium-carbonate bones of dead fish, shells and oceanic organisms

In warm seas the chemical way is the dominant, but in cold water, as well as globally, the biological way is the dominant.

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, The "REE" abbreviation is for the Rare Earth Elements. In bauxite there are three appearance mode, such as:

1, own mineral (eg. monacite, bastnäsite, xenotime),
2, trace element as replacing element (replaces the calcium in apatite)
3, free ion (by ad- or absorption, especially in clays)

6, There are two polymorphs of carbon:

1, diamond (high-pressure polymorph of carbon): origin is the Earth mantle and moves to the crusts with quick magmatic processes. It is resistant against pressure, but not against the heat, it simply catch fire at higher temperature.
2, graphite (high-temperature polymorph of carbon): often used as a temperature resistant lubricant because its two dimensional structure allows planes to slip laterally. It forms mainly metamorph processes, or it has pegmatitic origin. It is resistant against the heat, but not the pressure.

7, 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 and on seminar 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. 2020.

Dr. Norbert Zajzon
associate professor