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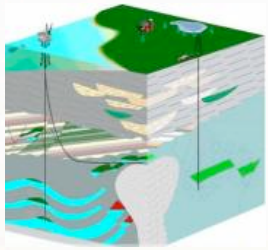
Case histories of using magnetotellurics for geothermal exploration

Strack, K. M., Tulinius, H., Vozoff, K., and Yu, G.

21 ASEG Conference and Exhibition, Sydney
2010



Case histories of using MT (magnetotellurics) for geothermal exploration

Strack, K.[1], Tulinius, H.[2], Yu, G. [1], and Vozoff, K.[3]

1 KMS Technologies, USA
2 Mannvit, Iceland
3 Free spirit

 An EMGS/RXT company

Outline

- Background
- Iceland case history
- Hungary success
- EU island
- Conclusions

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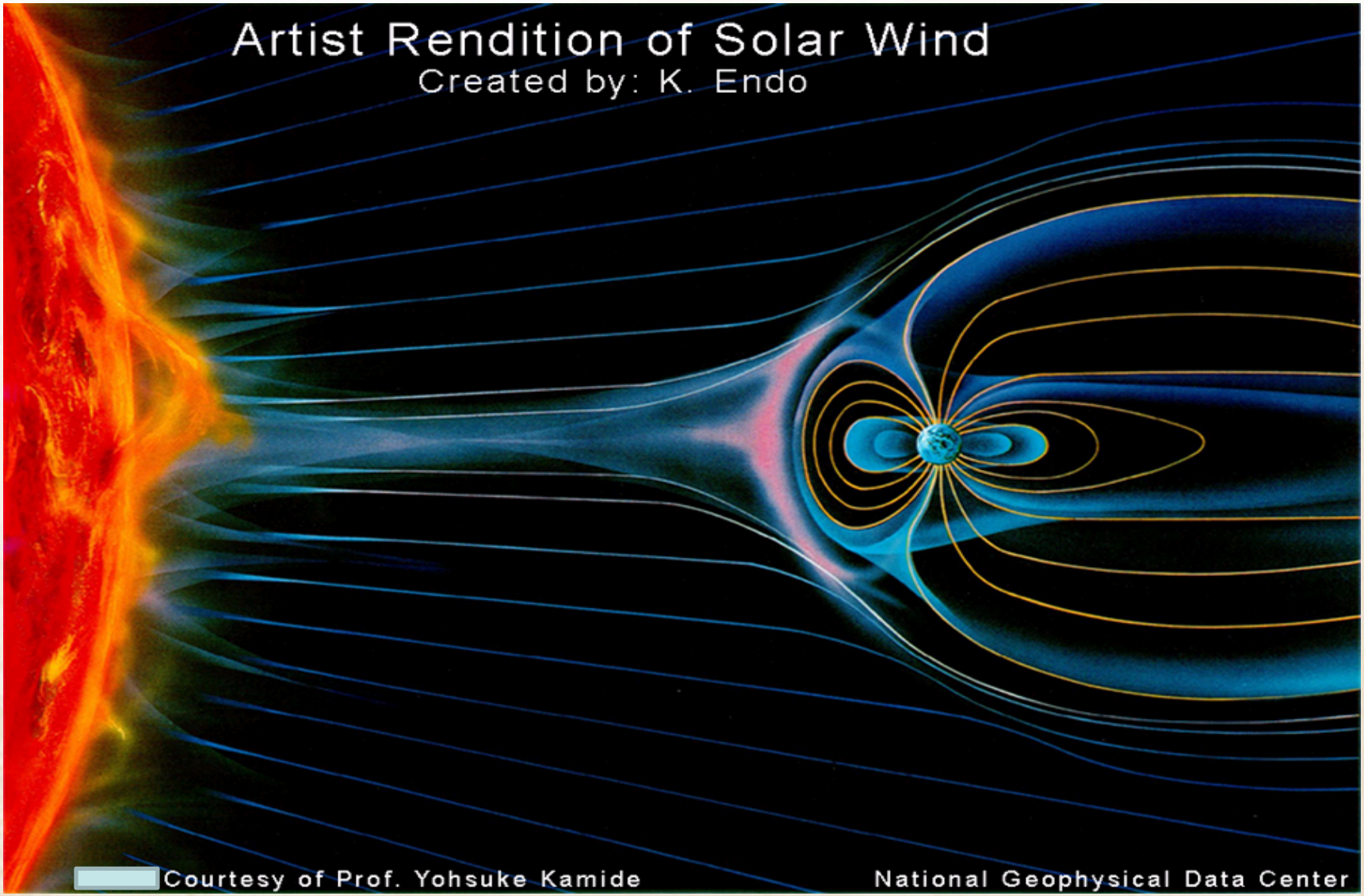
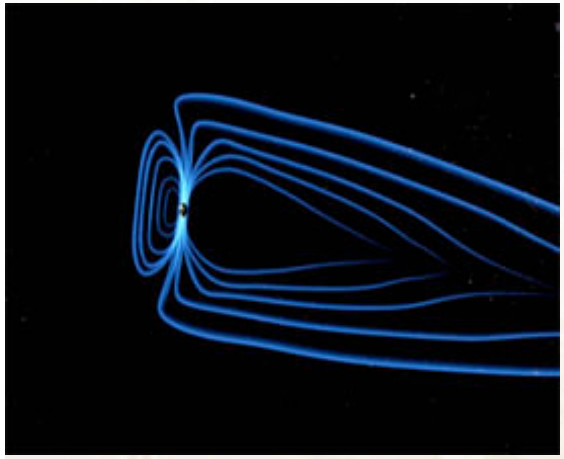
Mt: the origin of the signal

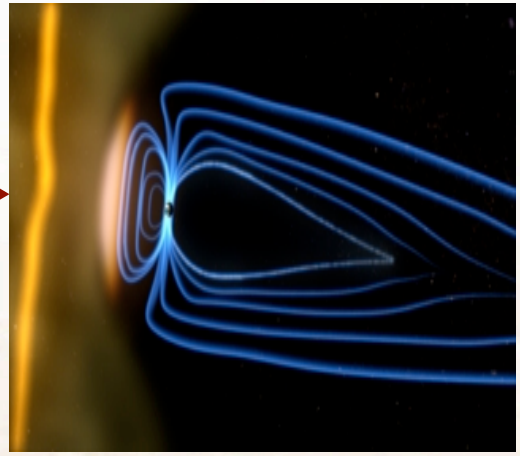


Ionosphere sources of MT field

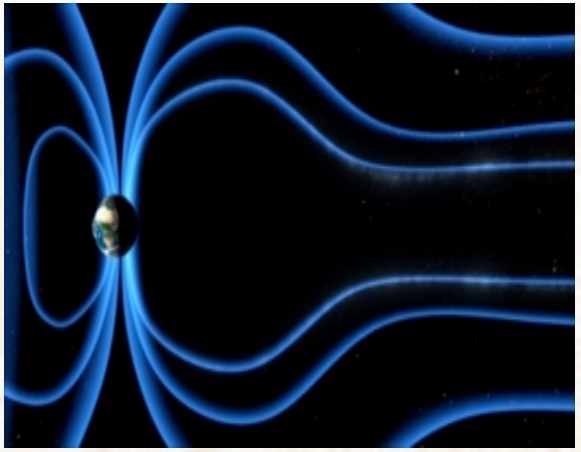
Model showing how electric field generates In Earth's Ionosphere



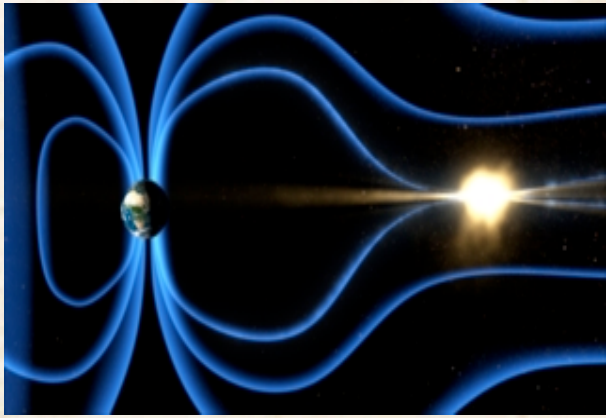
Earth's Magnetic Field



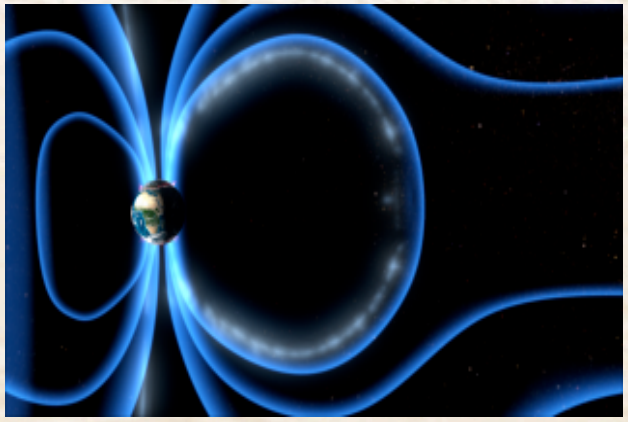
Massive solar outburst travels on the solar wind



The solar wind distorting earth's magnetic field



Two magnetic field lines are reconnecting



This fired particles towards the earth

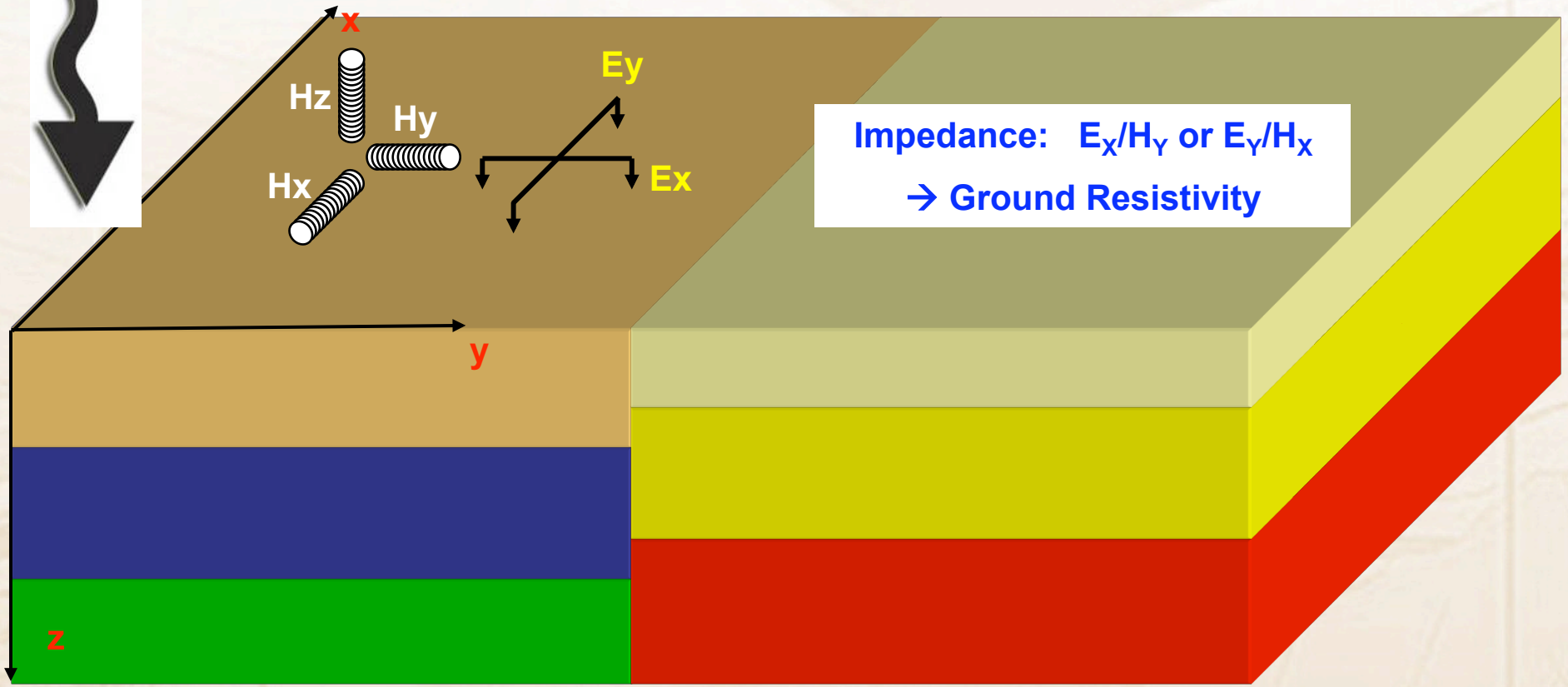
It induces electric field in Ionosphere and in extreme cases produces Auroras.

after http://svs.gsfc.nasa.gov/

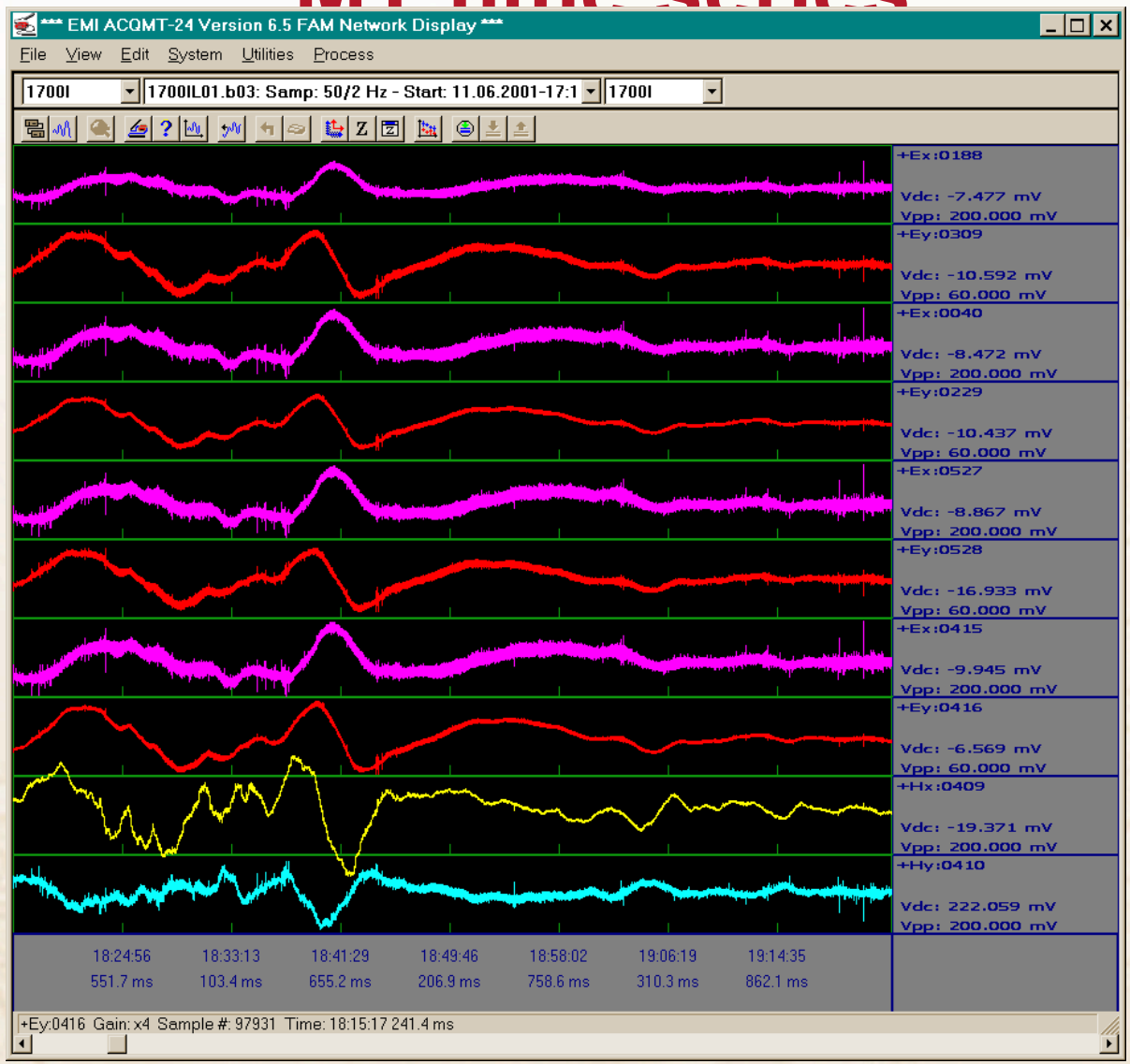
Magnetotelluric (MT) method

Measure natural variation of EM field;
Source: ionosphere & worldwide thunderstorm activity;

Source field is vertically incident plane wave, influenced by ground resistivity.



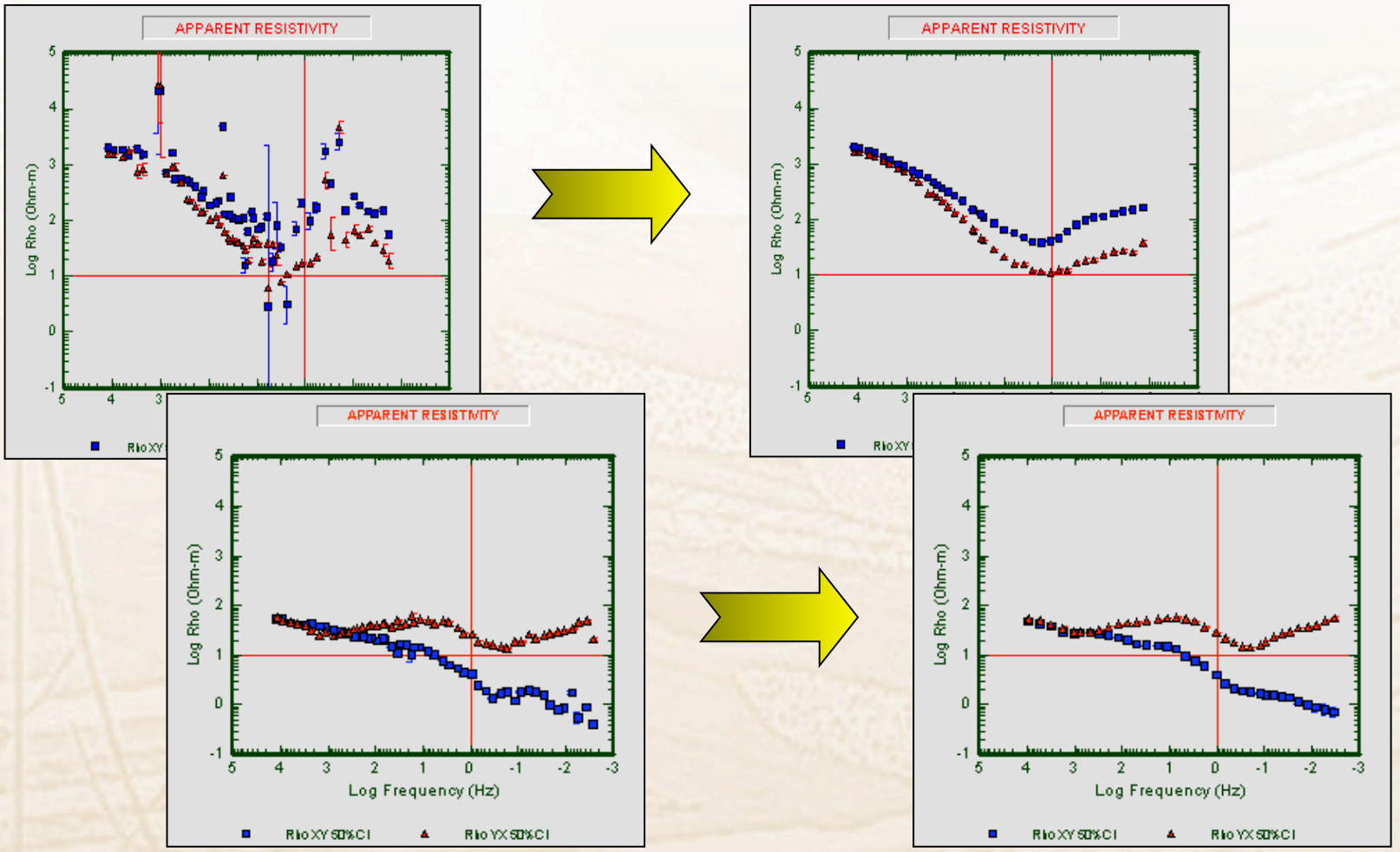
MT time series



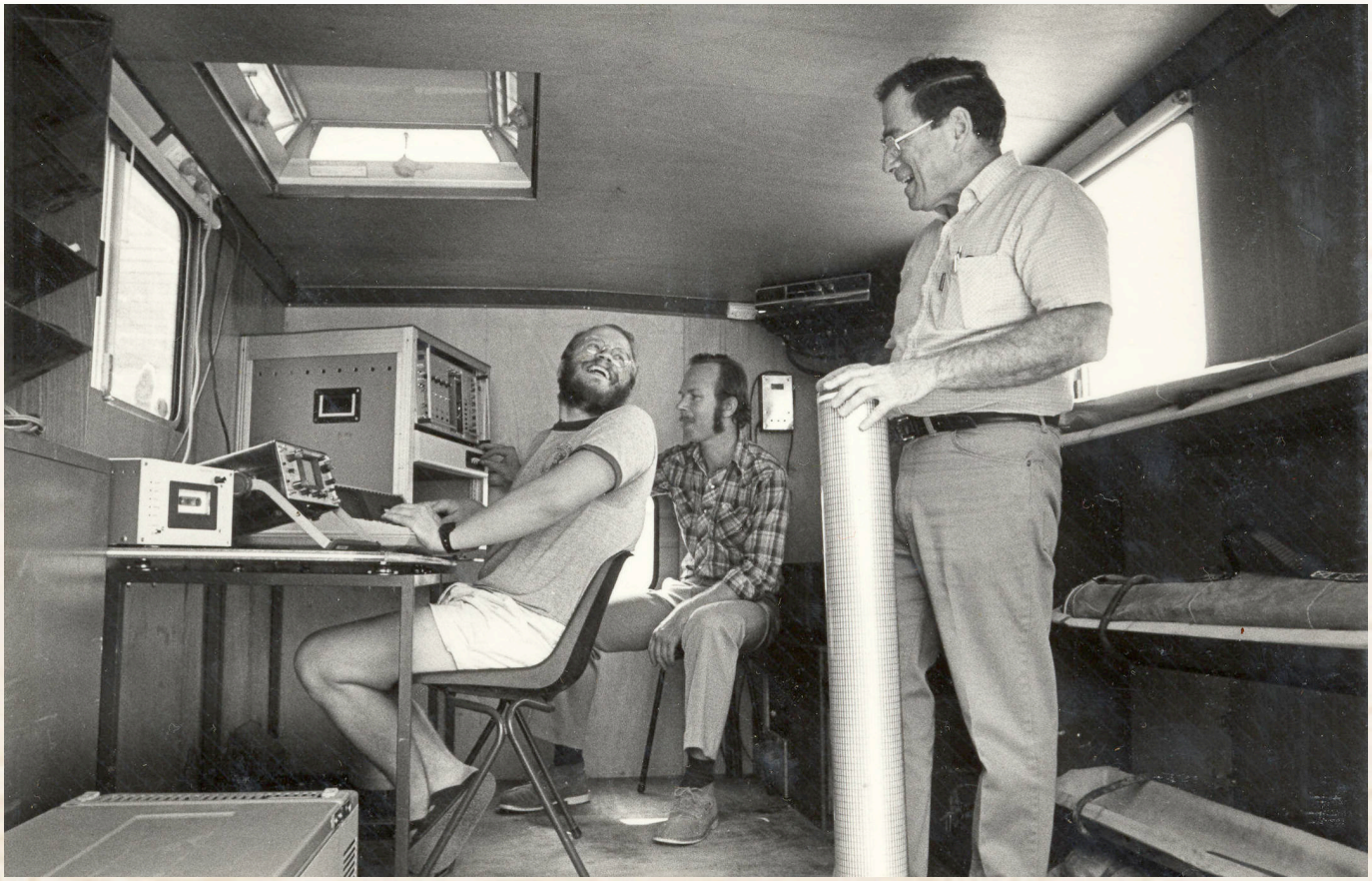
MT: robust processing

Before processing

After processing



Australian MT system 1982



NOBODY (except one) could stand in that truck!!!!

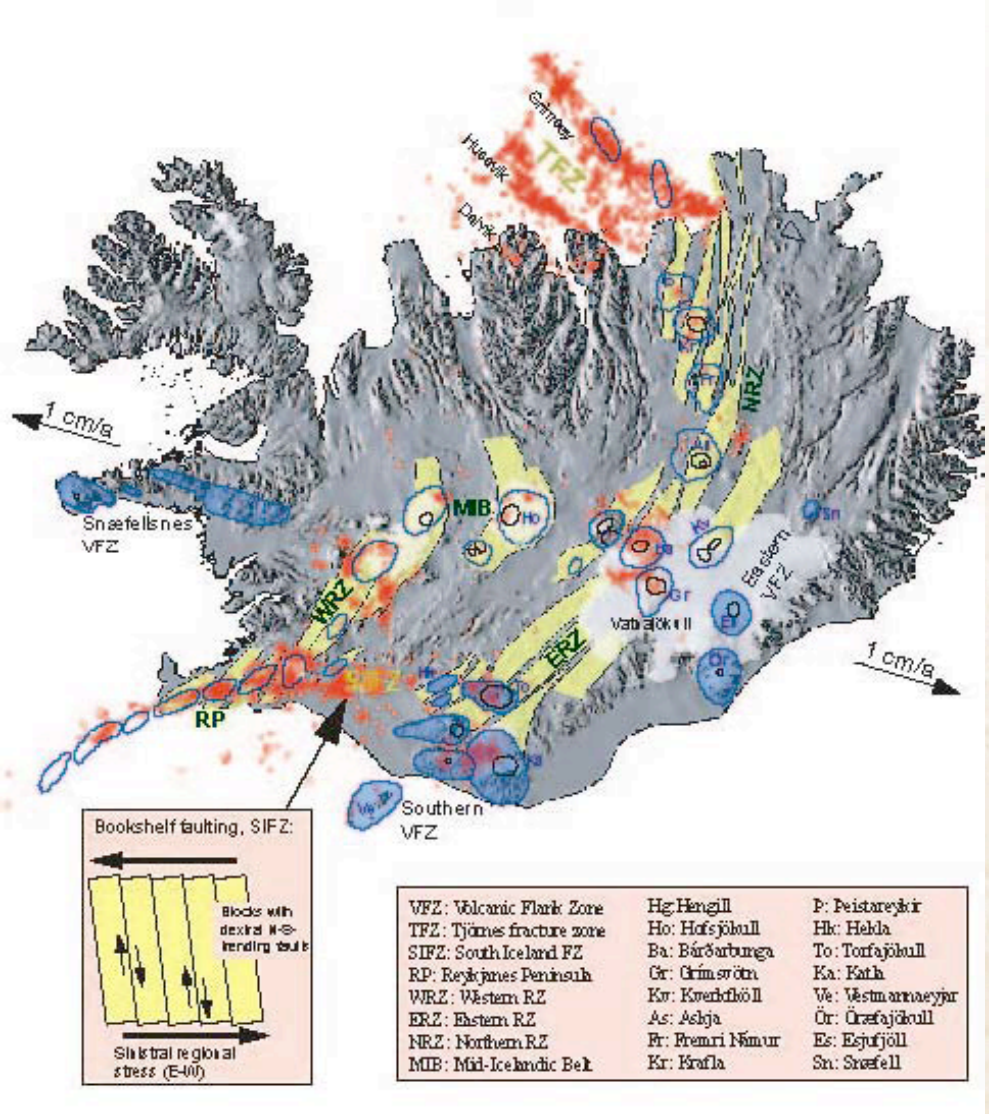
Geothermal applications

- Background
- Iceland case history
- Hungary success
- EU island
- Conclusions

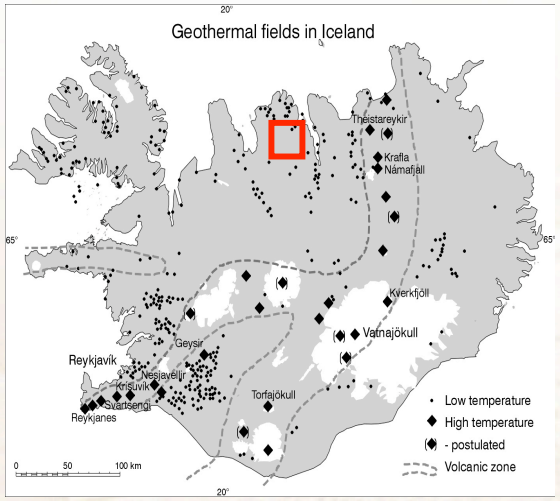
Iceland: punch line

- All volcanic material
- Target zone was additional reservoir to feed power plant
- Survey mapped resistive & conductive targets
- Data to be integrated with all others data (loop TEM)

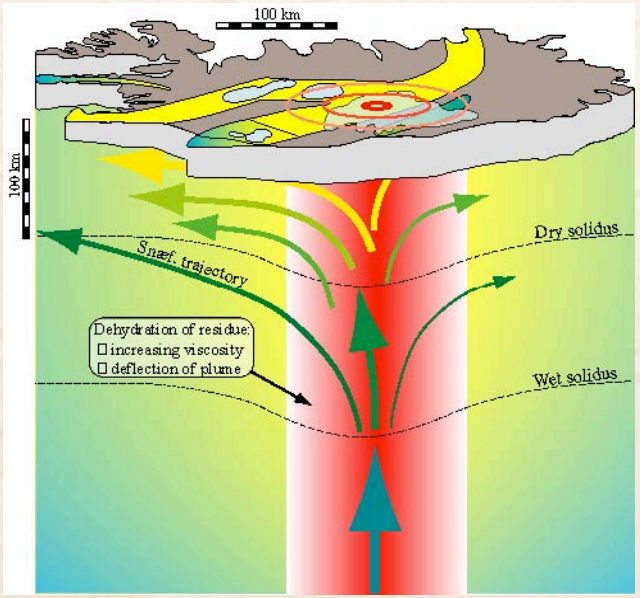
Iceland geothermal field distribution



(Trønnes, 2002)

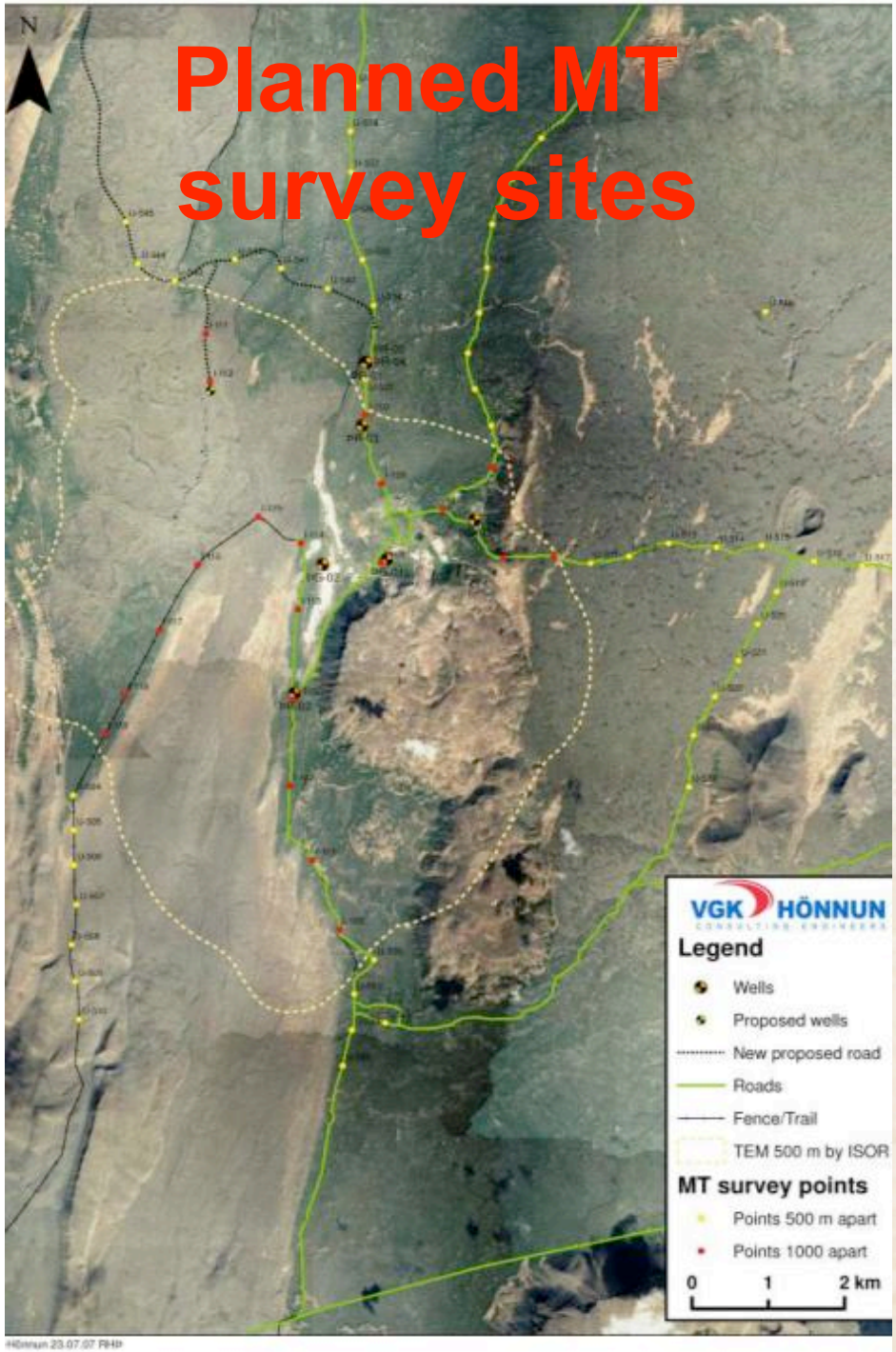


Armannsson 2000

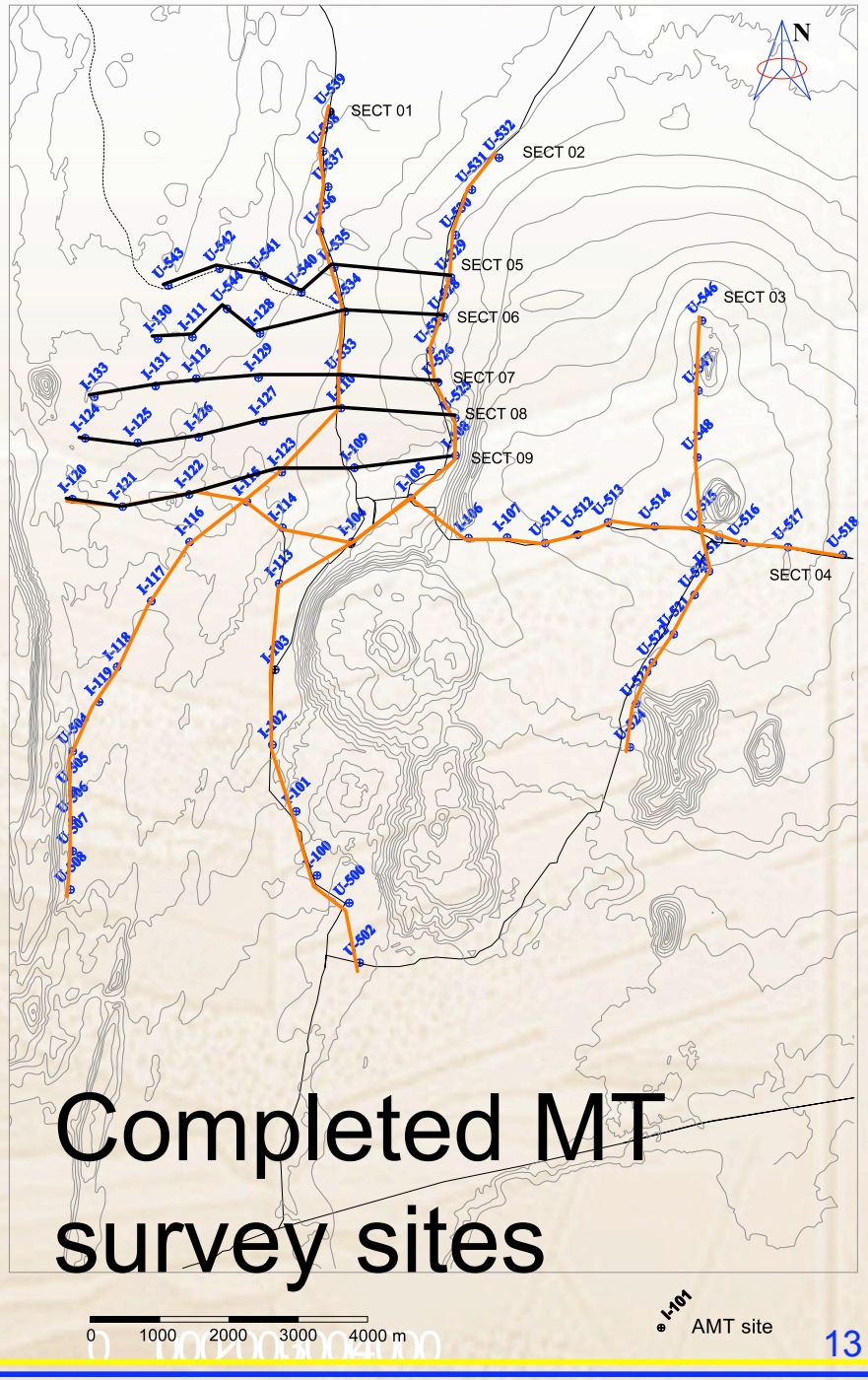


Wolfe et al., (1997), Shen et al., (2002)& Ito (2002)

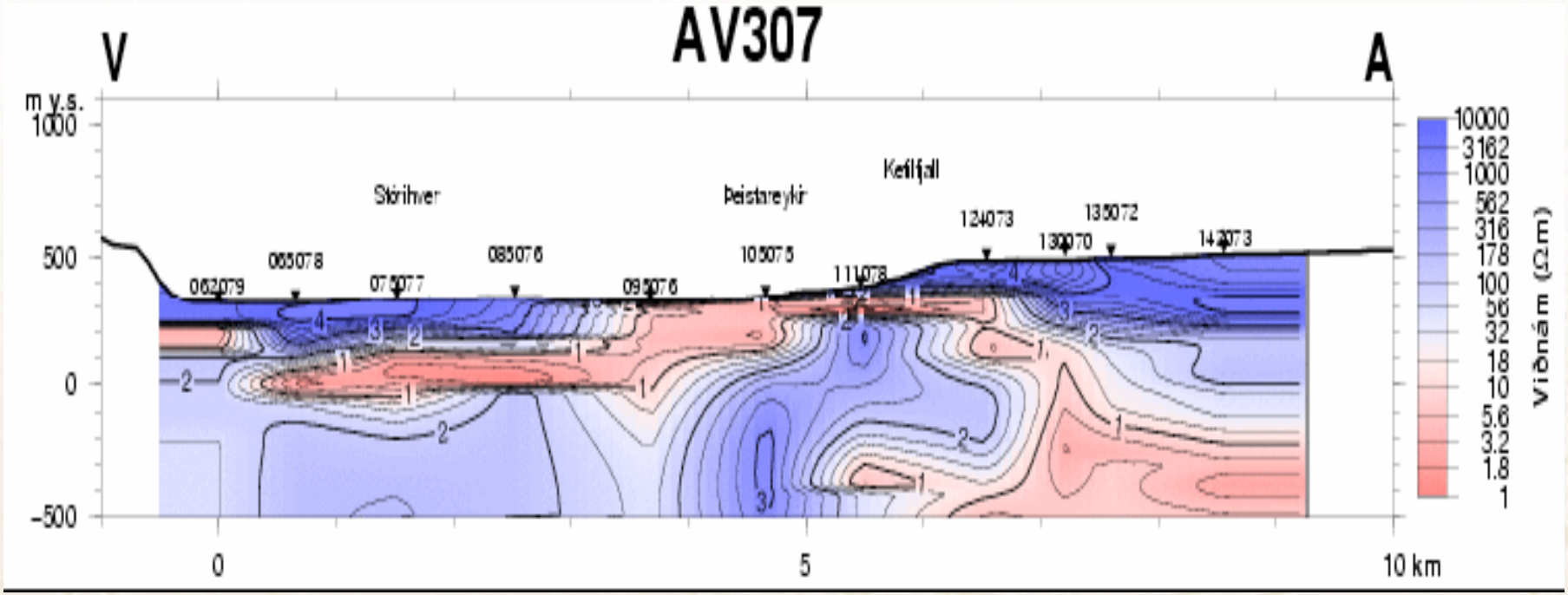
Planned MT survey sites



Completed MT survey sites



TEM inversion result of profile 307



Data

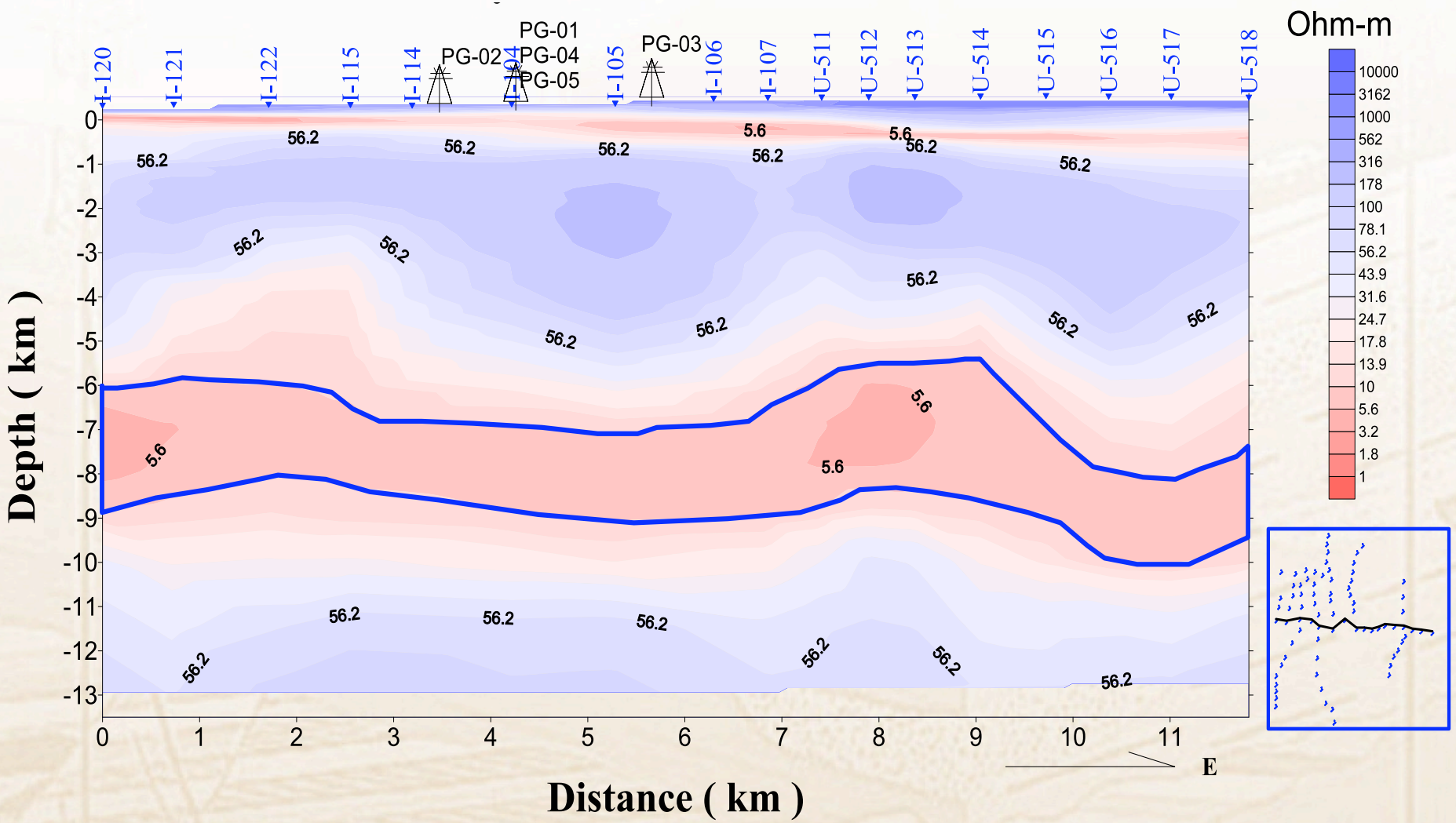
Forward modeling

Inversion

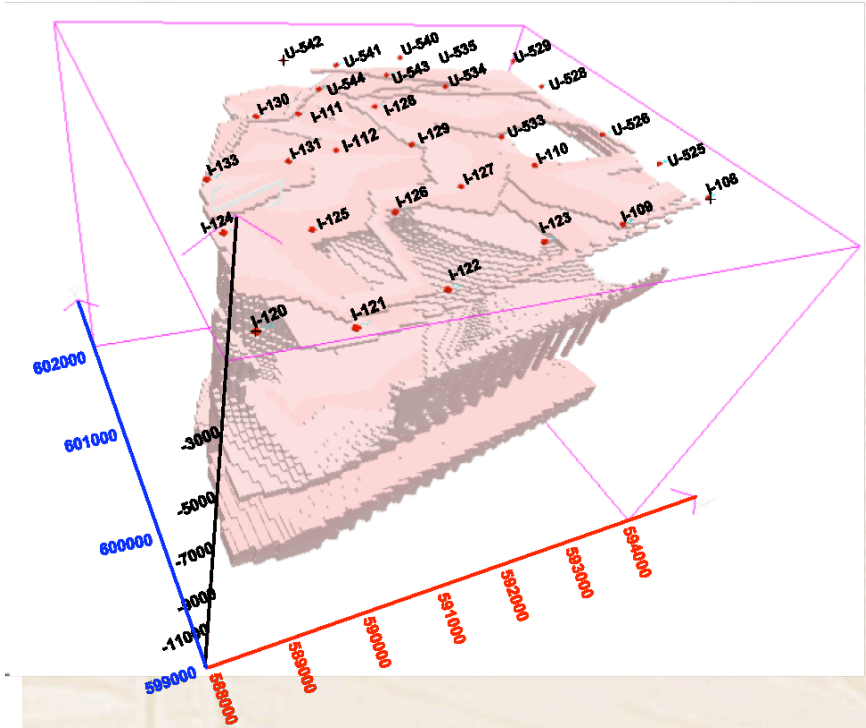
Model

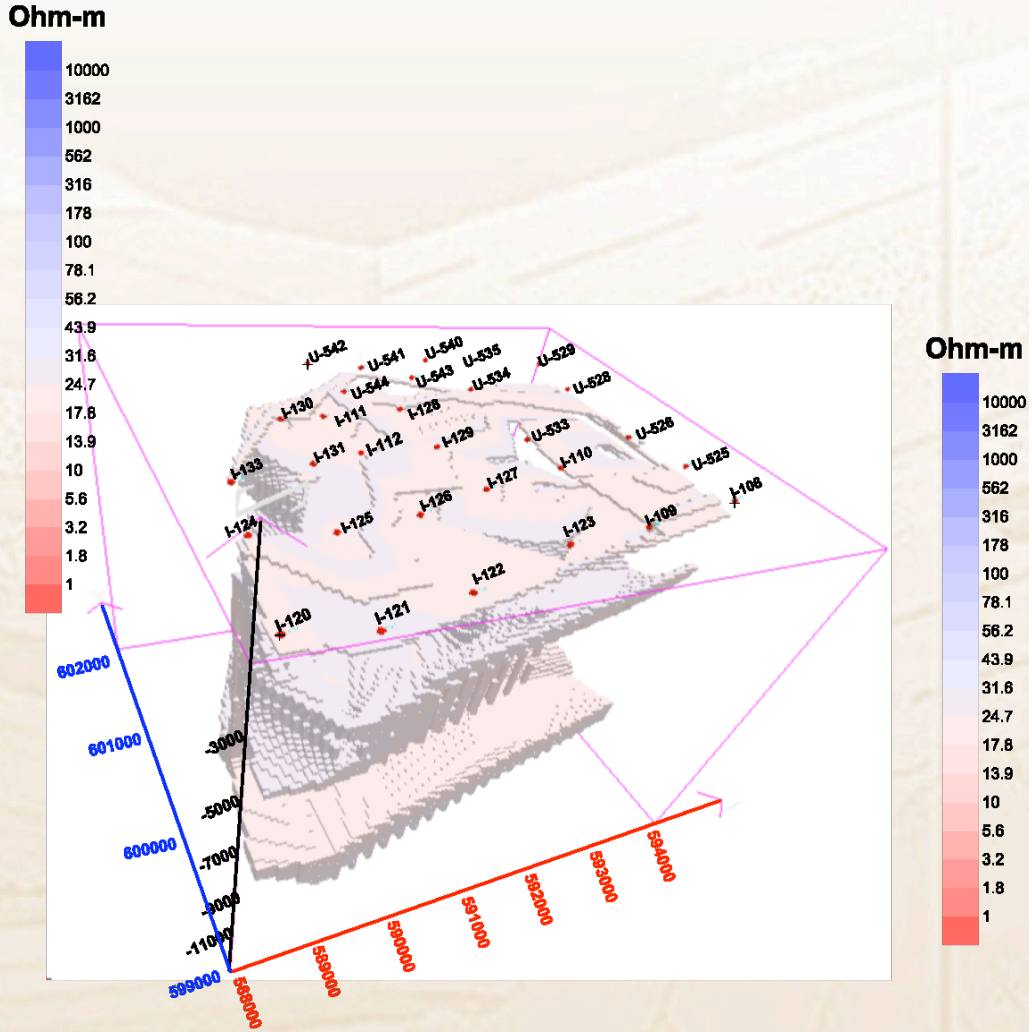
Subsurface resistivity

MT inversion result of Section 04



3-D volume shows contribution of moderate (6~15 Ωm, left, & 15~25 Ωm, right) resistivity value





Outline

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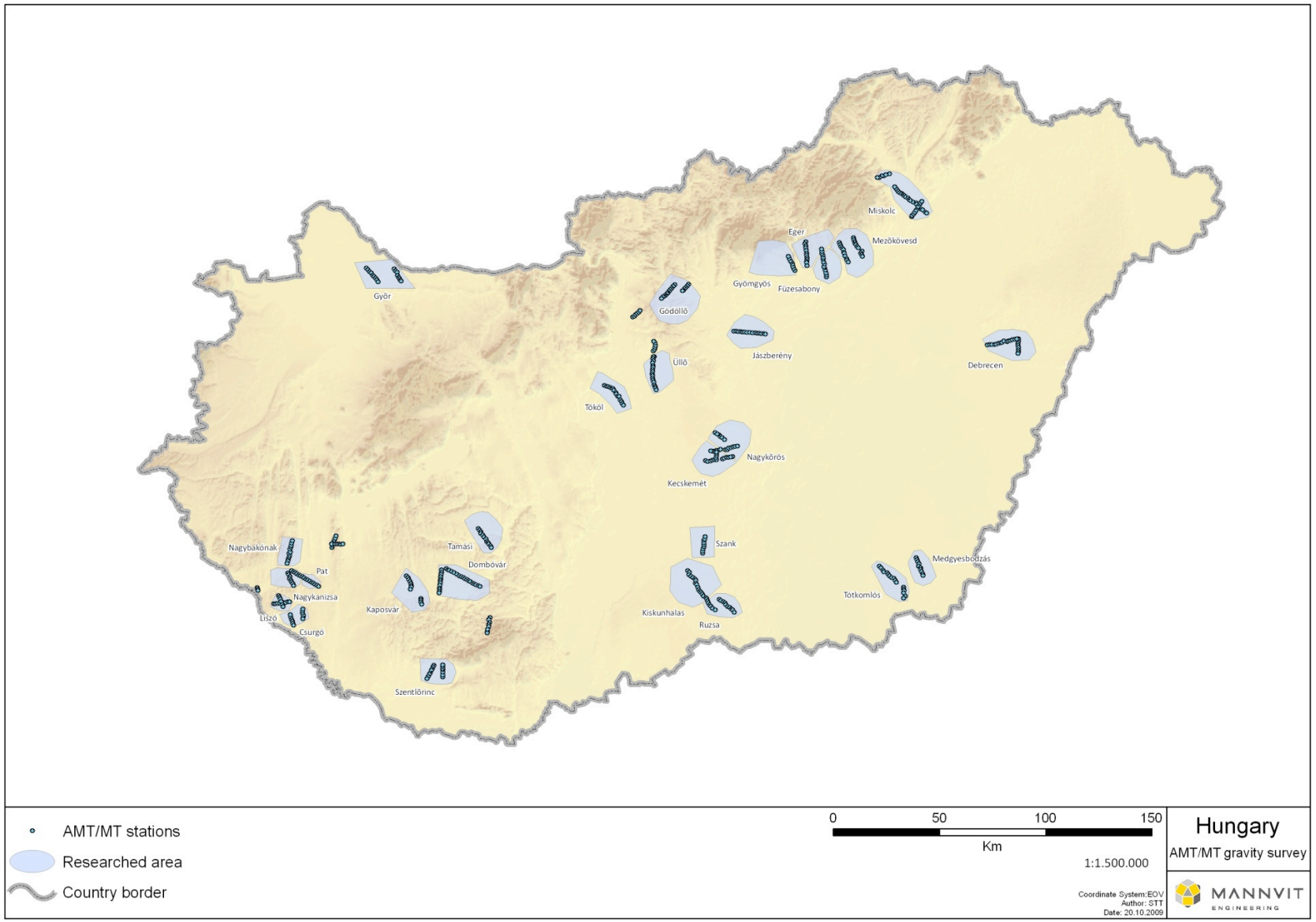
Project objectives

- **Find geothermal area for electricity & space heating:**
  - **Delineate potential geothermal locations;**
  - **Select drilling sites to evaluate geothermal reservoir potential.**

Hungary AMT/MT & gravity survey map



MT instrument field calibration

Field gravity survey calibration

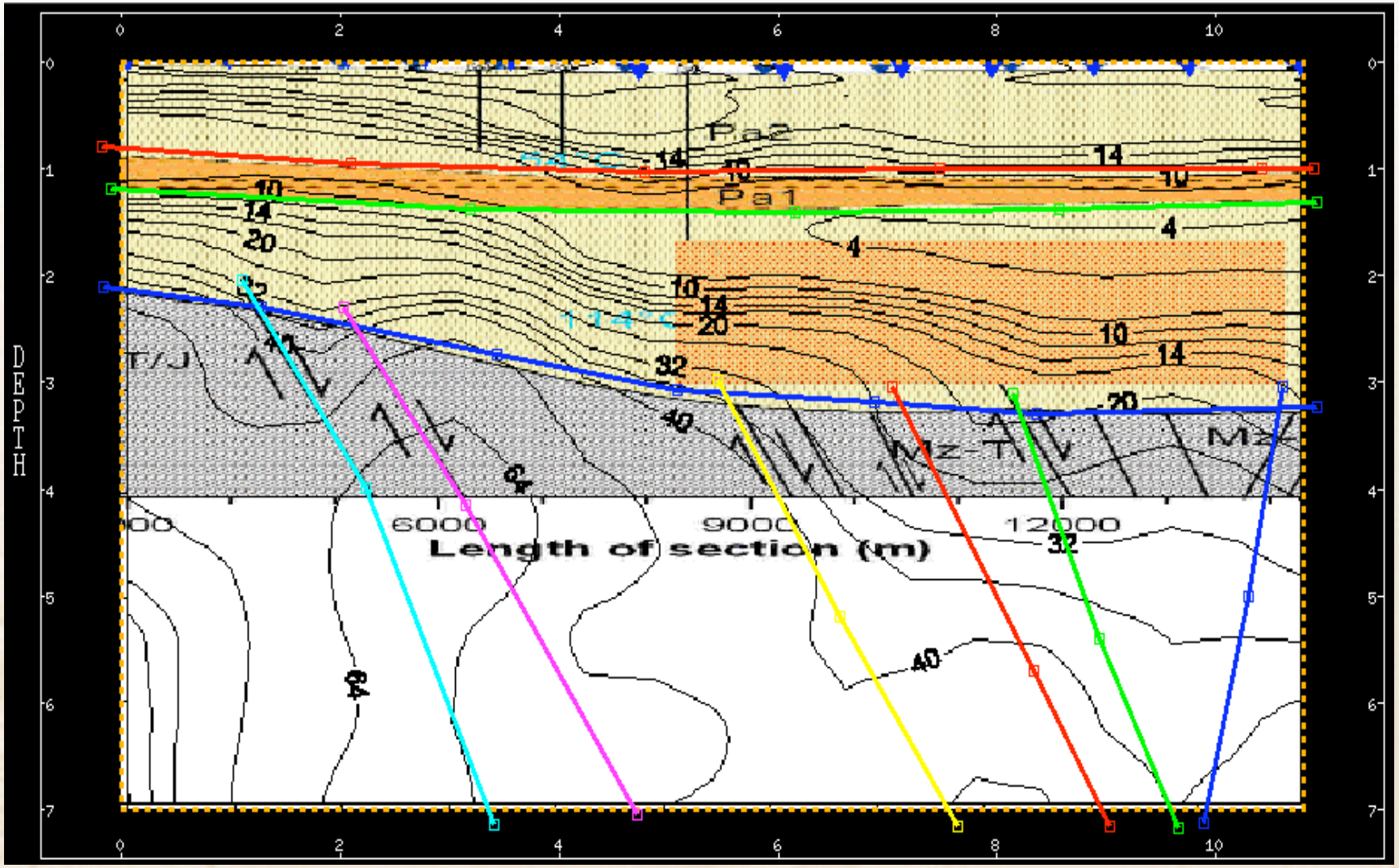
Hungary Gravity Base Network Data

4145. Csákán
Y= 513 961;
X= 133 820;
Elevation: 126.653 m
g **= 980 718.679 mgal**

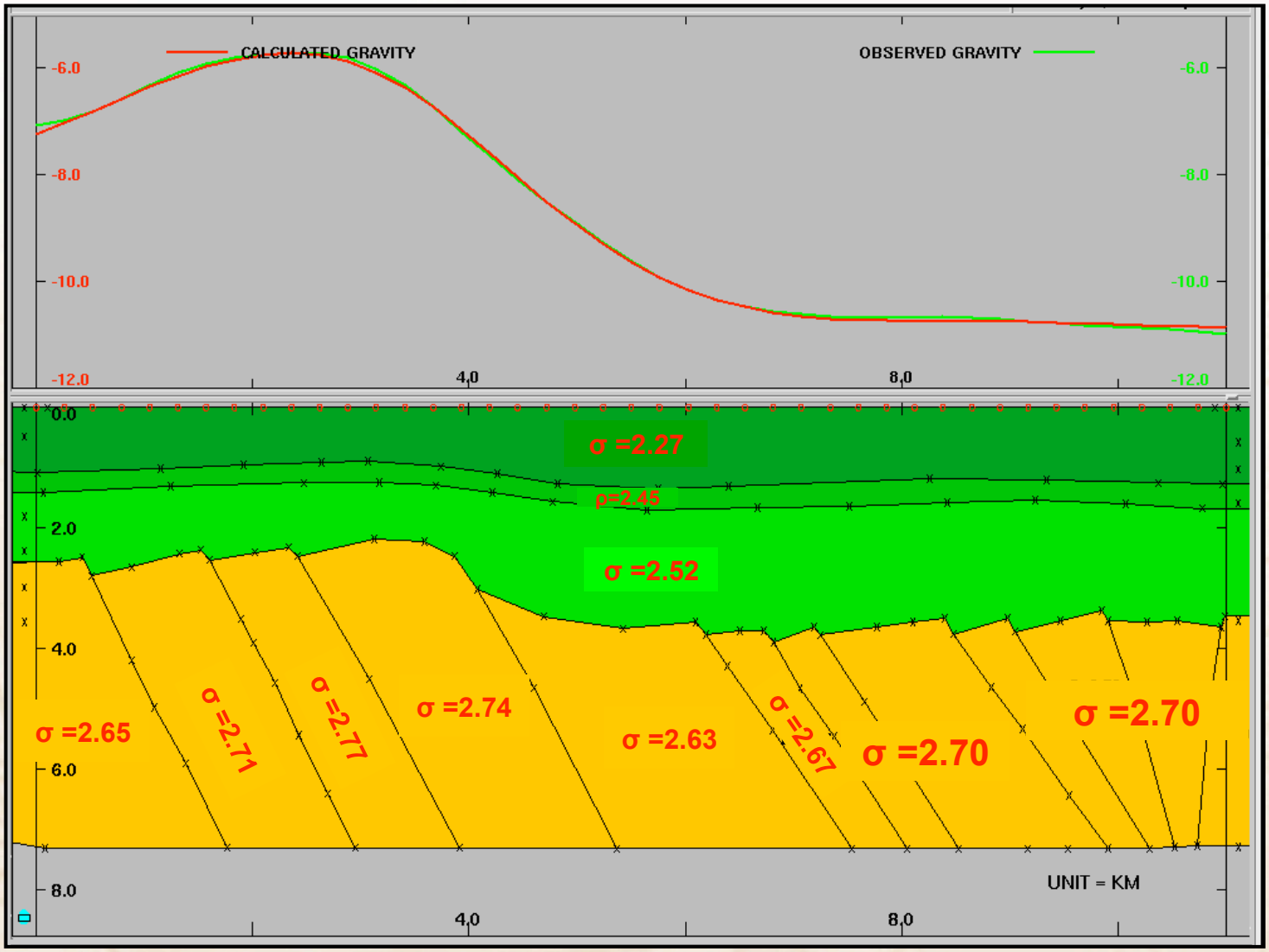
Data processing

- **MT data processing**
  - Edit data
  - Static correction
    - Remove near surface inhomogeneities (electrical property)
  - Terrain correction
- **Gravity data processing**
  - Upward continuation
  - Gravity gradient calculation
- **Cooperative inversion of MT & gravity data**

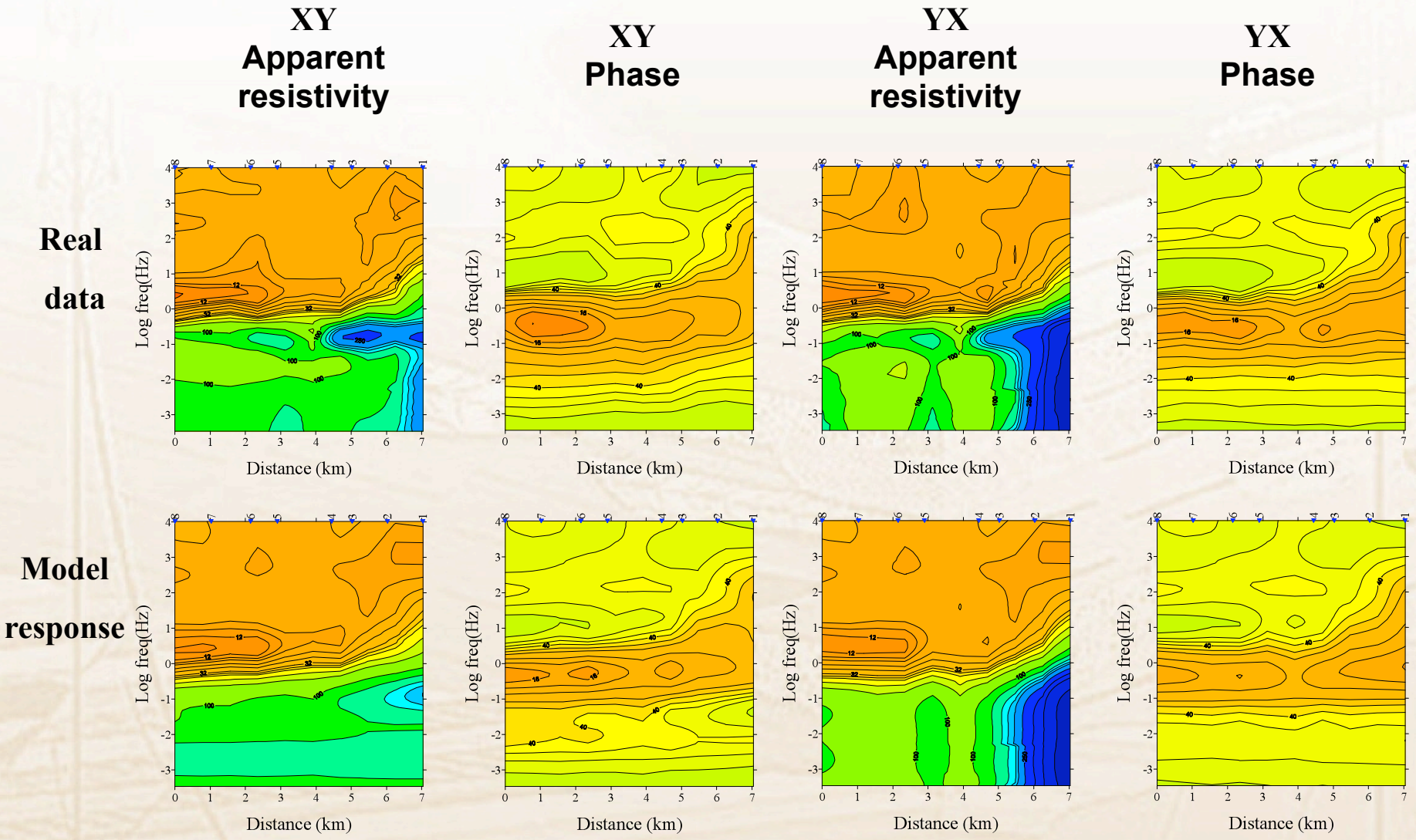
MT/Gravity cooperative inversions:
Draw layers & faults



MT/Gravity cooperative inversions:
Final geological model



Szentlörine Line Szl-01 inversion



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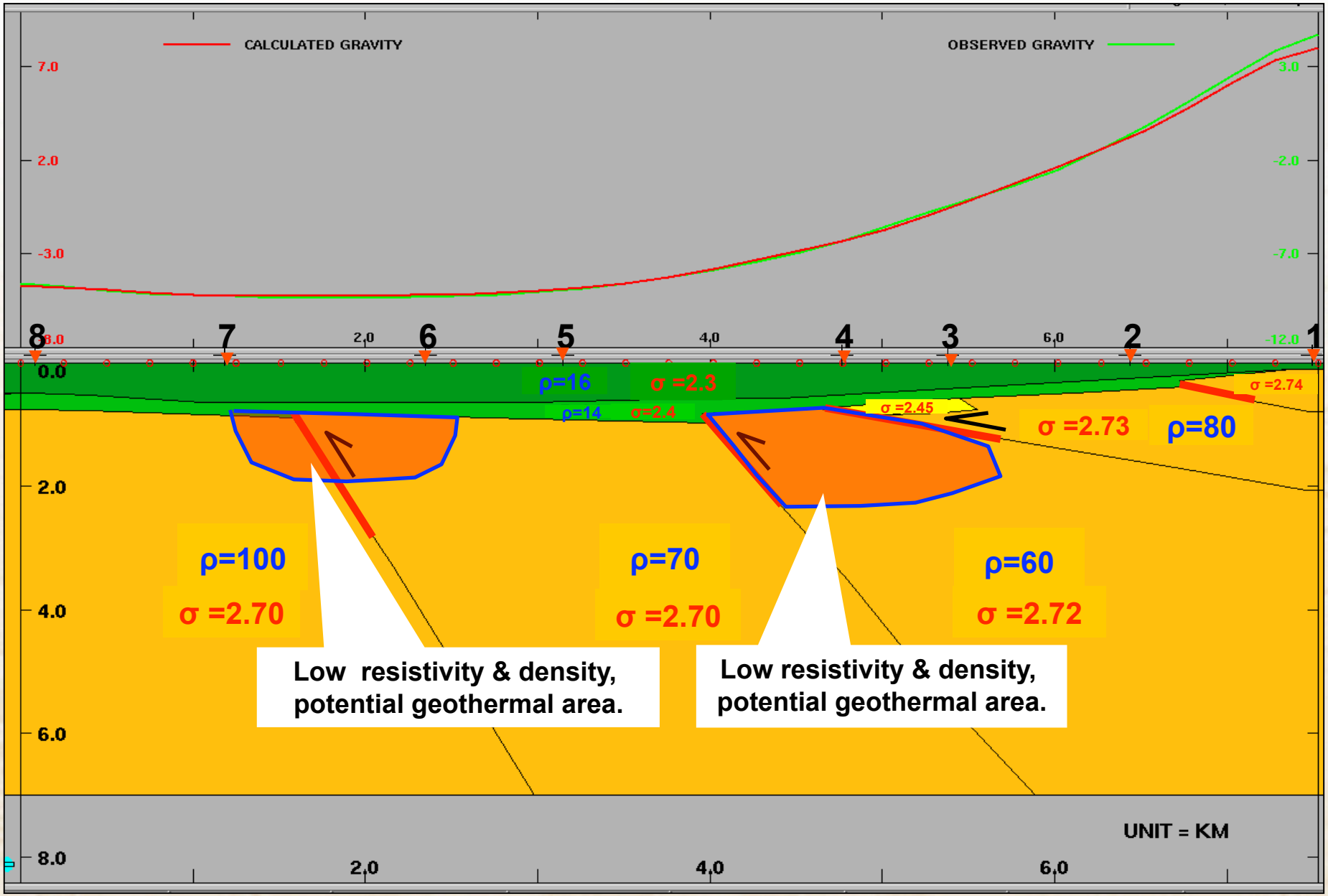
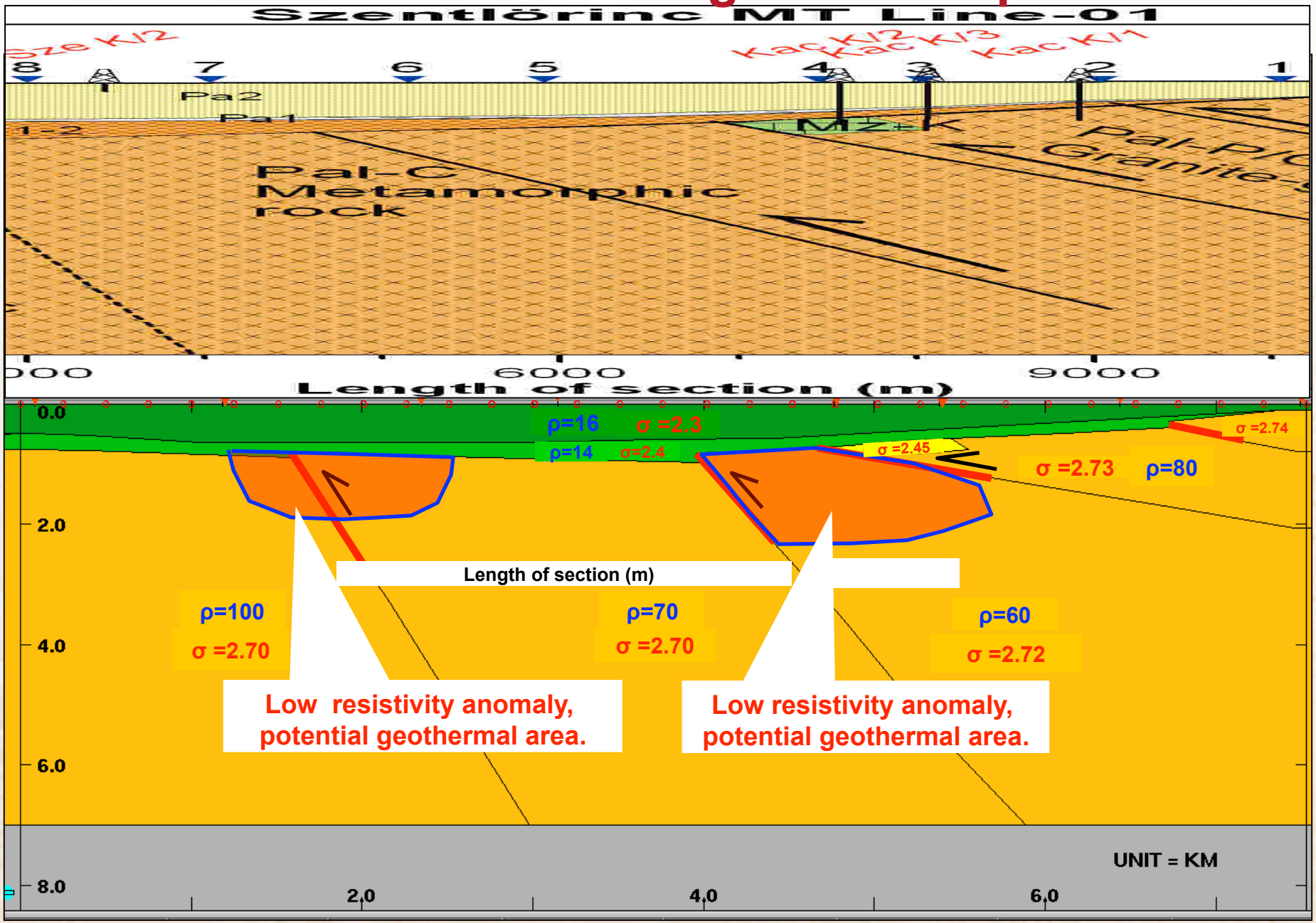
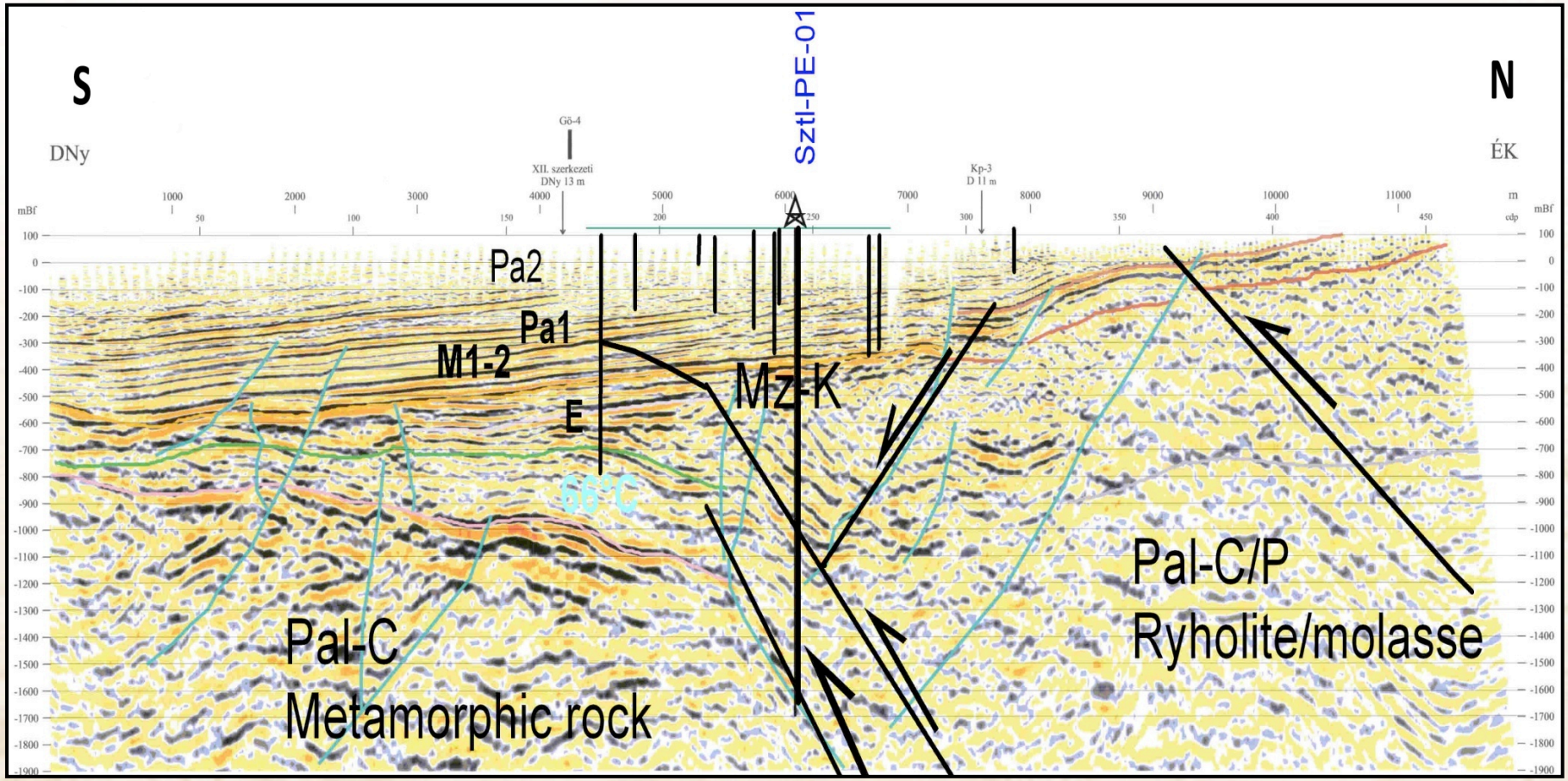
Szentlörine Line Szl-01 integrated interpretation



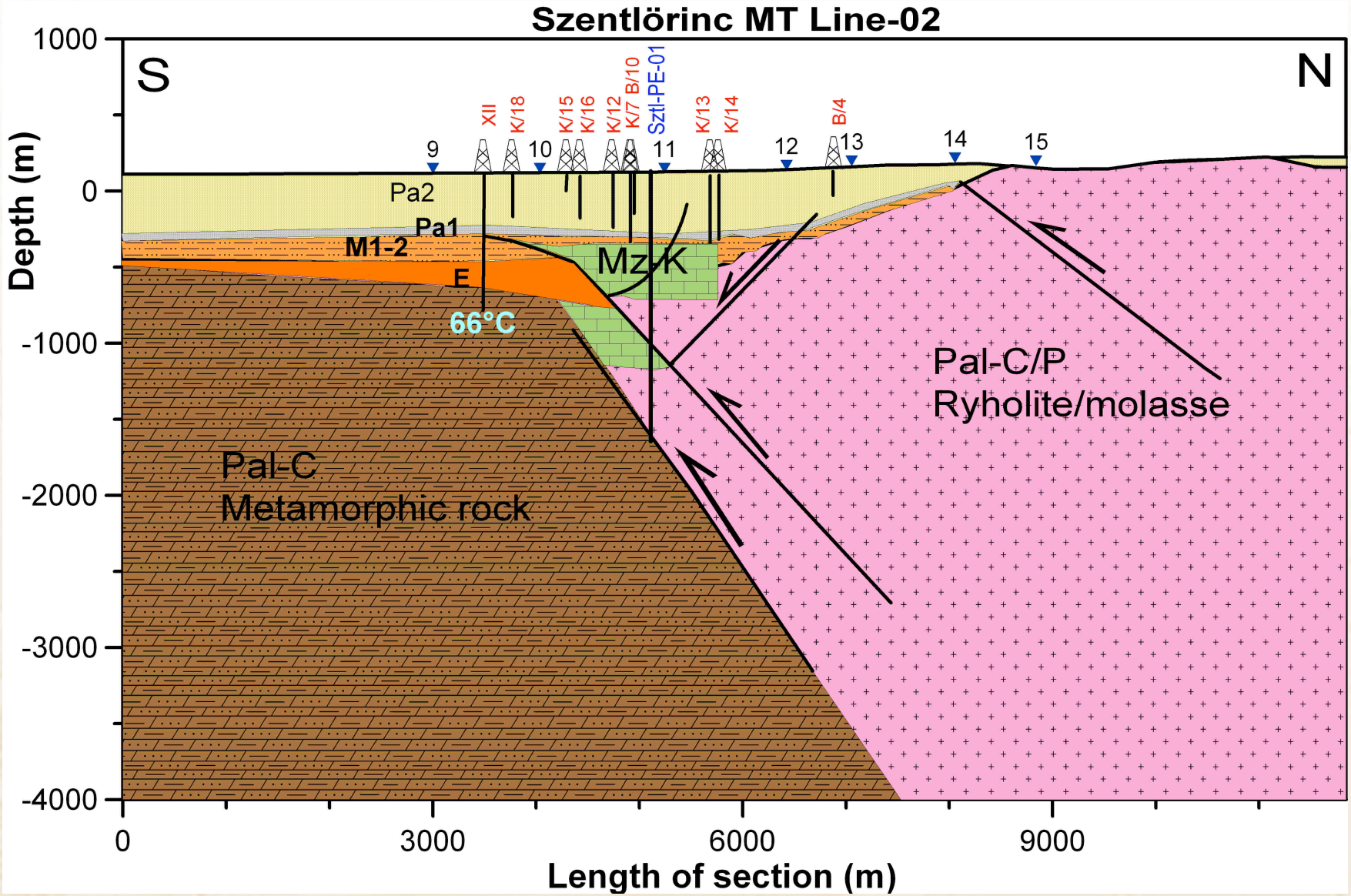
Szentlörine Line Slz-01 integrated interpretation



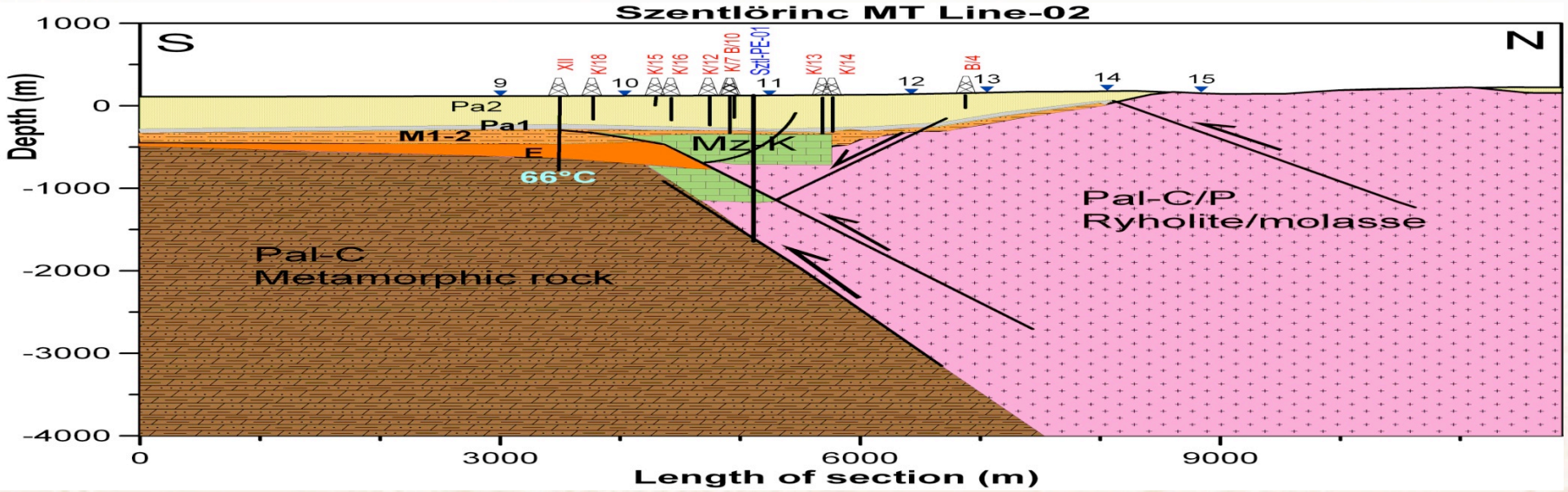
Seismic data interpretation

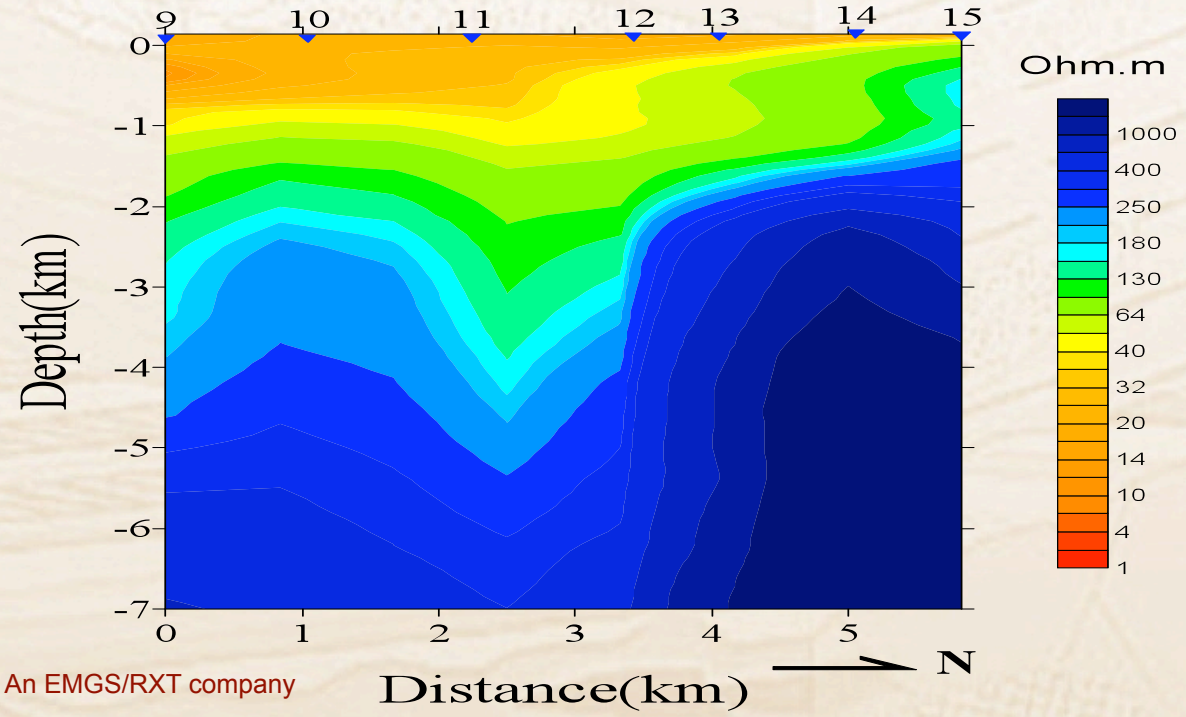


Geological model



Szentlörine Line Szl-02 AMT/MT inversion





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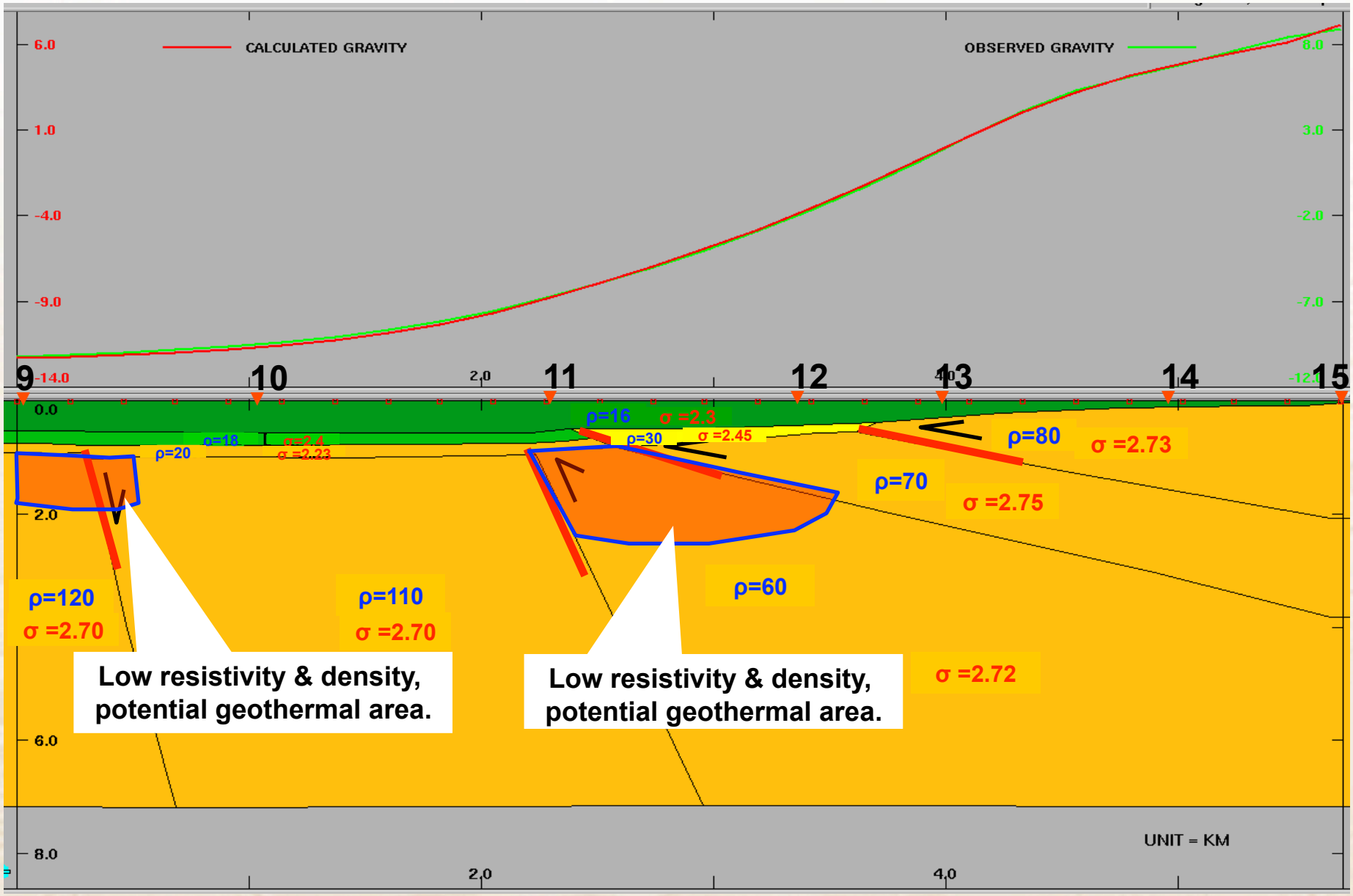
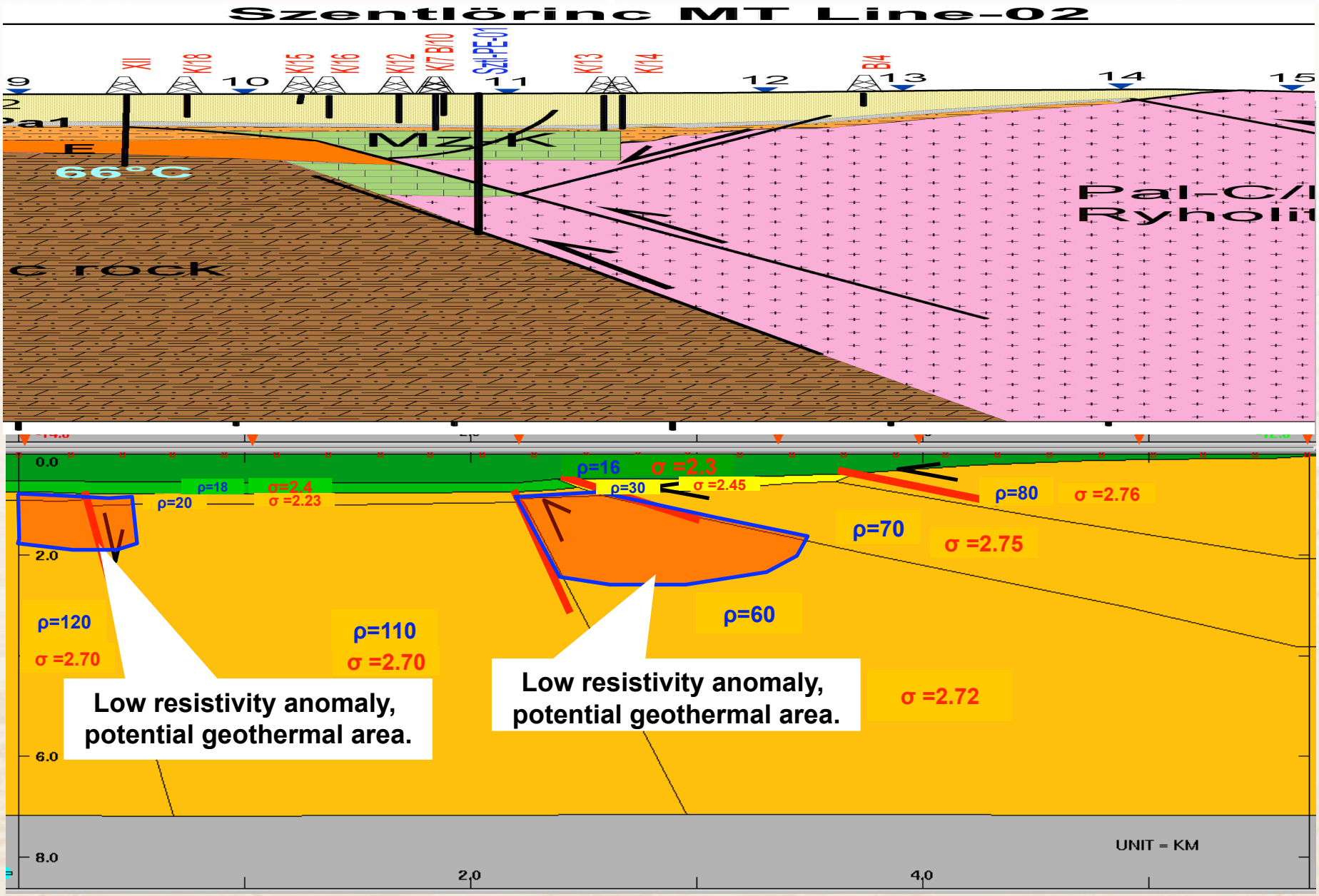
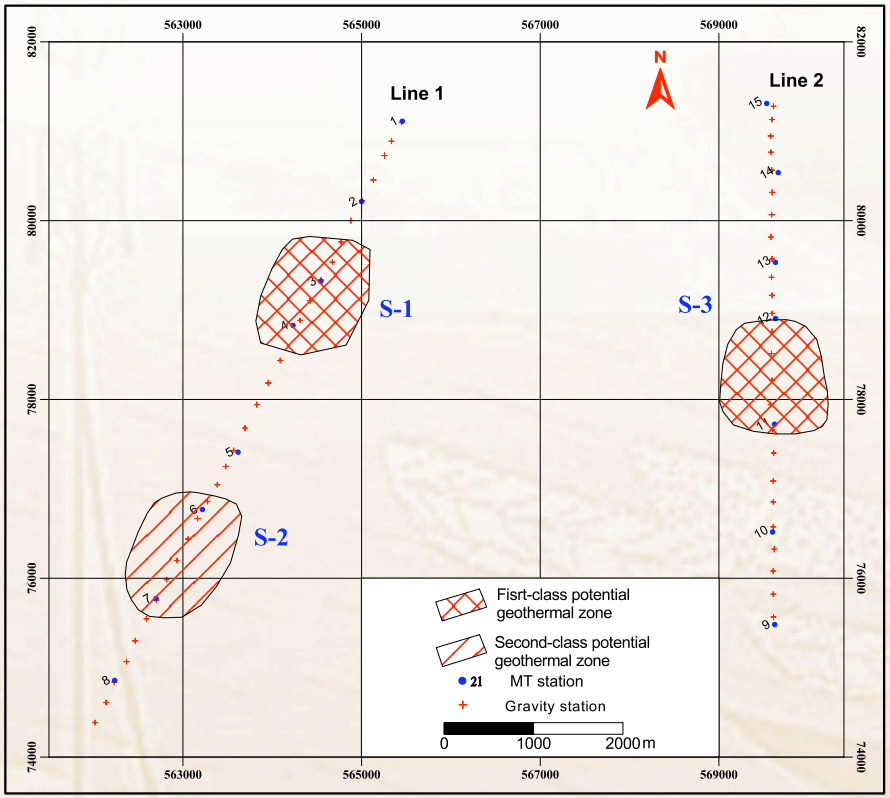
Szentlörine Line SzI-02 integrated interpretation



Szentlörine Line SzI-02 integrated interpretation

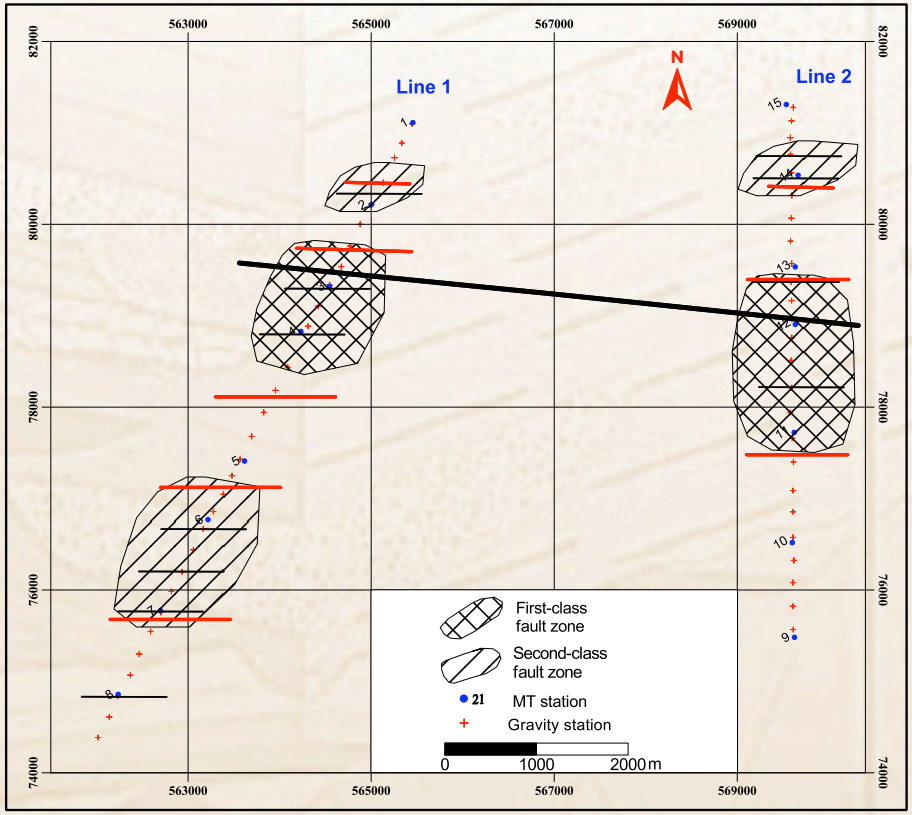


Align geothermal anomalies & fault zones



Geothermal zones

Fault zones



Geothermal drilling success! 4 MW

Video is at www.
KMStechnologies.com

Hungary conclusions

- Interpreted two 1st-class (deep faults) & one 2nd-class (shallow faults) potential geothermal targets
- Depth between 1,000 m ~ 2,000 m;
- Deep fault may extend through crust & reach mantle;
- Successfully drilled 1st evaluation well near Szl in 09/2009;
- 85°C hot water with heating capacity of 4 MW (1,620 to 1,790 m)
- 10 Y Target: to supply 700,000 homes with geothermal energy

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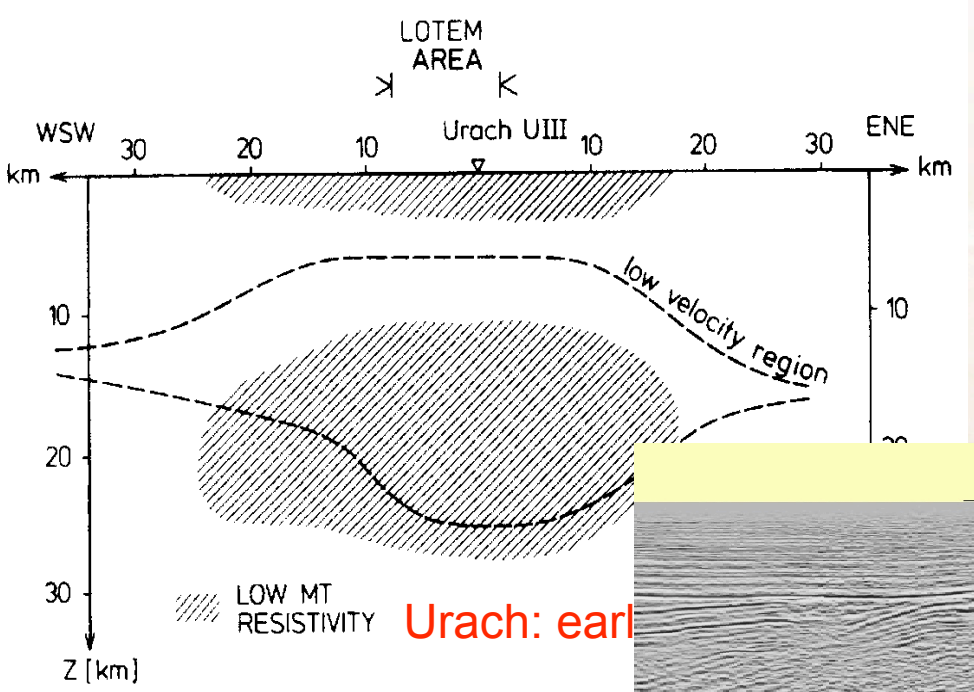
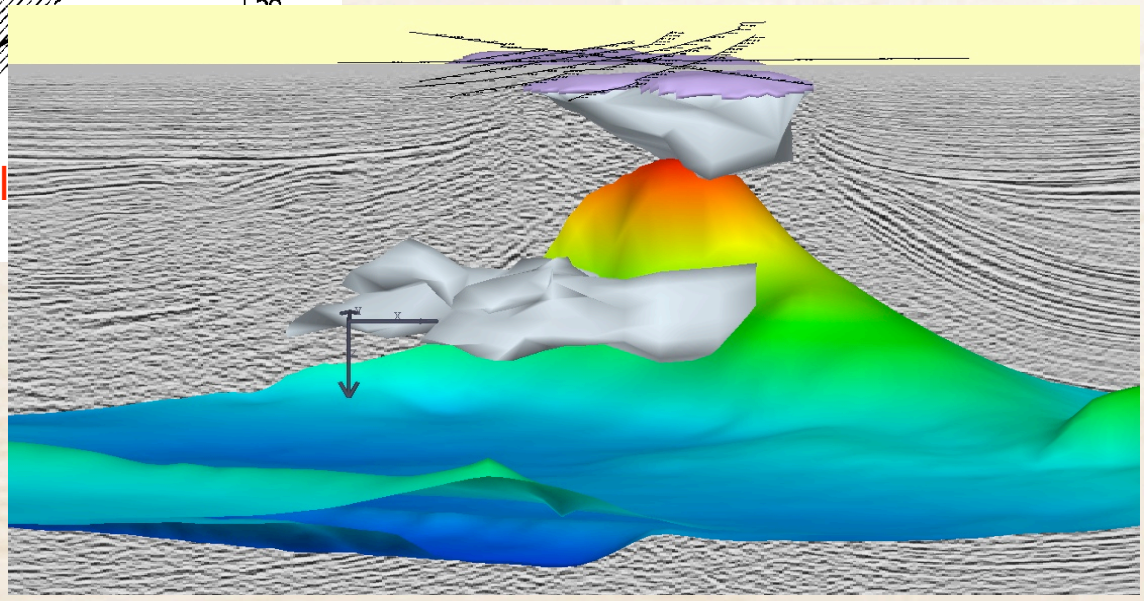
Conclusion

- MT has come a long way from rough outlines to fully integrated images
- Acquisition is still not competitive and need newer systems (like seismic)
- MT needs to be integrated with CSEM where needed and seismic and other methods (everywhere) → geologic constraints

MT: 30 years of progress

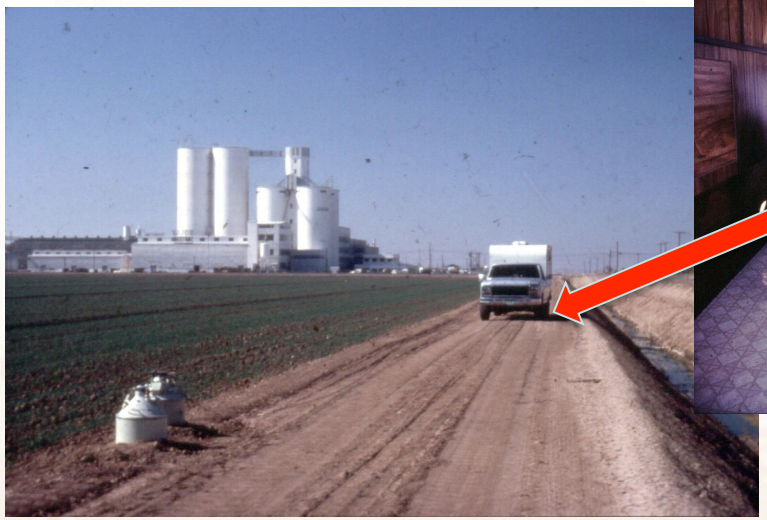


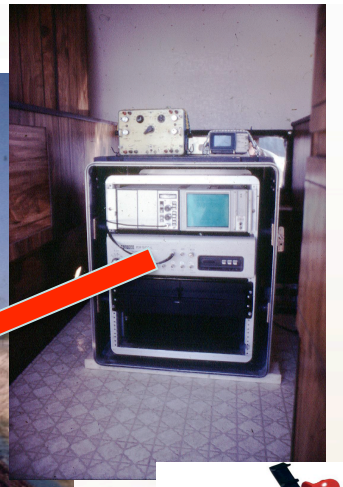
Urach: earl



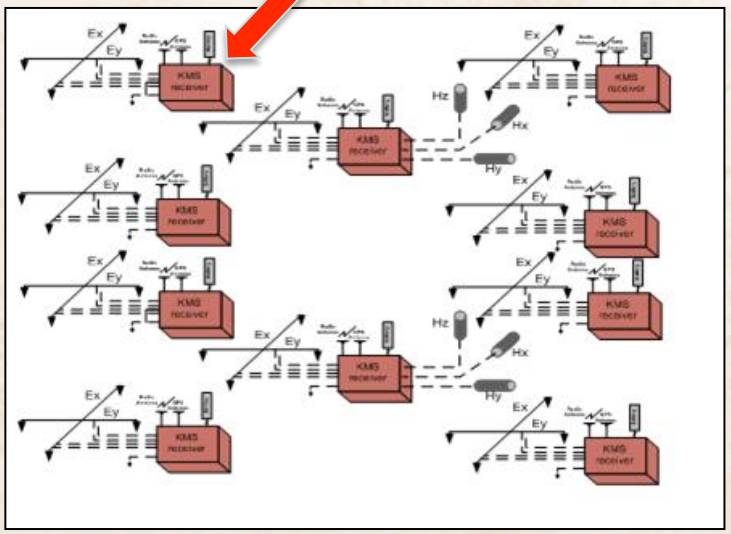
MT: 2002 vintage

UNPUBLISHED,
courtesy RWE-Dea





1981



3D receiver bin

Handheld QA/Qc

2010

Acknowledgements

Thanks to many professionals at Mannvit (formally VGK-Hönnun) and clients & collaborators.

Special thanks also to BGP, Yangtze University and KMS crew and many others for their great contributions to these projects.

This presentation will be at:
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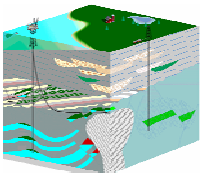
>> Technology library

Always pointing
in the right direction



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