János Kiss, Zoltán Szabó:

Dream of Eötvös — results of gravity and magnetic deep geological research

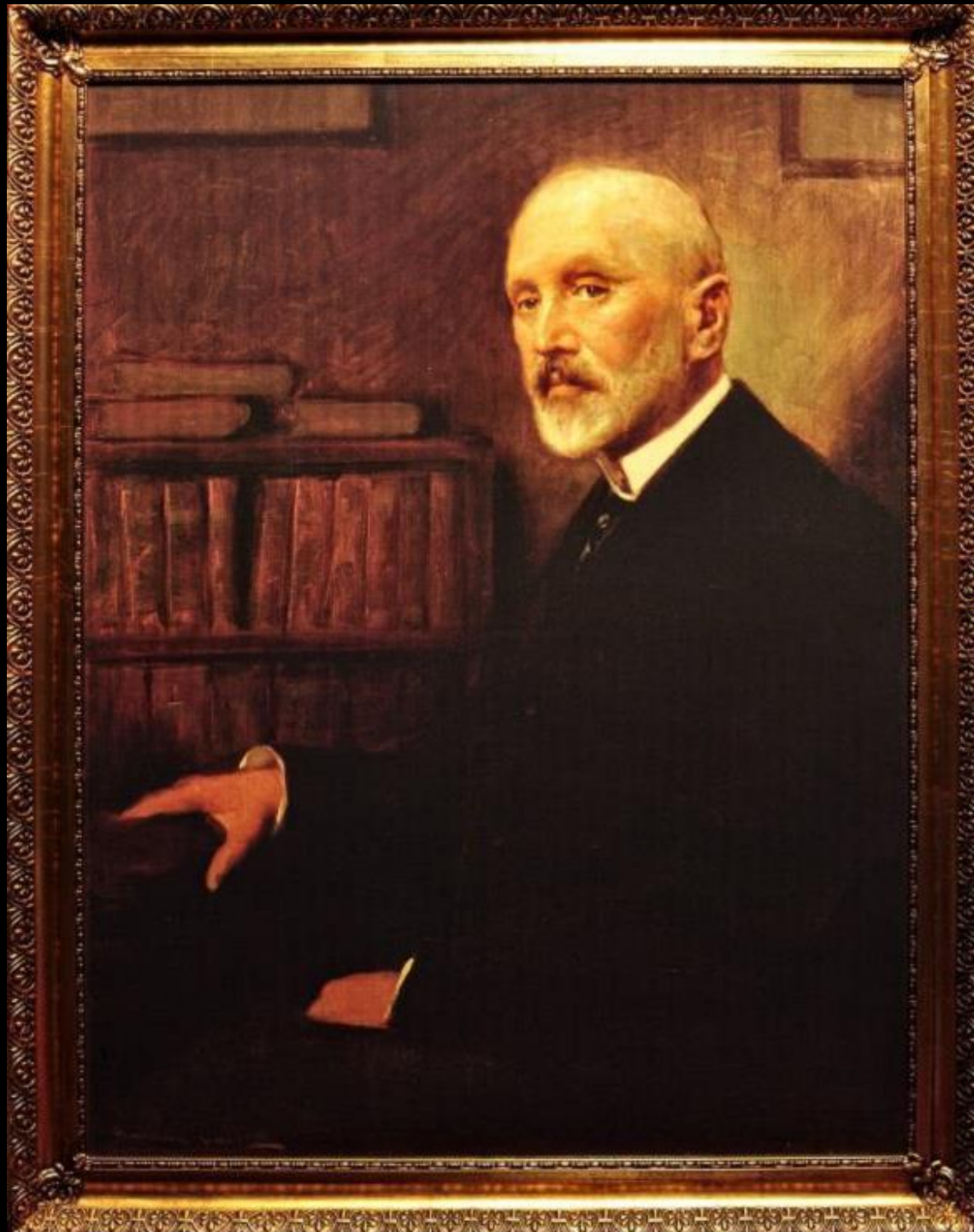
(The application of gravity and magnetic data for the investigation of the deep structure of the Carpathian Basin)

„Beneath our feet stretches the open country of the Hungarian Plain, crowned with hills.

It was gravity which smoothed its surface. I wonder what it was like in former days. What sort of hills have been eroded and what valleys filled with loose deposits before this fertile area of golden grain came into being, this life-giving Hungarian Plain?

While I walk upon it and eat its bread my mind dwells upon these questions which would give me such joy to answer."

Baron Loránd Eötvös

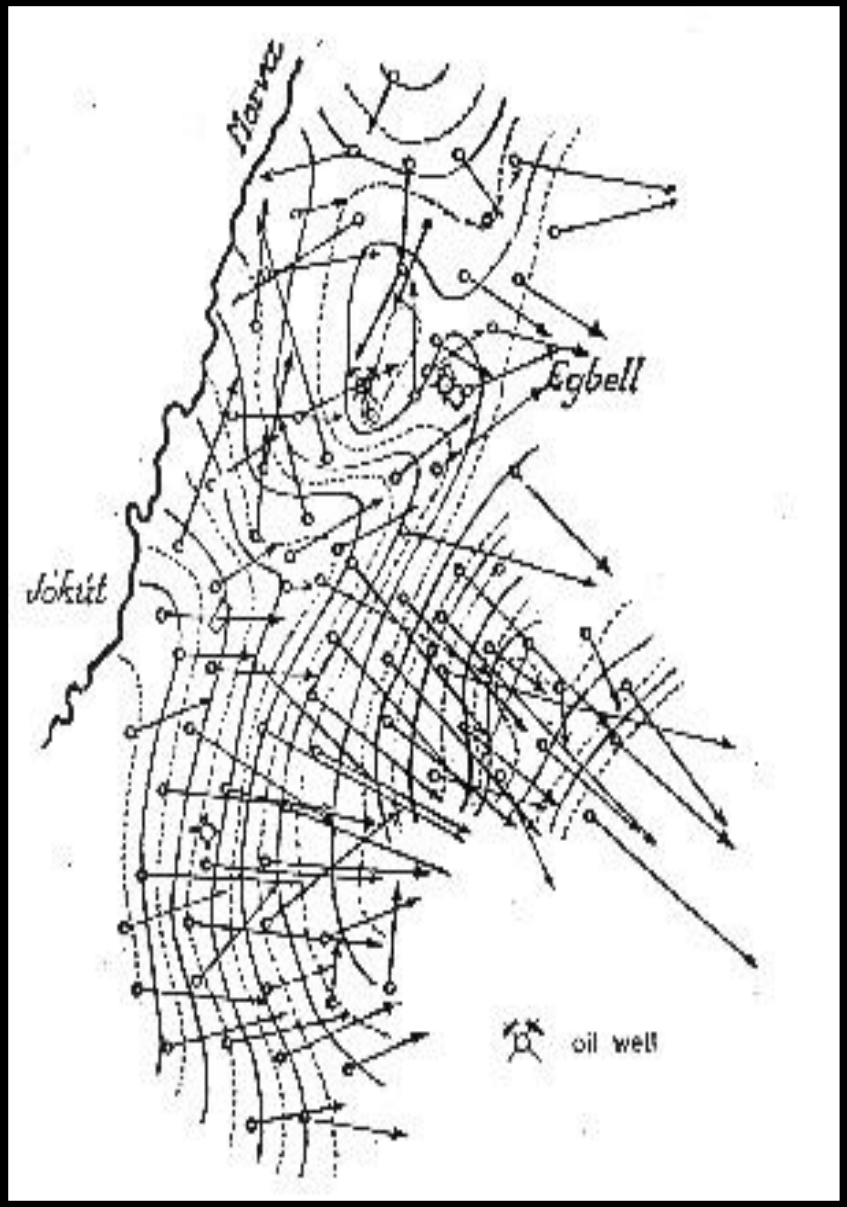


Double balance, 1902

In 1891, Eötvös chose for the first field test of his torsion-balance – initially developed for basic research purposes and primarily for laboratory use – the location of Colonel Sterneck's former pendulum survey on Ság-hill (near Celldömölk) where he found 33 mGal difference between two points about 150 m apart.

Eötvös considered such a high difference suspicious: „our theories of gravity are unable to account for such a high change in such a short distance". The gravity effect of the truncated cone-shaped basalt hill was relatively well predictable.

Eötvös' measurements proved not only the applicability of his torsion-balance in field conditions, but in accordance with geology resulted in 4,7 mGal between Sterneck's two points. Thus he could declare: „everything is all right on Ság-hill".



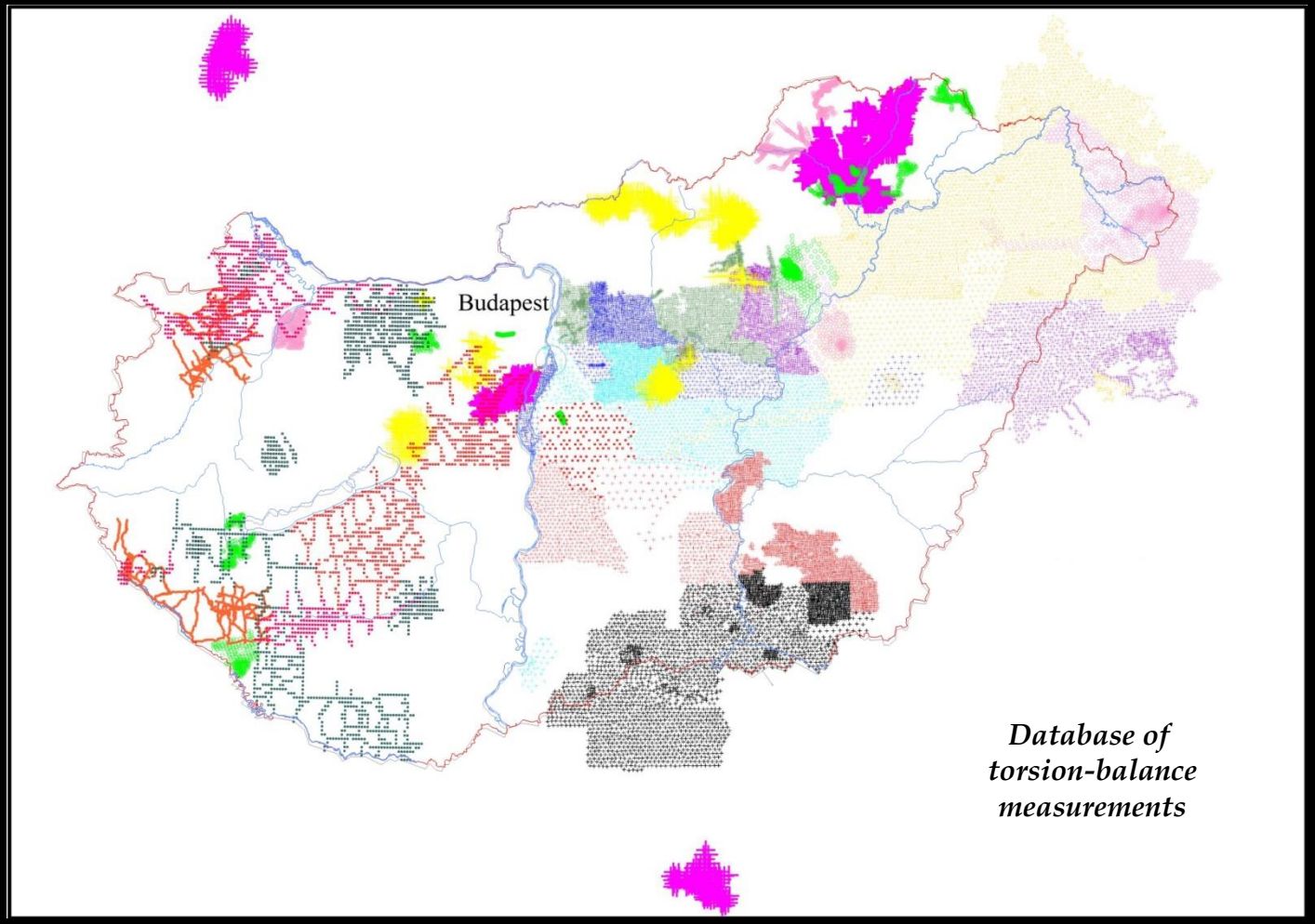
The first successful torsion-balance survey over an oil-bearing geological structure was near Egbell (Gbely).

The gradients and the Bouguer-anomaly map inferred from them, outline the contours of the anticline.

This survey opened the way for hydrocarbon exploration with the torsion-balance all over the world and for a new science: exploration geophysics.

…and the Eötvös torsion-balance revealed hundreds of productive structures and billions of barrels of crude oil.

Torsion-balance surveys in Hungary. By the end of the 1930s the smaller and more easy-to-handle gravimeters — although are less intelligent and of lower sensitivity than torsion balances — were more productive and gradually took over the role of the latter in hydrocarbon exploration.

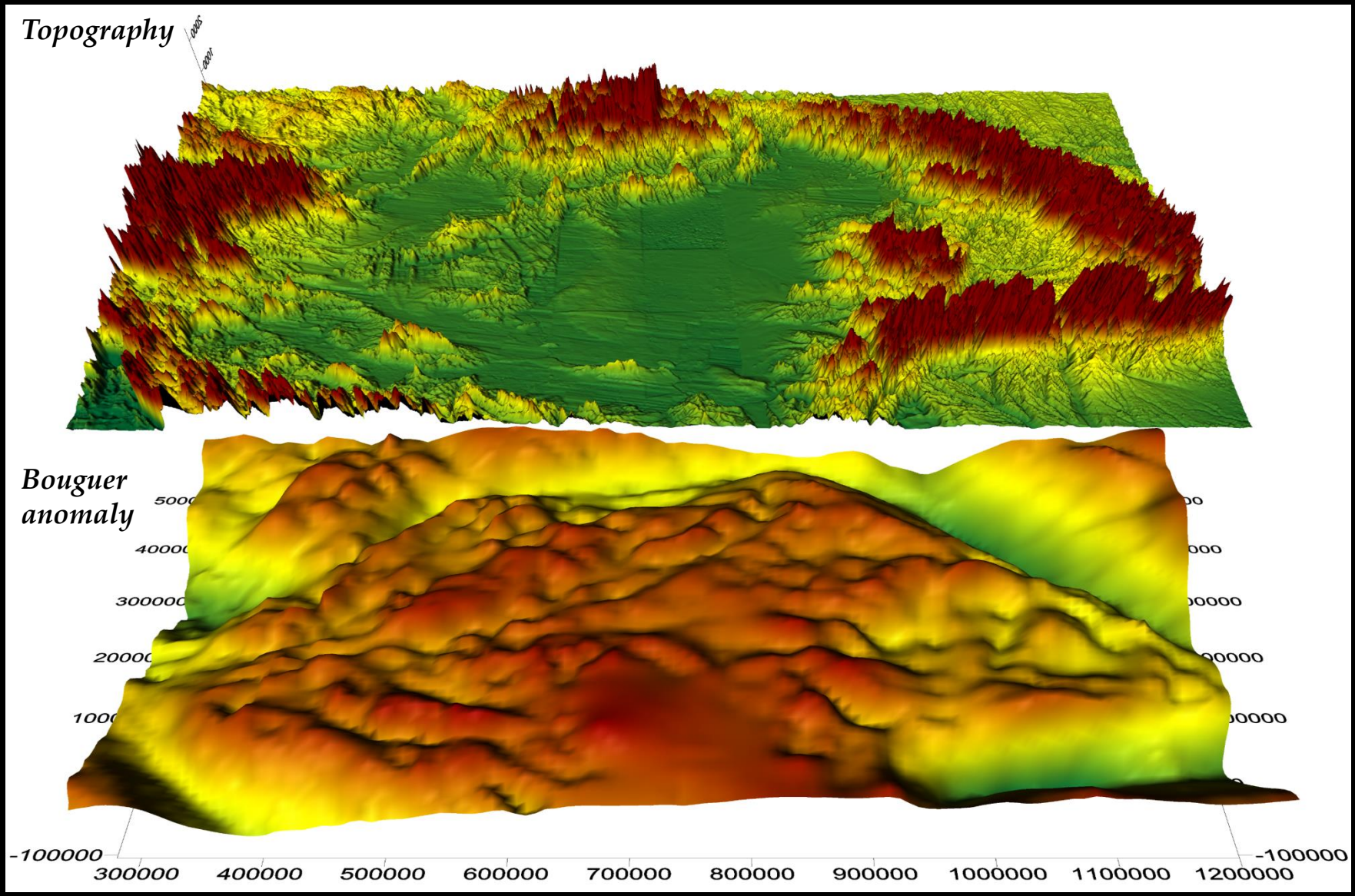


Database of torsion-balance measurements

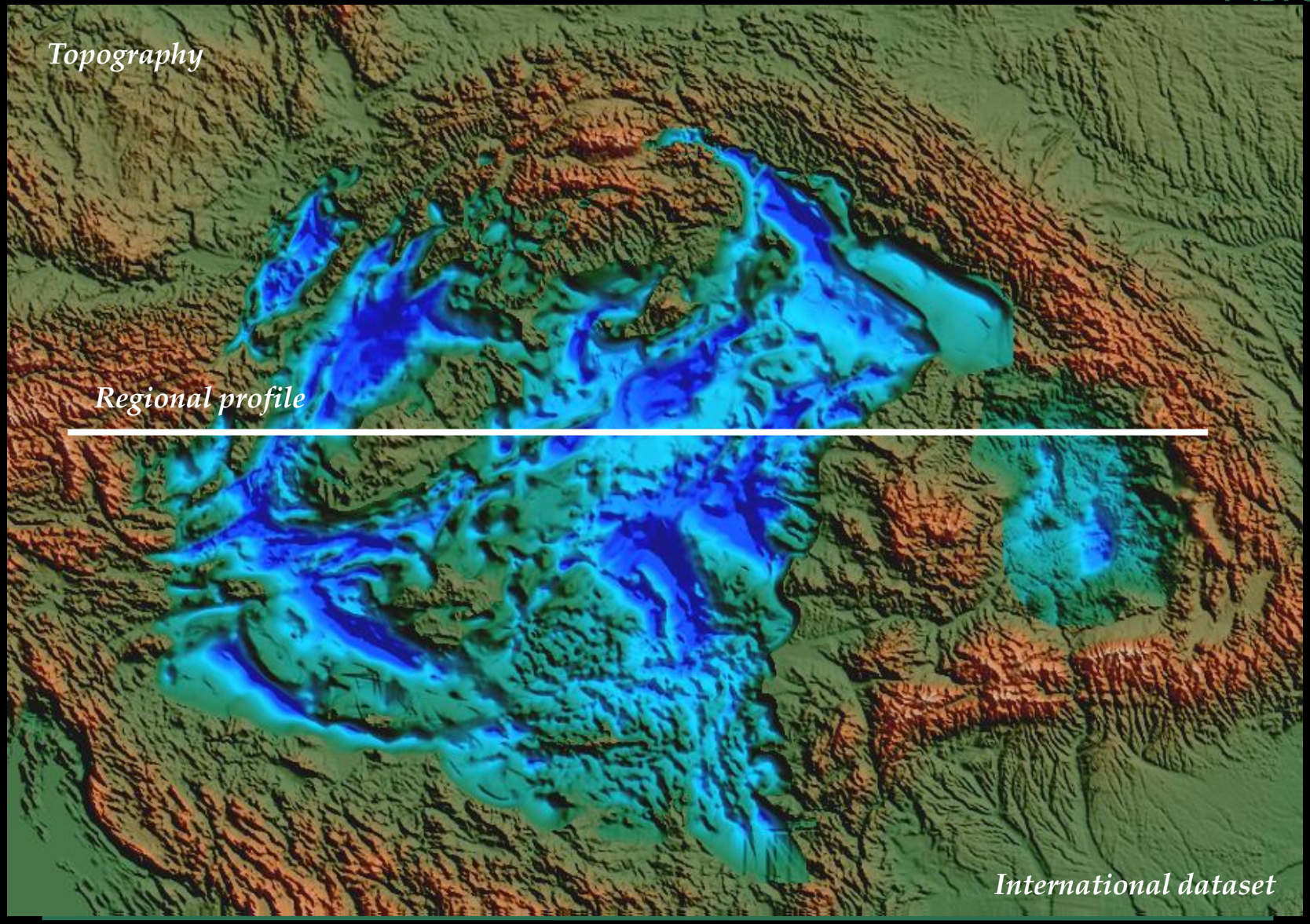
In Hungary, however, torsion-balance surveys continued till 1966 parallel to gravimeters.

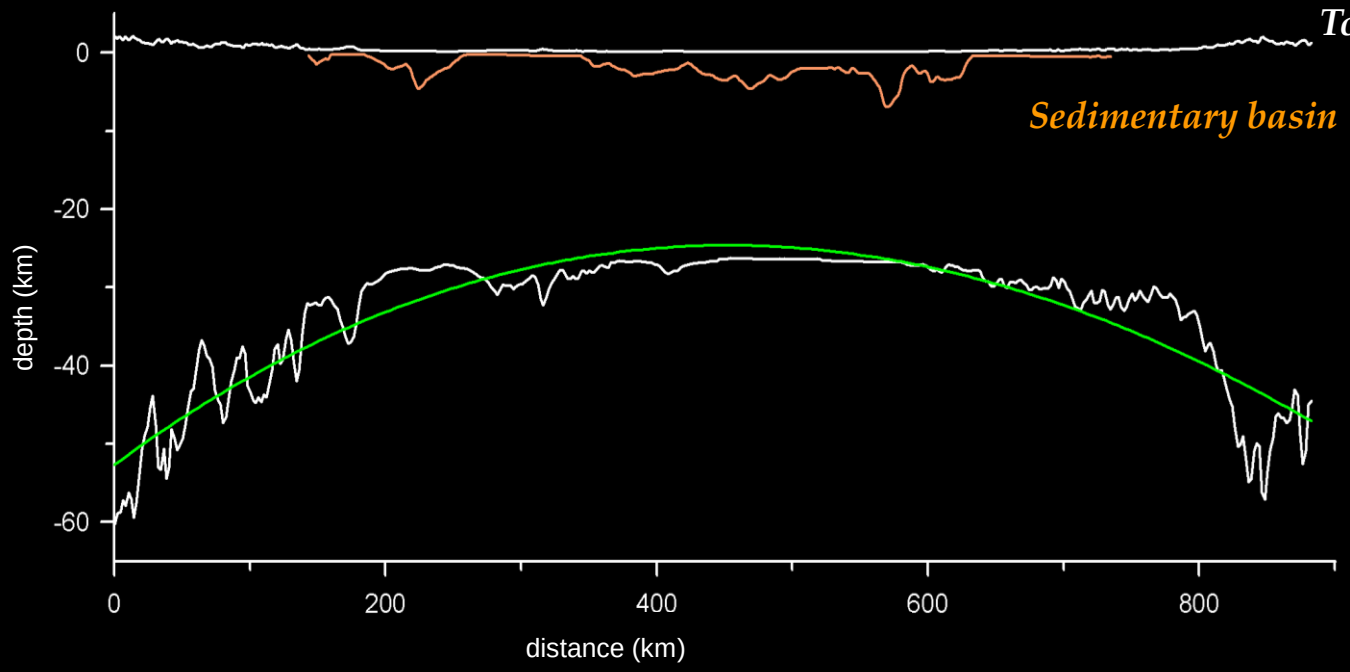
Originally, there were about 60.000 stations from which 41.983 could be inserted into the databank.

The topography and the gravity anomaly map. There is a robust regional gravity effect due to the Mohorovičić discontinuity of the Carpathian–Pannonian region. A negative correlation is between the two surfaces.

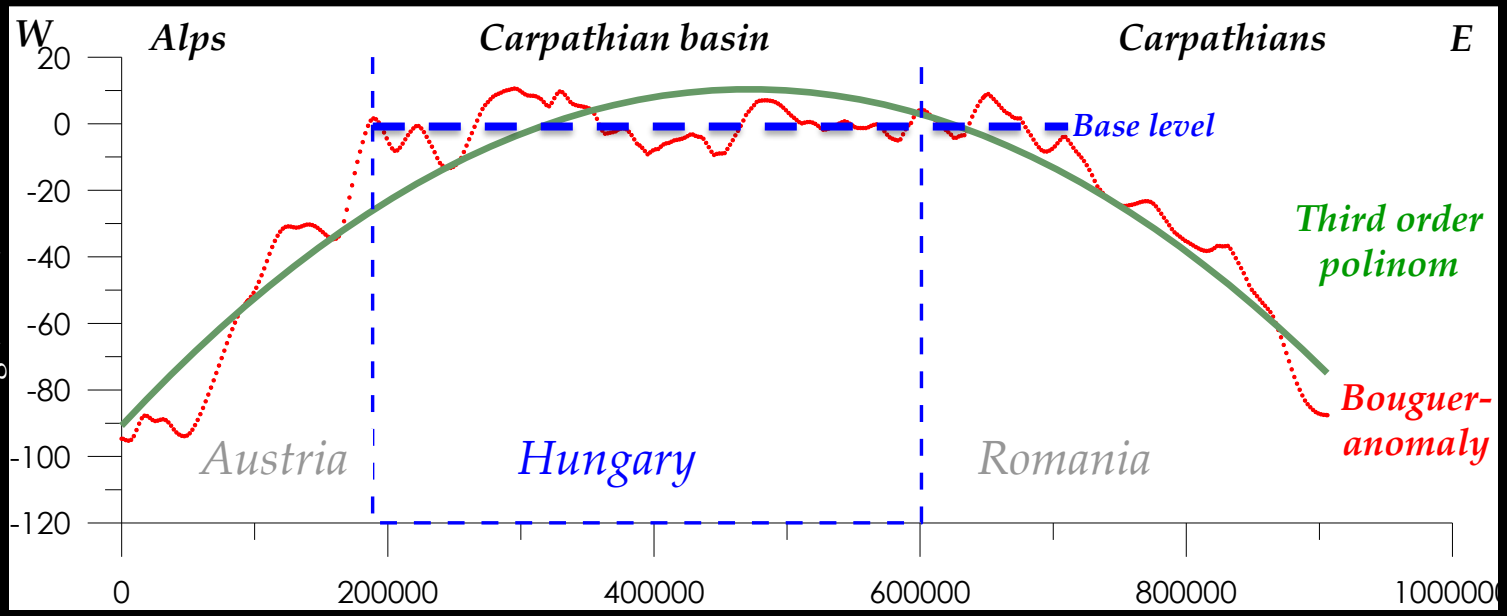


Beyond the crustal thickness, we can identify further density changes that occur above the sedimentary basins and are primarily related to the thickness of the loose sediments.

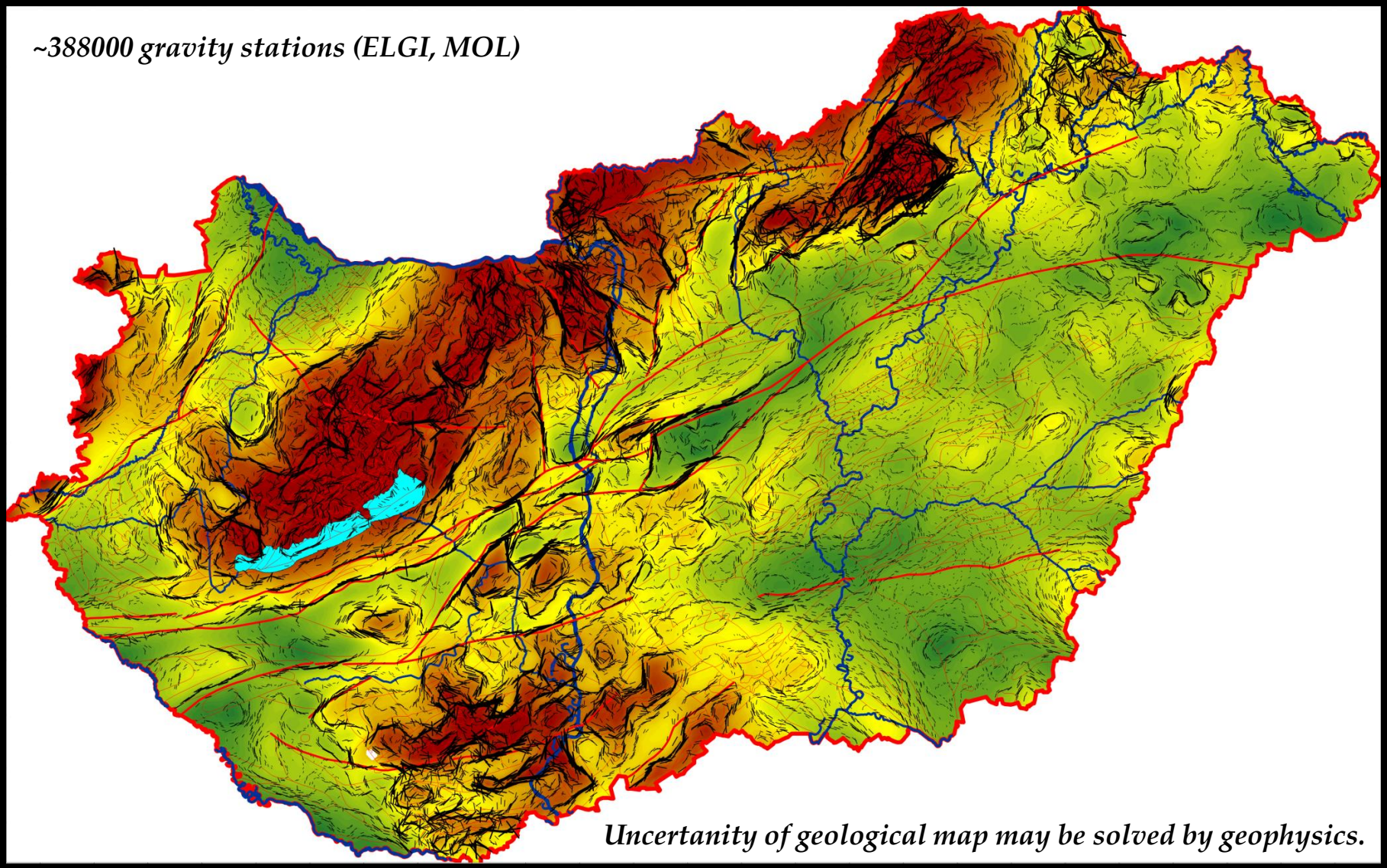




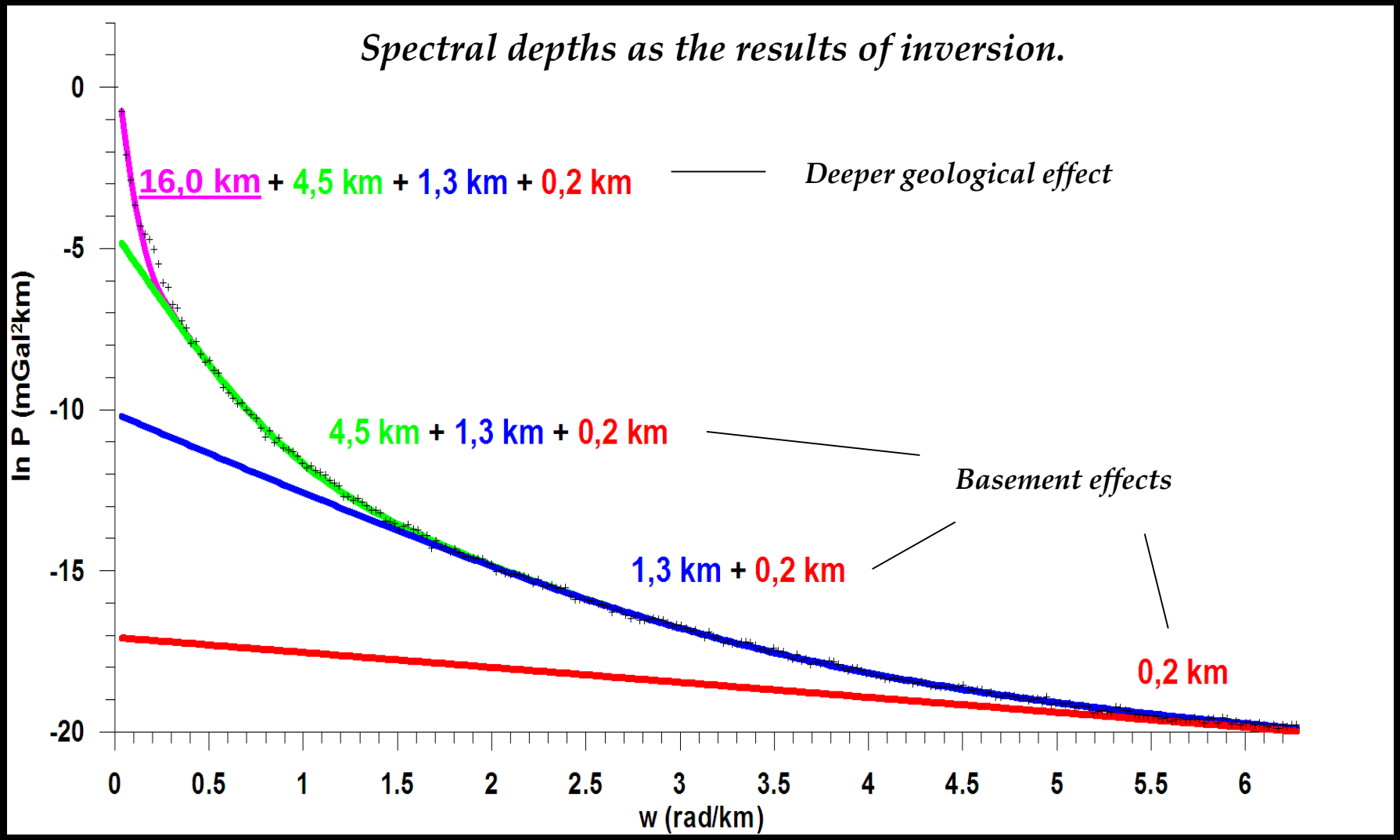
Calculated crust-mantle boundary based on isostasy



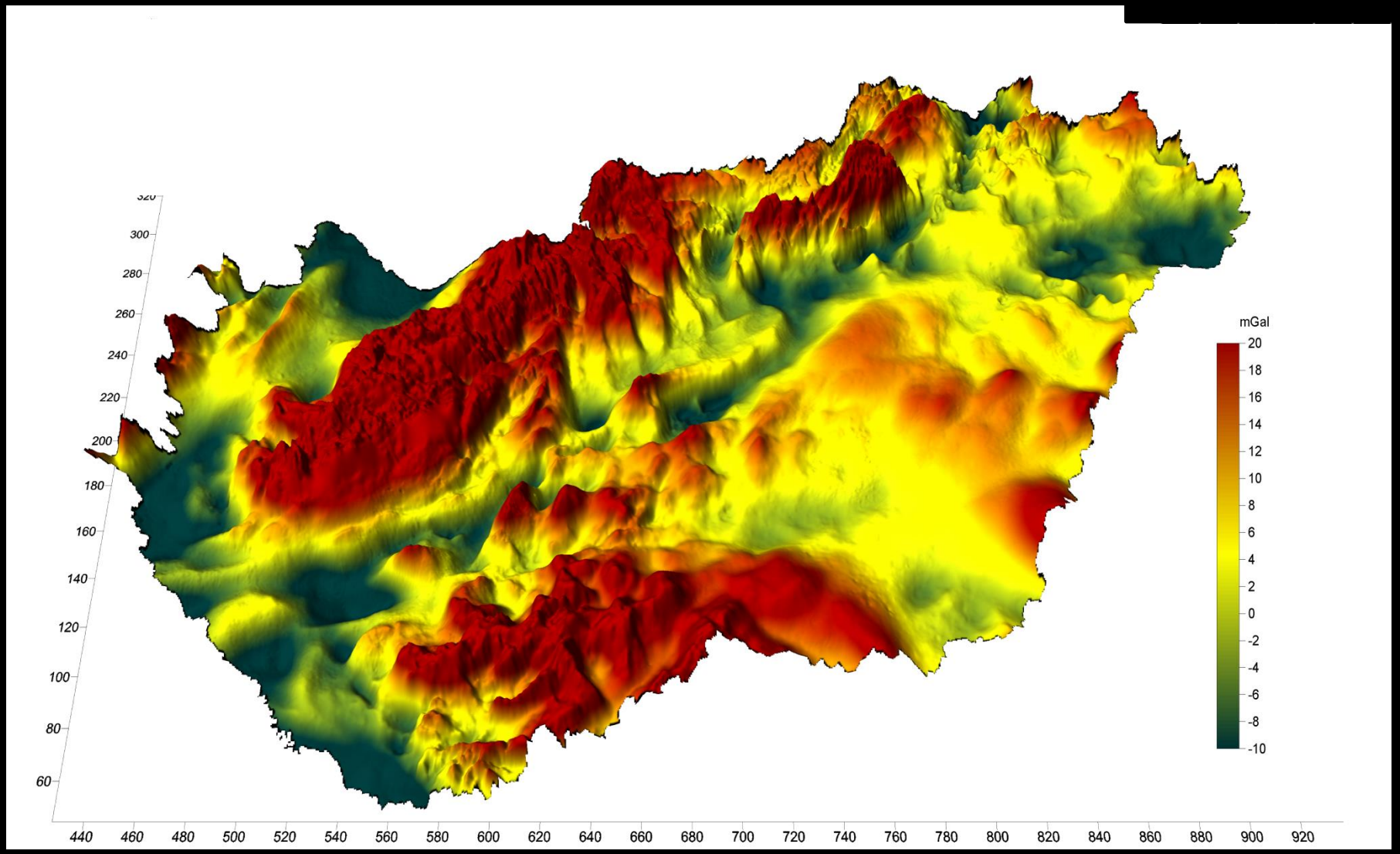
The measured data and its horizontal gradients (already used by Eötvös) also indicate the location of boundaries of buried geological formation, the location of the faults and the tilt angle or strike direction of the structures.



The power density spectrum is the sum of the spectra of gravity effects of different depths, this can be interpreted by inversion of spectra of equivalent gravity sources.

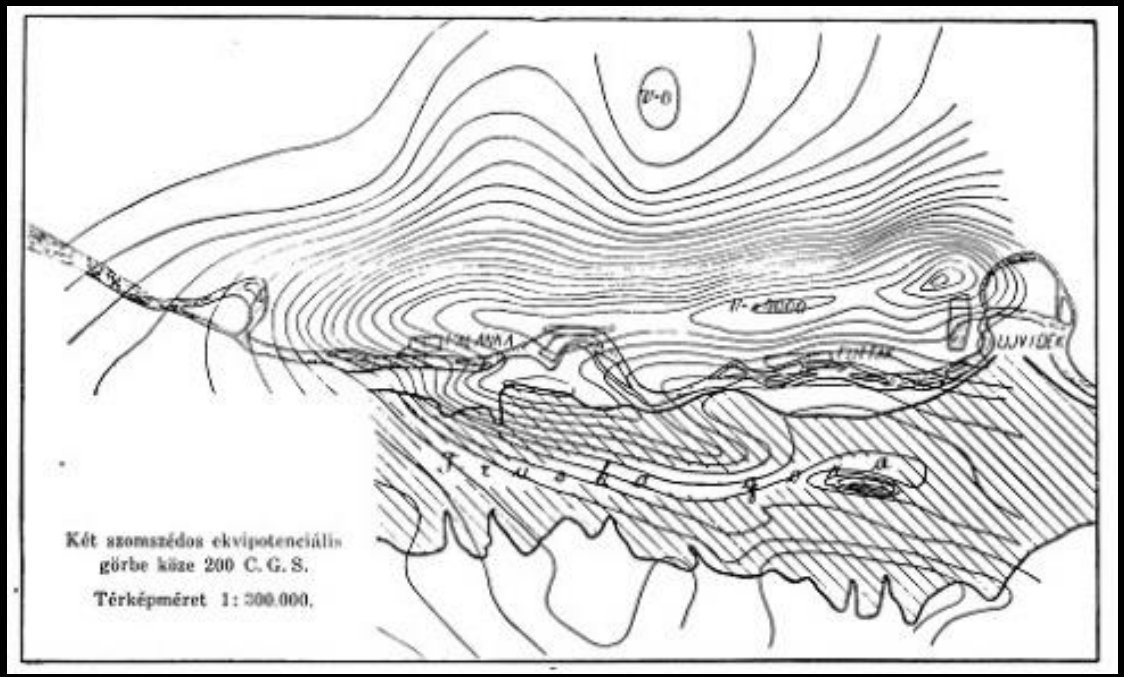


Gravity effects of different depth domains cause anomalies of different lengths. We detect all these signals together as parts of gravity Bouguer anomaly.

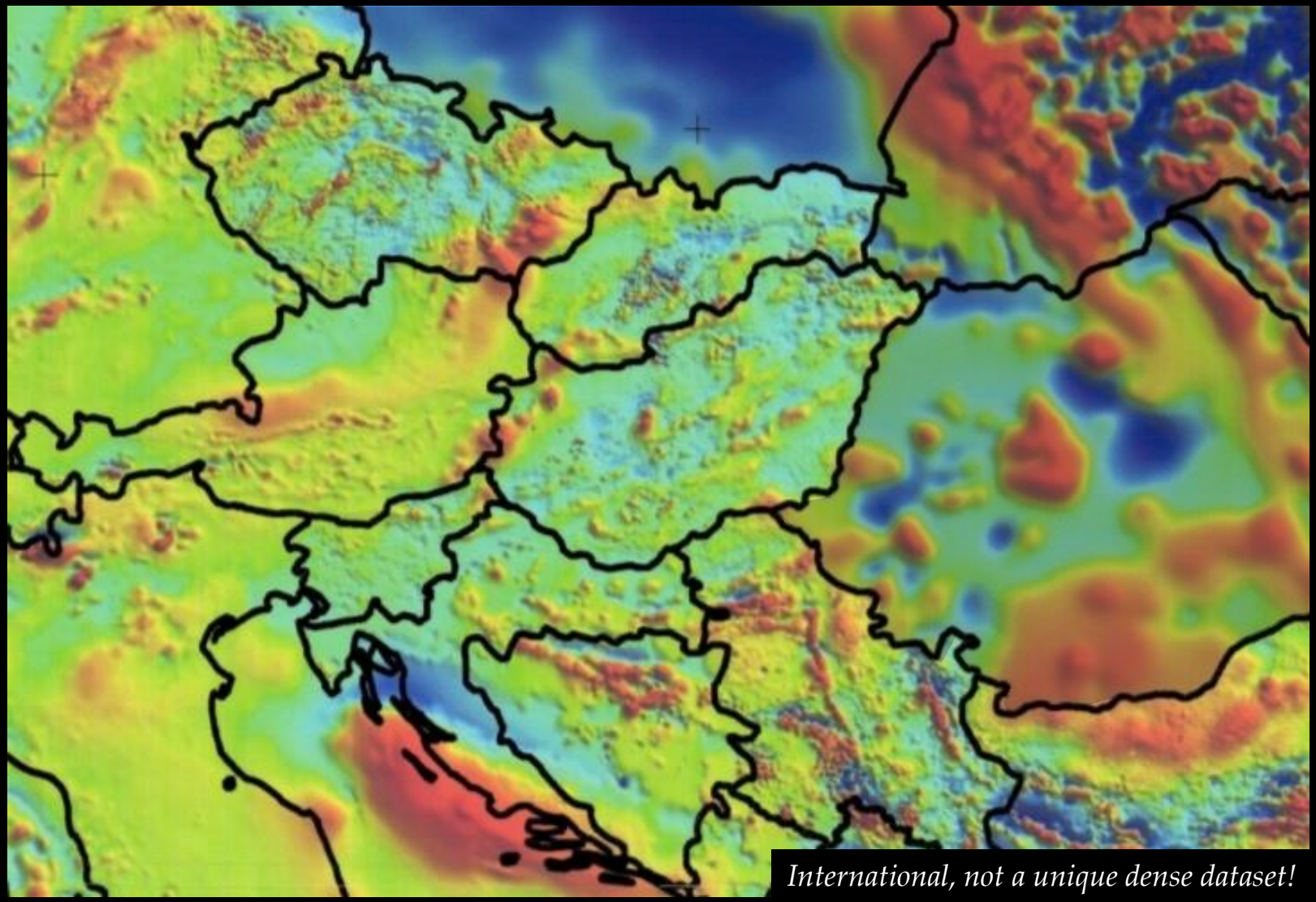


Eötvös developed geomagnetic instruments too, similarly to his torsion balance . The too sophisticated and too sensitive instruments were found not practical on field use, but he could use them for paleo- and archaeomagnetic investigations.

Eötvös' geomagnetic survey over the Fruska Gora area (1902–04). From the very beginning of field surveys, Eötvös used gravity and magnetic measurements opening the possibility for integrated interpretation.

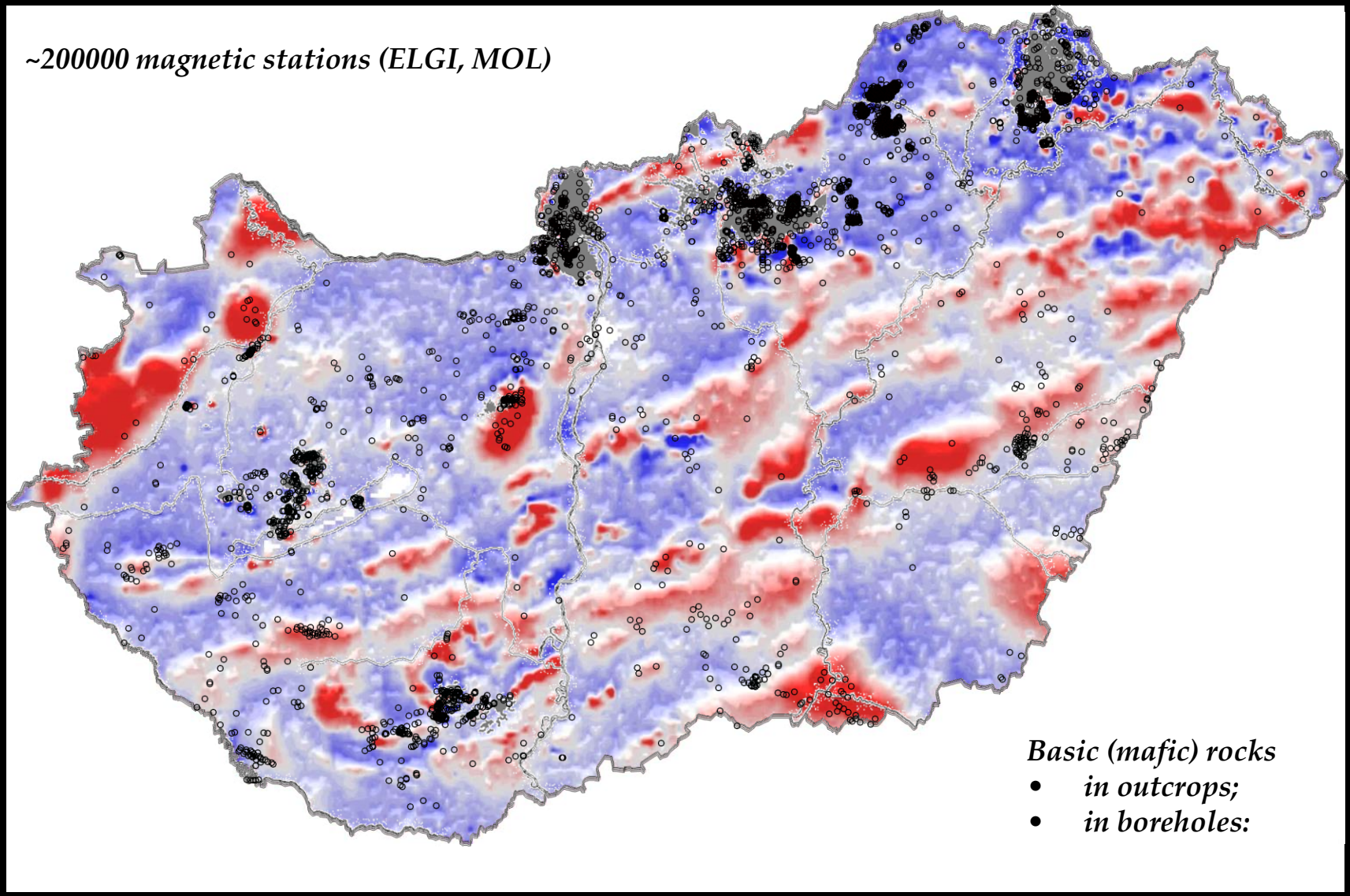


Geomagnetic map of Europe based on a non-uniform-density magnetic dataset

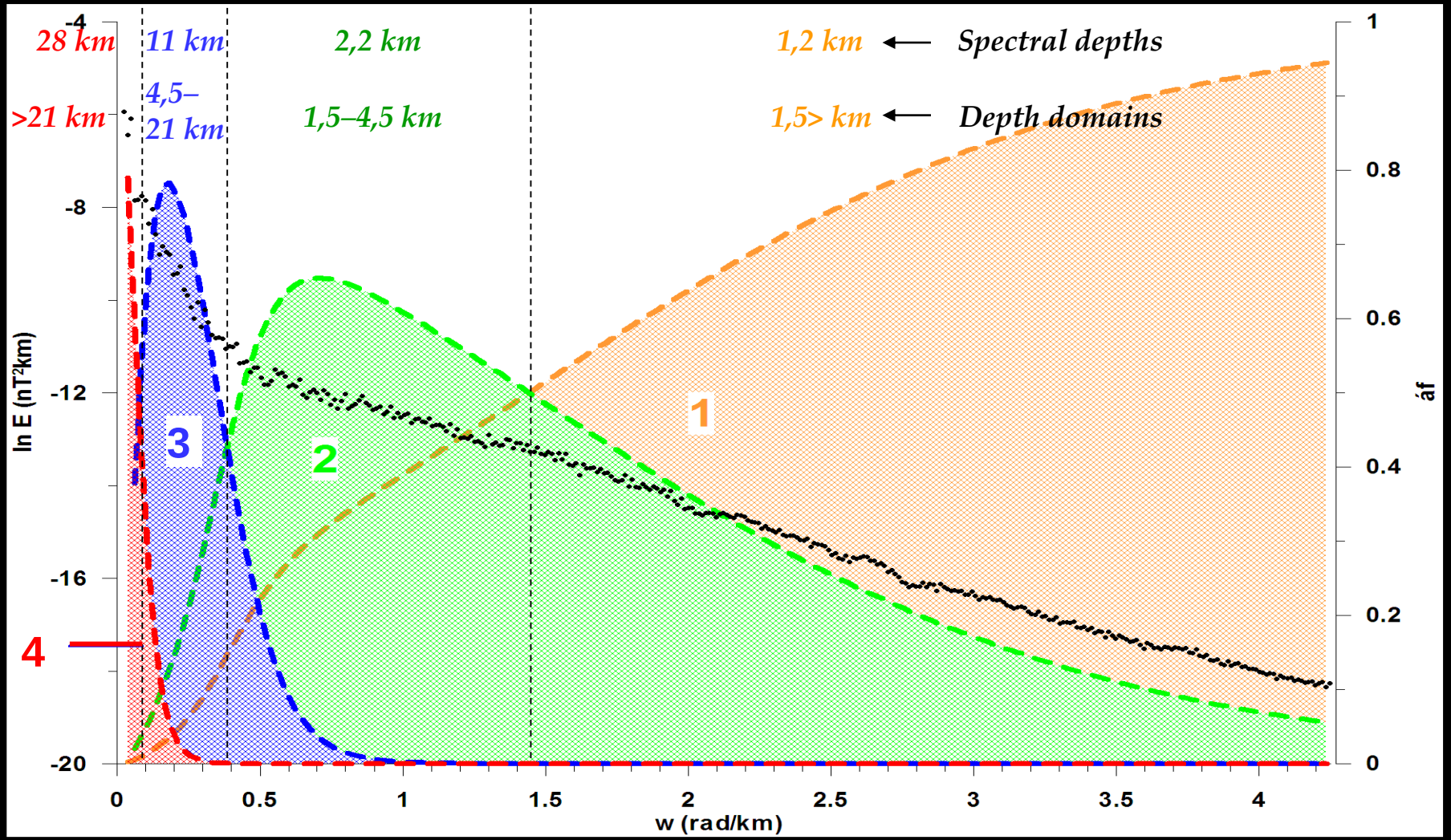


International, not a unique dense dataset!

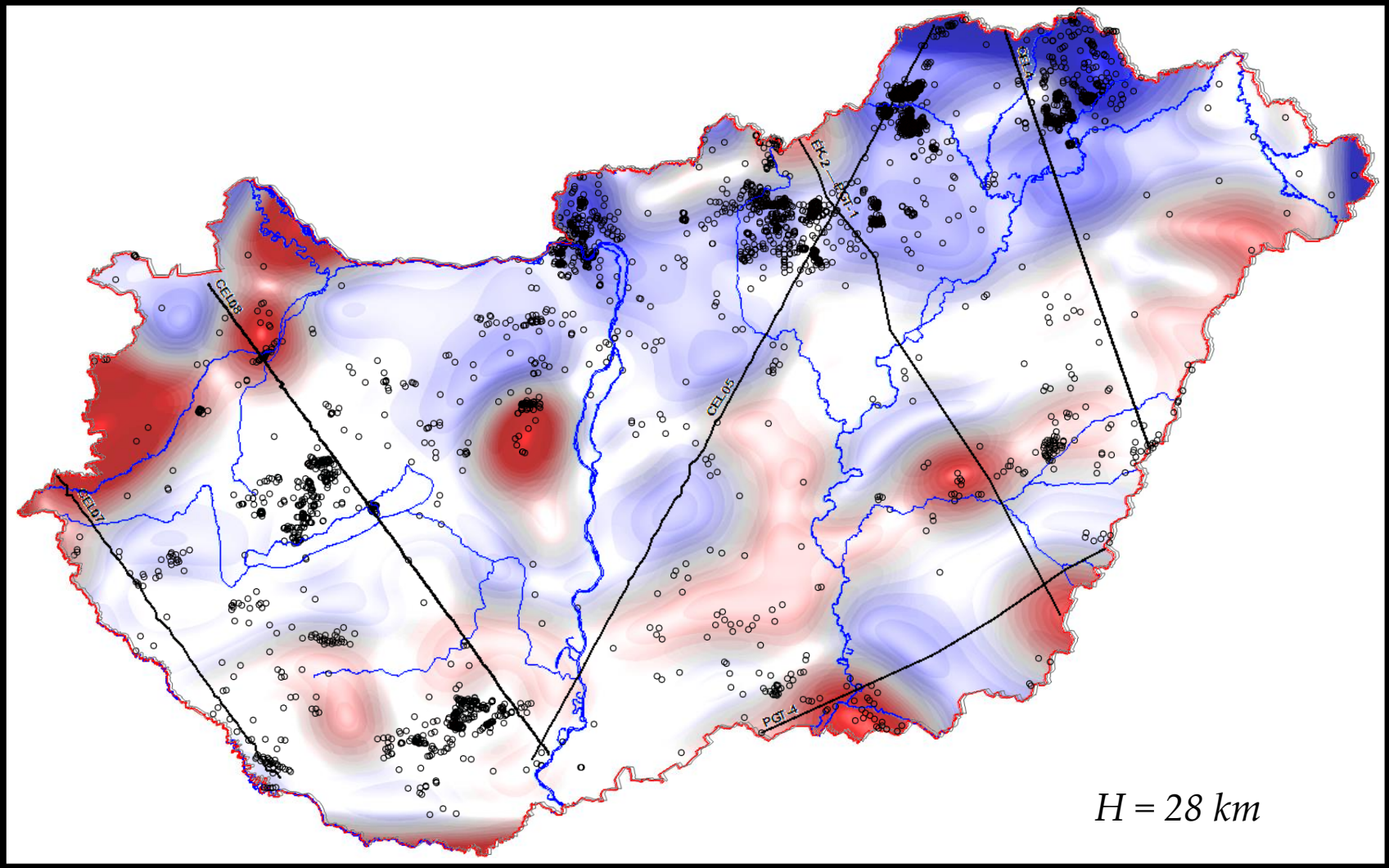
Geomagnetic anomaly map of Hungary is reflecting the magnetic volcanic and metamorphic rock formations of the crust.



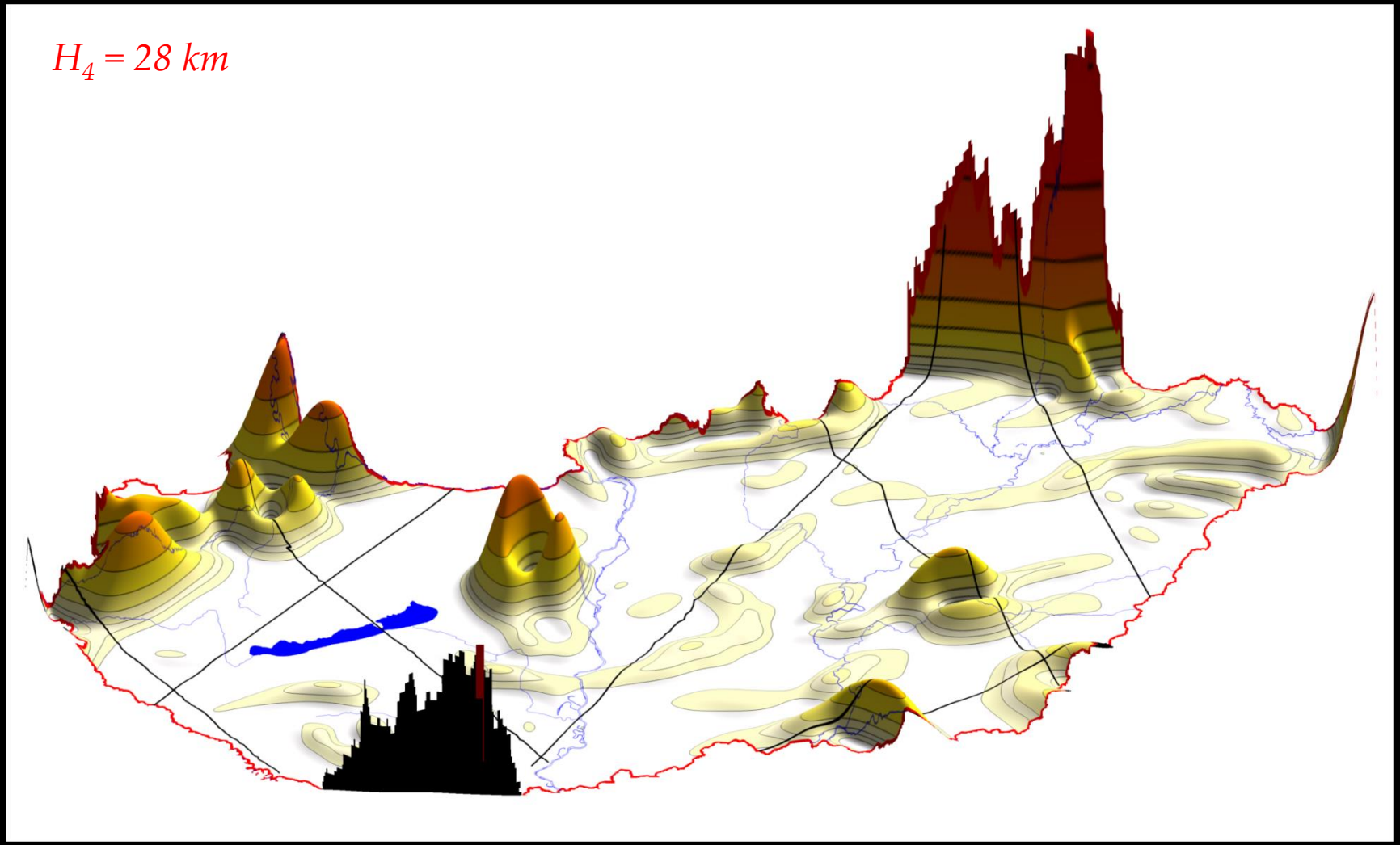
Components of the magnetic anomaly field can be examined by spectral analysis. By spectral filtering the magnetic sources of different depth can be identified.



The transfer functions can be used to isolate the anomaly effects of different depths. Displaying it can help to interpret the anomalies — extension of information known from wells, for example.

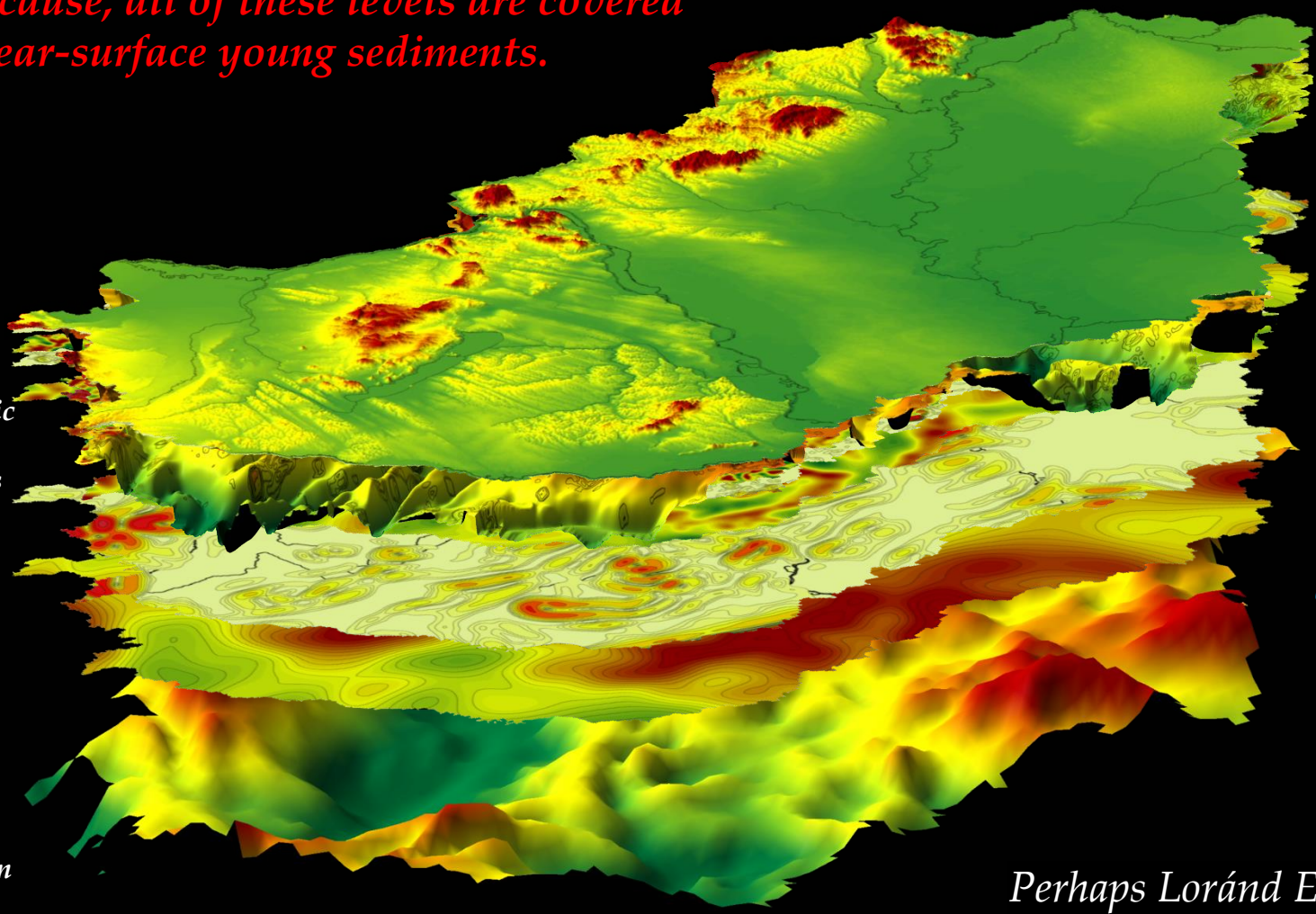


By transforming geomagnetic data the double anomaly pairs due to the dipole nature can be eliminated, in this case the anomaly appears above the magnetic body. It is presented by 3D pictures.



Gravity and magnetic sources of different depths in the Pannonian basin

…because, all of these levels are covered by near-surface young sediments.



Perhaps Loránd Eötvös has dreamt about these levels…

Thank you for your attention!

With respect to the memory of Loránd Eötvös and to all the members of the Institute founded by him in 1907.

(1907 – 2012)