Geochemical exploration methods

MFFAT720005

Earth Science Engineering MSc, geological engineering specialisation

2024/25 2nd semester

TANTÁRGYI KOMMUNIKÁCIÓS DOSSZIÉ

Miskolci Egyetem
Műszaki Föld- és Környezettudományi Kar
Nyersanyagkutató Földtudományi Intézet

Tantárgy leírás

Course name: Geochemical exploration methods **Course leader:** Dr. Mádai Ferenc, egyetemi docens	**Course code:** MFFAT720005 **Depatrtment:** Department of Mineralogy and Petrology
Recommended semester: 2	**Pre-requisits:** MFFAT710001
Weekly hours: 1+2	**Assignment (a/gy/v):** Practical mark
Credits: 4	**division:** full time

Main objectives of the course:
Introduction into a basic area of mineral exploration methods, including the theorethical background of geochemical sampling, the detailed discussion of different sampling and analytical methods, as well as the methods of data processing and interpretation.
Completion of a geochemical exploration project, including field sampling, sample preparation, data processing and interpretation is an important part of the course.

Relevant competences:

- Applies the techniques and practices best available for geochemical sampling.
- To apply the right selection of analytical technics and digestion solution for geochemical samples.
- To apply the hierarchical planning approach for geochemical sampling.
- Combines the applied and theoretical knowledge required for the complex interpretation of geochemical datasets and processes.

knowledge:

- Knows and applies scientific and technical theory and practice related to the profession of environmental engineering.
- Has a comprehensive knowledge of measurement technology and measurement theory related to the field of environmental engineering.
- Knows and applies environmental and remediation procedures (operations, equipment, devices), environmental remediation methods.
- Knows the operation of environmental protection facilities (especially water and wastewater treatment plants, hazardous and communal landfills, waste incinerators), their structures and the possibilities of their development.
- Knows and applies the rules of environmental impact assessment and preparation of environmental technical documentation.
- Knows and applies the methodology and tools of environmental informatics and modeling in a complex way.
- Knows the basics, boundaries, and requirements of the fields of work, as well as fire protection, safety technology, information technology, law, economics and management related to environmental engineering.
- Knows the promotion and opinion-forming methods related to environmental engineering.

skills:

- Can apply the acquired general and specific mathematical, natural and social science principles, rules connections and procedures in solving problems arising in the field of environmental protection.
- Able to conduct publications and negotiations in his/her field in his/her mother tongue and at least o foreign language.
- Able to perform environmental management tasks.
- During work, examines the possibility of setting research, development and innovation goals and strives to achieve them.
- Able to plan in a complex way, implement and maintain engineering interventions in the fields of soil subsurface, water, air, noise and vibration protection, wildlife protection, remediation and waste reduction, treatment, and processing.

attitude:

- Open and receptive to the knowledge and acceptance of professional, technological development an innovation in the field of environmental protection, and its authentic mediation.
- Assumes the professional and moral values related to the field of environmental protection.
- Seeks to plan and carry out tasks independently or in a working group at a professional level.

Strives to carry out the required work in a complex approach based on a systems-based and process-oriented way of thinking.

autonomy and responsibility:

- Can solve environmental engineering tasks independently, takes decisions carefully, in consultation with the representatives of other (mainly legal, economic, energy) fields, independently, takes responsibility for the decisions.
- In making decisions, takes into account the basic requirements of occupational health and safety, technical, economic and legal regulations, and engineering ethics.
- takes the initiative in solving environmental problems, identifies the shortcomings of the applied technologies, the risks of the processes and initiates the measures to reduce them.

Short curriculum of the course:

- Geochemical distribution of chemical elements in different rock types,
- Periodic table for geochemists
- Concept of the geochemical background.
- Geochemical delineation of a mineralization, a mineral deposit.
- Primary dispersion, methods of its exploration.
- Geochemical aspects of weathering.
- Geochemistry of the surface environment.
- Sorption processes
- Secondary dispersion and methods of its exploration.
- Sampling methods, sampling standards.
- Soil surveys, vegetation and water surveys.
- Stream sediment sampling methods, heavy minerals geochemistry.
- Major analytical methods.
- Data processing and statistical methods.

Assignment: completion of three exercises during the semester and participation in a 2-3 days field trip and completion of a sampling plan based on the field trip.

1. CIPW norm calculation excercise (20%)
2. Evaluation of a REE dataset (15%)
3. Geochemical evaluation of a drillcore (15%)
4. Field trip work and completion of the sampling plan (50%)

Grading limits:

> 80 %: excellent
70 – 80 %: good
60 – 70 %: medium
50 – 60 %: passed
< 50 %: failed

The 3-5 most important compulsory, or recommended literature (textbook, book) resources:

- Reedman J.H.: Techniques in mineral exploration (Appl. Sci. Publ. London, 1979)
- Kuzvart M. & Böhmer M.: Prospecting and exploration of mineral deposits (Elsevier, 1986)
- Wite W.M. (2007): Geochemistry. Online textbook, (John Hopkins University, 2007)
- Matveev A.A. (2003): Geokhimicheskie poiski MPI. (Izd. MGU, 2003)
- Grigoryan S.V.; Morozov V.I. (1985): Vtorichnie litogeokhimicheskie oreoli pri poiskah skritogo orudineniya (Nauka, Moskva, 1985)
- Hawkes H.E.: Principles of geochemical prospecting. (US DOE, Geological survey bulletin 1000-F)
- Geboj N.J.; Engle E.A. (2011): Quality Assurance and Quality Control of Geochemical Data: A Primer for the Research Scientist (USGS Open-File Report 2011–1187)

Sarkar D., Datta R., Hannigan R.: Concepts and applications in environmental geochemistry. (Elsevier, 2007)

Féléves órabeosztás

2024/25 2. félév

csütörtök 14 - 17 intézeti könyvtár / számítógépes terem

dátum	téma
13.02.2025	requirements, program, geochemist's periodic table
20.02.2025	CIPW individual work
27.02.2025	hydrothermal model, mineral deposit model, primary dispersion
06.03.2025	Resource categories, geochemical landforms, geochemical barriers
13.03.2025	IoGAS practical class
20.03.2025	Thermodynamics basics, eH-Ph relations
27.03.2025	Element mobility, Sorption, secondary dispersion, soil
03.04.2025	analytical methods (ICP, XRF, classical analytics)
10.05.2025	portable equipment, calibration
17.05.2025	Sampling, construction of a sampling plan
24.05.2025	szünet
01.05.2025	szünet
08.05.2025	Sampling QAQC
15.05.2025	2d, 3d modeling
	vectoring

Assignments

1. exercise: CIPW norm calculation

The student should complete a norm calculation based on the given analytical data, following the algorithm given in the instructions. Received results should be evaluated according to the IUGS requirements (Streckeisen diagram, TAS diagram).
The CIPW norm calculation instruction can be downloaded from the Moodle site of the course.

Deadline: 25 March.

2. exercise: Using the database provided the student should do a normalization of the REE dataset relative to the REE distribution in the upper continental crust, The samples shall be classified according their distribution trends as:
   - L-type: light-REEs (La, Ce, Pr, Nd, Sm) normalized values are higher than that of the mid-REEs and heavy REEs.
   - M-type: Elements of the mid-section (Eu, Gd, Tb, Dy) show higher values compared to the others,
   - H-type: Heavy REEs show the highest relative concentration.

3. exeercise: The database given on the Mecsek coal basin from the Karolina valley open pit shall be evaluated based on distribution of Ge concentration values. Students shall interpret the data, considering the possible ways of Ge fixation change of lithology.
4. exercise: Geochemical sampling exercise: Students shall propare a sampling plan for geochemical prospecting works in the Telkibánya region for a 2 sq. km area. The sampling plan shall describe the steps of the expedition for a soil geochemistry sampling completed along an orthogonal net.

Tasks:
- step 1: Reconnaissance and stream sediment sampling
- step 2: Soil sampling campaign
- step 3: completion of a budget for sampling and chemical analyses

Soil sampling geometry could be either by orthogonal grid or ridge and spur method

Chapters of the sampling plan

step 1.
- definition of involved parties, tasks to be completed towards different stakeholders, expected relating costs
- evaluation of existing geological, geochemical data
- selection of chemical elements that should be sampled, explanation why these elements are selected
- designation of sampling points for stream sediment sampling (max. 12 points)
- technical instructions for stream sediment sampling (sample size, sampling depth, how to find traps)

- documentation requirements (system of labelling, list of parameters that should be characterized at the sampling point)
- sample processing instructions for stream sediment samples
- safety regulations
- Schedule for stream sediment campaign (max. 7 days)

step 2.

- delineation of the sampling area for soil sampling, based on the results of the stream sediment sampling campaign
- selection of chemical elements that should be sampled, explanation why these elements are selected
- designation of expected geochemical barriers on the sampling area for different selected elements
- characterization of the soil type expected on the area
- density and geometry of the sampling grid
- technical instructions for soil sampling (sample size, sampling depth, orientation)
- documentation requirements (system of labelling, list of parameters that should be characterized at the sampling point)
- sample processing instructions for soil samples (sieving, splitting, packing)
- sample storage instructions
- safety instructions
- Schedule for soil sampling (max 14 days)

Step 3:

- selection of analytical methods, chemical elements to be analysed, detection limits.
- Risk assessment: expected errors, pitfalls
- Composition of the sampling team (No. of geologists, technicians etc.)
- personnel costs
- wages
- catering (accommodation, food etc.)
- rental costs
- transportation costs in field
- housing / workshop / laboratory / office
- sample transportation costs to chemical laboratory
- analytical costs

Submission deadline: 14 May.

CIPW. norm calculation exercise

dataset: 6/65600

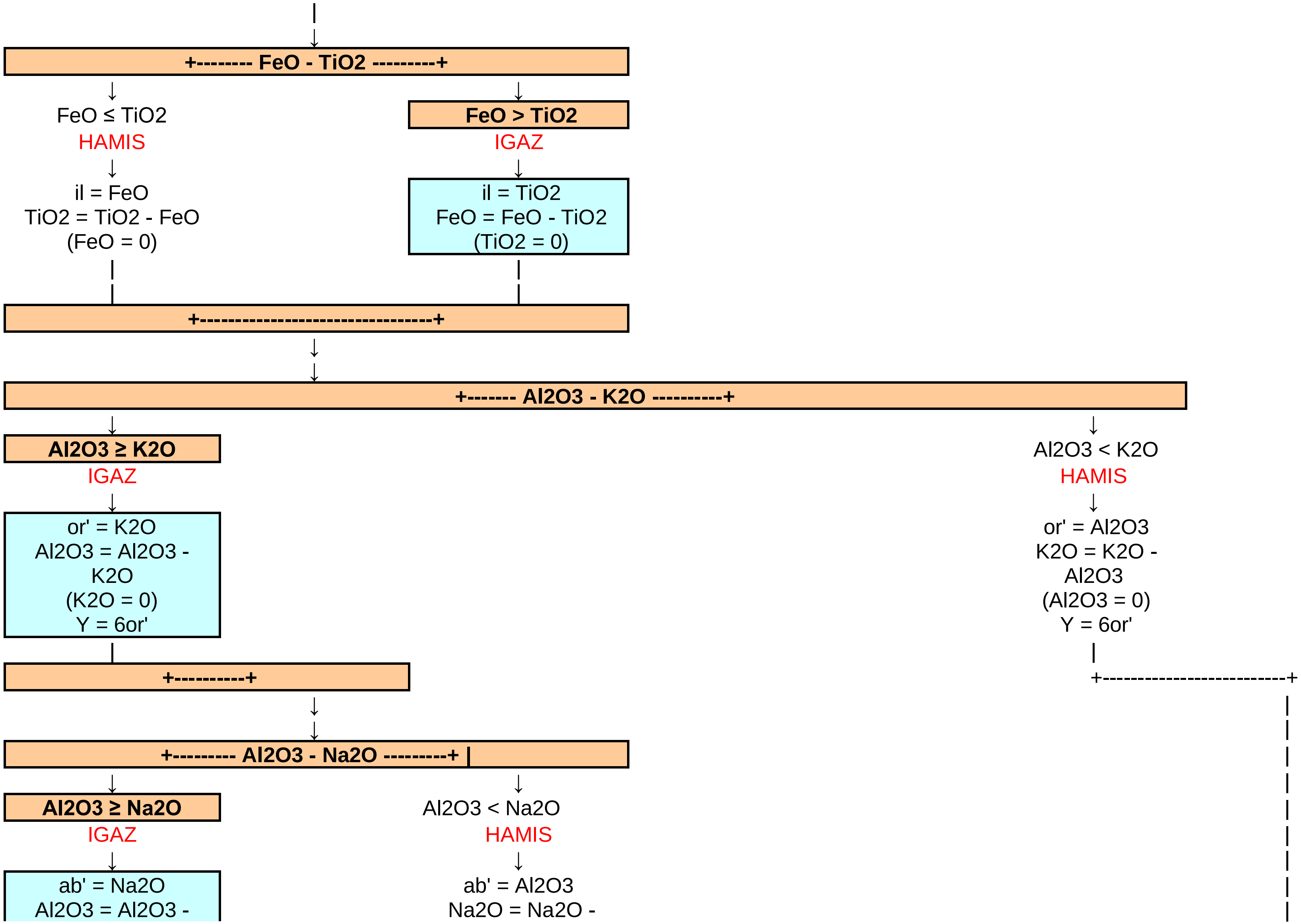
6 / 65600 input data:

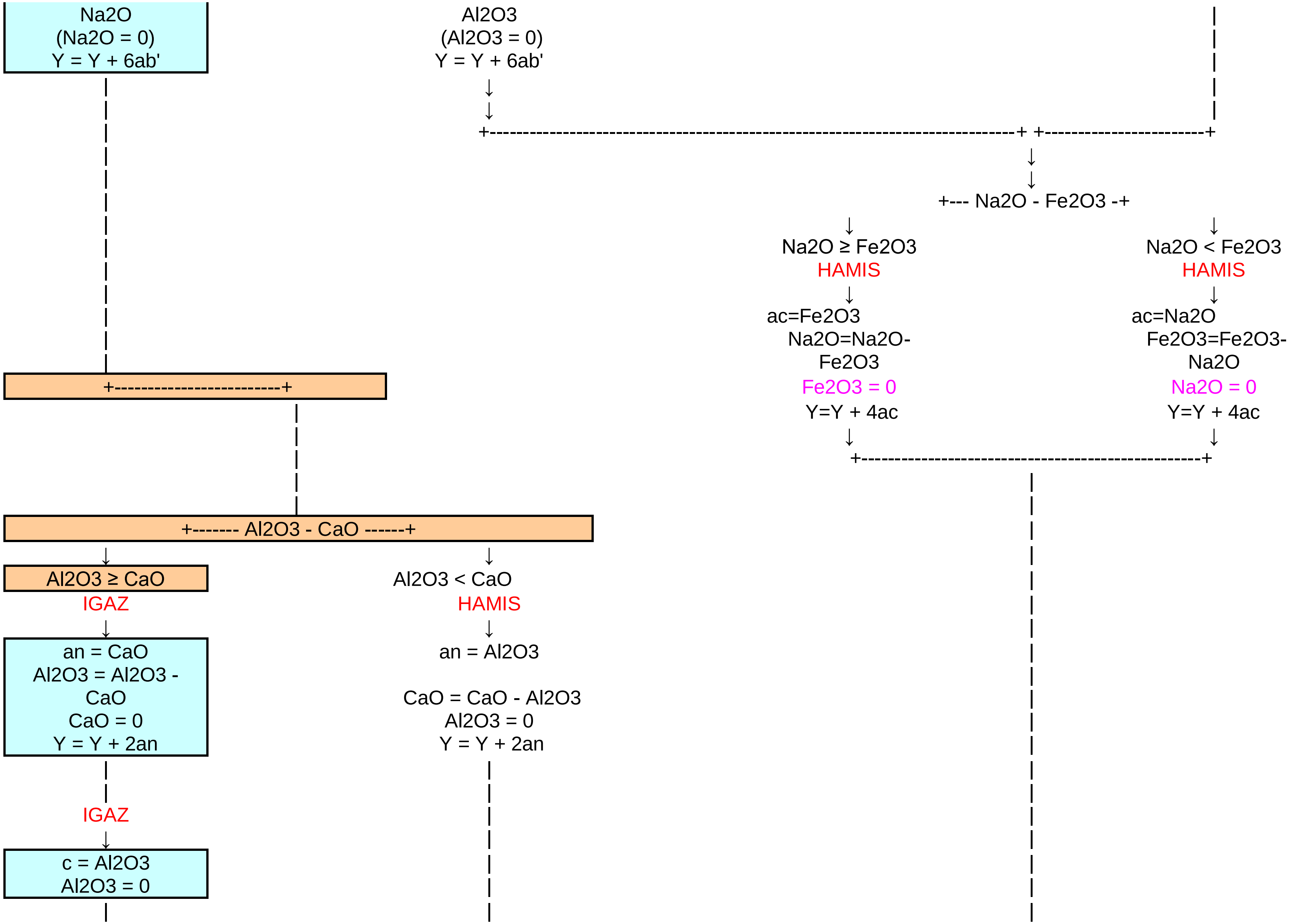
	Wt %	molecular weight:	mole ratio
SiO_2	73,79	60,0848	1,2281
TiO_2	0,98	79,8988	0,0123
Al_2O_3	13,83	101,9612	0,1356
Fe_2O_3	0	159,6922	0,0000
FeO	2,8	71,8464	0,0390
MnO	0	70,9374	0,0000
MgO	0,19	40,3114	0,0047
CaO	1,05	56,0794	0,0187
Na_2O	4,41	61,979	0,0712
K_2O	2,83	94,2034	0,0300
P_2O_5	0	141,9446	0,0000
CO_2	0	44,01	0,0000
Cr_2O_3		151,9902	0,0000
NiO		74,7094	0,0000
BaO		153,34	0,0000
SrO			
ZrO_2		123,2188	0,0000
F		18,9984	0,0000
Cl		35,453	0,0000
S			
H_2O	0	18,01534	0,0000
SO_3		80,0582	0,0000
Σ	99,88		

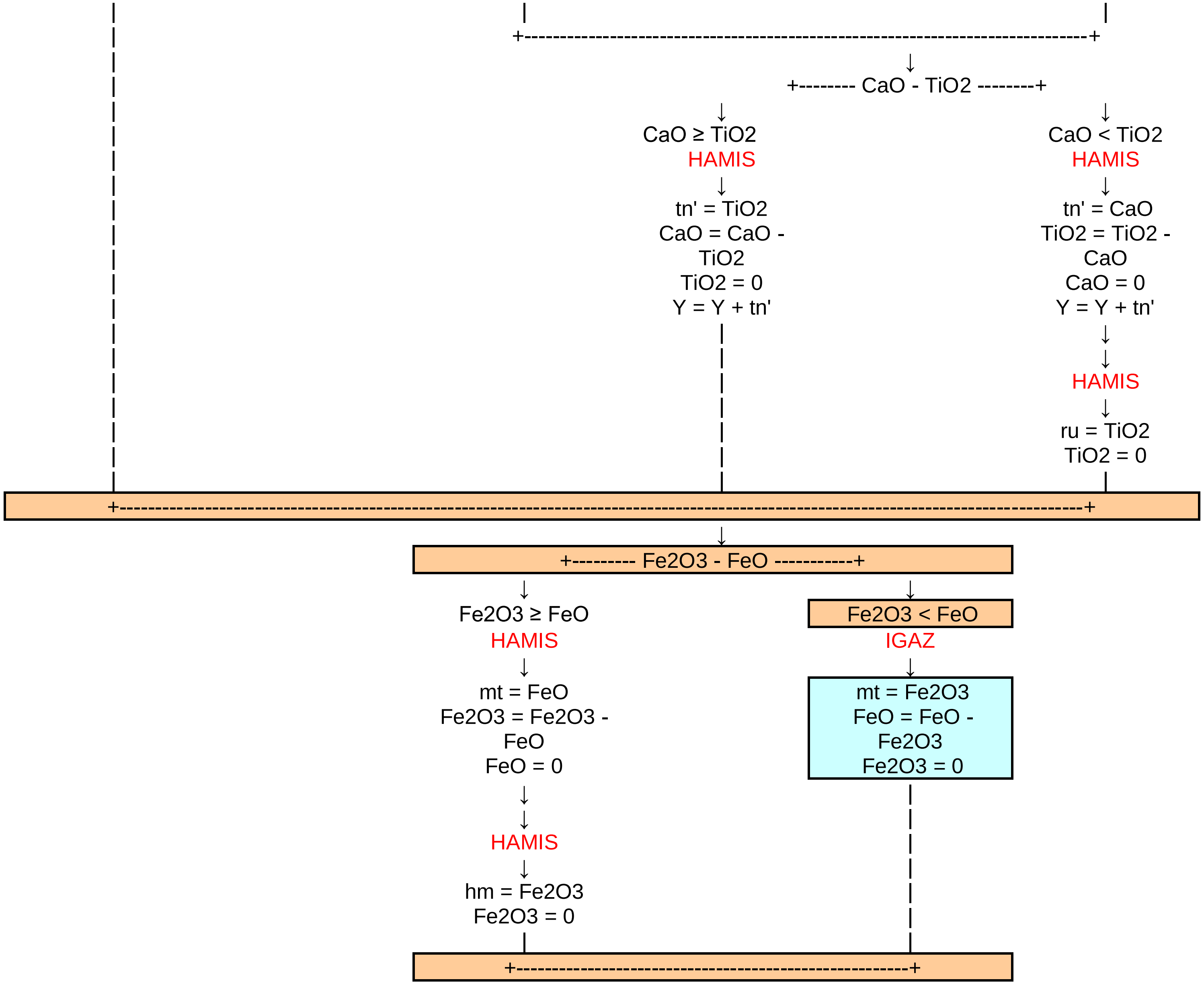
accompanying components:

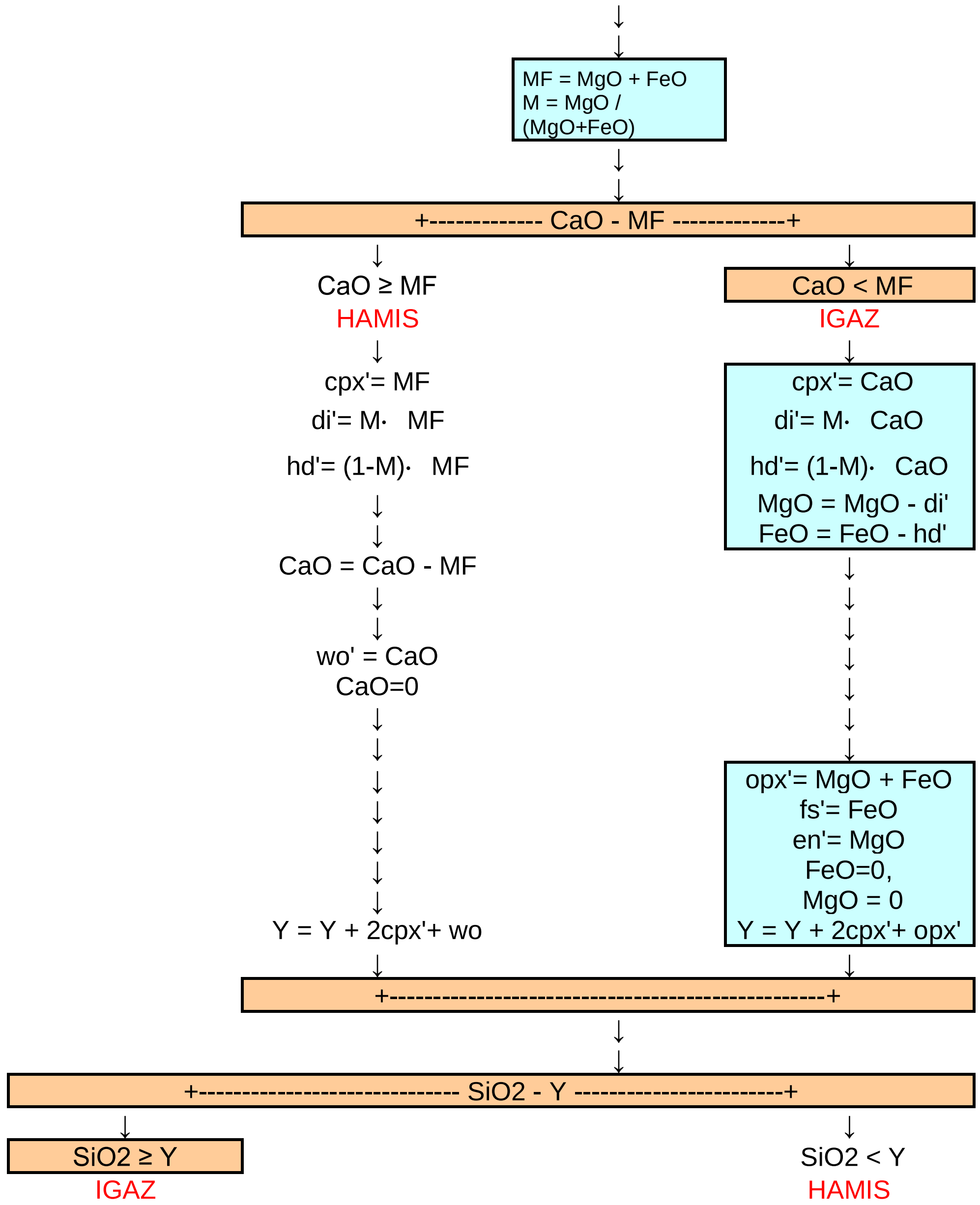
FeO = FeO + MnO + NiO	0,0390
CaO = CaO + BaO + SrO	0,0187
zr = ZrO_2	0,0000
ap = P_2O_5	0,0000
fr = F/2	0,0000
hl = Cl	0,0000
pr = S/2 (SO_3/2)	
cc = CO_2	0,0000
cm = Cr_2O_3	0,0000
CaO = CaO - 3,33 · P_2O_5	0,0187
F = F - 2/3 · ap	0,0000
CaO = CaO - F/2	0,0187
Na_2O = Na_2O - Cl/2	0,0712
FeO = FeO - S	0,0390
CaO = CaO - CO_2	0,0187
FeO = FeO - Cr_2O_3	0,0390
Y = zr	0,0000

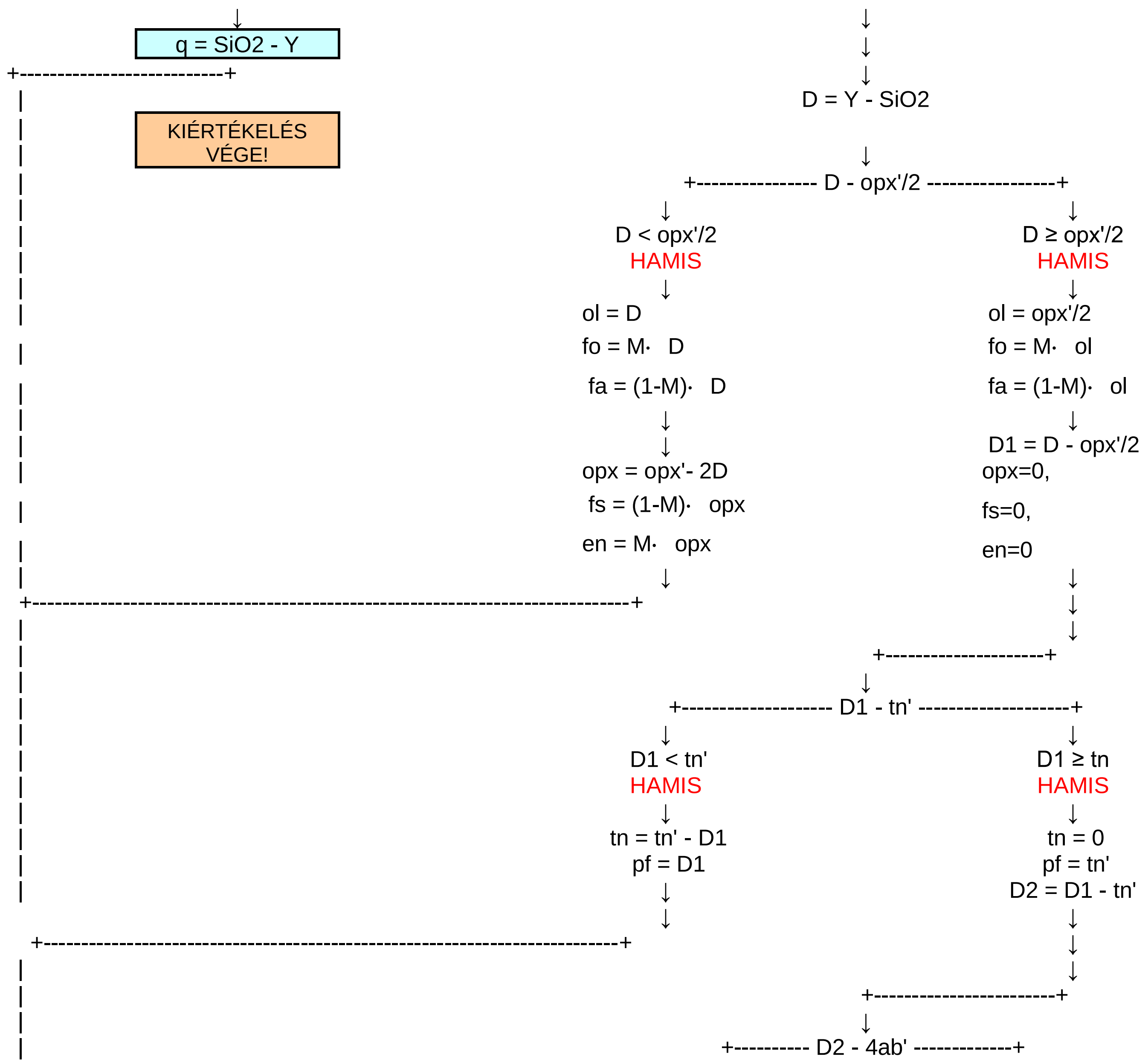
Calculation:




Na2O
(Na2O = 0)
Y = Y + 6ab'
Al2O3
(Al2O3 = 0)
Y = Y + 6ab'
+--+ +------------------------+
+--- Na2O - Fe2O3 -+
Na2O ≥ Fe2O3
HAMIS
ac=Fe2O3
Na2O=Na2O-Fe2O3
Fe2O3 = 0
Y=Y + 4ac
Na2O < Fe2O3
HAMIS
ac=Na2O
Fe2O3=Fe2O3-Na2O
Na2O = 0
Y=Y + 4ac
+--+
+--------------------------+
+-------- Al2O3 - CaO ------+
Al2O3 ≥ CaO
IGAZ
an = CaO
Al2O3 = Al2O3 - CaO
CaO = 0
Y = Y + 2an
IGAZ
c = Al2O3
Al2O3 = 0
Al2O3 < CaO
HAMIS
an = Al2O3
CaO = CaO - Al2O3
Al2O3 = 0
Y = Y + 2an


CaO - TiO2
CaO ≥ TiO2
HAMIS
tn' = TiO2
CaO = CaO - TiO2
TiO2 = 0
Y = Y + tn'
CaO < TiO2
HAMIS
tn' = CaO
TiO2 = TiO2 - CaO
CaO = 0
Y = Y + tn'
HAMIS
ru = TiO2
TiO2 = 0
Fe2O3 - FeO
Fe2O3 ≥ FeO
HAMIS
mt = FeO
Fe2O3 = Fe2O3 - FeO
FeO = 0
HAMIS
hm = Fe2O3
Fe2O3 = 0
Fe2O3 < FeO
IGAZ
mt = Fe2O3
FeO = FeO - Fe2O3
Fe2O3 = 0


MF = MgO + FeO
M = MgO / (MgO+FeO)
+------------- CaO - MF -------------+
CaO ≥ MF
HAMIS
cpx'= MF
di'= M· MF
hd'= (1-M)· MF
CaO = CaO - MF
wo' = CaO
CaO=0
Y = Y + 2cpx'+ wo
CaO < MF
IGAZ
cpx'= CaO
di'= M· CaO
hd'= (1-M)· CaO
MgO = MgO - di'
FeO = FeO - hd'
opx'= MgO + FeO
fs'= FeO
en'= MgO
FeO=0,
MgO = 0
Y = Y + 2cpx'+ opx'
+--+
+------------------------------ SiO2 - Y ------------------------+
SiO2 ≥ Y
IGAZ
SiO2 < Y
HAMIS


q = SiO2 - Y
KIÉRTÉKELÉS VÉGE!
D = Y - SiO2
D - opx'/2
D < opx'/2
HAMIS
ol = D
fo = M· D
fa = (1-M)· D
opx = opx'- 2D
fs = (1-M)· opx
en = M· opx
D ≥ opx'/2
HAMIS
ol = opx'/2
fo = M· ol
fa = (1-M)· ol
D1 = D - opx'/2
opx=0,
fs=0,
en=0
D1 - tn'
D1 < tn'
HAMIS
tn = tn' - D1
pf = D1
D1 ≥ tn
HAMIS
tn = 0
pf = tn'
D2 = D1 - tn'
D2 - 4ab'

```
|                                          ↓                          ↓
|                                     D2 < 4ab'                  D2 ≥ 4ab'
|                                       HAMIS                      HAMIS
|                                          ↓                          ↓
|                                     ne = D2/4                  ne = ab'
|                                  ab = ab' - D2/4                ab = 0
|                                          ↓                   D3 = D2 - 4ab'
+----------------------------------------+                            ↓
|                                                                     ↓
|                                                                     ↓
|                                                     +-------------------------+
|                                                     ↓
|                                       +---------- D3 - 2or' -------------+
|                                          ↓                          ↓
|                                     D3 < 2or'                  D3 ≥ 2or'
|                                       HAMIS                      HAMIS
|                                          ↓                          ↓
|                                     lc = D3/2                  lc' = or'
|                                  or = or' - D3/2                or = 0
|                                          ↓                   D4 = D3 - 2or'
+----------------------------------------+                            ↓
|                                                                     ↓
|                                                                     ↓
|                                                     +-------------------------+
|                                                     ↓
|                                       +----------- D4 - wo'/2 ------------+
|                                          ↓                          ↓
|                                     D4 < wo'/2                 D4  ≥ wo'/2
|                                       HAMIS                      HAMIS
|                                          ↓                          ↓
|                                     cs = D4                    cs = wo'/2
|                                     wo = wo'-2D4                wo = 0
|                                          ↓                    D5 = D4 - wo'/2
+----------------------------------------+                            ↓
|                                                                     ↓
|                                                                     ↓
|                                                     +-------------------------+
|                                                     ↓
|                                       +-------------- D5 - cpx' -------------+
|                                          ↓                          ↓
```

D5 < cpx'
HAMIS
↓
ol = ol + D5/2
fo = M· ol
fa = (1-M)· ol
cs = cs + D5/2
cpx = cpx'- D5
di = M· cpx
hd = (1-M)· cpx

D5 ≥ cpx'
HAMIS
↓
ol = ol + cpx'/2
fo = M· ol
fa = (1-M)· ol
cs = cs + cpx'/2
cpx = 0,
di=0,
hd=0
D6 = D5 - cpx'
↓
+------------------------+
↓
HAMIS
kp = D6/2
lc = lc'-D6/2
↓
+--+--+
↓
KIÉRTÉKELÉS VÉGE!

Calculation of norm components:

$FeO > TiO_2$	**Il = 0,0123**	**FeO= 0,0390-0,0123=0,0267**	
$Al_2O_3 \geq K_2O$	**or' = 0,0300**	**Al2O3 = 0,1356-0,0300=0,1056**	**Y=6*0,0300=0,1802**
$Al_2O_3 \geq Na_2O$	**ab' = 0,0712**	**AL2O3= 0,1056-0,0712=0,0344**	**Y=0,1802+6*0,0712=0,6072**
$Al_2O_3 \geq CaO$	**an = 0,0187**	**AL2O3= 0,0344-0,0187=0,0157**	**Y=0,6072+2*0,0187=0,6446**

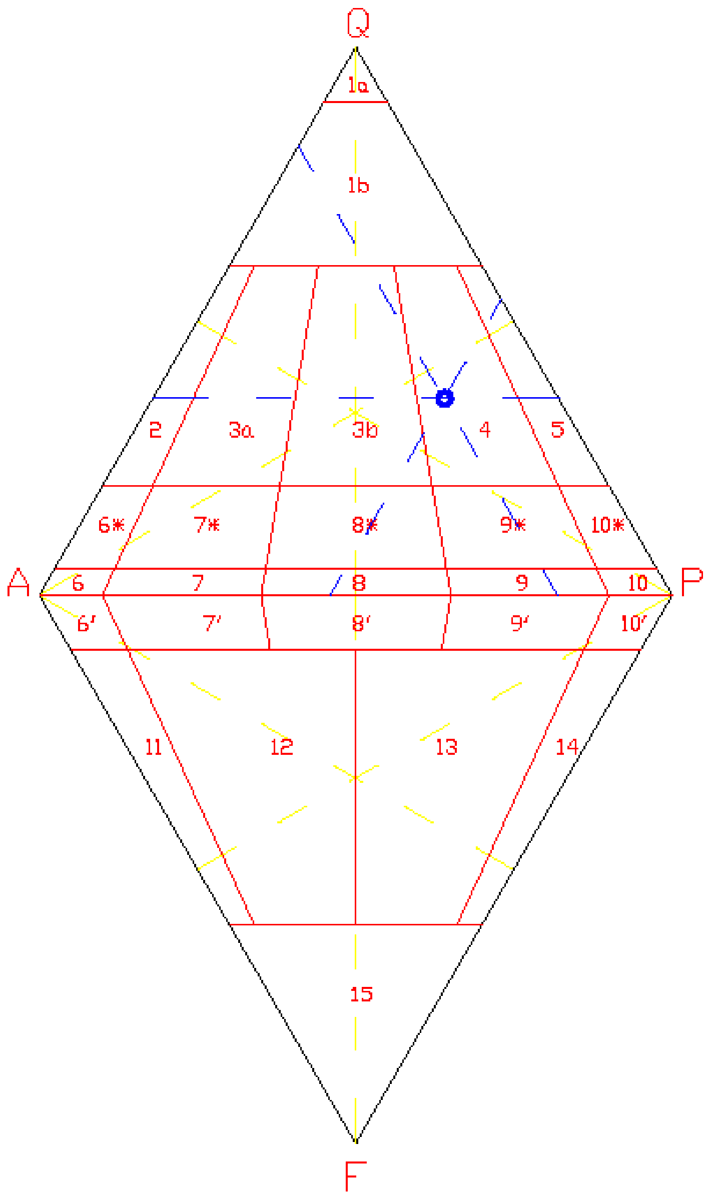
	c= 0,0157	**AL2O3= 0**	
Fe2O3 < FeO	**mt = 0**	**FeO = 0,0267-0=0,0267**	
MF= 0,0047+0,0267=0,0314 **M= 0,0047/(0,0047+0,0267)=0,1500**			
CaO < MF	**cpx'= 0** **di'= 0** **hd'= 0** **opx'= 0,0047+0,0267=0,0314** **fs'= 0,0267** **en'= 0,0047**		**Y=0,6446+0,0314=0,6760**
SiO2 ≥ Y	**q = 0,5521**		

Norm components (Wt%)

symbol	mineral	fomula	mol Wt	ratio	Wt%
q	kvarc	SiO2	60,09	0,5521	33,17352
c	korund	Al2O3	101,96	0,0157	1,603002
or	ortoklász	K2O-Al2O3-6SiO2	556,70	0,0300	16,72404
ab	albit	Na2O-Al2O3-6SiO2	524,48	0,0712	37,31839
an	anortit	CaO-Al2O3-2SiO2	278,22	0,0187	5,209239
lc	leucit	K2O-Al2O3-4SiO2	436,52	0,0000	0
ne	nefelin	Na2O-Al2O3-2SiO2	284,12	0,0000	0
kp	kaliofilit	K2O-Al2O3-2SiO2	316,34	0,0000	0
ac	akmit	Na2O-Fe2O3-4SiO2	462,03	0,0000	0
ns	Na-metaszilikát	Na2O-SiO2	122,07	0,0000	0
ks	K-metaszilikát	K2O-SiO2	154,29	0,0000	0
wo	wollasztonit	CaO-SiO2	116,17	0,0000	0
cpx	klinopiroxén				
di	diopszid	CaO-MgO-2SiO2	216,56	0,0000	0
hd	hedenbergit	CaO-FeO-2SiO2	248,11	0,0000	0
opx	ortopiroxén				
en	ensztatit	MgO-SiO2	100,39	0,0047	0,473169
fs	ferroszilit	FeO-SiO2	131,94	0,0267	3,523657
ol	olivin	(Mg,Fe)2SiO4			
fo	forszterit	2MgO-SiO2	140,69	0,0000	0
fa	fayalit	2FeO-SiO2	203,79	0,0000	0
cs	Ca-ortoszilikát	2CaO-SiO2	172,25	0,0000	0
mt	magnetit	FeO-Fe2O3	231,54	0,0000	0
il	ilmenit	FeO-TiO2	151,75	0,0123	1,861292
hm	hematit	Fe2O3	159,69	0,0000	0
nc	Na-karbonát	Na2O-CO2	105,99	0,0000	0
tn	titanit	CaO-TiO2-SiO2	196,07	0,0000	0
pf	perovszkit	CaO-TiO2	135,98	0,0000	0
ru	rutil	TiO2	79,90	0,0000	0
ap	apatit	3CaO-P2O5-1/3CaF2	336,22	0,0000	0
cc	kalcit	CaO-CO2	100,09	0,0000	0
zr	cirkon	ZrO2-SiO2	183,31	0,0000	0
fr	fluorit	CaF2	78,07	0,0000	0
hl	halit	NaCl	58,44	0,0000	0
cm	kromit	FeO-Cr2O3	223,84	0,0000	0
pr	pirit	FeS2	119,97	0,0000	0
				Összesen:	**99,8863**

Mafic total=	**1,8613**	**M<90%**
Q (quartz)=	**33,1735**	**35,89%**
A (alkali feldspars)=	**16,7240**	**18,09%**
P (plagioclase)=	**42,5276**	**46,01%**
F (feldspathoids)=	**0**	**0%**
Σ=	**92,43**	

QAPF diagram:

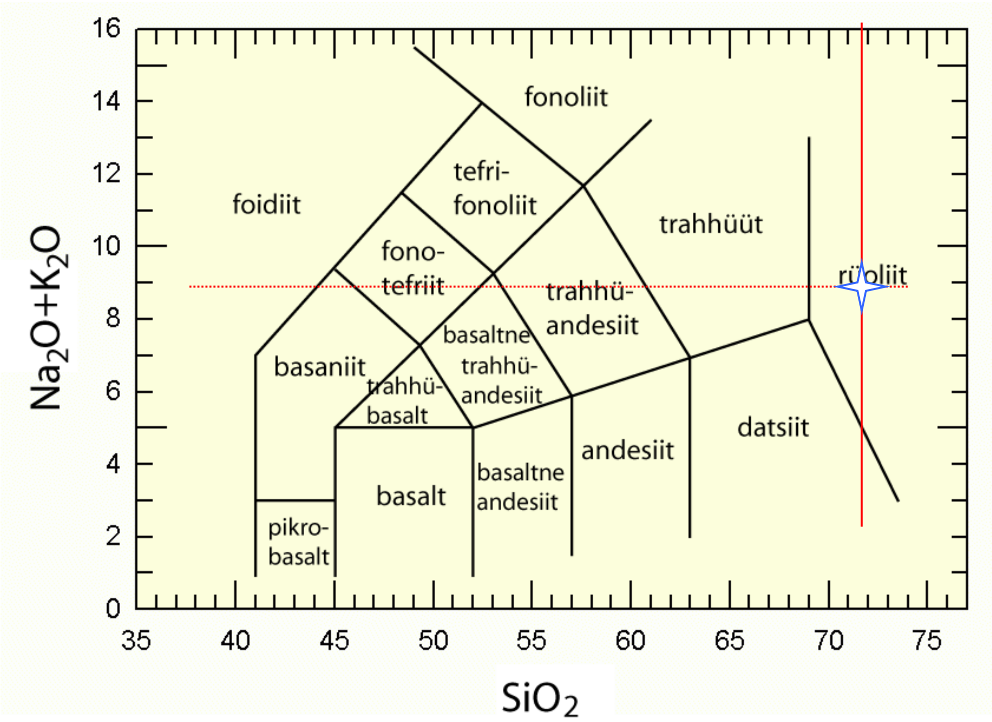


QAPF diagramm

Interpretation

coarse grained rock:	**Granodiorite**
fine grained rock:	**Dacite**

Interpretation by the TAS diagram:



TAS diagramm

According to the TAS diagram: **Riolite**

GEOCHEMICAL SAMPLING PLAN FOR TELKIBANYA AREA

By: Gunbileg Ganbat
Neptun code: GZG2WB

- **Step 1.1 Definition of involved parties, tasks to be completed towards different stakeholders, expected relating costs.**

There are usually 3 parties involved in exploration work License owner (client), government (local government and environmental agency) and servicing company. Local residents sometimes involved in permission to work, due to location of exploration area. Permission to conduct exploration work would be given only after plan of exploration work previewed and validated by local authority, at least a week prior to exploration work. Therefore, cost of a geologist or project manager's travelling cost to the area.

- **Step 1.2 Evaluation of existing geological, geochemical data**.

Geology of the area of basically consists of Miocene volcanic rocks and related clastic rocks (due to Carpathian volcanism). There are 2 intensification occurred during Miocene first in Badenian age then Sarmatian.

The late stage of Sarmatian volcanism developes succession of pyroxene andesites, rhyolite tuff and dacite. The Sarmatian sediments and pyroclastics lie concordantly on the Badenian ones. Intrusive breccias were found along its contacts with both Upper Badenian clays and Sarmatian clays and rhyolite tuff (Horváth and Zelenka, 1997).

While Badenian volcanic activity created dacitic domes, tuffs of dacitic-rhyolitic composition and tuff breccia deposited in a shallow marine environment.

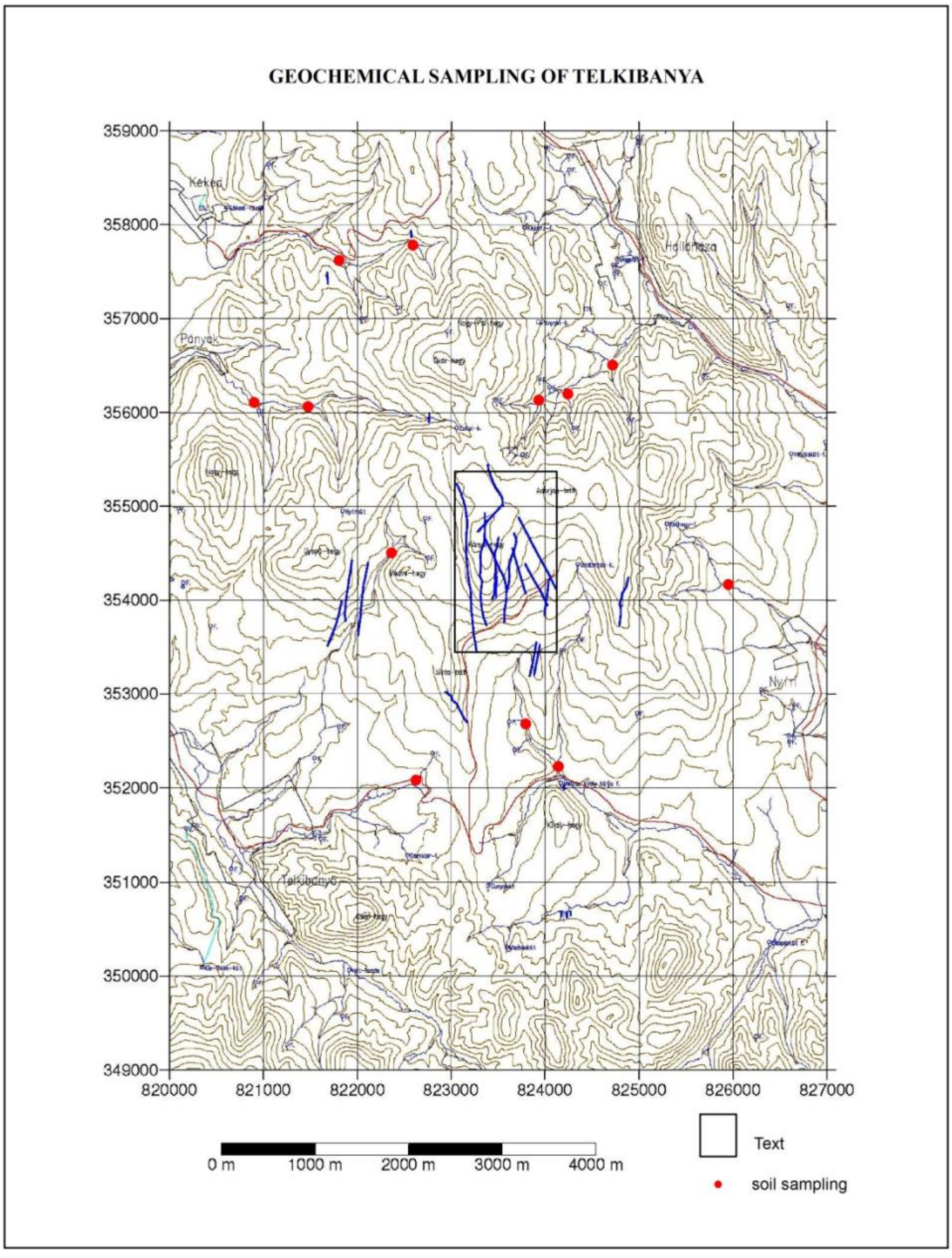
During and after the formation of the calderas and emplacement of the intrusion, faulting along NNW-SSE, NE-SW and E-W strikes occurred. Base-metal mineralization formed in association with both the Badenian and the Sarmatian volcanic stages. The rock material of the Badenian subvolcanic bodies became K-metasomatized, accompanied by an epithermal-hydrothermal veinstockwerk type ore mineralization. Mineralization in the area is found in veins along striking NNW that's parallel to the major faults of the area. Veins are at least 0.5-1 meters long and their width varies between 0.1-1 meters and their known depth is about 200 meters. In these ore zones polymetallic (Pb, Zn, Cu) ores were formed on deep levels and precious metal (Au-Ag) ores on high levels.

Correlation between drilling hole and geochemical analysis, K metasomatism is not related to gold mineralization, eventhough zonation of K enrichment coninceides with Au enrichment.

- **Step 1.3. Selection of chemical elements that should be sampled**

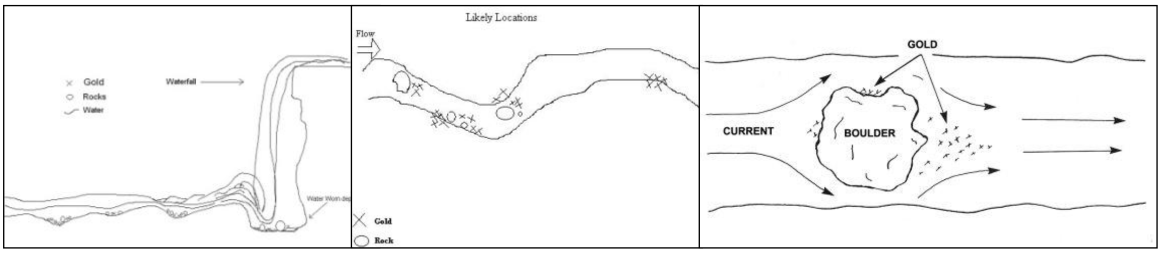
In low sulphidation epithermal Au, Ag deposits develop phyllic, argillic, propylitic alterations, especially in our case adularia, sericitic, hydrothermal alteration and K metasomatism. Ore minerals consist of native gold, electrum, native silver, pyrite, chalcopyrite, sphalerite, galena, arsenopyrite, cubanite, marcasite, covellite and tennantite, which are commonly associated with argillic alteration. Therefore, selection for chemical analysis should be concerning above mentioned mineralization and alteration.

- **Step.1.4. Designation of sampling points for stream sediment sampling**



step.1.5. Technical instruction for stream sediment sampling (sampling size, sampling depth, how to find traps)

In order to get all the possible anomalies following figure display basic traps where potential mineral



concentration.

- **Step.1.6. Documentation requirements (system of labeling, list of parameters that should be characterized at the sampling point)**

1. Date of sample taken
2. GPS coordinates of sample
3. General description of the sample
4. Sample weight

- **Step.1.8. Safety regulations**

✓ It is important to follow instructions of the tools.
✓ Wear safety gloves, glass and helmet if it’s necessary
✓ Not to leave one another in the field
✓ carry radio transmitter while working in a field has to (walky talky)
✓ Carry First aid kit in the vehicle

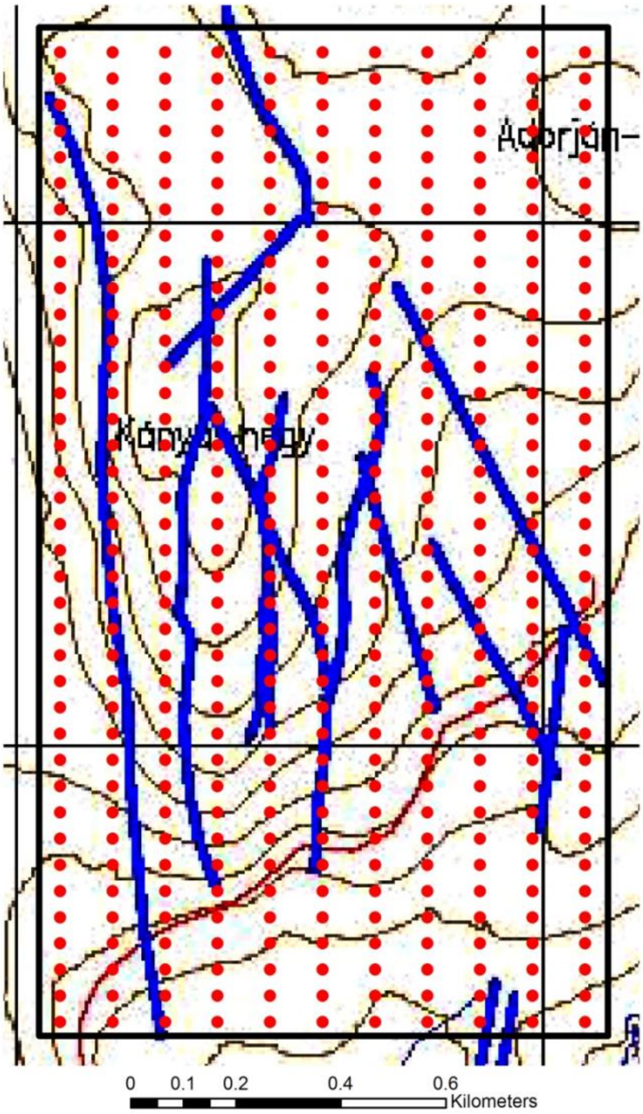
- **Step.1.9. Schedule for stream sediment campaign (max 7 days)**

These points located very difficult area to reach. Therefore, dividing these tasks into 2 teams for 2 two days. Each team will consist of 1 geologist and 1 technician. And driver for both team.

	Day 1	Day 2
Team 1	3 points	3 points
Team 2	3 points	3points

In total 5 personals: 2 geologist, 2 technician and a driver

- **Step.2.1. Delineation of the sampling area for soil sampling, based on result of the stream sampling campaign.**



- **Step.2.2. Selection of chemical elements that should be sampled, explanation why these elements are selected**

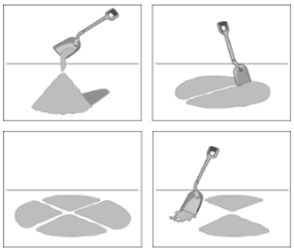
In this case, gold and silver should be measured, together with pathfinder elements (Sb, As, Pb, Zn, Mo, Cu, Bi, Co, Ni, W, Be). Moreover, most of the gold is linked to pyrite, then iron should be also measured.

- **Step.2.7. Documentation requirements (system of labelling, lists of parameters that should be characterized at the sampling point).**

Labeling The standard European documentation EN 14899 :2005 should be used for the sampling documentation that should include.

1. Date of sample taken
2. GPS coordinates of sample
3. General description of the sample
4. Sample weight

- **Step.2.8. sample processing instructions for soil samples (sieving, splitting, packing)**


- **Step.2.9. sample storage instruction**

Sample bag should be plastic for free contamination and sealable. Sample has to be stored elevated from ground in cold and dry place.

- **Step.2.10. Safety instruction**

Soil sampling techniques involve shovels, hand augers and drill rigs. Some of the potential risks include sampling in areas containing buried utilities, pit cave-in, equipment failure. For personal health dehydration, muscle skeletal injury, and allergic reactions to plants and insect stings. Key safety issues associated with these actions. Each of these methods can have significant safety hazards, some of which can result in longterm injury or death. Therefore:

- ✓ It is important to follow instructions of tools.
- ✓ Wear safety gloves, glass and helmet if it's necessary
- ✓ Not to leave one another in the field
- ✓ Carry First aid kit in the vehicle

- **Step.2.11. Schedule for soil sampling (max 14 days)**

3 geologist and 3 technician divided into 3 teams consist of 1 geologist and 1 technician. To gather 418 soil sampling.

Team/days	1	2	3	4	5	6	7	8	9	10	11	12	13	14
First team	10	10	10	10	10	10	10	10	10	10	10	10	10	10
Second team	10	10	10	10	10	10	10	10	10	10	10	10	10	9
Third team	10	10	10	10	10	10	10	10	10	10	10	10	10	9

- **Step 3.1. Selection of analytical methods, chemical elements to be analyzed, detection limit**

ANALYTE	RANGE (ppm)	DESCRIPTION	CODE	PRICE PER SAMPLE (€)
Au	0.0001-10	BLEG – ICP-MS finish BLEG – extraction AA finish	Au-CN12* Au-AA12	26.80
Au	0.001-10	BLEG – ICP-MS finish BLEG – extraction AA finish	Au-CN11* Au-AA11	17.85

Table 1. Bulk Leach Extractable Gold(BLEG), detection limit

ANALYTES & RANGES (ppm)								CODE	PRICE PER SAMPLE (€)
Ag	0.2-40	Cd	1-5,000	Mn	5-10,000	Sb	2-10,000	ME-ICP43 (25g) ME-ICP44 (50g)	8.95 complete package or 5.40 plus 0.40/element
As	1-10,000	Co	1-10,000	Mo	1-5,000	Zn	1-10,000		
Ba	10-10,000	Cu	1-10,000	Ni	1-10,000				
Bi	2-10,000	Fe	0.01%-20%	P	10-10,000				
Ca	0.01%-15%	Mg	0.01%-15%	Pb	1-4,000				
Ag	0.01-25	Co	0.1-250	Se	0.2-250	U	0.05-100	ME-MS43 (25g) ME-MS44 (50g)	16.00 complete package or 7.20 plus 0.95/element
As	0.1-250	Hg	0.01-250	Sn	0.1-250	W	0.05-250		
Bi	0.01-250	Mo	0.05-250	Te	0.01-250				
Cd	0.01-250	Sb	0.05-250	Tl	0.02-250				

Table 2. Aqua regia digestion using the ICP-AES or ICP-MS, Detection limit

In order to achieve both adequate data and reduce price range, firstly, for gold anomalies Bulk Leach Extractable Gold (BLEG) method, for other trace elements Inductively Coupled Plasma Mass Spectrometry (ICP-MS) should be used.

In low sulphidation epithermal Au, Ag deposits develop phyllic, argillic, propylitic alterations, especially in our case adularia, sericitic, hydrothermal alteration and K metasomatism. Ore minerals consist of native gold, electrum, native silver, pyrite, chalcopyrite, sphalerite, galena, arsenopyrite, cubanite, marcasite, covellite and tennantite, which are commonly associated with argillic alteration. Therefore, selection for chemical analysis should be concerning above mentioned mineralization and alteration.

- **Step 3.2. risk assessment: expected errors, pitfalls**

There is possibility of 2 types of error could face with this project. Firstly, error with inadequate sampling, wrong numbering, sample loss on the transportation. Secondly, errors(such as accidents)which leads to with delay on progress, to its 7 people and in the mountainous area in 21 days. To deal with these issues at the same time, contingency 10% introduce in plan.

- **Step 3.3. composition of sampling team**

Team would consist of:

- ✓ 3 geologist – make sure technical geologists sampling procedure under instruction, and responsible for documentation of the point
- ✓ 3 technician – responsible for technical works such as taking samples under instruction of geologist
- ✓ Driver – responsible for delivering workers to the exploration area and back

- **Step 3.4. personal costs**

Wages

- ✓ Geologist 35euro per day
- ✓ Technician 25 euro per day
- ✓ Driver 25 euro per day

Total: 1190euro

Catering

	Food	Accommodation
Geologists, Technician,driver - 7 person for 14 days	2058 Euro	4410 euro
	total	**6468 euro**

Rental costs

	Unit price	piece	price
Car rental	29 euro	14 days	406 euro
Gas for the field work	0.923 euro	168km	155 euro
Gas price for Sample transportation cost (Telkibanya to Budapest)	0.923 euro	247km	228 euro
	total		**789 euro**