University of Miskolc, Faculty of Earth Science and Technology
Department of Geophysics

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Magnotelluric survey and interpretation near Irota, Hungary

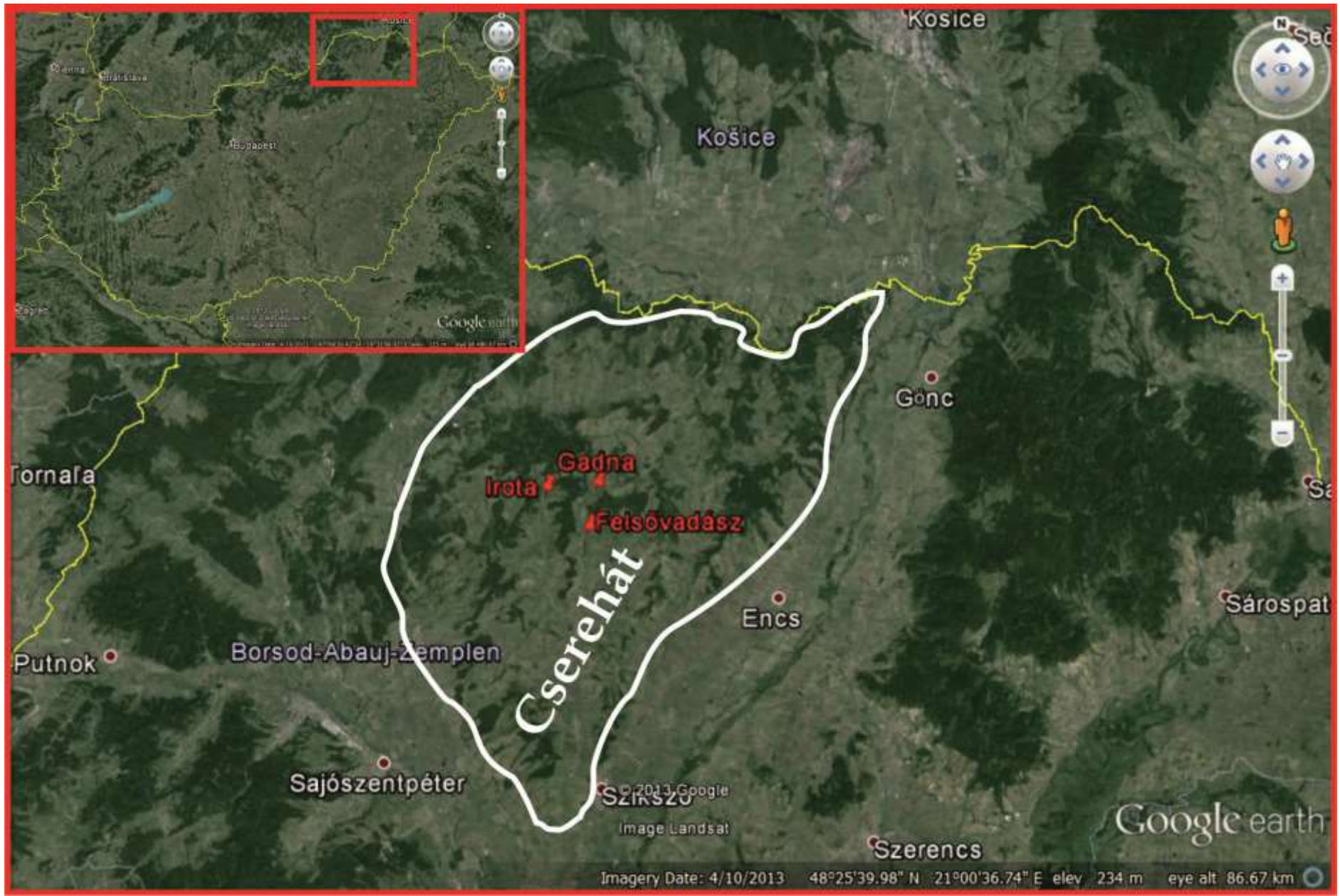
Balatonföldvár, 2014.03.29.

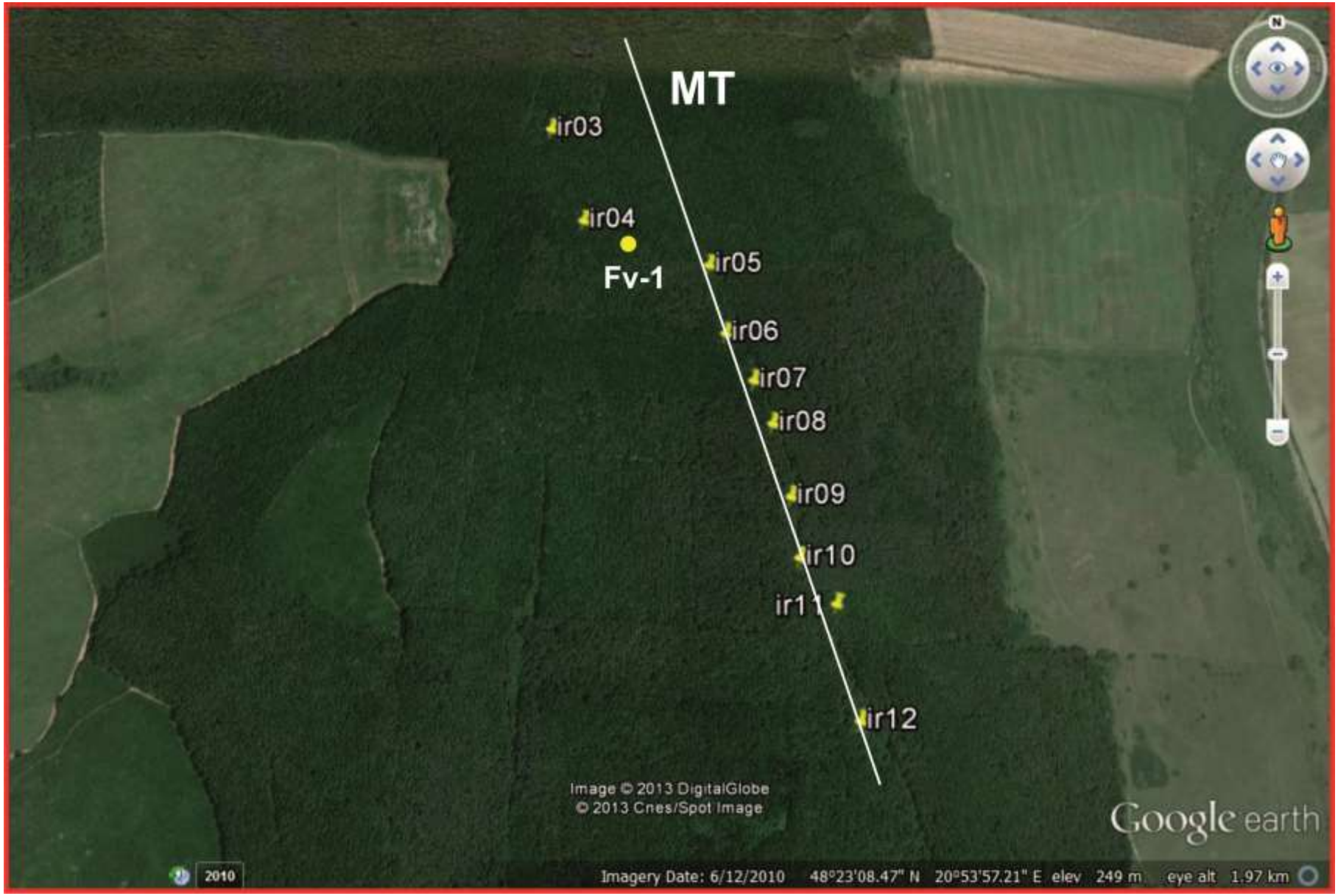
XLV. Meeting of Young Geoscientists

Content

- Introduction of surveying area
  - Location
  - Geological setting
  - Earlier applied geophysical measurements (gravity, magnetics, reflection seismics, **VES, tellurics**)
- The **magnetotelluric (MT) method**
- Surveying
- Data processing
- Geophysical and geological interpretation
- Conclusion, summary

Location


Kosice
Košice
Gonc
Tornaľa
Gagna
Irota
Feisővadász
Cserehát
Encs
Sárospat
Putnok
Borsod-Abauj-Zemplen
Sajószentpéter
Szikszó
Szerencs
© 2013 Google
Image Landsat
Google earth
Imagery Date: 4/10/2013 48°25'39.98" N 21°00'36.74" E elev 234 m eye alt 86.67 km



The surveying area (Sept 2013)

Geological setting

- Neogene rocks

  sedimentary hiatus (Devonian, Carboniferous–Miocene)

- Paleozolic rocks

  Outcrop in Szendrő mountain

  Hundreds of kms lateral moving

  Greenschist facies dynamo-thermal metamorphism (Cretateous)

Geophysical exploration history

MÁELGI

- 1951, 1960–1961: magnetic measurements
- 1964: complex geophysical surveying

MÉV

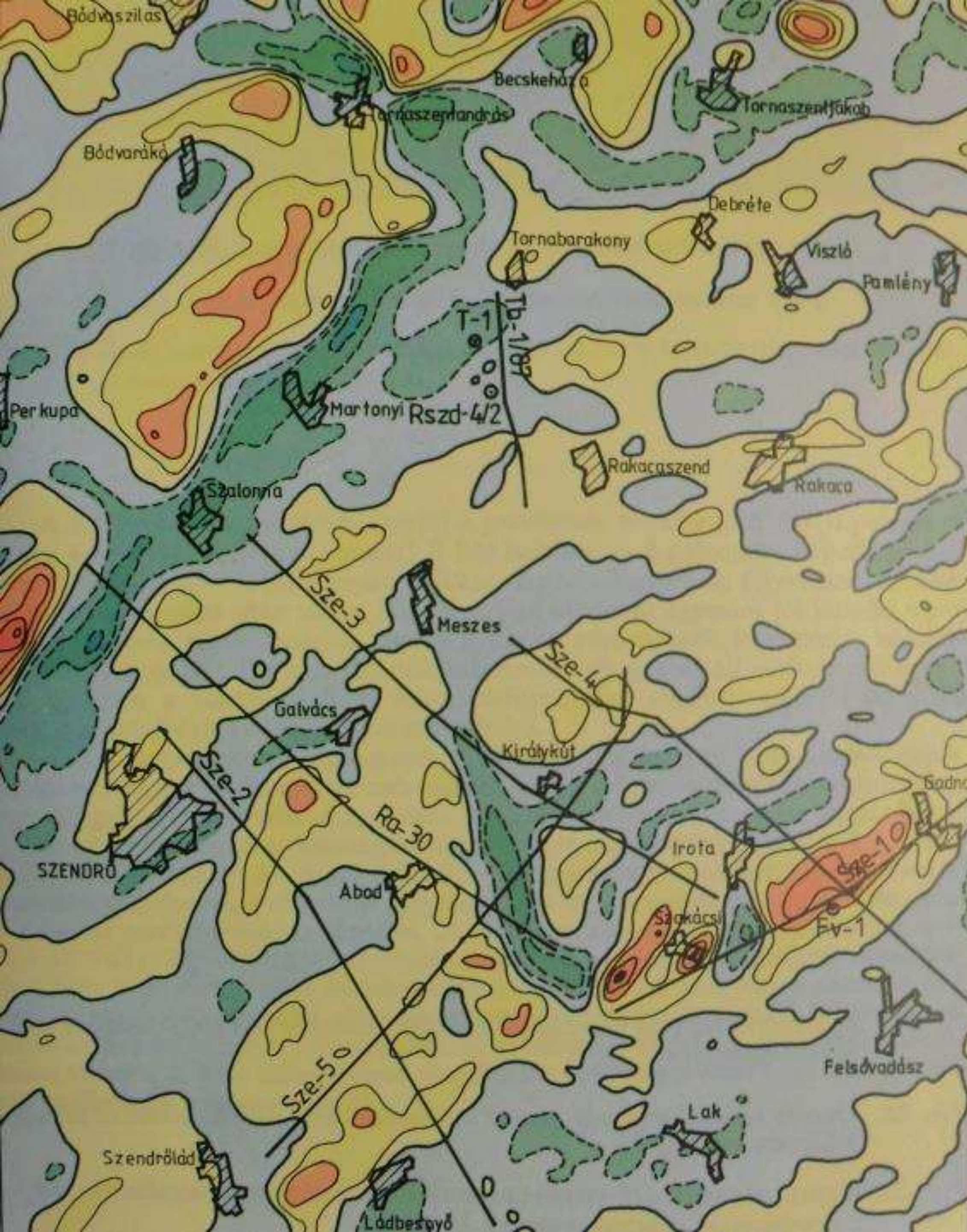
Uranium exploration

1967–1969: radiometric measurements

1969–1970: VES (Szendrő mts.)

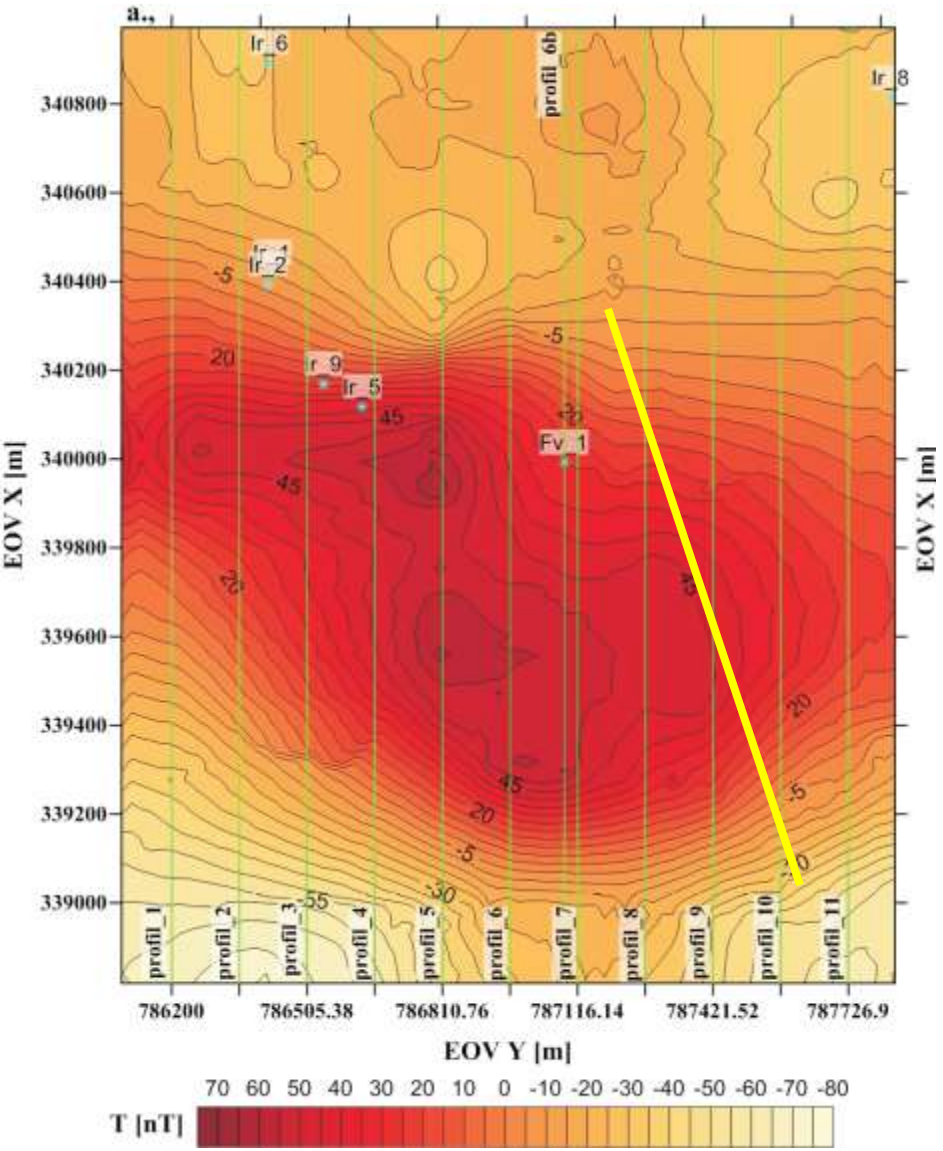
MÁELGI

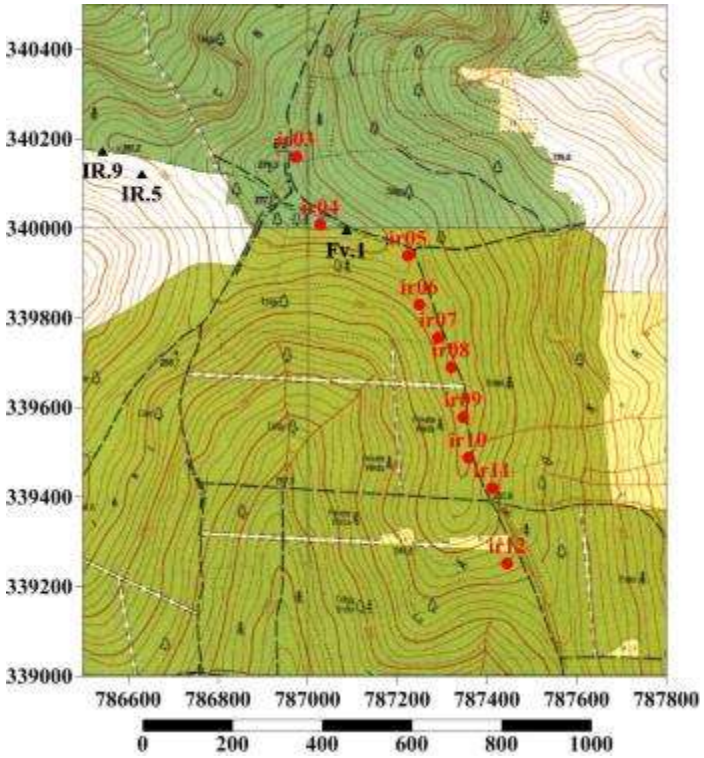
1980’s: gravity, airborne magnetic



Gravity residual anomaly map of the Szendrő area with location of seismic reflection profiles (Szalay et al. 1986)

Position of the magnetic body near Irota on the aeromagnetic (ΔT) anomaly map and in cross section (Szalay et al. 1986)

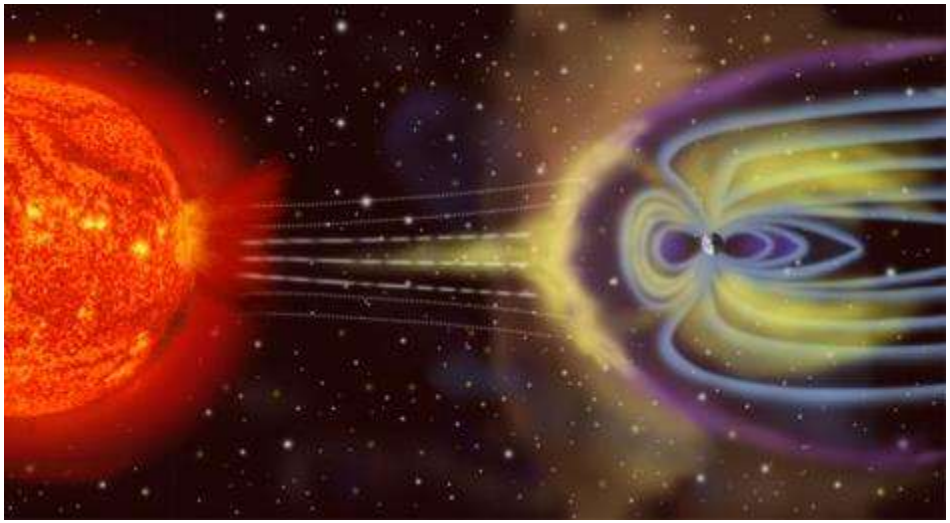




(Czeglédi, 2011)

The magnetotelluric (MT) method

- Passive electromagnetic geophysical exploration method
- Physical background
- **Tikhonov** (1950), **Cagniard** (1953)
- Hazai bevezetés: **Antal Ádám**, **Ernő Takács**
- Superposition of primer and secunder electromagnetic field



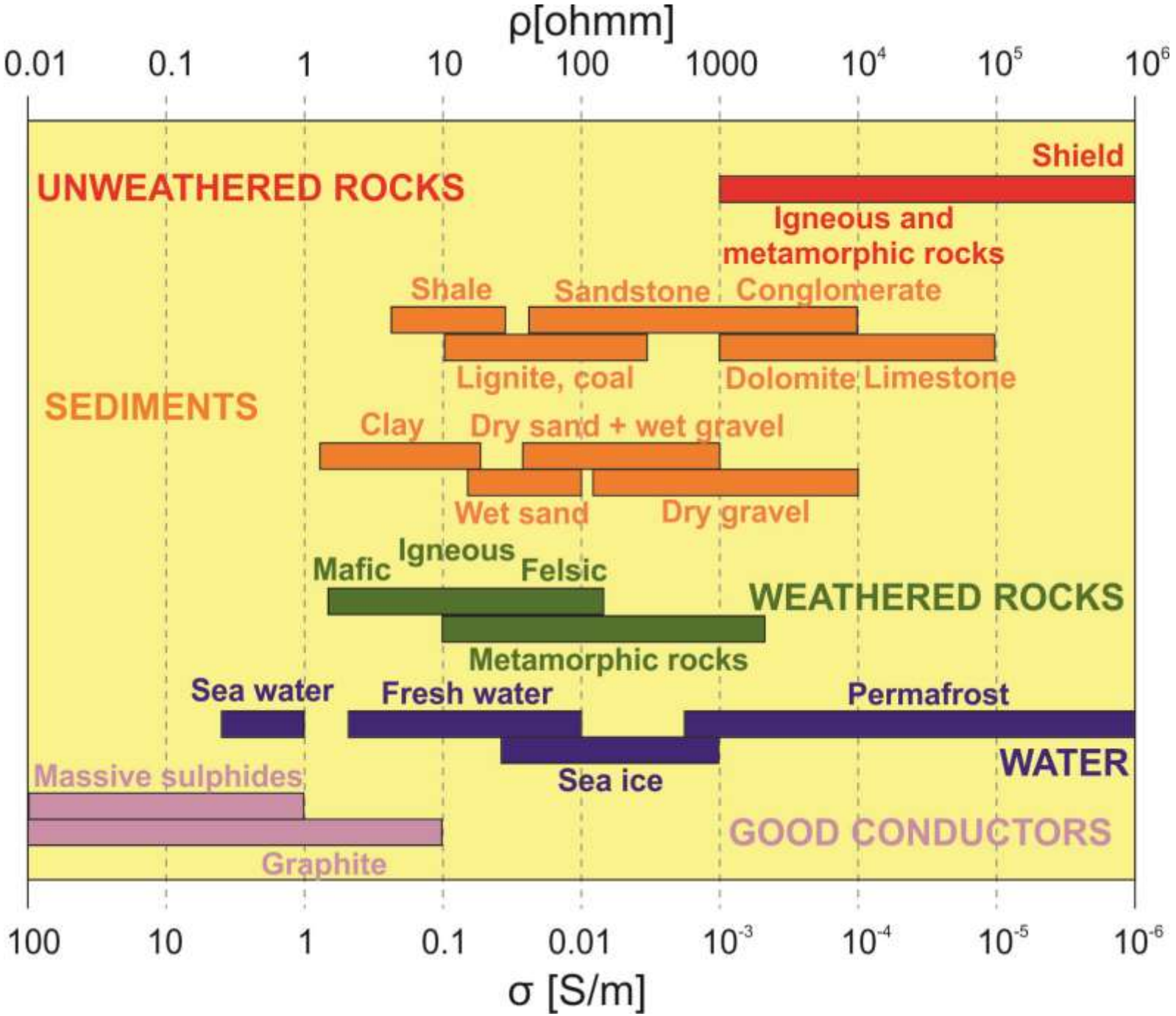
Magnetosphere solar wind interaction: 0,001 – 1 Hz
Meteorological activity: > 1 Hz

The degree of attennuation depends on the angular frequency (ω), and the medium's electromagnetic features (ε, μ, σ).

absorption coefficient $$a = \sqrt{\frac{\mu\sigma\omega}{2}}$$

skin-depth $$d_s = \sqrt{\frac{2}{\mu\sigma\omega}} \cong 500\sqrt{\rho T}$$

Resistivity [ohmm]	Period [s] T							
	0.0002	**0.001**	**0.002**	**0.01**	**0.1**	**1**	**10**	**100**
1	7	16	23	50	159	503	1592	5033
10	23	50	71	159	503	1592	5033	15915
50	50	113	159	356	1125	3559	11254	35588
100	71	159	225	503	1592	5033	15915	50329
500	159	356	503	1125	3559	11254	35588	112540
1000	225	503	712	1592	5033	15915	50329	159155
Skin-depth [m]	**5000**	**1000**	**500**	**100**	**10**	**1**	**0.1**	**0.01**
	Frequency [Hz] f							


ρ[ohmm]
0.01
0.1
1
10
100
1000
10^4
10^5
10^6
UNWEATHERED ROCKS
Shield
Igneous and metamorphic rocks
Shale
Sandstone
Conglomerate
Lignite, coal
Dolomite
Limestone
SEDIMENTS
Clay
Dry sand + wet gravel
Wet sand
Dry gravel
Igneous
Mafic
Felsic
WEATHERED ROCKS
Metamorphic rocks
Sea water
Fresh water
Permafrost
WATER
Sea ice
Massive sulphides
GOOD CONDUCTORS
Graphite
100
10
1
0.1
0.01
10^-3
10^-4
10^-5
10^-6
σ [S/m]

Impedance tensor: $\underline{\underline{Z}}$

$$\overline{E} = \underline{\underline{Z}} \cdot \overline{H} \qquad \begin{bmatrix} E_x \\ E_y \end{bmatrix} = \begin{bmatrix} Z_{xx} Z_{xy} \\ Z_{yx} Z_{yy} \end{bmatrix} \cdot \begin{bmatrix} H_x \\ H_y \end{bmatrix}$$

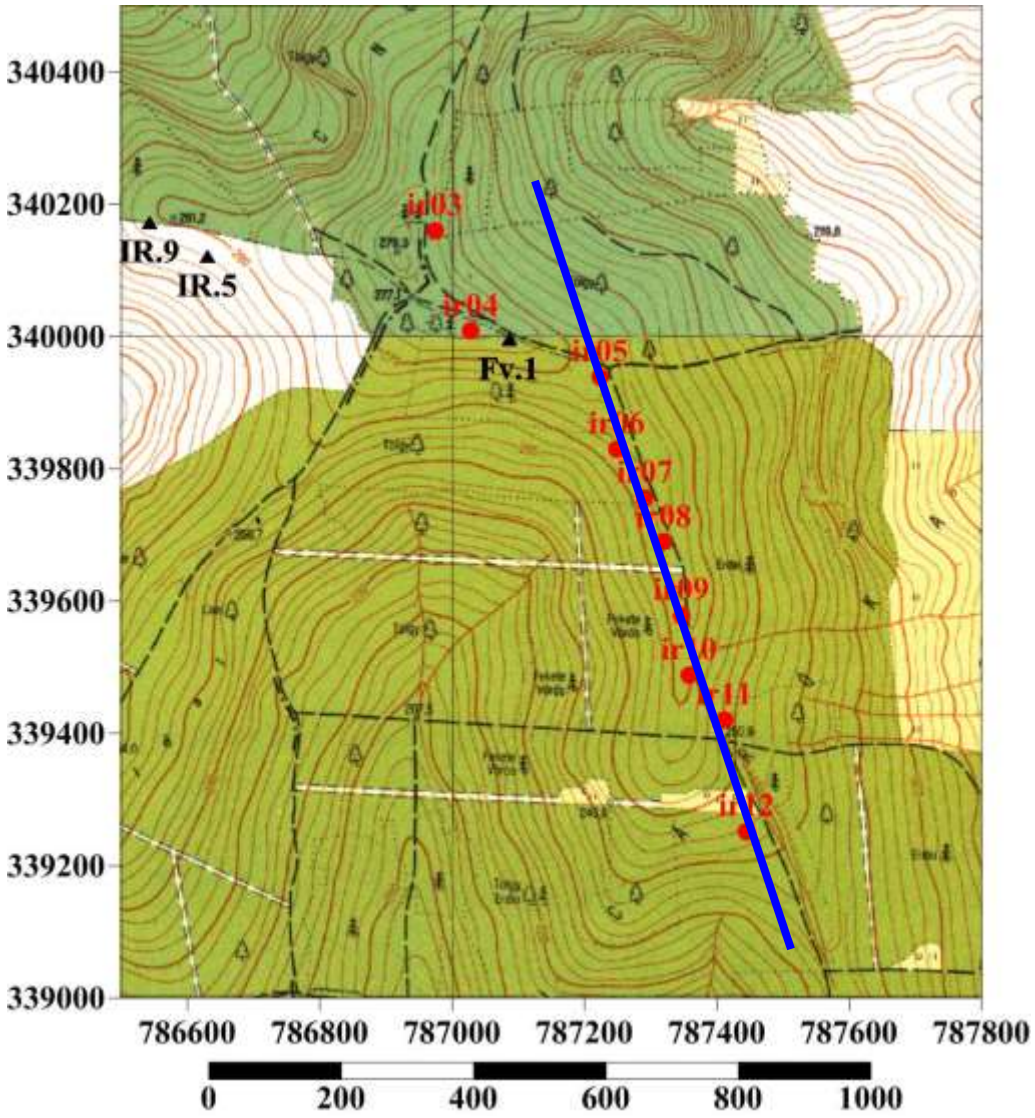
apparent resistivity $$\rho_a = \frac{1}{\mu\omega} \left| Z_{ij} \right|^2$$

impedance tensor phase $$\varphi_{ij}(\omega) = \operatorname{arctg}\left(\frac{\operatorname{Im}(Z_{ij}(\omega))}{\operatorname{Re}(Z_{ij}(\omega))} \right)$$

Geomagnetic induction vector („tipper”): $\overline{T}$

$$\left[H_z \right] = \left[T_x T_y \right] \cdot \begin{bmatrix} H_x \\ H_y \end{bmatrix}$$

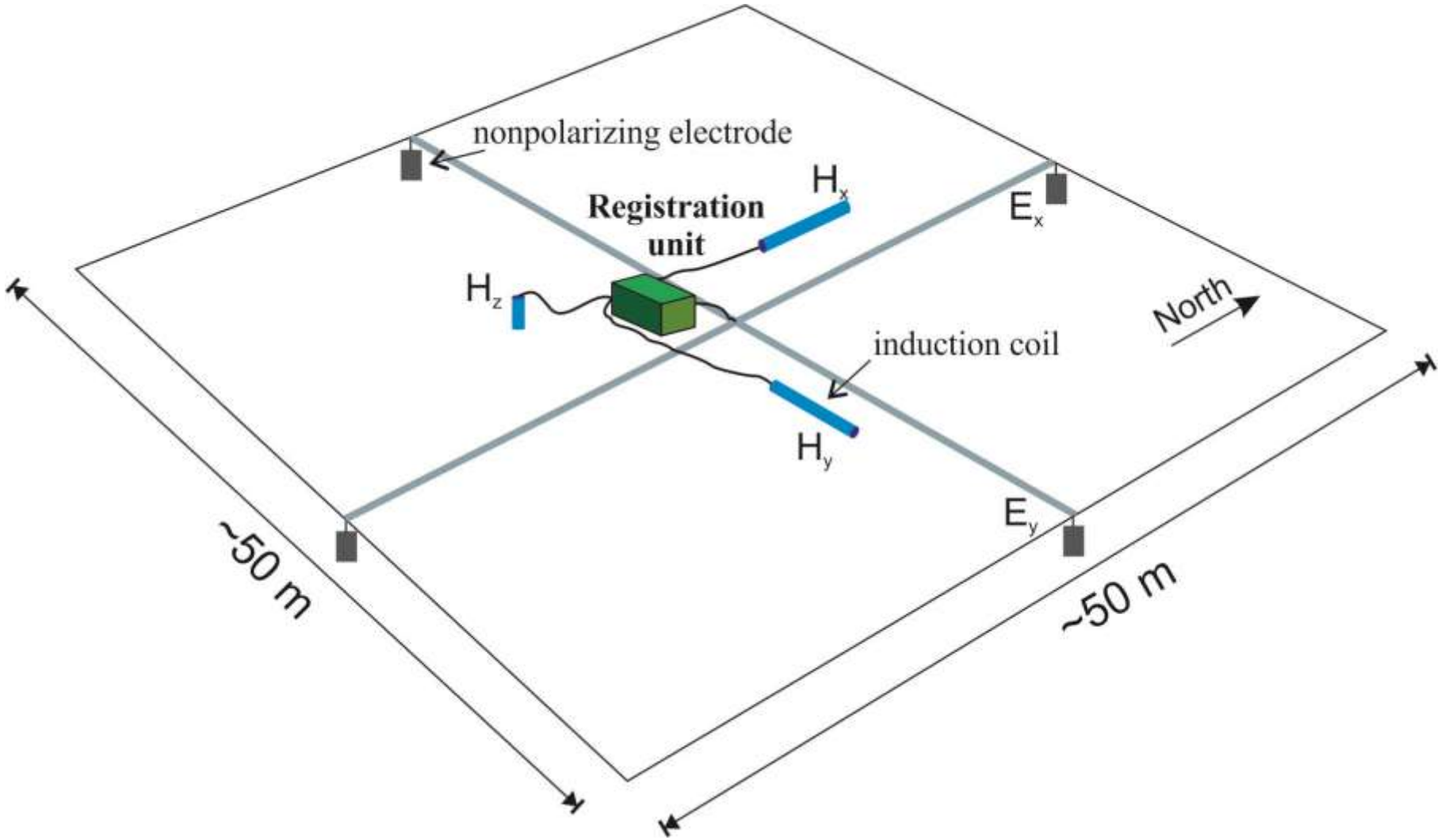
Field campaign



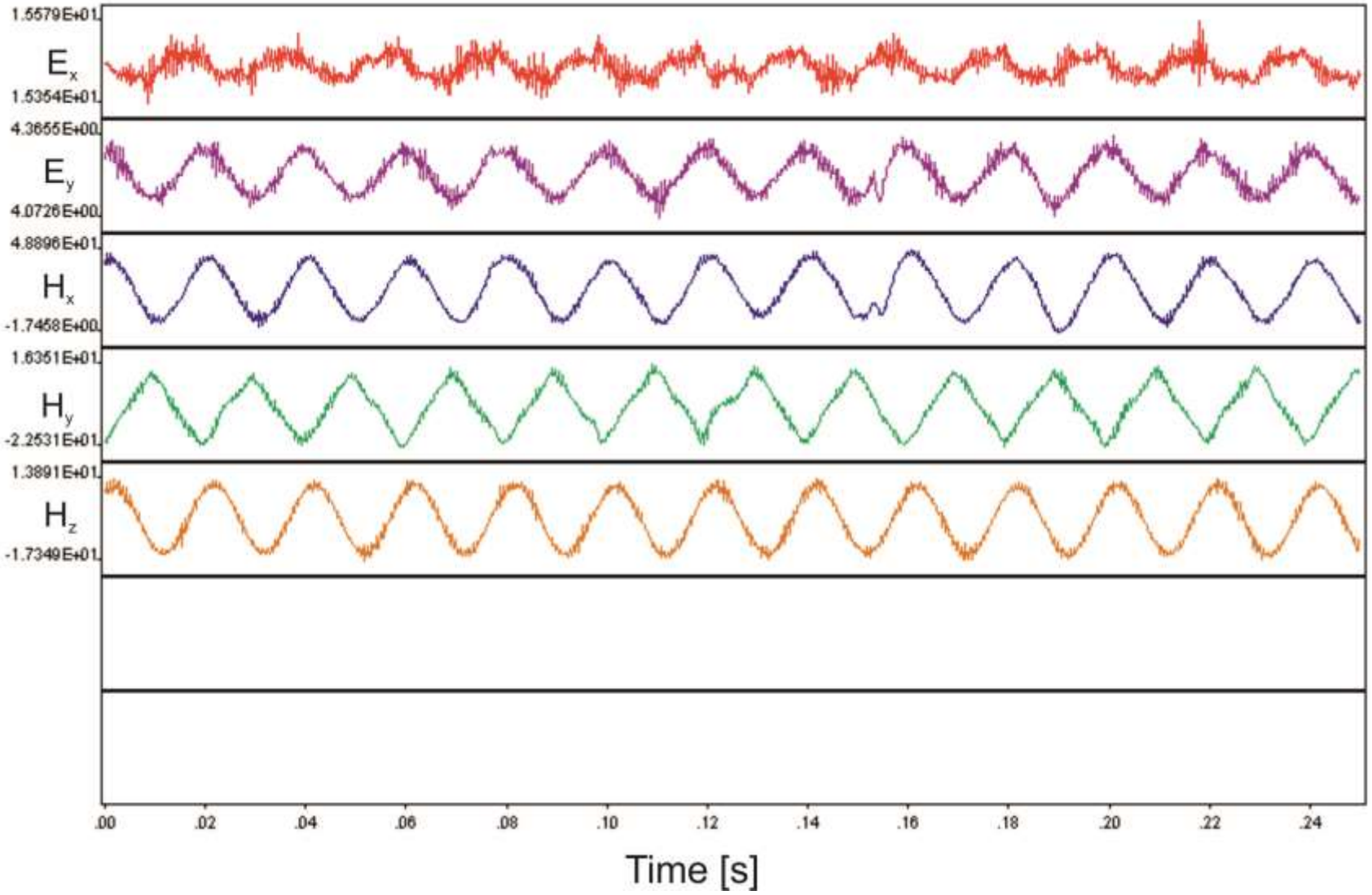
Registration unit and sensors

The Metronix multi-channel Geophysical Measurement System (GMS-06)

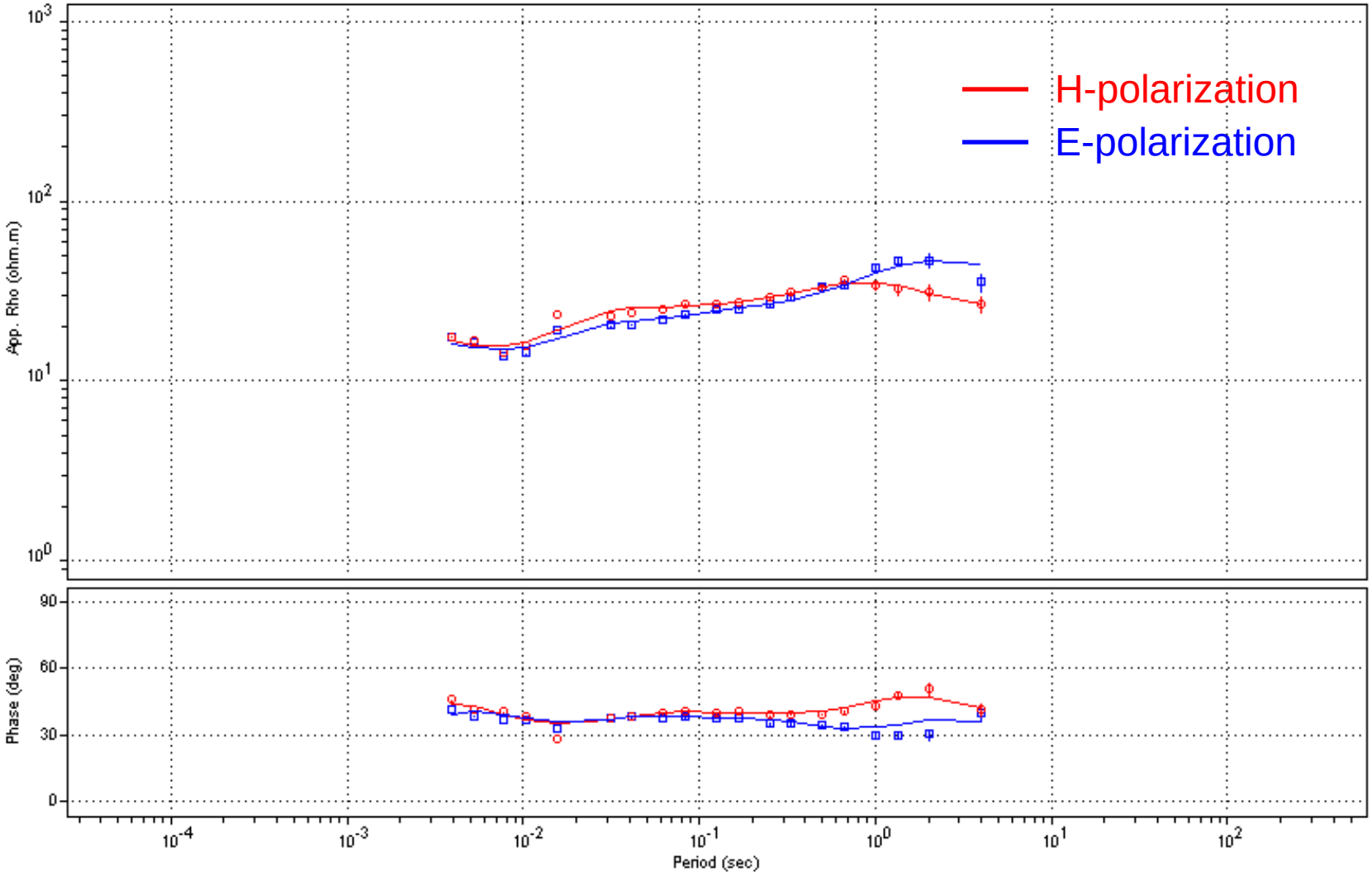
Field setup


nonpolarizing electrode
Registration unit
H_x
E_x
H_z
North
induction coil
H_y
E_y
~50 m
~50 m

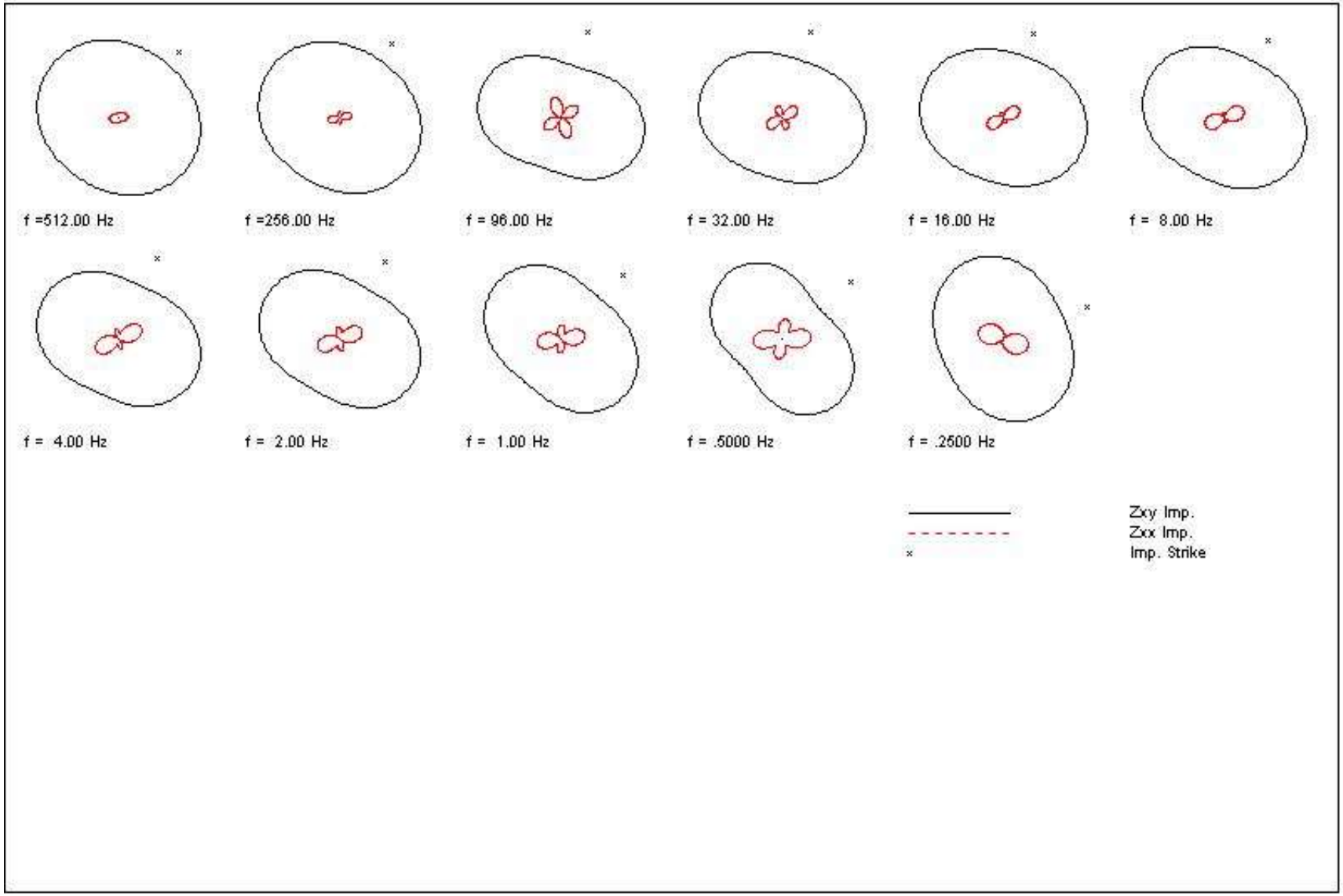
Data processing



Apparent resistivity and impedance phase curves



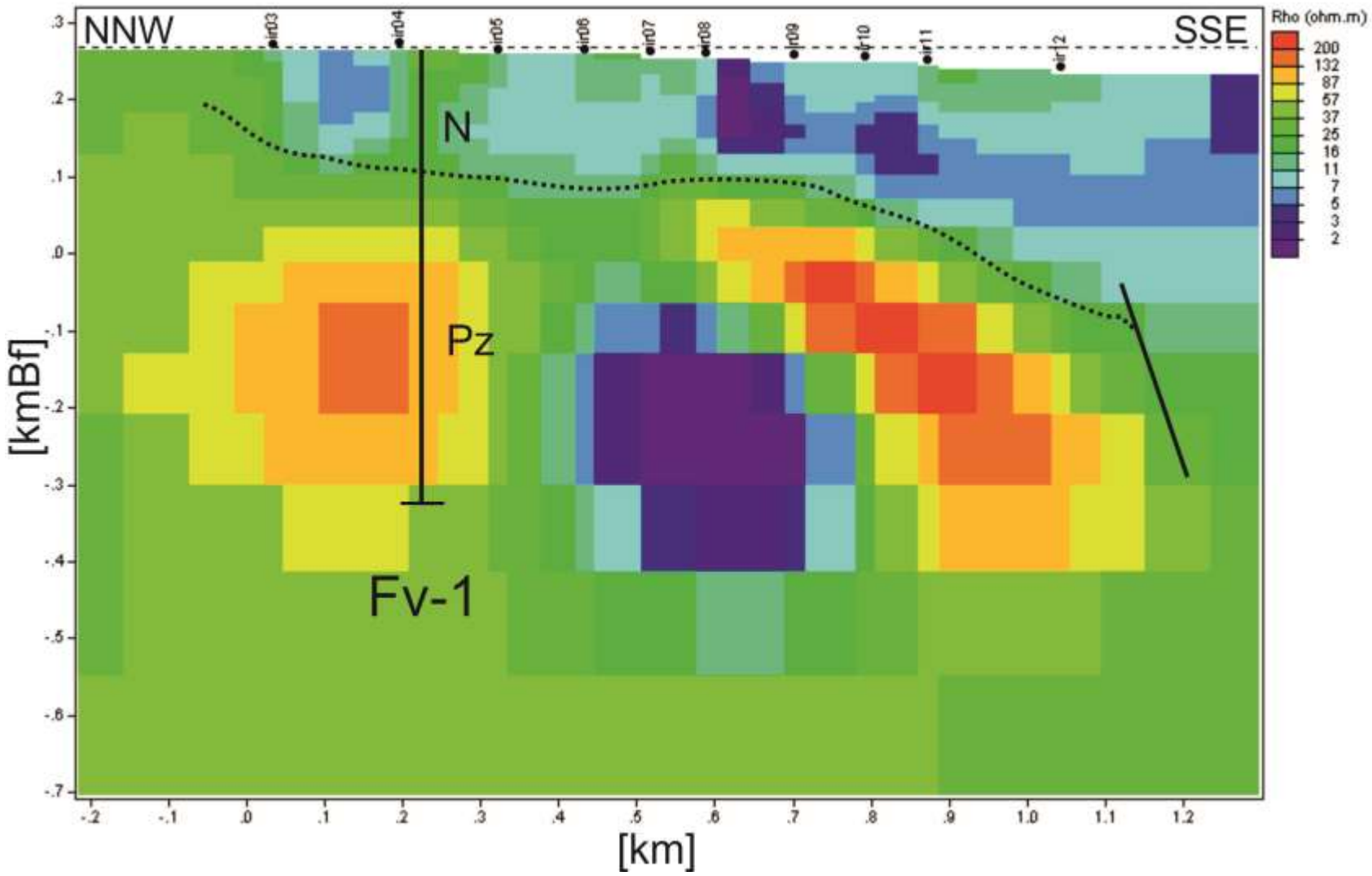
Polar diagrams (ir06-ir07-ir08)



Complex interpretation

- Geological data
  Felsővadász-1 well
- Geophysical measurements
  gravity, magnetic (airborne and surface), seismic, geoelectric
- **MT 2D inversion**
  - Nonlinear conjugate gradient algorithm
  - START model: 10 ohmm resistivity homogenous half space
  - Number of iterations: 150
  - RMS error: 1,45 %

2D inversion



Conclusion

- Specifying the depth of the Paleozoic basement
- Resistivity inhomogenity in the basement
- Sulphides, graphite, clay minerals
- Sediments with low resistivity near the surface
- Ore mineralization is possible connected to the fault zone
- IP
- more MT profiles

Acknowledgements

Madarasi András (MFGI)
Dr. Turai Endre (ME)
Dr. Földessy János (ME)
Tóth Szabolcs (Rotaqua Ltd.)

„This work was carried out as part of the TÁMOP-4.2.2.A-11/1/KONV -2012-0005 project in the framework of the New Széchenyi Plan supported by the European Union, cofinanced by the European Social Fund.”

„This research was supported by the **European Union** and the **State of Hungary, co-financed by the European Social Fund** in the framework of TÁMOP 4.2.4. A/2-11-1-2012-0001 ‘National Excellence Program’.”

Thank you for your attention!