A process from regional geochemical survey through drilling phase exploration

An example: Tokaji Mts. –Füzérradvány (NE-Hungary)

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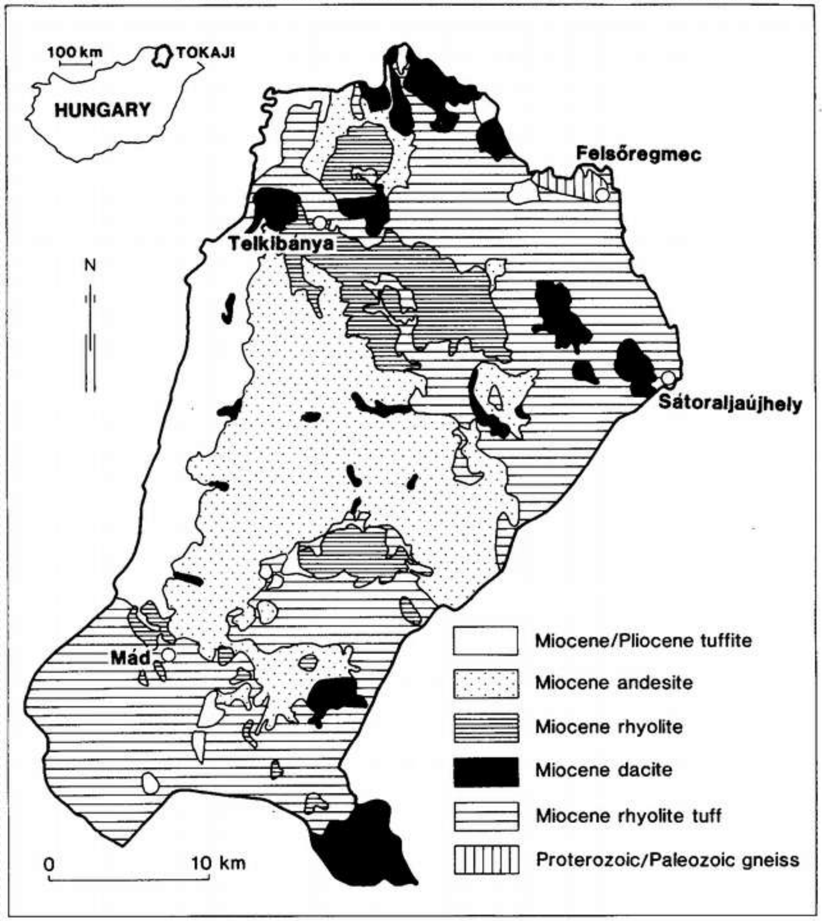
Miskolc, 2017.

Introduction

- The author learned about the application of low density regional geochemical survey during a scholarship in Finland in 1981.
- The method applied to establish geochemical provinces and select areas potentially mineralized for detailed ore exploration
- Although main sample media is the glacial till in Finland the method can be adjusted to Central-European climatic and geological conditions
- The advantage is that several independent sampling media gives reliable results
- Due to the low density sampling pattern and therefore smaller amount of samples this method is not only robust but fast and cheap as well.

Generalized geological map of the Tokaji Mts.



Methodology

- Based on the relief of the study area elementary catchment areas were delineated by the watersheds
- In case of Tokaji Mts. a total of 207 catchment areas of an average 4 kmsq area was resulted.
- As a rule four different sampling media was sampled in each cachment areas: stream sediment, heavy mineral concentrate(HMC), soil and rock chips
- Stream sediments and HMC samples were collected at the lowest point of the cell, while soil and rock chips from 2 to 10 sites in each cell.
- Soil as well as rock chip subsamples were put together to form one composite sample from each catchment area.

Laboratory work and evaluation

- Assays were carried out in the HGI(MÁFI): 32 elements spectrography and in GSF laboratory: Au,Ag, As, Sb, Hg(AAS and ICP check assays).
- During the evaluation of the assay results correlation was established between Au and the usual epithermal pathfinder elements (Ag, As, Sb, Hg).
- Two types of anomaly maps were compiled based on the cumulative frequency curves (anomaly thresholds at 95%)

Cumulative frequency curves of gold and pathfinder elements

538 A. Hartikainen *et al.*

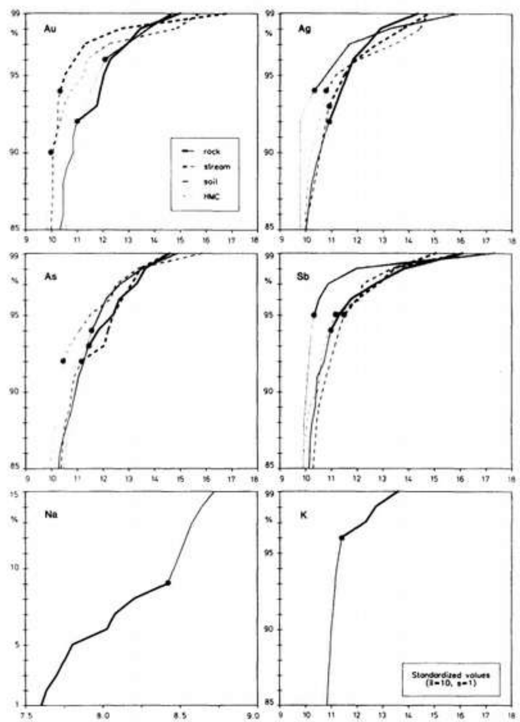


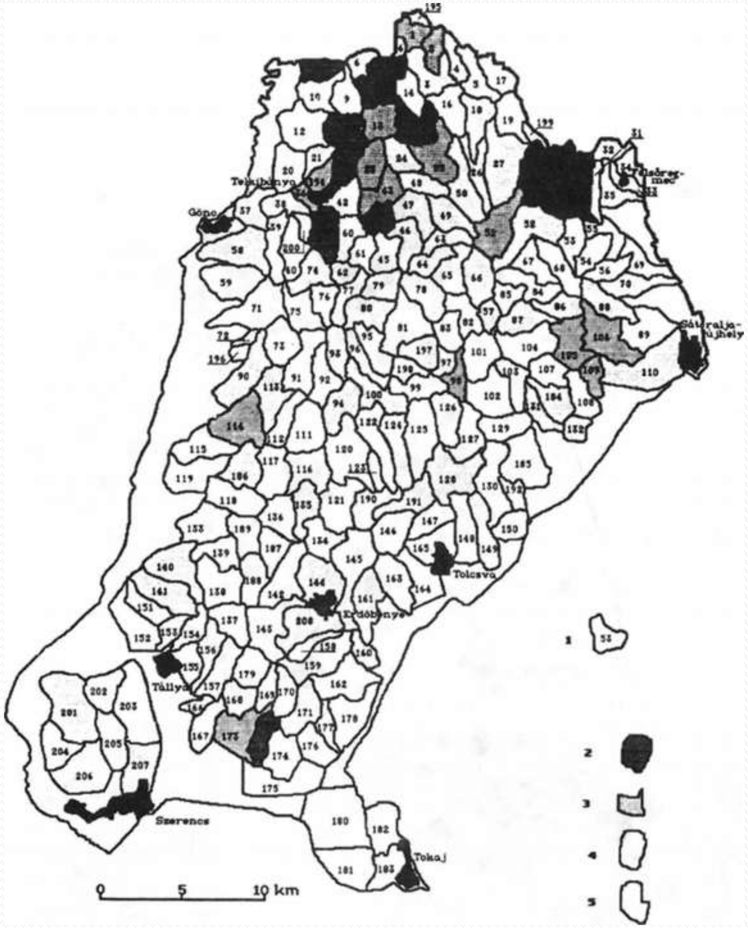
FIG. 3. Cumulative frequency curves (Σ85%–Σ99% and for Na Σ1%–Σ15%) of Au, Ag, As, Sb, K and Na in different sampling media (standardized values used: average = 10, S.D. = 1). Anomaly thresholds (stars) and anomalous values (strengthened lines) are shown. See also Table 1.

Presentation on two types of maps

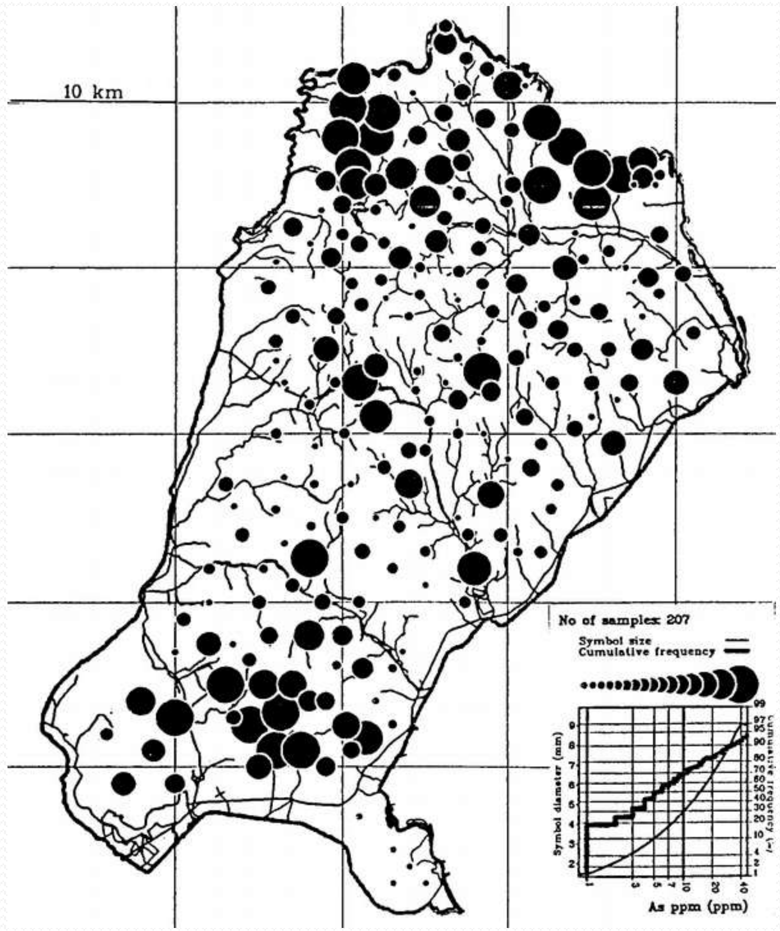
- Anomaly additive patch map of gold and/or pathfinder elements. An anomalous sample means a score of 1. If each of the four sampling media returned anomalous gold contents that means a score of 4.

- Another type of maps were compiled by the GSF, where the contents were rational with the circular symbol size drawn on the given catchment area. Maps of gold and pathfinder elements were produced.

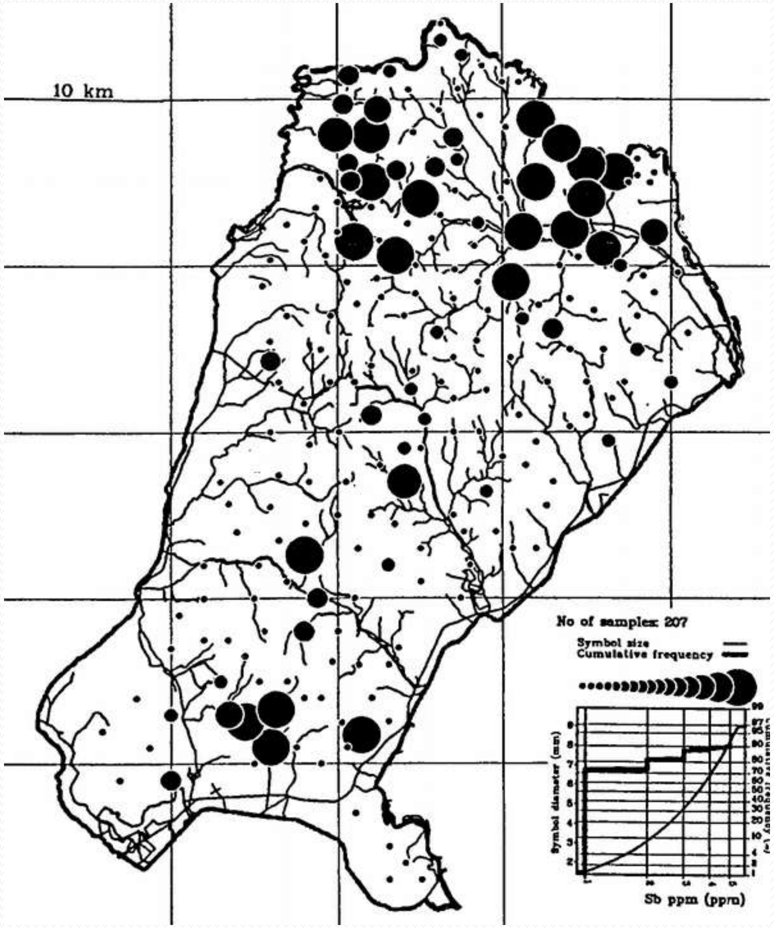
Anomaly additive map of gold(4 sampling media)



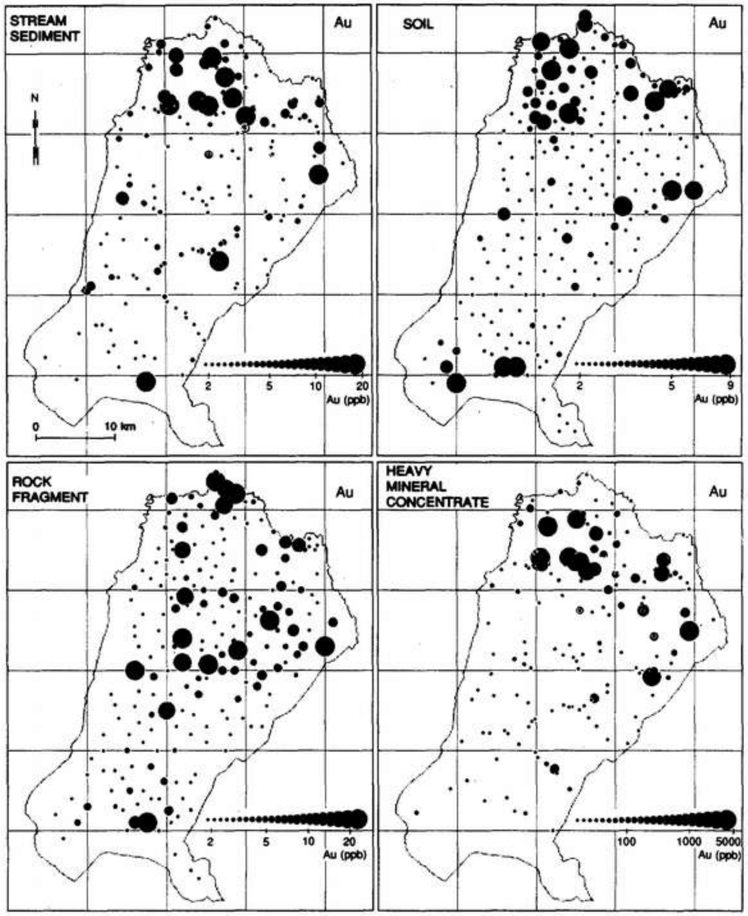
Distribution of arsenic in soil



Distribution of antimony in soil

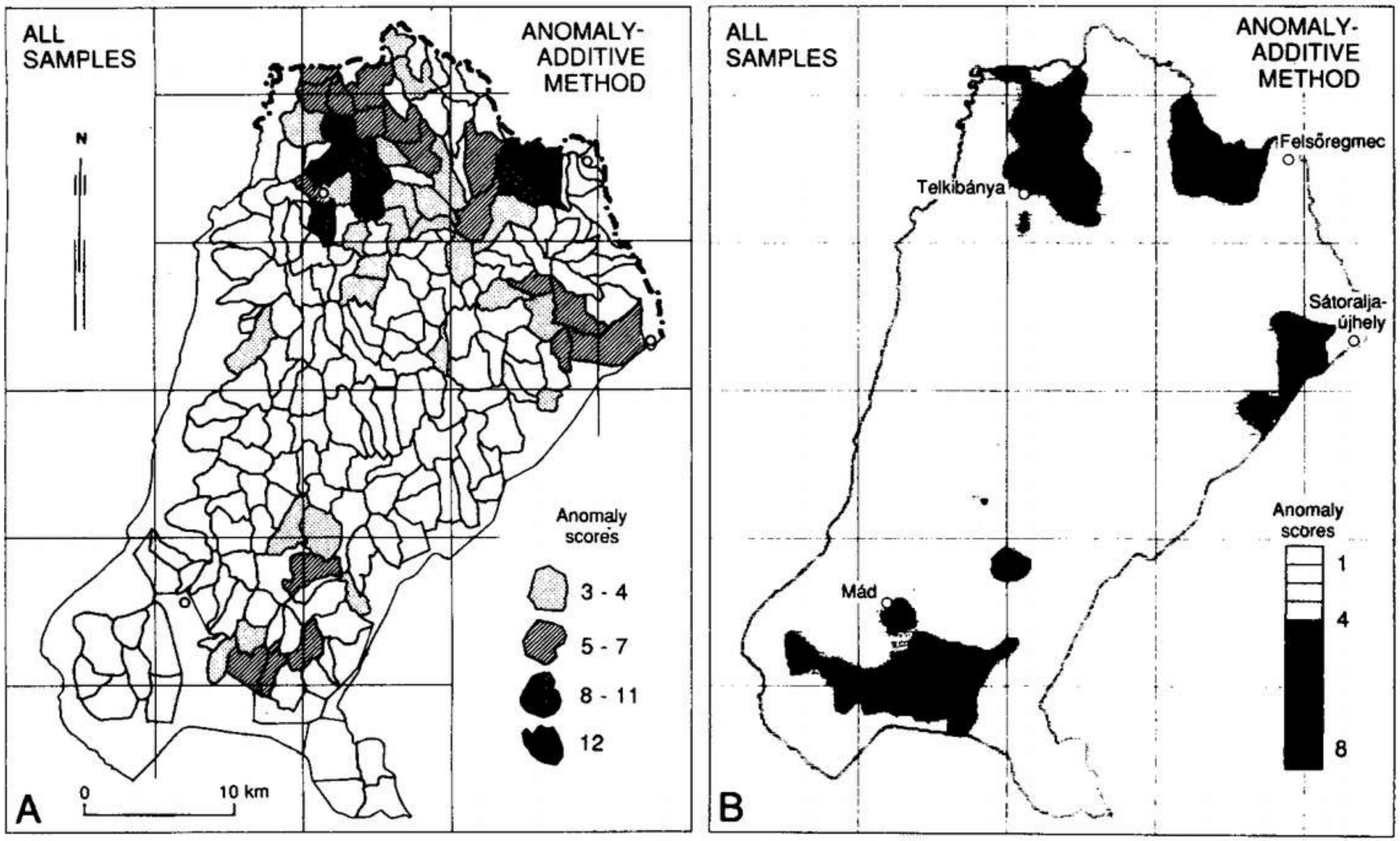


Au anomalies in 4 sampling media



Summary maps of the Tokaj survey

A:patch map, B: 95% anomaly thresholds of Au+pathfinders



Area selection for the first exploration phase

The following areas (shown on the previous slide) are potential gold exploration targets:

- the medieval mining camp, Telkibánya,
- Felsőregmec-Vilyvitány(Füzérradvány)
- Rudabányácska
- Erdőbénye-Mád
- Szerencs Hills

Telkibánya and Rudabányácska areas were already known as gold occurrences. The most robust anomaly of Felsőregmec-Vilyvitány was choosen for a grid soil sampling program.

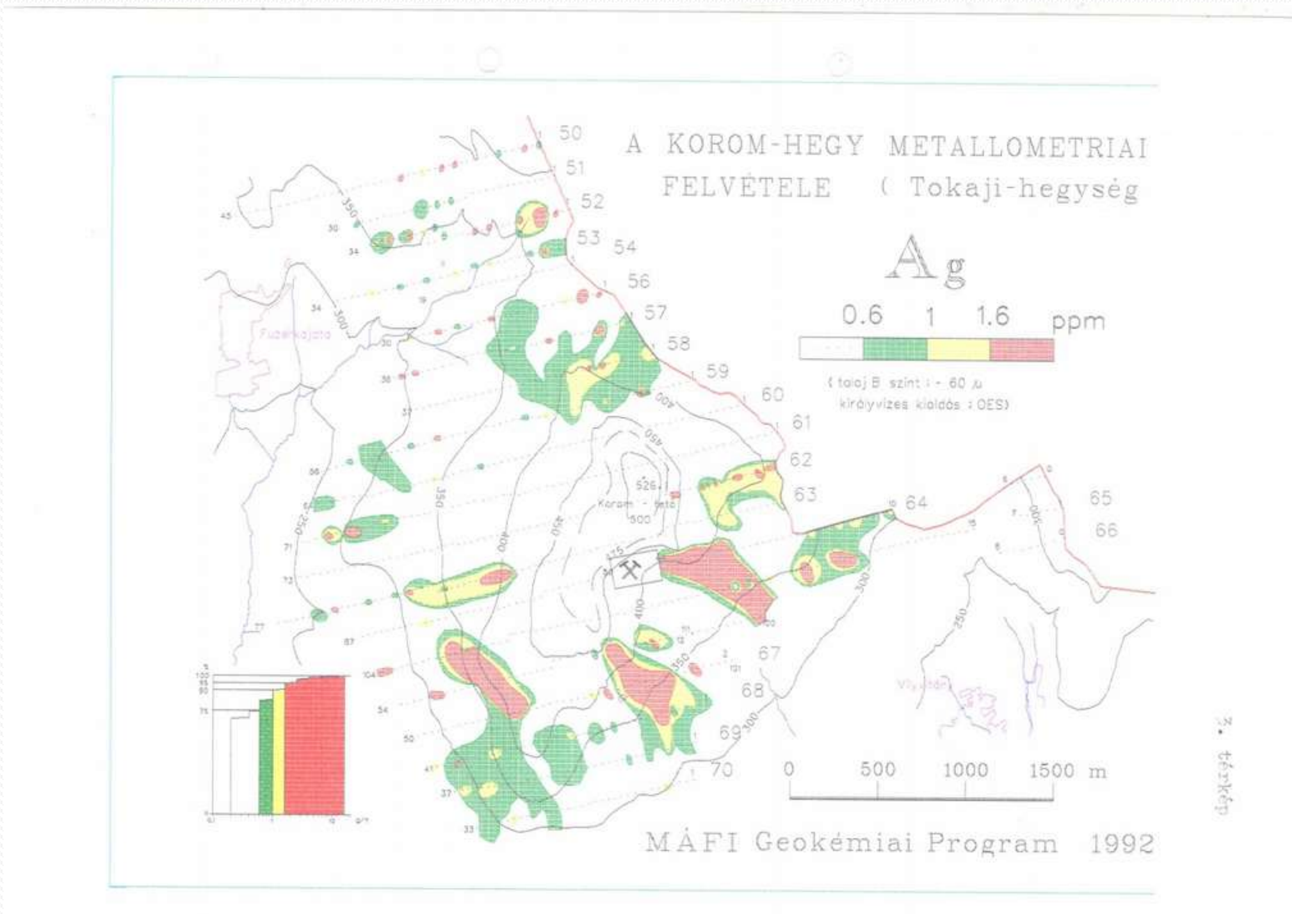
Soil survey on Füzérradvány area

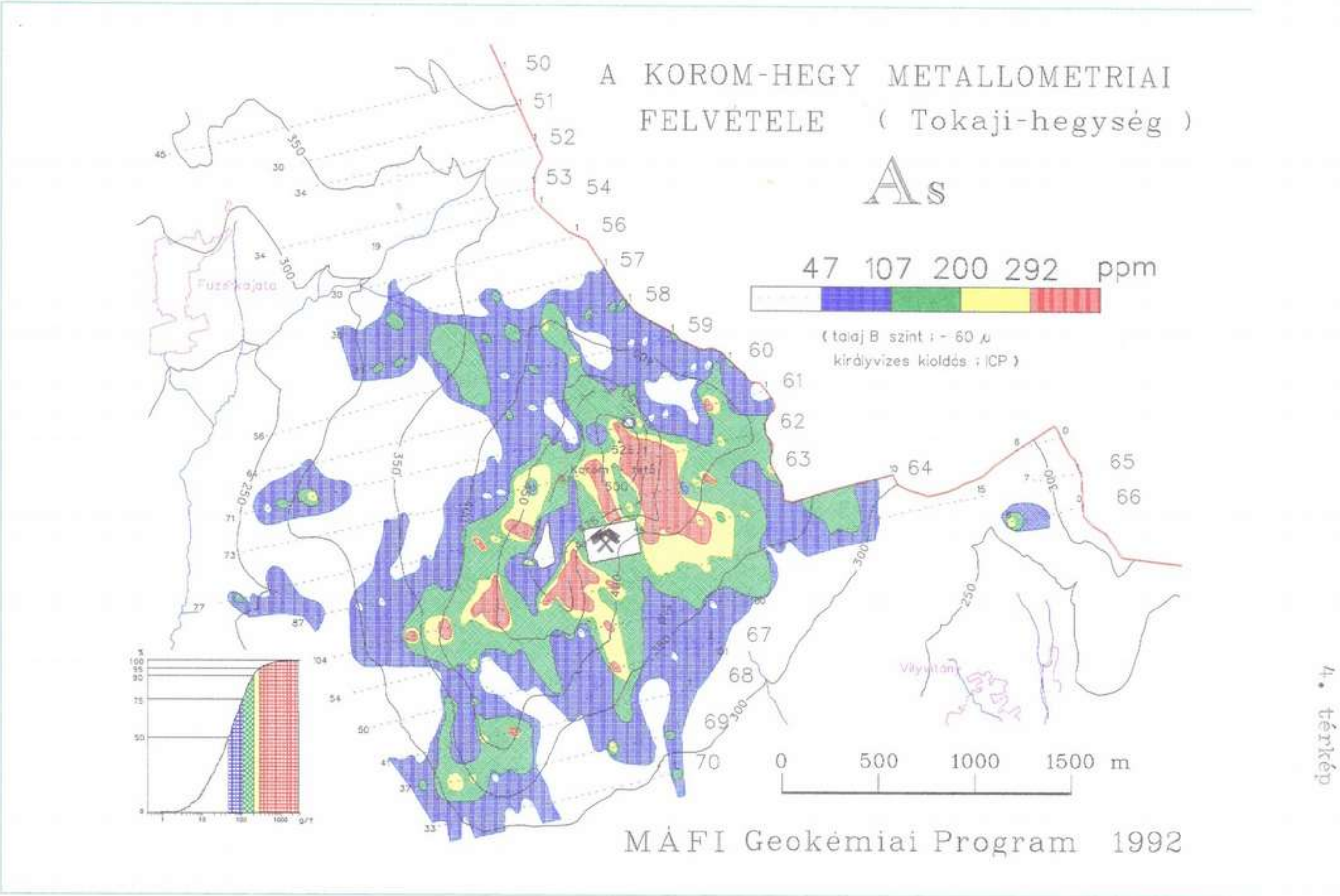
An area of about 6 kmsq was designated and sampled by MÁFI team(Horváth, Fügedi, Ódor) in 1991. ENE oriented grid lines of 200 m spacing at 40 m steps along lines were sampled.

Results confirm the anomalies interpreted as a result of the regional geochemical survey. More details are visible.

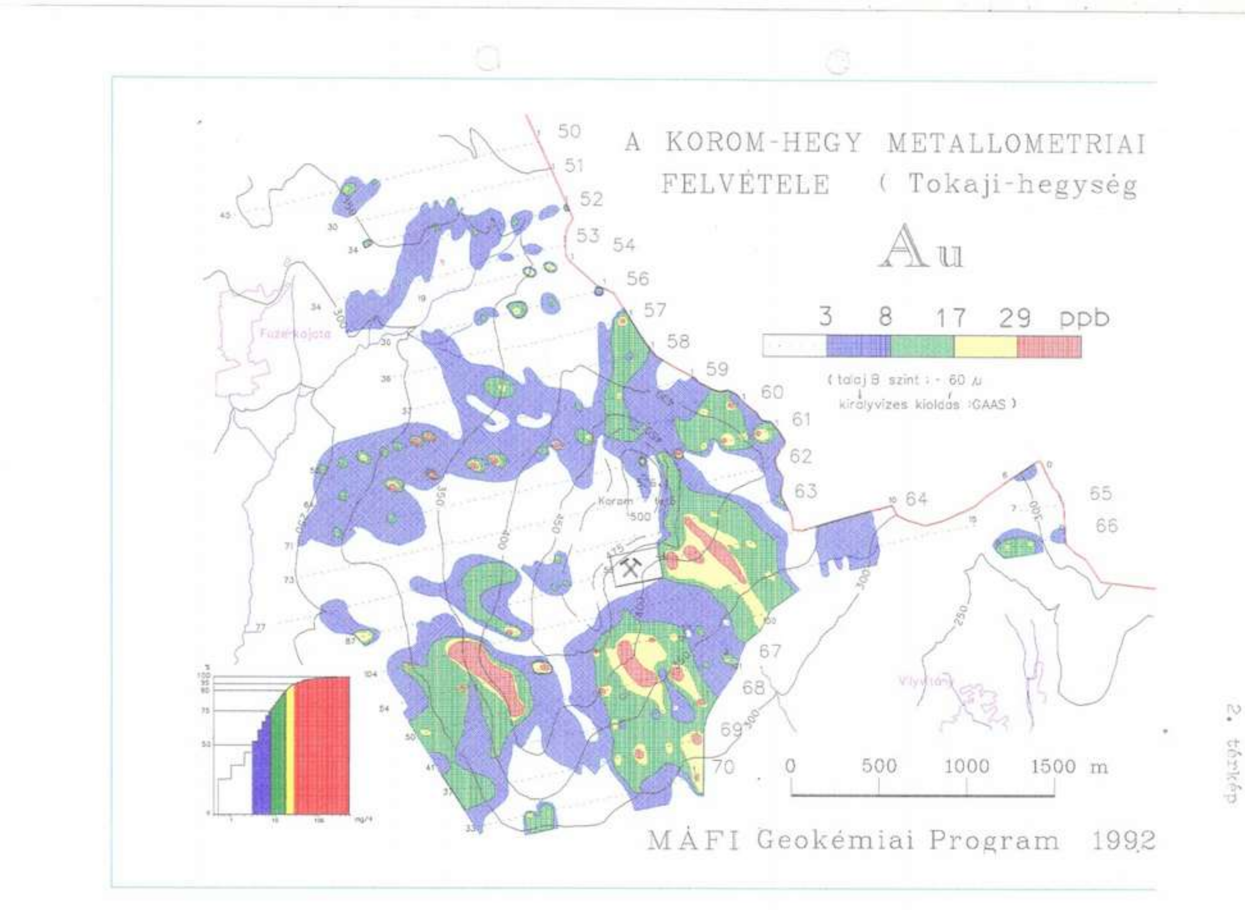
A set of NNW oriented intense anomalies of Ag, As, Au, Sb and Hg gave a strong signal of an epithermal gold mineralization.

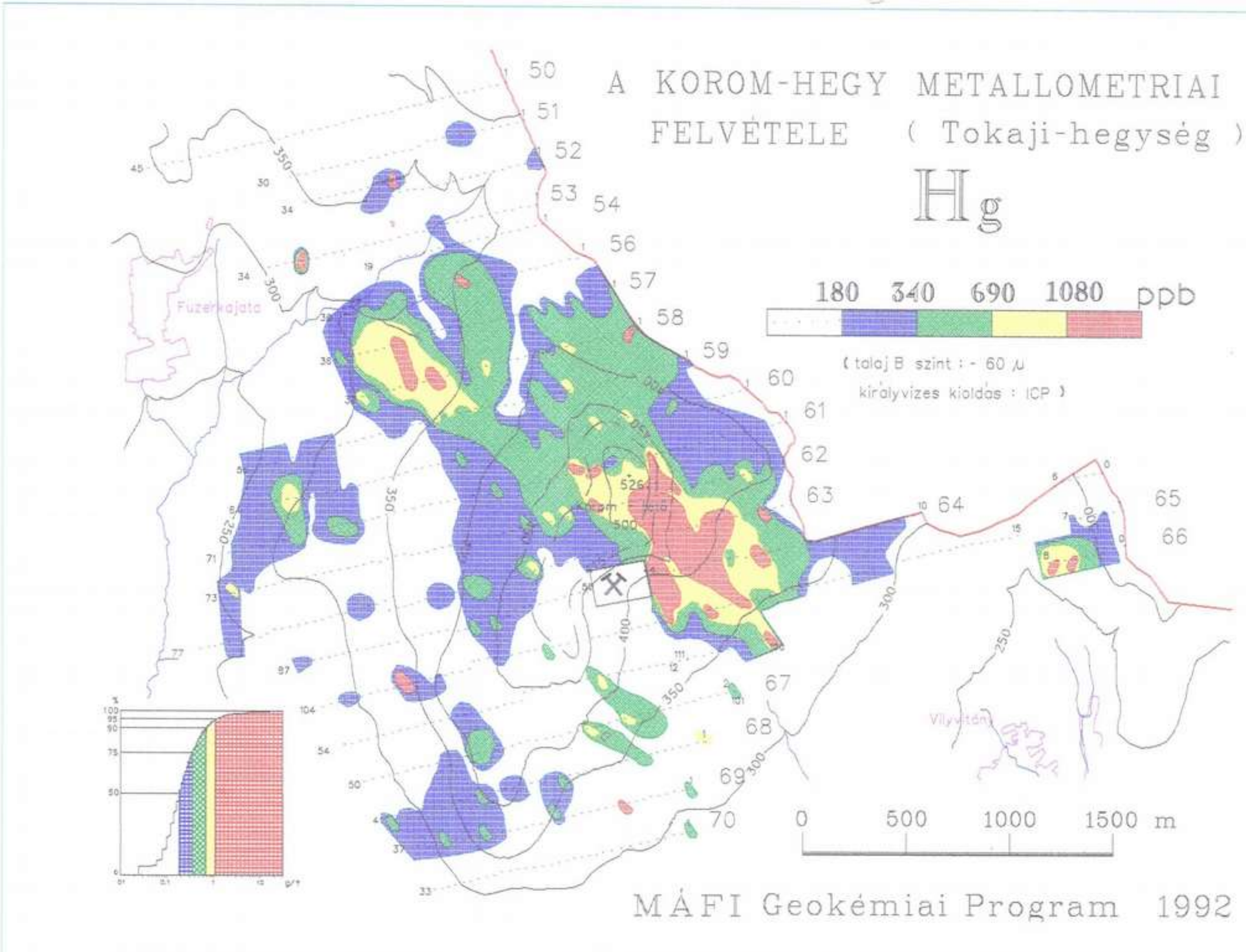
Gold & pathfinder element maps





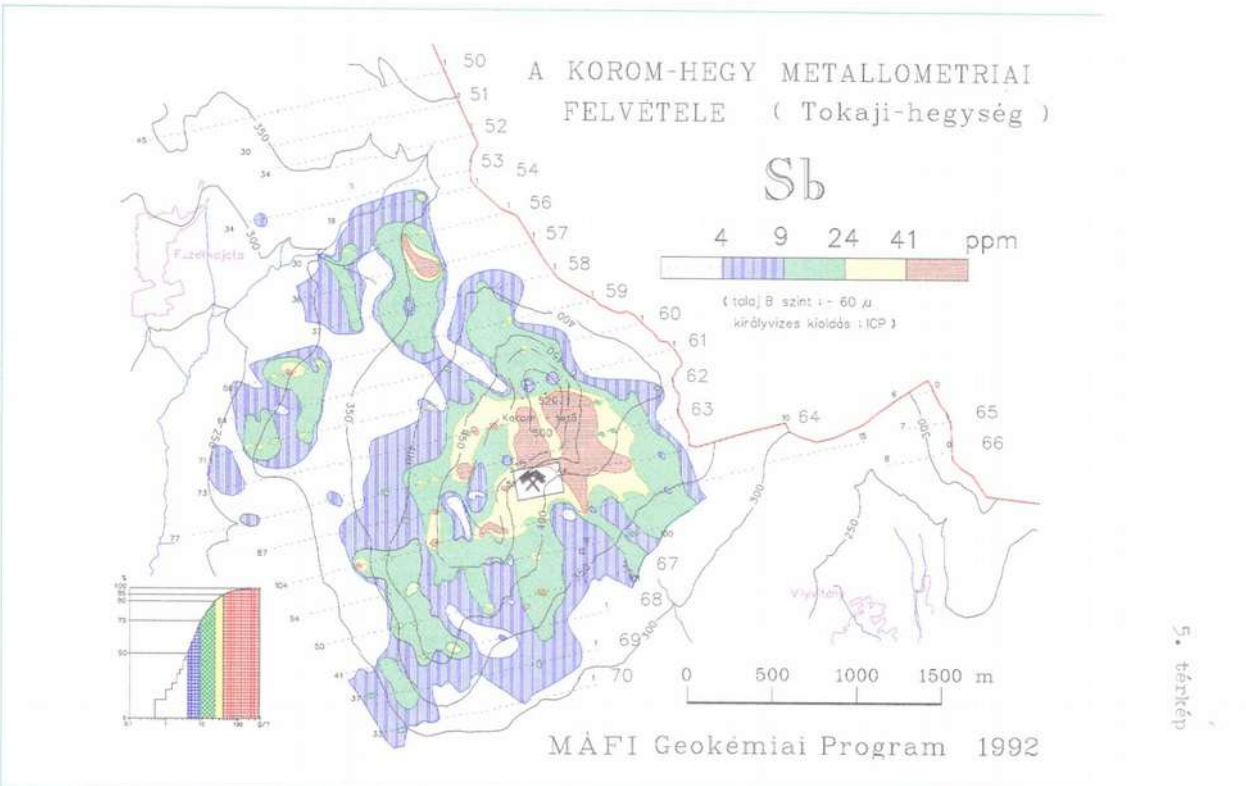
A KOROM-HEGY METALLOMETRIAI
FELVÉTELE (Tokaji-hegység)
As
47 107 200 292 ppm
(talaj B szint ; - 60 μ
királyvizes kioldás ; ICP)
0 500 1000 1500 m
MÁFI Geokémiai Program 1992
4. térkép


A KOROM-HEGY METALLOMETRIAI
FELVÉTELE (Tokaji-hegység
Au
3 8 17 29 ppb
(talaj B szint : - 60 µ
királyvizes kioldás :GAAS)
Korom
0 500 1000 1500 m
MÁFI Geokémiai Program 1992
2. térkép



A KOROM-HEGY METALLOMETRIAI
FELVÉTELE (Tokaji-hegység)
Hg
180 340 690 1080 ppb
(talaj B szint : - 60 µ
királyvizes kioldás : ICP)
Füzérkajata
Vilyvitány
0 500 1000 1500 m
MÁFI Geokémiai Program 1992

6. térkép


A KOROM-HEGY METALLOMETRIAI FELVÉTELE (Tokaji-hegység)
Sb
4 9 24 41 ppm
MÁFI Geokémiai Program 1992
0 500 1000 1500 m
5. térkép

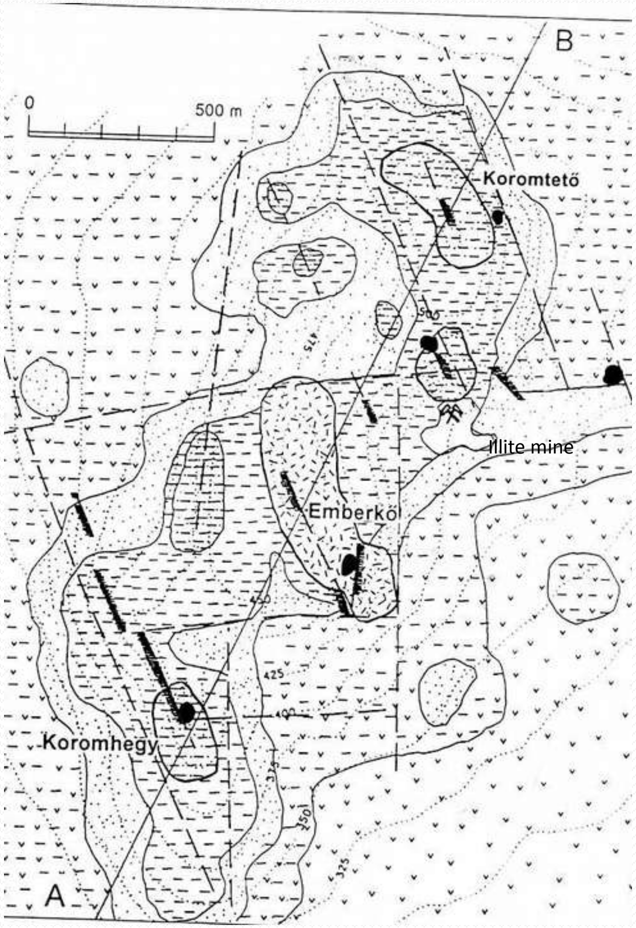
Reconnaissance mapping to interpret the geochem anomalies

- In 1993 Csongrádi, Tungli and Zelenka (as well as Perlaky) field checked the area of gold and pathfinder elements soil anomaly
- First time a detailed geological mapping of the Füzérradvány – Koromhegy area was carried out combined with rock chip sampling accross the main anomalous zones.
- Source of the soil anomalies was identified in form of silicified, brecciated zones without any doubt.

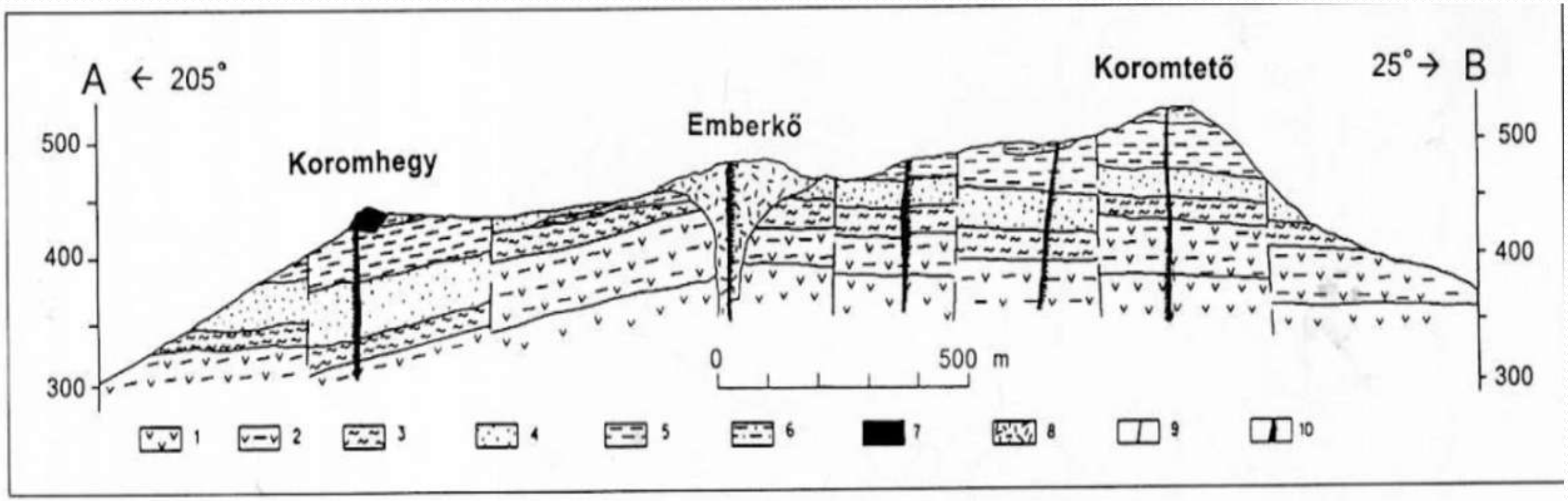
Füzérradvány Geological Setting

- Early Paleozoic metamorphic basement rocks: gneiss, amphybolite and micaschists. Exposed on the surface in Slovakia and in the Füzérkajata 2 drillhole (960 m depth) in Hungary.
- Overlain by Miocene clays
- Pumice tuffs
- Silicified rhyolitic tuffits
- Lacustrine sequence of sandstones, siltstones and illite
- Sinters and geysirites

Geological map 1993(Csongrádi, Tungli, Zelenka)



Geological section 1993



3. *ábra*. A Koromhegy-Koromtető földtani szelvénye. Jelmagyarázat: 1. horzsaköves riolittufa; 2. kovásodott tufit; 3. illites összlet; 4. kovásodott homokkő; 5. kovásodott agyagkő; 6. limnokvarcit; 7. kovás gejzirit; 8. riolit; 9. törések; 10. ércesedett breccsa zónák

Fig. 3. Geological section of the Koromhegy–Koromtető prospect. Legend: 1. pumice tuff; 2. silicified tuffit; 3. illite; 4. silicified sandstone; 5. silicified siltstone; 6. limnoquartzite; 7. gejserite; 8. rhyolite; 9. faults; 10. mineralized breccia zones

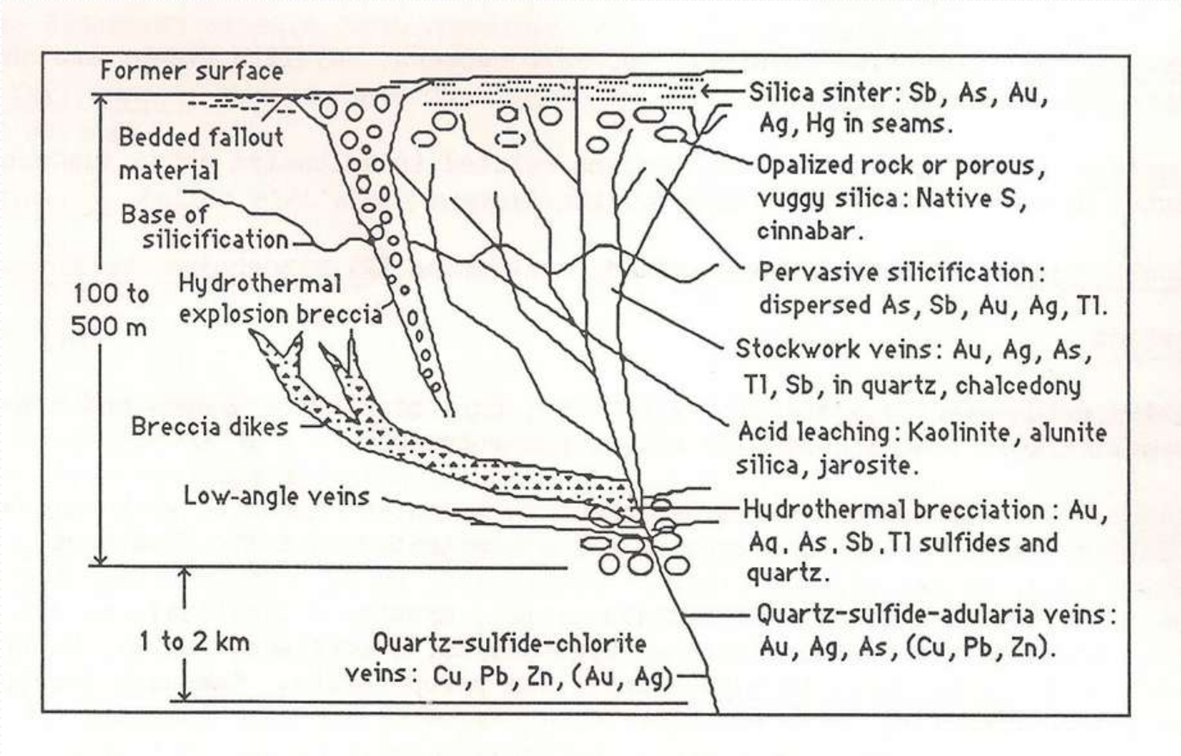
- Traverses were performed perpendicular to the axis of major Au in soil anomalies
- Outcrops and floats were chip sampled accross the anomalies
- The best interval assayed 10m @0.76 ppm Au
- During the reconnaissance mapping based on the field observations and rock chip sampling the source of gold and pathfinder anomalies was clearly identified
- All significant anomalies related to NNW striking silicified breccia zones
- Mineralization style is epithermal hot-spring gold (Berger 1985)

Model of epithermal hot-spring gold-silver mineralization(Berger)

- Description: fine-grained silica in silicified breccia with gold, pyrite and Sb, As sulphides
- Environment: Felsic volcanic centers and shallow parts of related geothermal systems
- Mineralogy: native Au, Ag-selenide or tellurides, pyrite
- Texture: banded qtz veins, stockworks, silica cemented breccias
- Alteration: chalcedonic sinter, massive silicification, stockworks and (chalcedonic)veins of qtz
- Geochem signature: Au,As,Sb,Hg,Tl + increasing Ag with depth

Cartoon section of a hot-spring Au- Ag deposit(Berger 1985)

Clearly identical with our Füzérradvány hot-spring gold-silver mineralization



Silicified breccia on the Koromtető (one of the six mapped zones)

First drilling campaign by Carpathian Gold(Humex) in 2007

- Obvious drill targets are the brecciated zones known in outcrops on the surface (around 0.5 g/t Au)
- András Zone sampled in the illite mine and returned 158m @0.36 g/t Au (true thickness is about 50 m)
- During late 2007 6 diamond core holes were drilled on the prospect area. Four of them (FR-74, -55,-57, -61) explored a nearly 500 m strike length of the Koromtető Breccia Ridge Zone(KBRZ) and intercepted the gold-silver mineralization between 460 and 310 m elevations. Two holes were drilled as a fork near the Andras Zone, recognized in the Andras Adit of the illite mine.

- Drillholes FR-74 and -55 were collared on the eastern margin of the Koromteto Ridge Zone an intercepted almost continuous, low-grade gold-silver mineralization including several 1-2 m wide, ore grade intervals.
- Drillholes FR-57 and -61 were drilled 170 and 300 m further to the SSE from FR-55 respectively. The surface relief refers to a possible change in the strike of the mineralized zone (closer to a NW strike). Partly due to the collar locations these holes gave much shorter mineralized intercepts, but somewhat higher grade mineralization.
- It must be noted, that the two northern holes were terminated in mineralization and they should be drilled at least 50 m longer to reach the western contact of the mineralization.

- Drillhole FR-68 was drilled to intersect the Andras Zone, exposed in the illite mine. This hole intersected four separate 3 to 12 m wide, low grade (0.6 g/t Au, 10-20 g/t Ag) mineralized structure, with the best grade in the last 3 m of the hole (1.34 g/t Au, 24 g/t Ag) just reached the eastern margin of the Andras Zone and could be drilled another 50 m longer to penetrate the AZ.
- Drillhole FR-69 was collared from the same site as 68, but was the only hole with an eastern azimuth. It didn’t reach the targeted KBRZ and was terminated due to technical problems without intercepting any mineralization.

Characteristics of mineralization

- At several places (FR-55 38-39.3 m, FR-57 111.7 m) textures of qtz pseudomorphs after bladed calcite were observed, referring to boiling environment and accompanied by better grades.
- Three types of qtz, probably representing different generations were distinguished: sugar- texture, comb and chalcedonic. Sugar- texture qtz veining is the most widespread, sometimes accompanied by drusy qtz in vugs. Chalcedonic qtz is less frequent and it was not observed in the deepest horizons of mineralization (below 350 m asl). Cm-size comb qtz veins mainly occurred in FR-57, below 350 m asl.

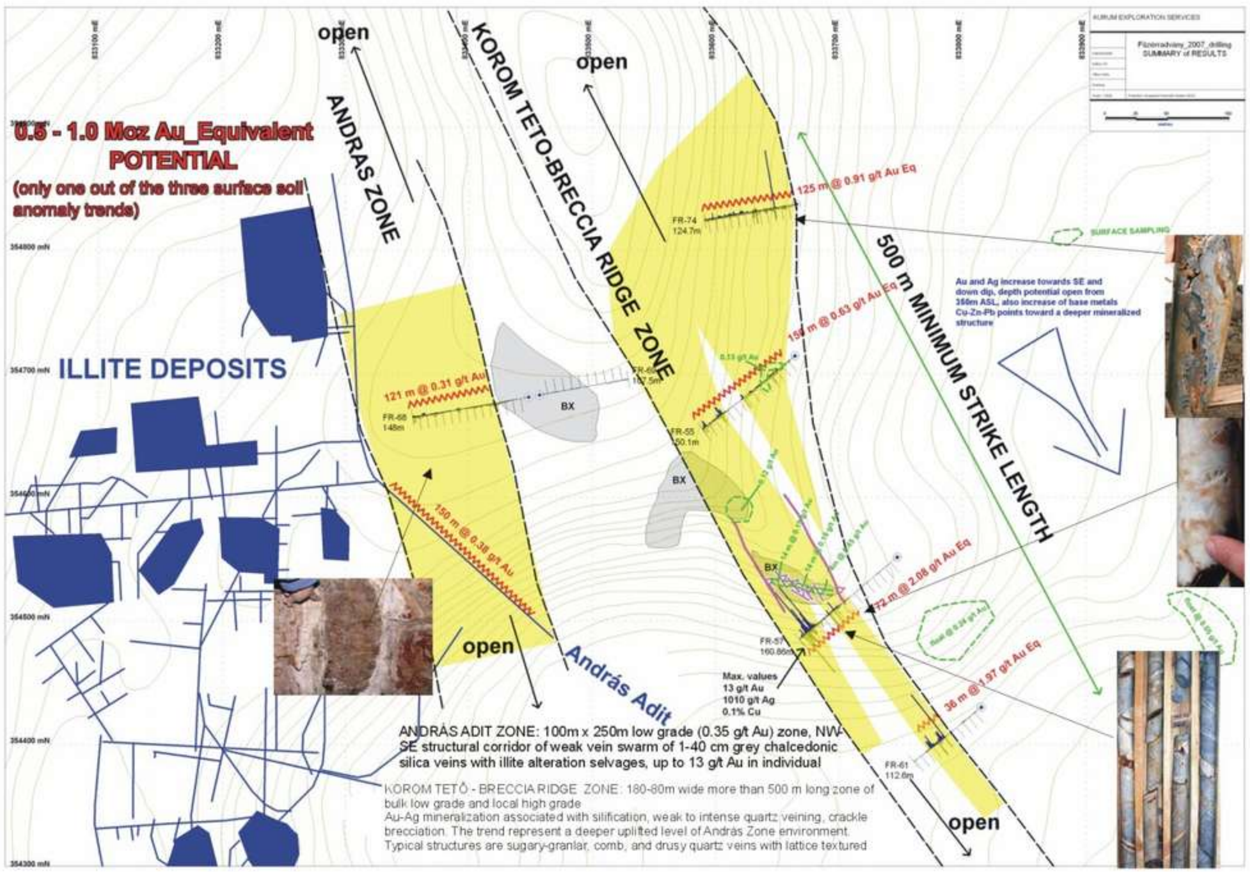
Gold/silver ratio varies in wide range (from 1:3 to 1: 200), not showing clear vertical zonation and referring to a multistage mineralization.

There is a general trend of increased silver content by depth, especially below 350 m. In FR-61 high silver contents seem to be related to qtz-sulphide veins.

- Arsenic is widespread and averages about 0.1-0.2% in the mineralized intervals. In single mineralized samples rarely exceeds 1%.

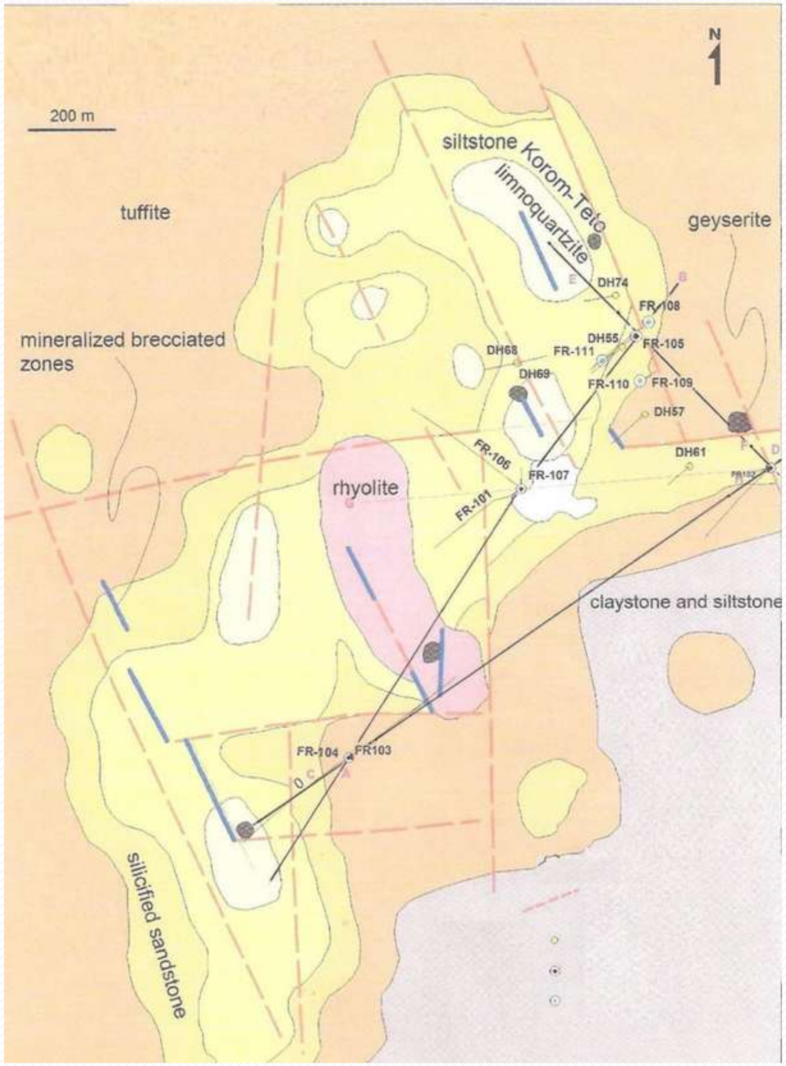
Of the base metals only copper is anomalous in single samples at lower elevations (typically around 100-200 ppm, max. 600 ppm).

Summary map of the first drilling campaign



Second drilling campaign by Electrum

- Electrum signed an option agreement with Humex on the Füzérradvány project
- San Cristobal model: lacustrine sediments intruded by rhyolite, brecciated volcanics and sediments host Pb-Zn-Ag mineralization
- L.Buchanan (who explored San Cristobal) suggested to test his SC epithermal model on the Füzérradvány prospect
- Targets were the possibly mineralized, brecciated contact zones of the Emberkő rhyolite.

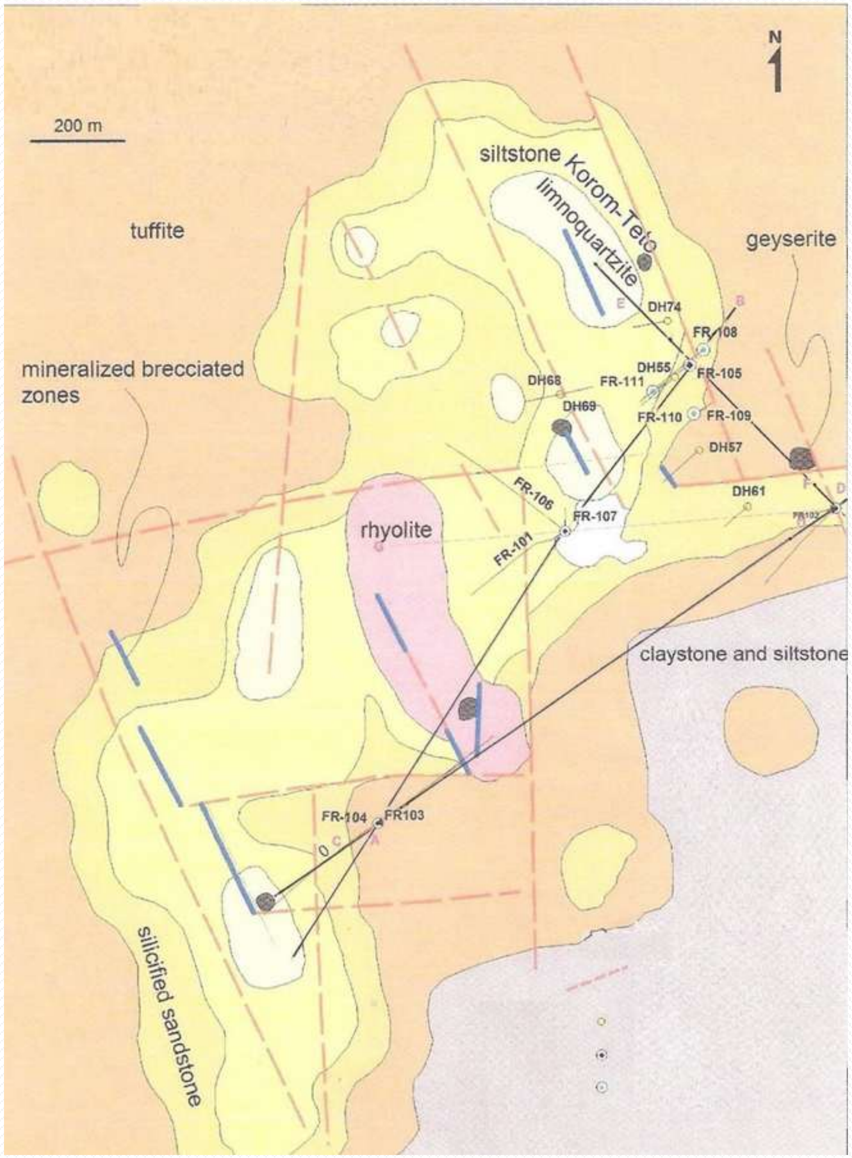


N
200 m
siltstone
Korom-Teto
limnoquartzite
geyserite
tuffite
mineralized brecciated
zones
DH74
FR-108
DH55
FR-105
DH68
FR-111
DH69
FR-110
FR-109
DH57
DH61
FR-106
FR-107
FR-101
rhyolite
claystone and siltstone
FR-104
FR103
silicified sandstone

Drillholes targeting the Emberkő rhyolite contact

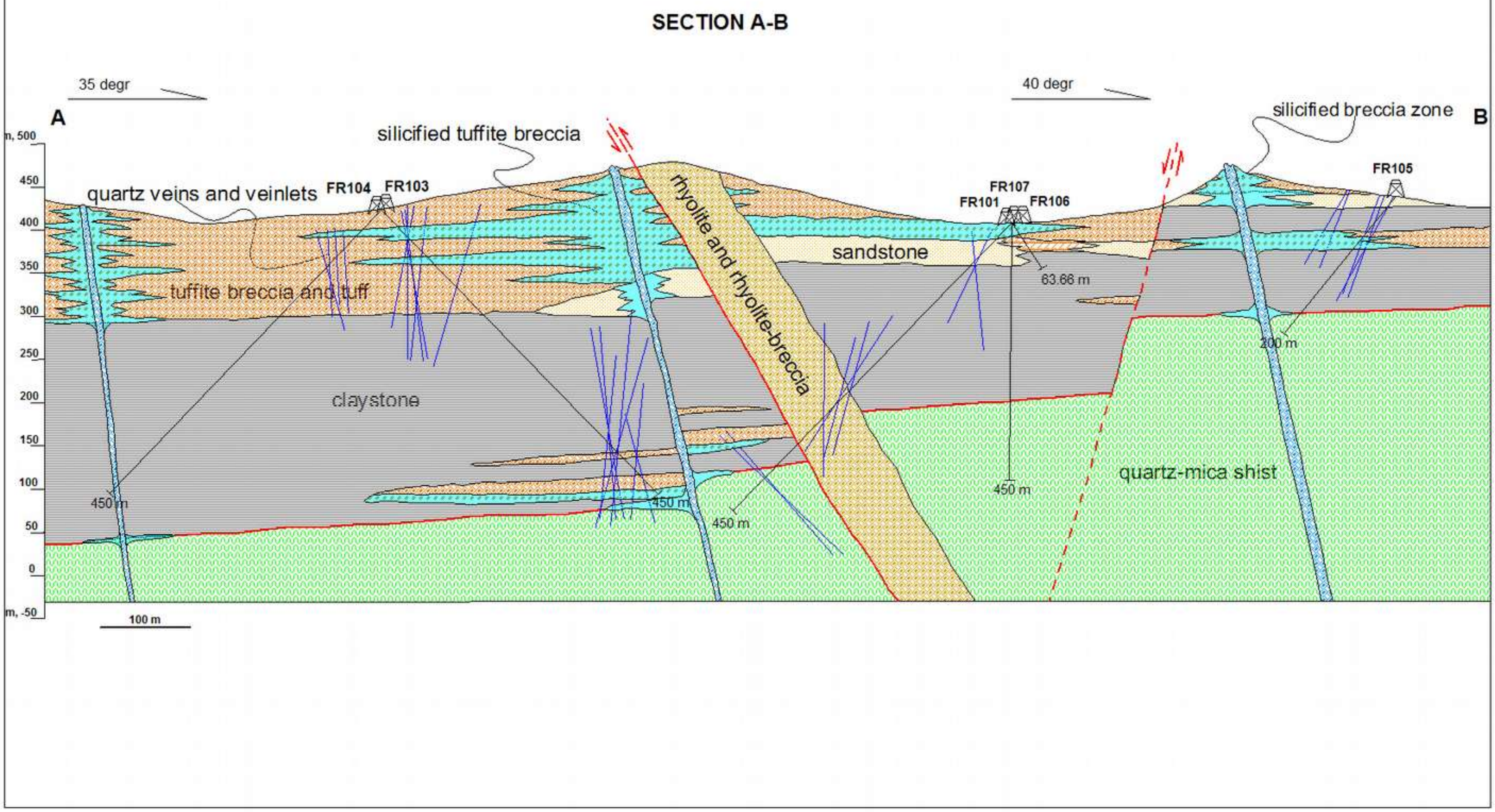
- Based on outcrops and floats the Emberkő rhyolite supposed to be about 200 x 600m in horizontal projection
- A downwards widening laccolith shape was expected
- FR-101 was aiming to drill the eastern contact of rhyolite
- Upper 250 m – silicified lacustrine sediments
- 250-350 m rhyolite breccia with sediment xenolithes

< 0.1 g/t Au



N
200 m
tuffite
siltstone
Korom-Teto
limnoquartzite
geyserite
mineralized brecciated zones
DH74
FR-108
DH55
FR-105
DH68
FR-111
DH69
FR-110
FR-109
DH57
DH61
FR-106
FR-107
rhyolite
FR-101
claystone and siltstone
FR-104
FR103
silicified sandstone

- FR-103 was targeting the SW contact of the rhyolite body
- From surface to 140 m rhyolite tuff, tuffite(illite horizon 45.9-51.4) with variable silicification and qtz veinlets (125.5m @ 0.14 g/t Au). Low grade mineralized slab near the feeder zone in porous lacustrine sediments and volcs
- Further on claystone to the EOH(450 m) with a few narrow rhyolite and tuffite interbedding, no crystalline basement reached
- FR-104 was targeting the root zone of Koromhegy Breccia Zone(KBZ), rhyolite tuff and tuffite to 175.8 m, below clay. Interval 434-440 pyrite-bearing silicified tuffite and sandstone with anomalous Ag, As, Hg, Sb, Tl.
- Possible root zone of KBZ



SECTION A-B
35 degr
40 degr
A
B
silicified tuffite breccia
silicified breccia zone
quartz veins and veinlets
FR104
FR103
FR107
FR101
FR106
FR105
rhyolite and rhyolite-breccia
sandstone
63.66 m
tuffite breccia and tuff
claystone
200 m
quartz-mica shist
450 m
450 m
450 m
450 m
m, 500
450
400
350
300
250
200
150
100
50
0
m, -50
100 m

Return to the KBRZ target

- The Emberkő rhyolite had no significant gold mineralization, new plan to drill longer holes to fully penetrate the KBRZ gold-silver mineralization
- FR-105 was collared 50 m SE of FR-55 and penetrated typical epithermal environment with significant gold mineralization
- Between 60 and 112 m qtz pseudomorphs after balded calcite were seen at several places (referring to a boiling environment).
- A significant mineralized zone was intercepted from 31 to 125 m (94 m @ 2.78 g/t Au and 73.2 g/t Ag).

- This zone includes two major vein zones: 36-45 m, 9 m @ 15.3 g/t Au and 312.6 g/t Ag and 77-82 m, 5 m @ 8.84 g/t Au and 253 g/t Ag.
- The two higher grade zone is strongly silicified with a few cm to few tens of cm thick, banded, chalcedonic qtz veins forming a vein zone with brecciated structures (often with limonitic matrix).
- The ore grade mineralization is accompanied by strongly elevated As , Hg, Sb and Tl contents.
- Last 5 m of FR-105 intercepted sulfide mineralization, hosted by micaschist. The sulfide (mainly pyrite) content is up to 50%. The interval 195-200m averages 0.93 g/t Au, 14.7 g/t Ag, 0.6% As, 67 g/t Hg, 743 g/t Sb and 180 g/t Tl (max 530 g/t). This level of Tl could be additional value.

HUMEX Kft., HUNGARY – Füzérradvány License Drill Lo

Method

Analysis

Drill_Hole	No	Sample_No	From	To	Length
FR-105	1	1210	3,00	4,00	1,00
FR-105	2	1211	4,00	5,00	1,00
FR-105	3	1212	5,00	6,00	1,00
FR-105	4	1213	6,00	7,00	1,00
FR-105	5	1214	7,00	9,00	2,00
FR-105	6	1215	9,00	12,00	3,00
FR-105	7	1216	12,00	13,00	1,00
FR-105	8	1217	13,00	14,00	1,00

Qtz after bladed calcite FR105,81.5 m

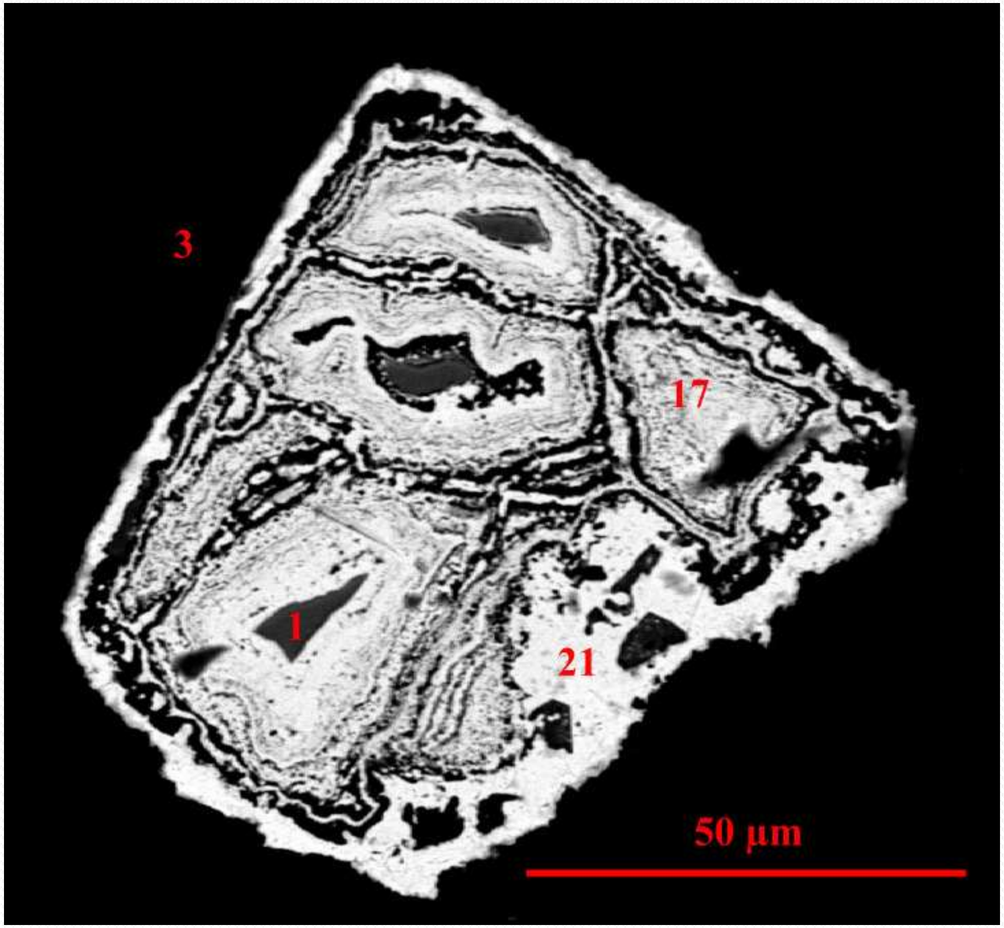
Banded chalcedonic qtz vein FR-68 145m

Rhyolite tuff with banded chalcedonic qtz veining (FR-105, 80.4-82 m)

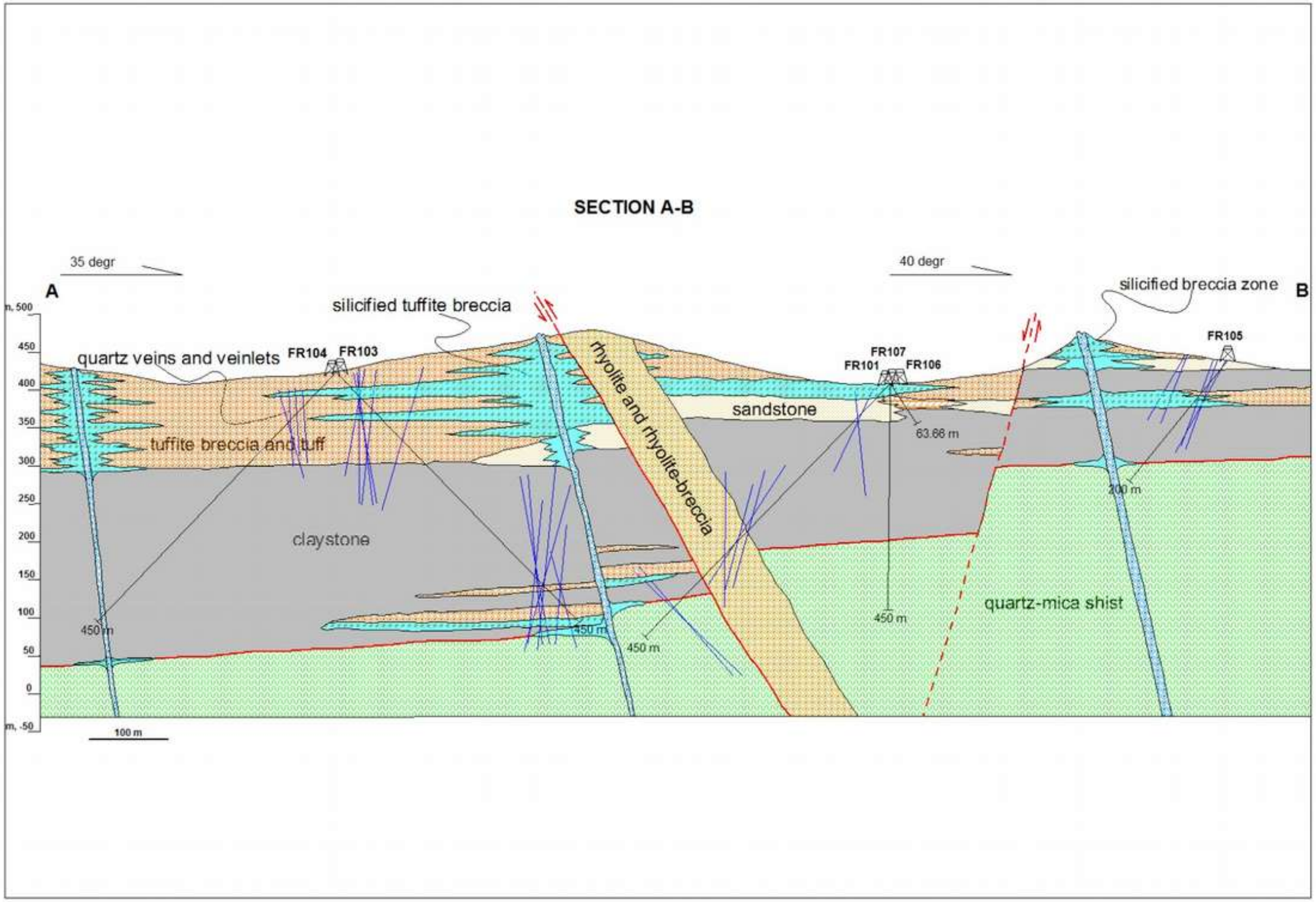
Ore minerals identified

- Pyrite occurs in several generations, some of them As- and Sb-bearing with zoned texture
- Au occurs in form of electrum either enclosed in quartz or intergrown with acanthite
- Main Ag minerals are acanthite and naumannite
- Minor amount of sphalerite occurs at some places with zoned Hg

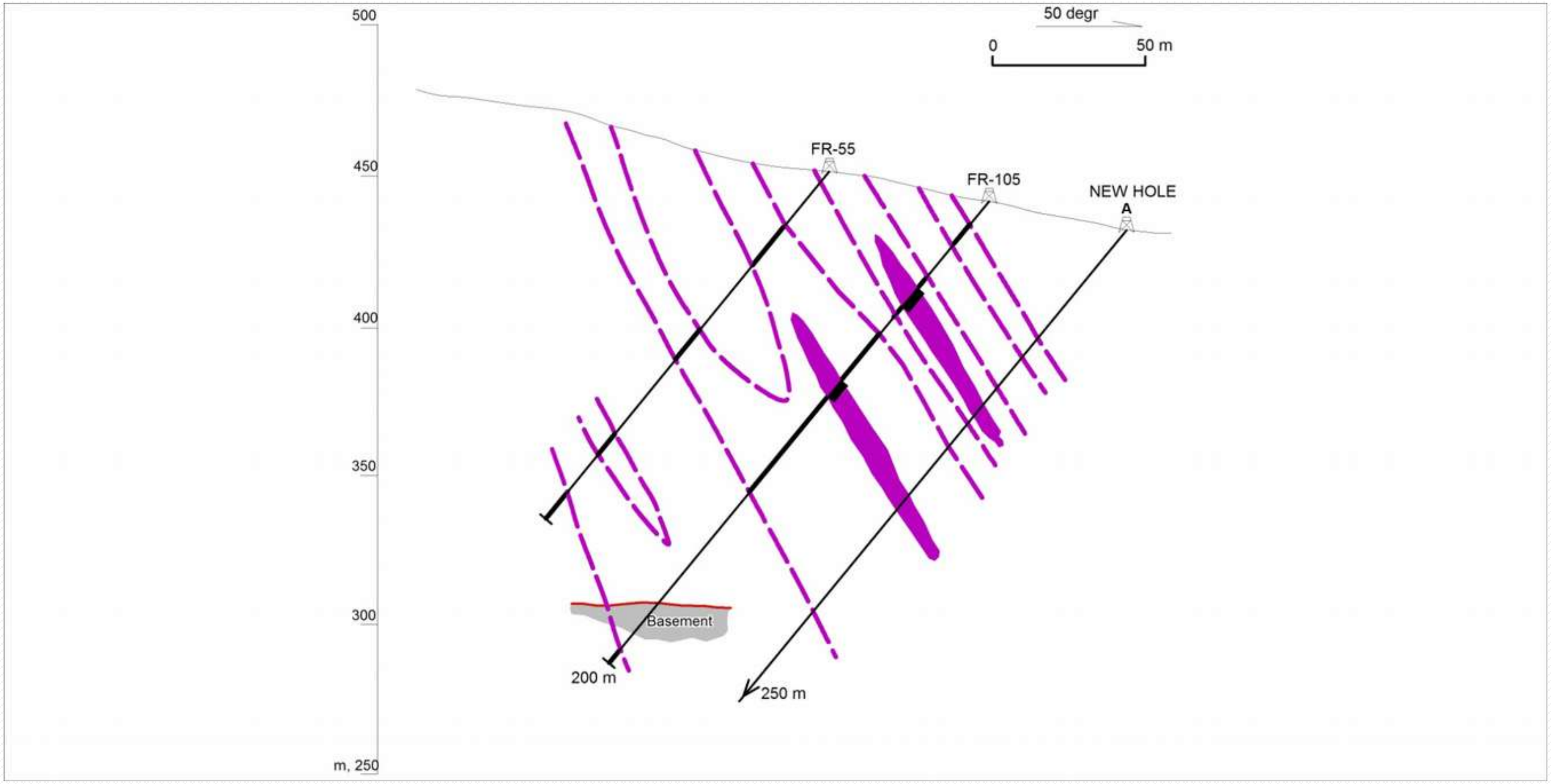
Naumannite (Ag_2Se) (21) with acanthite (Ag_2S) (17)
in quartz (3), from the FR-105, 37.8 m (photo by Dr.Zajzon)



Massive pyrite vein in qtz-micaschist(FR-102, 180m) with anomalous As,Hg,Sb, Tl contents



SECTION A-B
35 degr
40 degr
A
B
silicified tuffite breccia
silicified breccia zone
quartz veins and veinlets
FR104
FR103
FR107
FR101
FR106
FR105
tuffite breccia and tuff
sandstone
63.66 m
rhyolite and rhyolite-breccia
claystone
quartz-mica shist
450 m
200 m
100 m


500
450
400
350
300
m, 250
50 degr
0
50 m
FR-55
FR-105
NEW HOLE
A
Basement
200 m
250 m

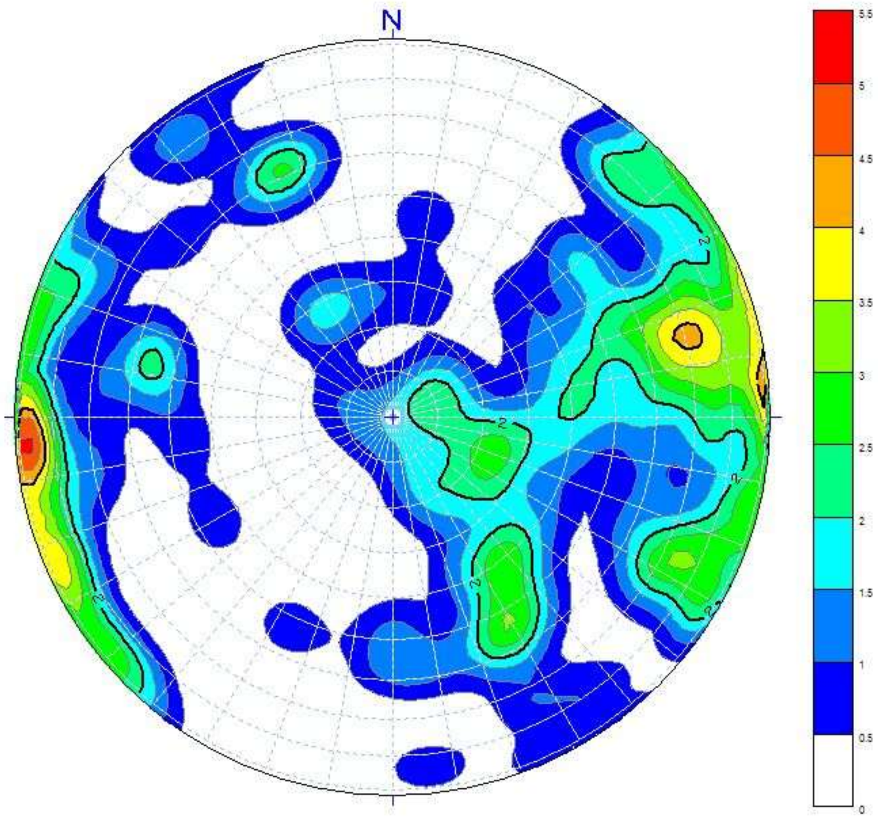
Where the high-grade gold mineralization continues?

- Try to prove the continuity of the mineralized at depth collaring FR-108 about 40m NE of FR-105
- Upper 100 m is silicified tuffite with narrow qtz veins, veinlets
- As a whole similar to FR-105 but with poor gold mineralization, no continuation of high-grade zone…
- Perhaps the zone isn’t diping to NE but to SW???
- Let’s drill FR-111 50 m SW of FR-55 with NE azimuth and take oriented core!
- FR-111(depth 123m) intercepted similar but lower grade mineralization as FR-105 between 35and 113m

Good to have oriented core drilling!

- Both FR-108 and FR-111 was drilled with oriented core
- It turned out that besides the NNW and N striking ore controlling structures (observed on the surface) there are also NE striking qtz veins
- All the former drillholes collared on the KBRZ were perpendicular to the wider low-grade NNW ore zones but they were at oblique angle to the high-grade qtz veins…

KorHeg_All_Veins

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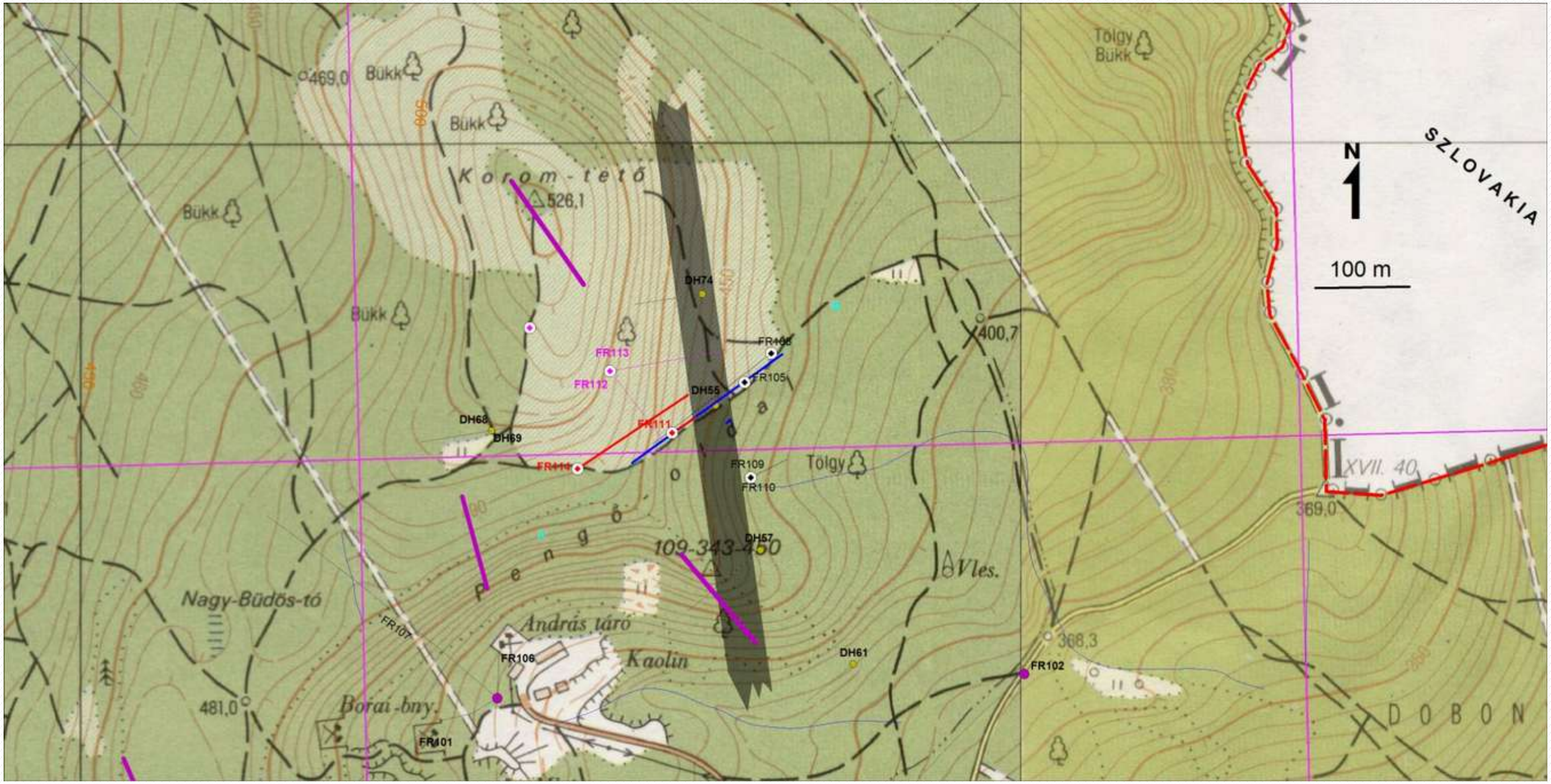
Projection ................. Schmidt (Equal Area)
Number of Sample Points .... 120
Mean Lineation Azimuth ..... 91.3
Mean Lineation Plunge ...... 21.3
Great Circle Azimuth ....... 86.7
Great Circle Plunge ........ 78.5
1st Eigenvalue ............. 0.54
2nd Eigenvalue ............. 0.256
3rd Eigenvalue ............. 0.204
LN ( E1 / E2 ) ............. 0.748
LN ( E2 / E3 ) ............. 0.226
(LN(E1/E2)] / (LN(E2/E3)) .. 3.309
Spherical variance ......... 0.5227
Rbar ....................... 0.4773
```

- Now it is clear if someone wants to trace the high-grade gold-silver chalcedonic qtz veins has to drill with SE azimuth
- Unfortunately there wasn’t budget to drill FR-112 shown on the next slide
- In spite of the > 1 M oz gold potential no foreign companies were eager to continue exploration due to the cyanide-ban

KBRZ with existing and suggested drillhole collars



THANKS FOR YOUR ATTENTION!

Petrified trunk in tuffite FR-103, 120.5 m

References

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