



Eötvös Centenary Event

Gbely, 17th October 2019



STUDY OF THE LITHOSPHERE IN THE CARPATHIAN-PANNONIAN REGION: BASED ON INTEGRATED INTERPRETATION OF GRAVITY FIELD

Bielik M., Zeyen H., Alasonati Tašárová Z., Goetze H.J., Lillie J.R., Starostenko V., Makarenko I., Legosteva O., Horváth F., Paštka R., Dérerová J., Pánisová J., Grinč M., Šimonová B., Balász A., Zalai Z., Harangi S. and others



Contents

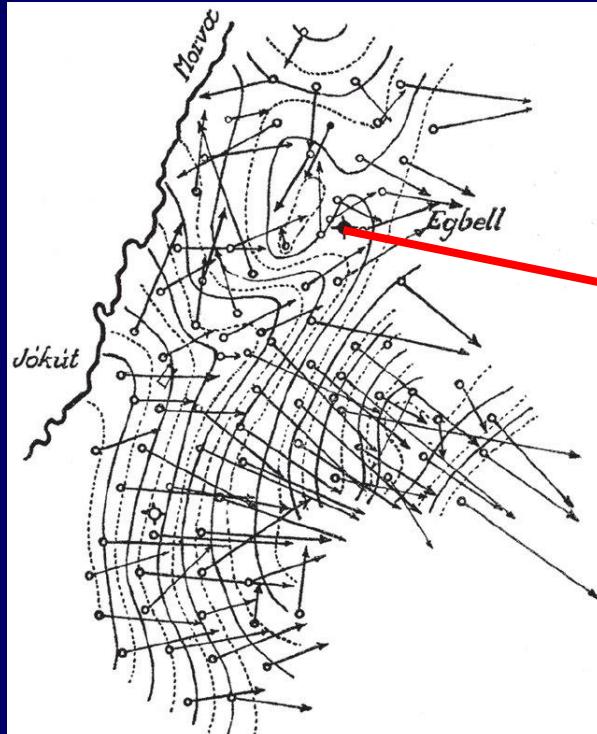


- *Why were the Eötvös gravity measurements made in Egbell (now Gbely in Slovakia)?*
- *What dominant regional gravity anomalies in the Carpathian-Pannonian Basin region can we observe?*
- *Results obtained by 2D and 3D integrated interpretation of gravity field*



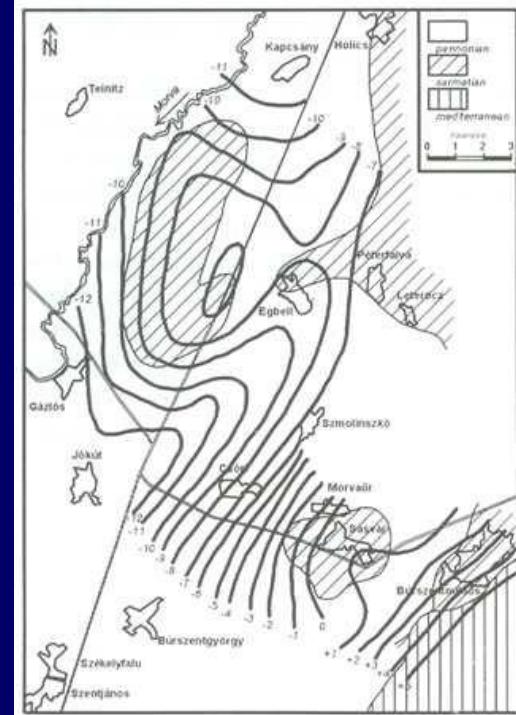
Eötvös gravity measurements in Gbely

Eötvös torsion-balance map in Gbely oil field



Positive oil
borehole sited
by Böckh and
Papp in 1913

Gravity anomaly map in Gbely oil field



Length arrows, showing magnitude and
directions of the horizontal gradient of gravity.
The contours (isogams) are in Eötvös units (10^{-6}
 mGal cm^{-1}).

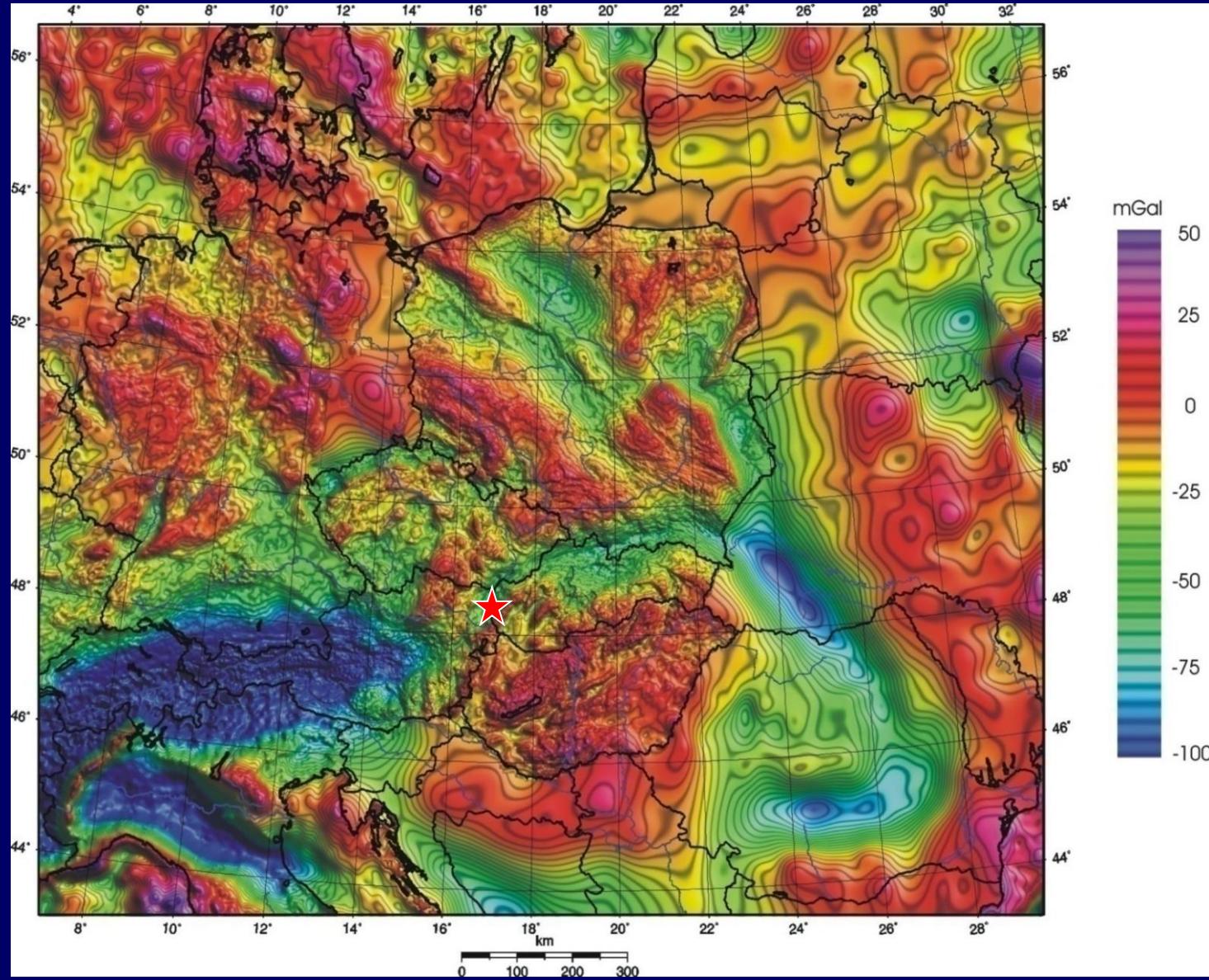


The first Eötvös gravimetric measurements carried out in Gbely
were

**THE BEGINNING OF A HUGE DEVELOPMENT
FOR
EUROPEAN AND WORLD GRAVIMETRY**



COMPLETE BOUGUER GRAVITY ANOMALY MAP IN CENTRAL EUROPE

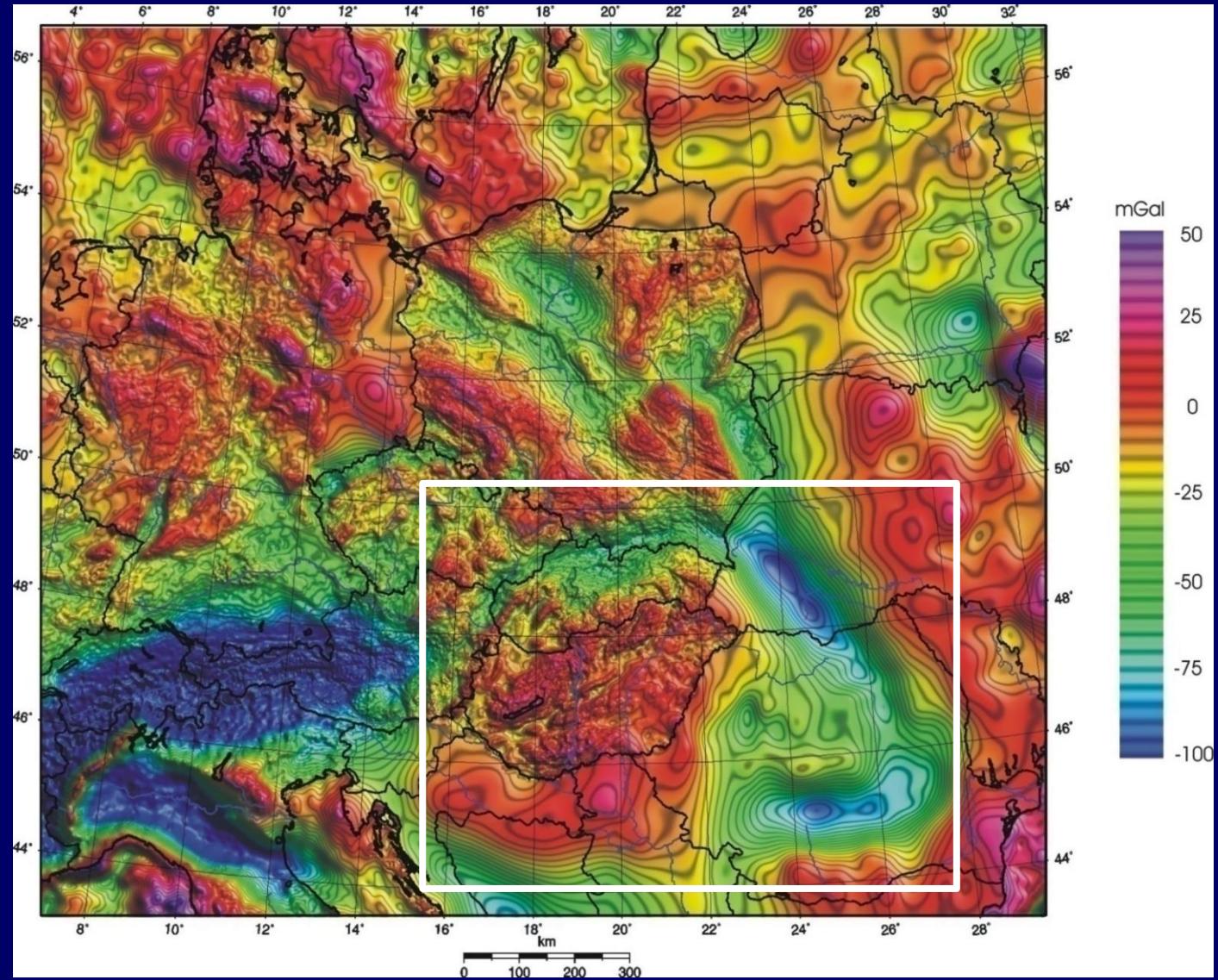
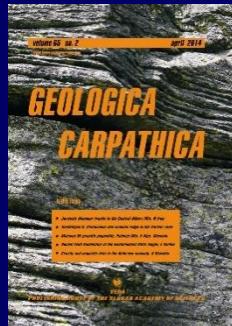




COMPLETE BOUGUER GRAVITY ANOMALY MAP IN CENTRAL EUROPE



2006

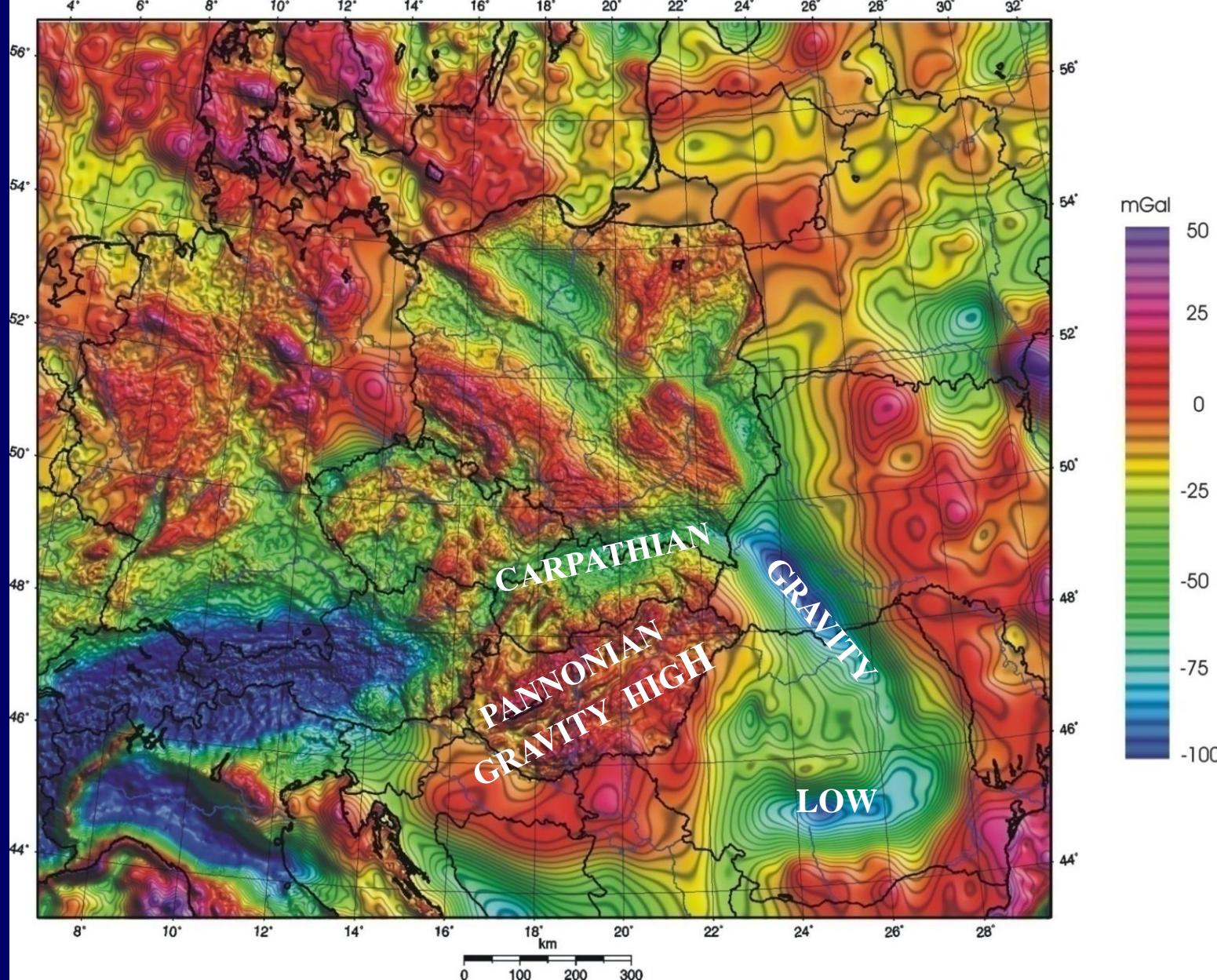


Bielik, M., Kloska, K., Meurers, B., Švancara, J., Wybraniec, S., Fancsik, T., Grad, M., Grand, T., Guterch, A., Katona, M., Krolikowski, C., Mikuška, J., Pašeka, R., Petecký, Z., Polechonska, O., Rues, D., Szalaiová, V., Šefara, J., Vozár, J., 2006. Gravity anomaly map of the CELEBRATION, 2000 region. *Geologica Carpathica*, 57, 3, 145–156.

compiled in frame of International project CELEBRATION 2000

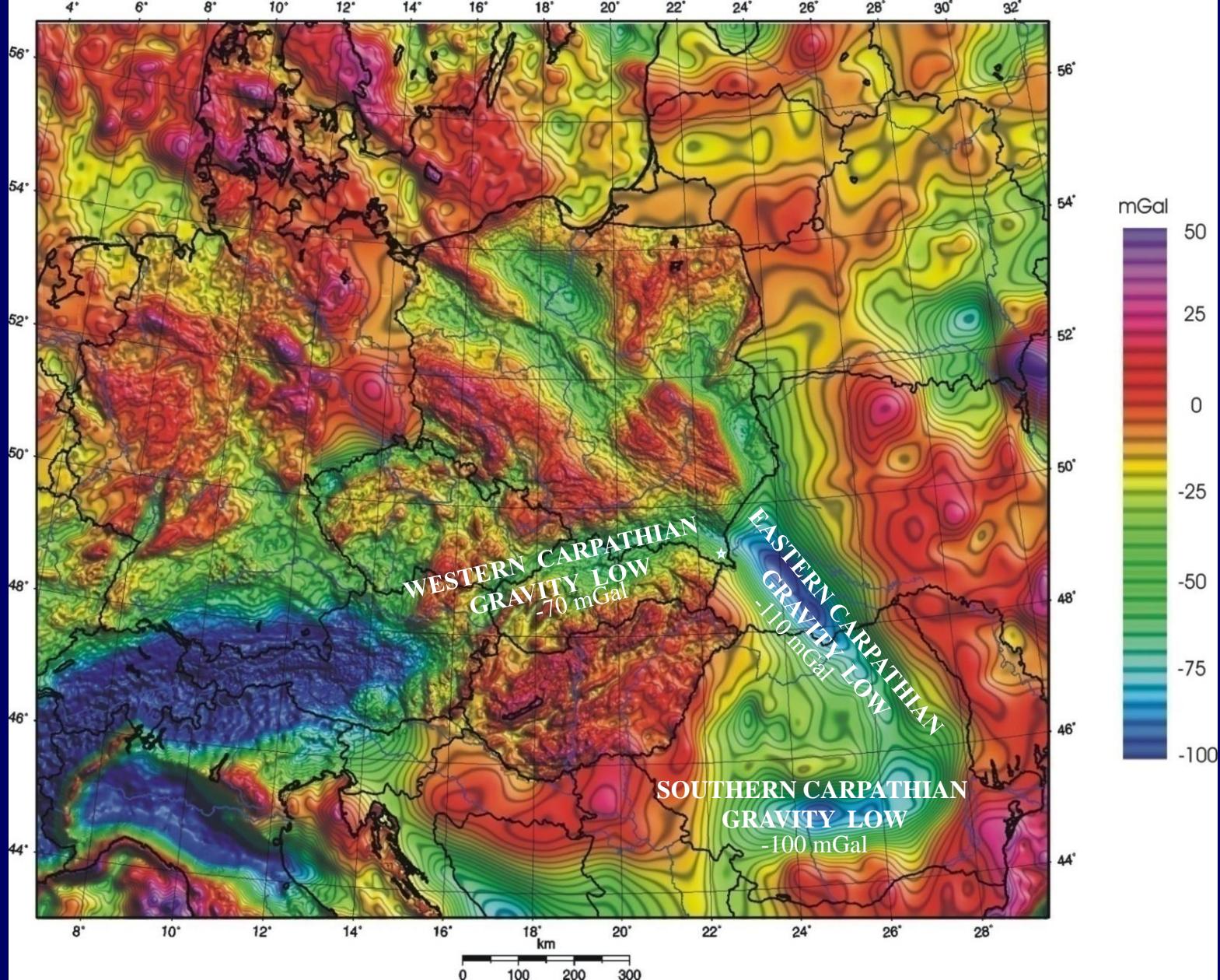


BOUGUER GRAVITY ANOMALY MAP IN CENTRAL EUROPE





BOUGUER GRAVITY ANOMALY MAP IN CENTRAL EUROPE

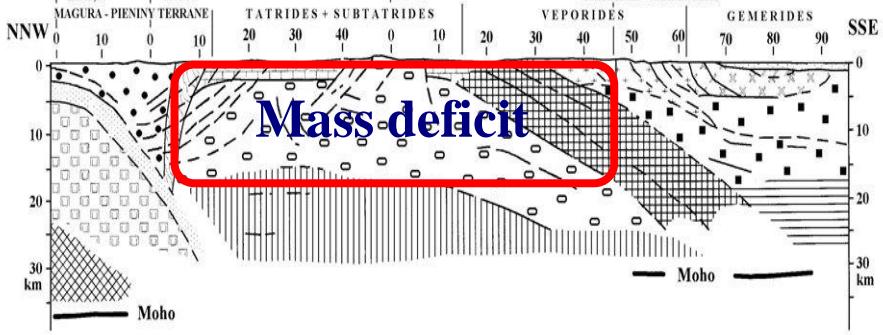
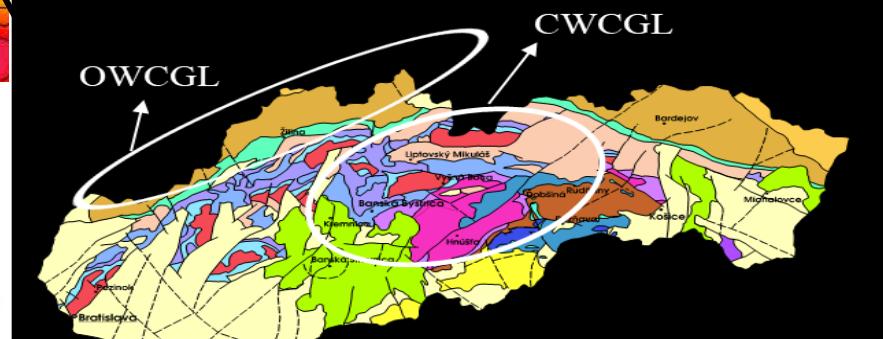
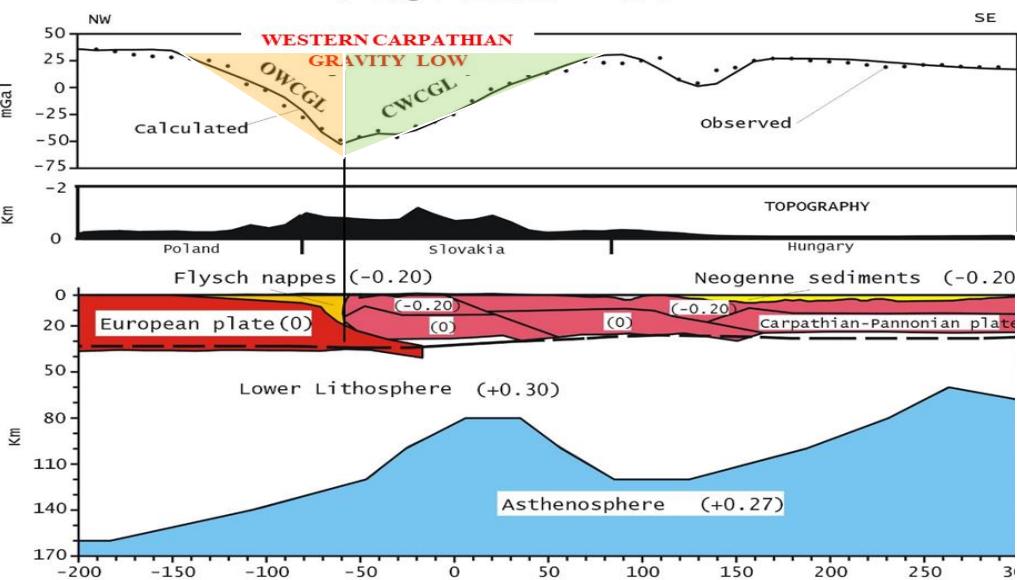
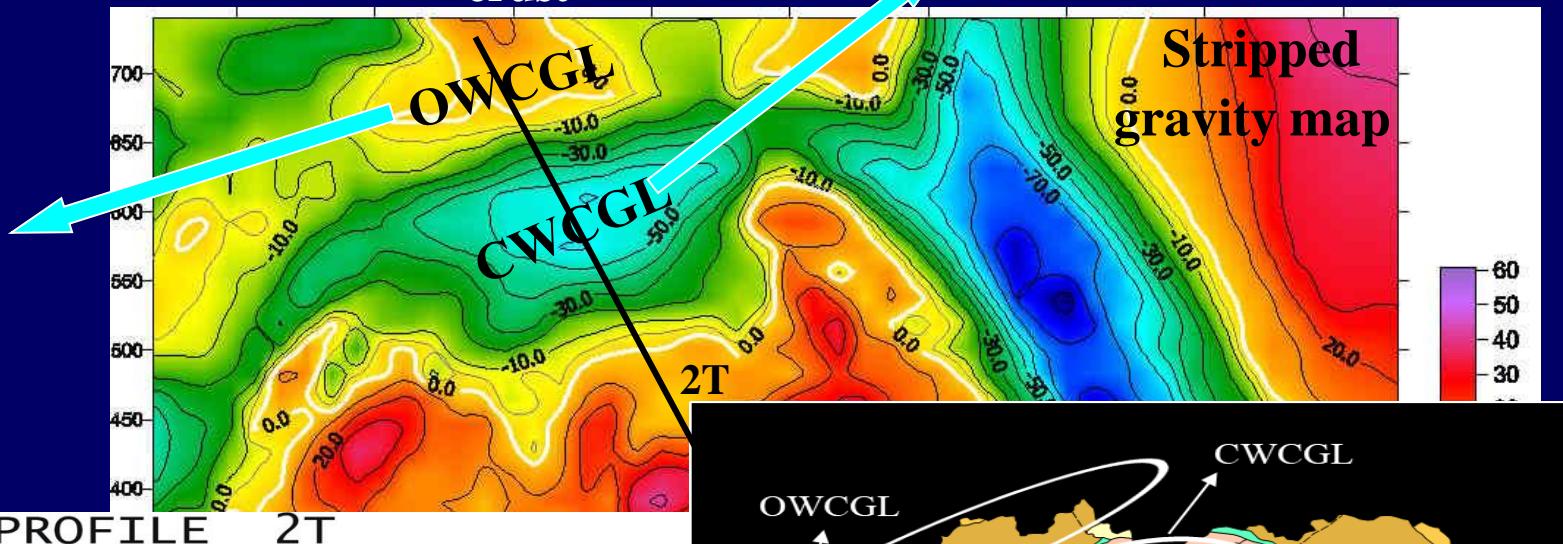




SOURCES OF THE WESTERN CARPATHIAN GRAVITY LOWS

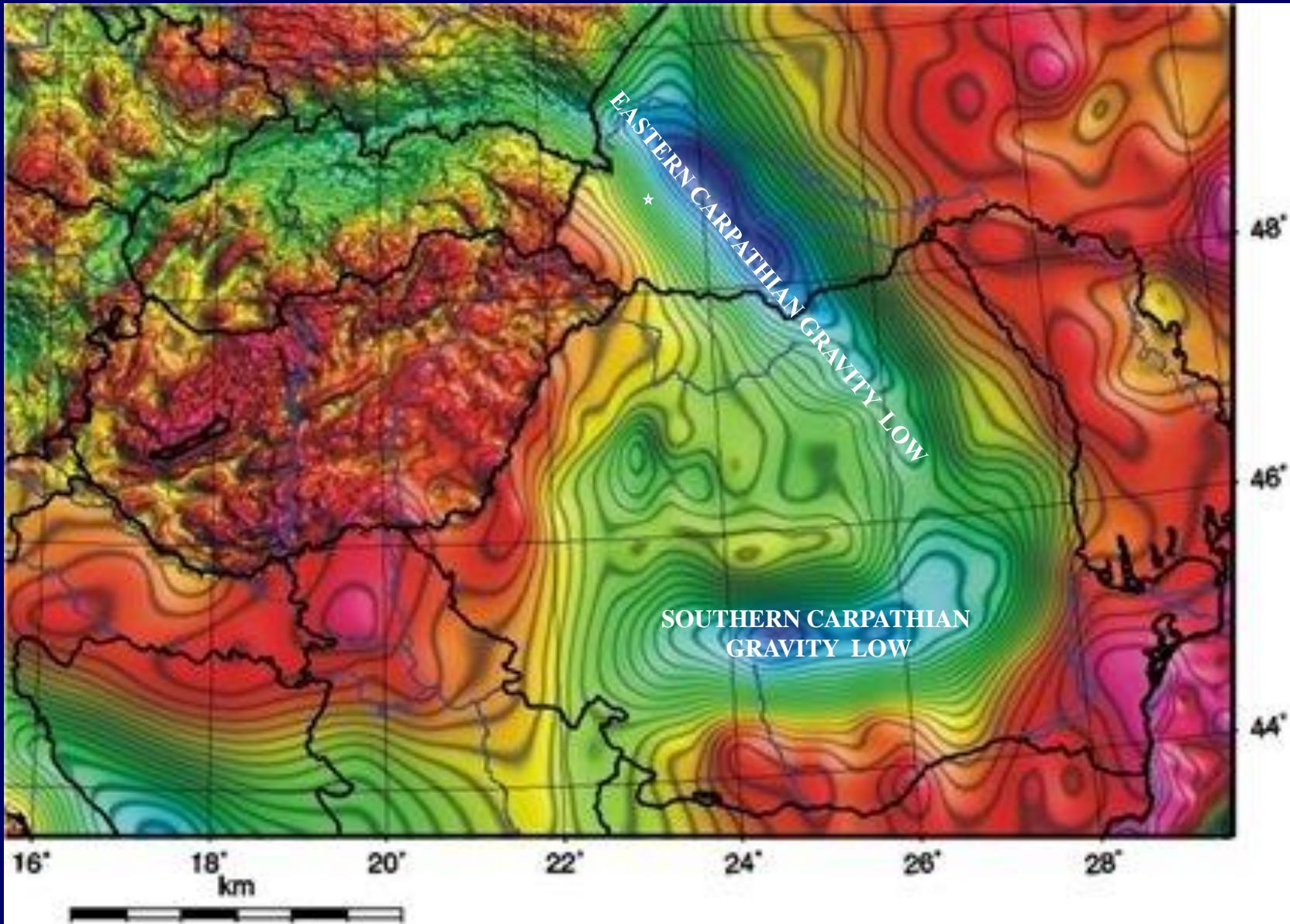
CWCGL source: mostly Low density Upper Crust and partly thicker crust

OWCGL
source:
Low density
Sediments



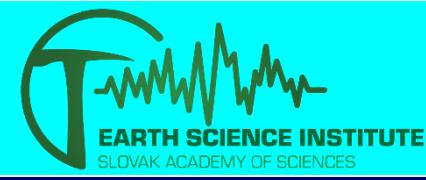


SOURCES OF THE EASTERN AND SOUTHERN CARPATHIAN GRAVITY LOWS



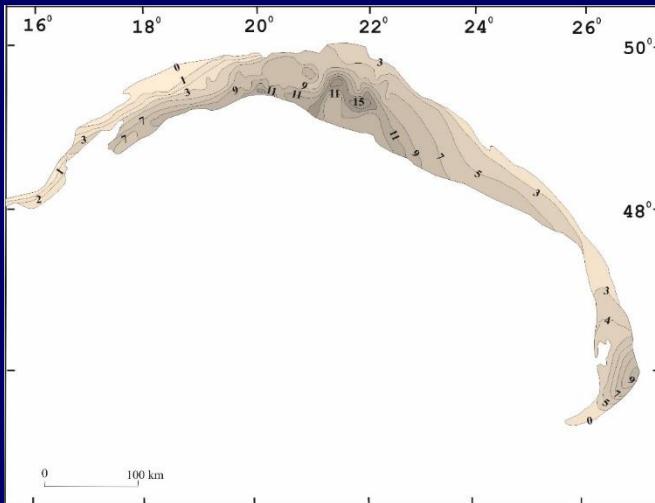


SEDIMENTARY THICKNESS MODEL AND ITS GRAVITY EFFECT

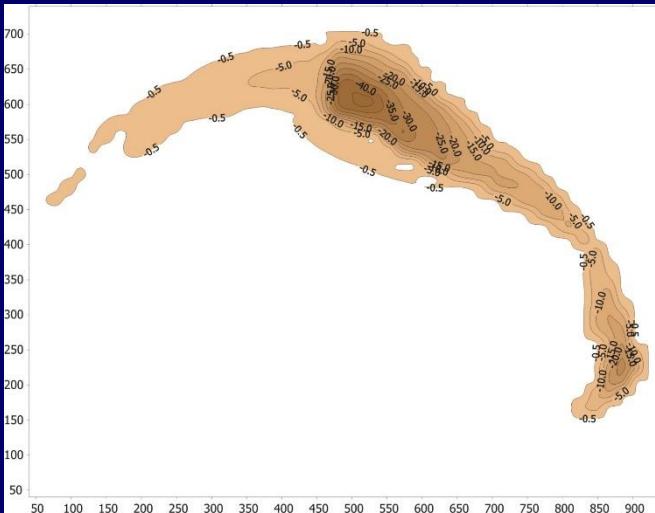


Surface source

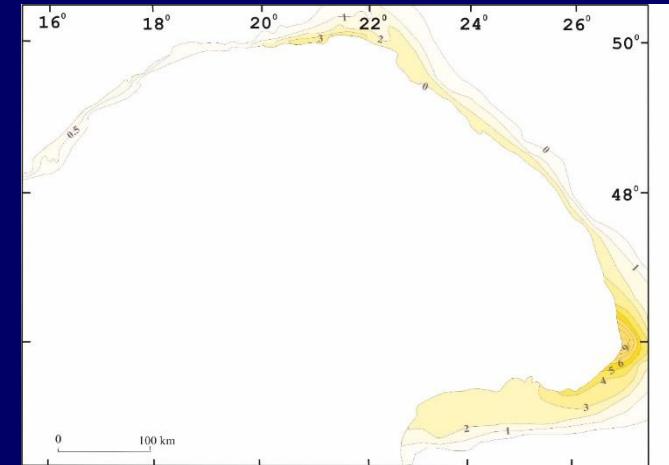
Carpathian Flysh zone



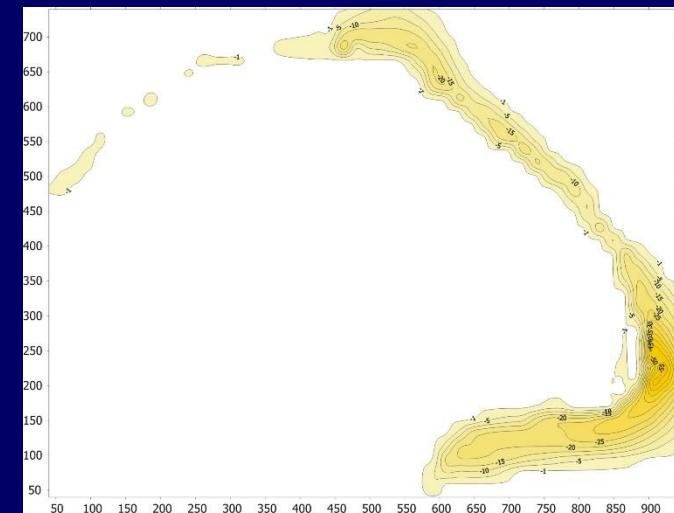
Gravity effect of Carpathian Flysh zone



Carpathian Foredeep

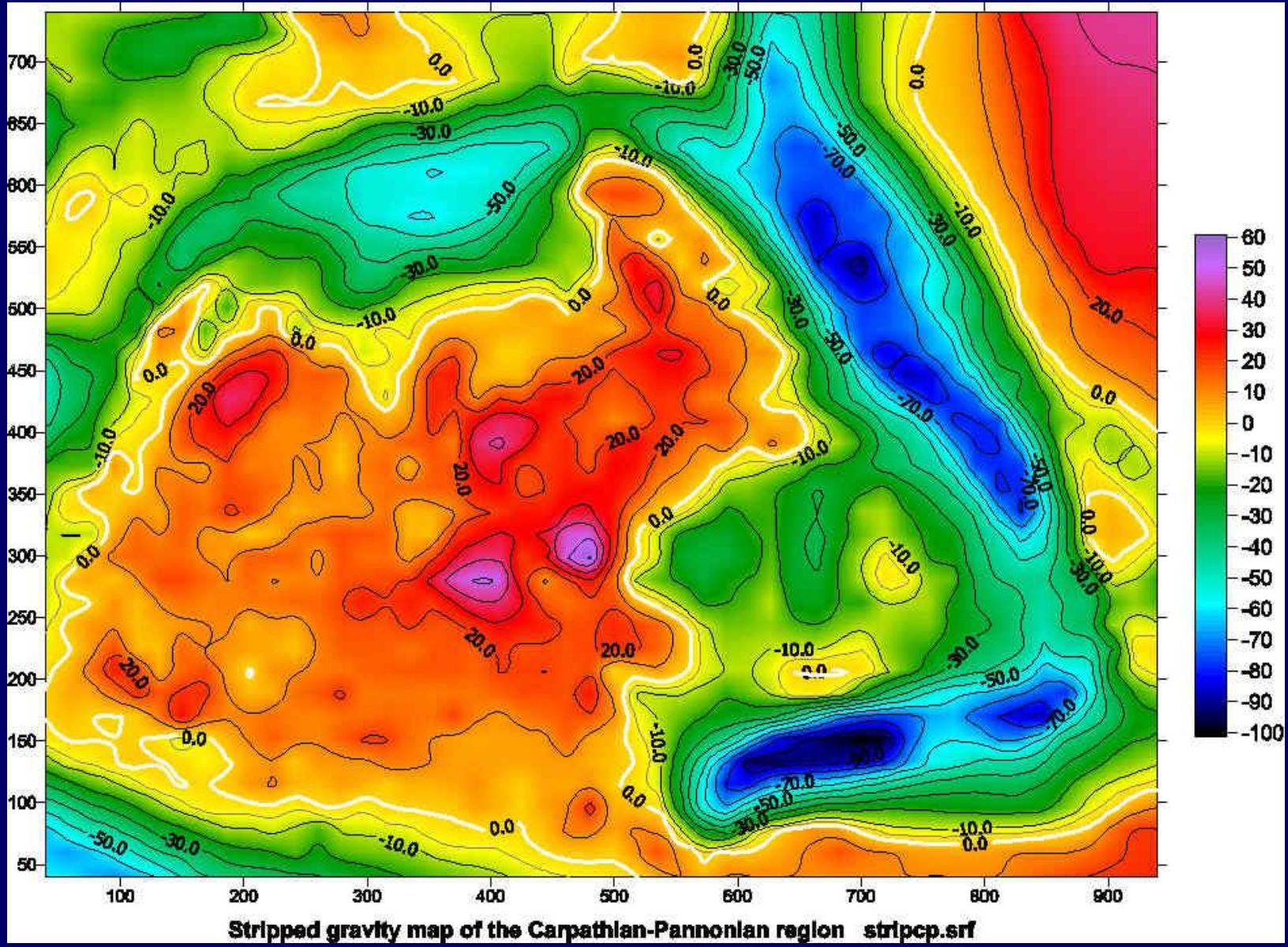
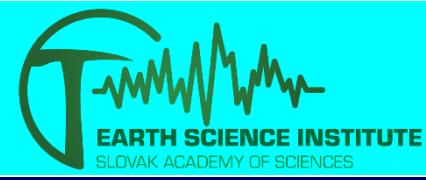


Gravity effect of Carpathian Foredeep



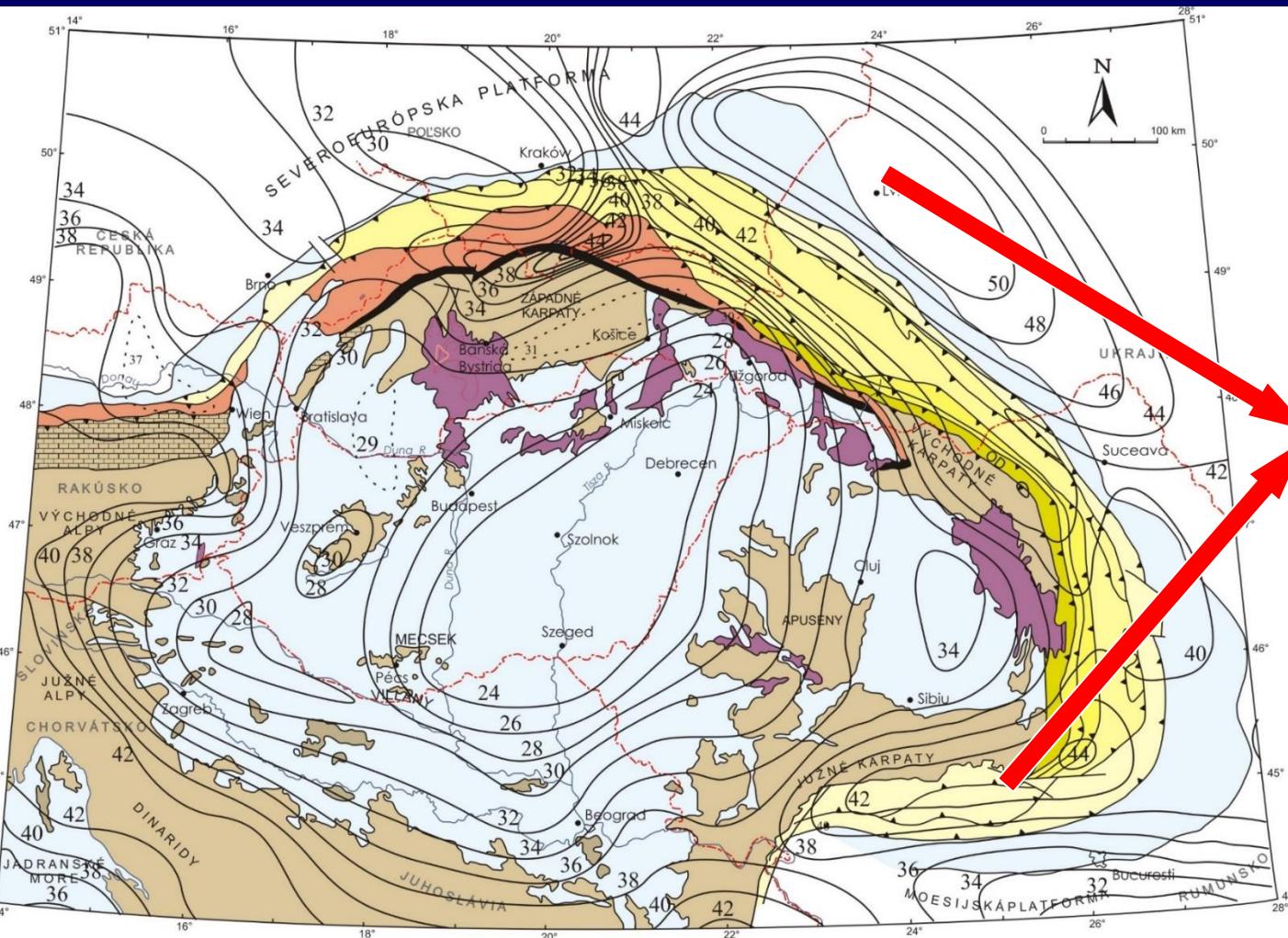


Stripped gravity map





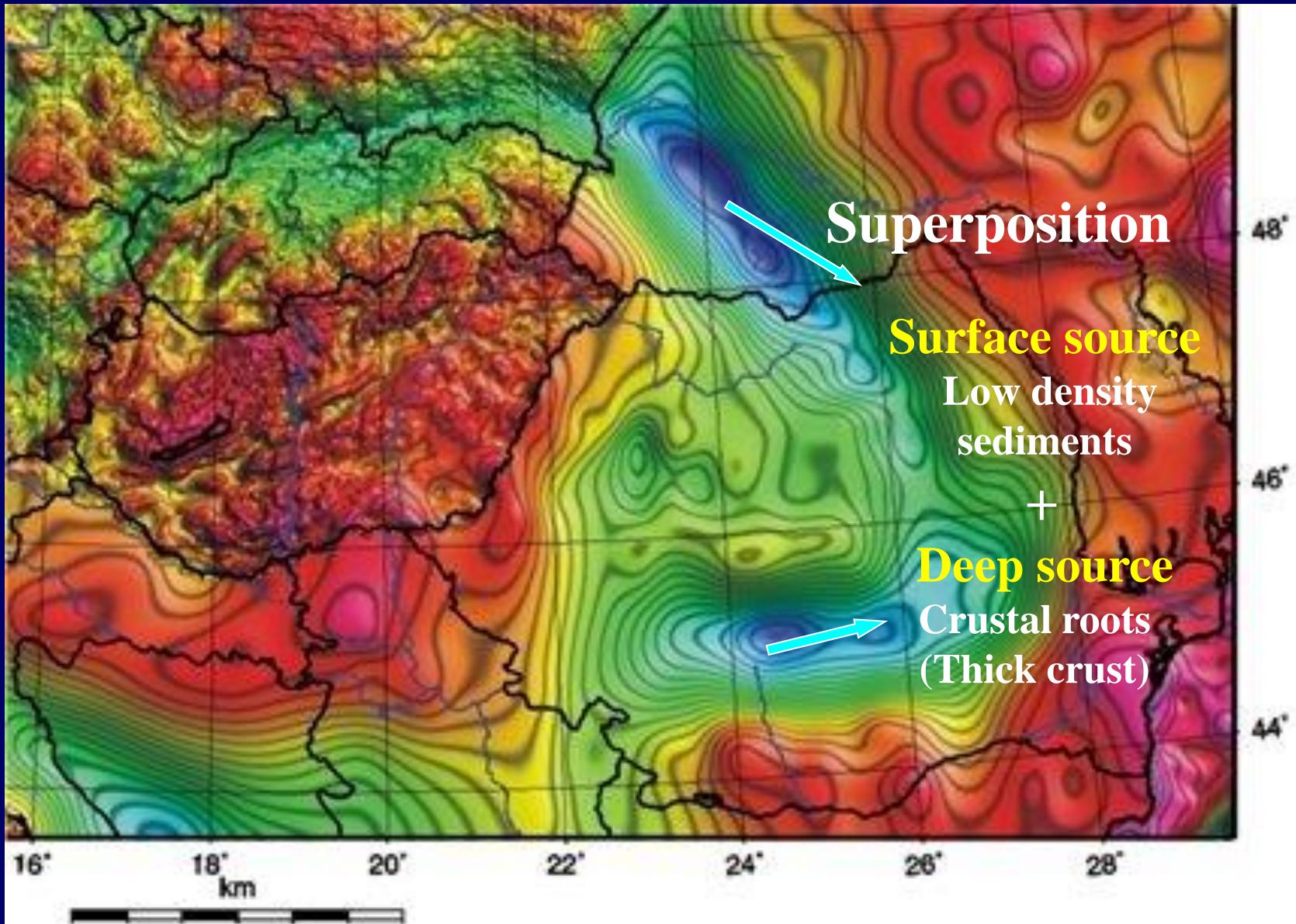
Moho depth



Deep source

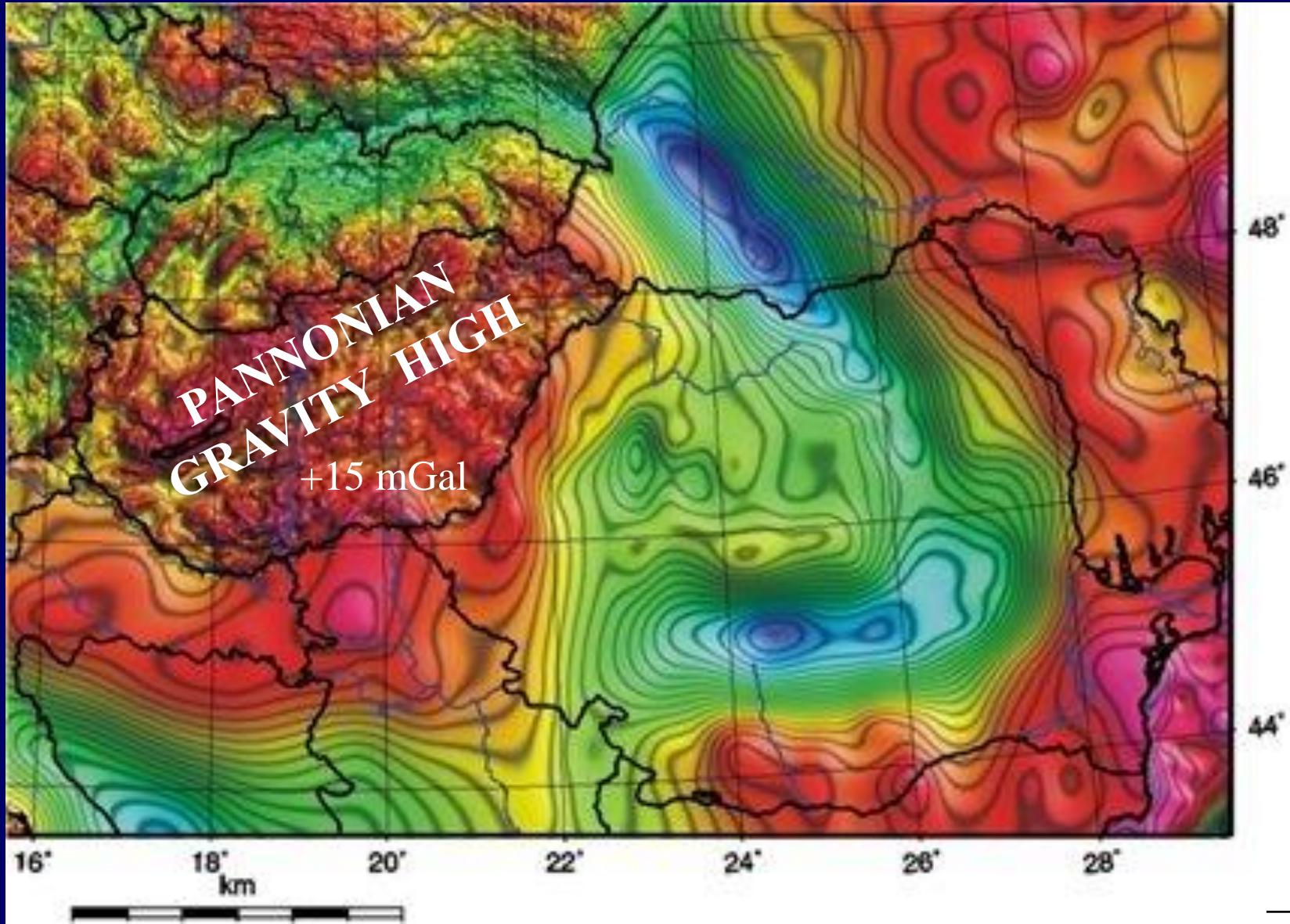
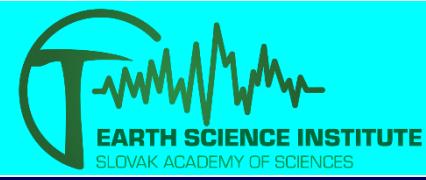


SOURCES OF THE EASTERN AND SOUTHERN CARPATHIAN GRAVITY LOWS





Bouguer gravity anomaly map



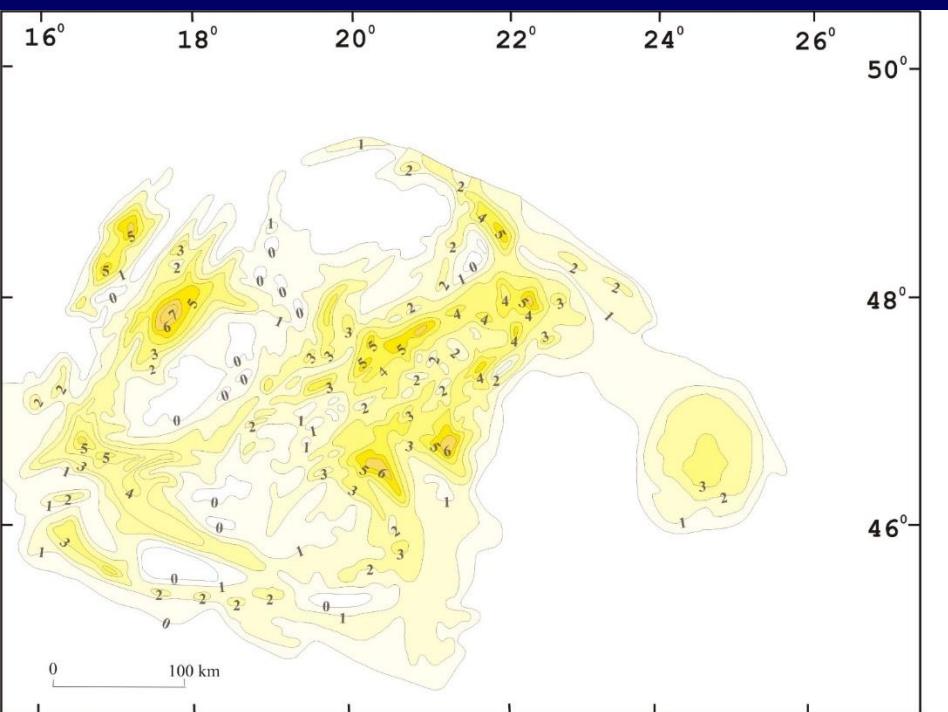


Sedimentary thickness model and its gravity model

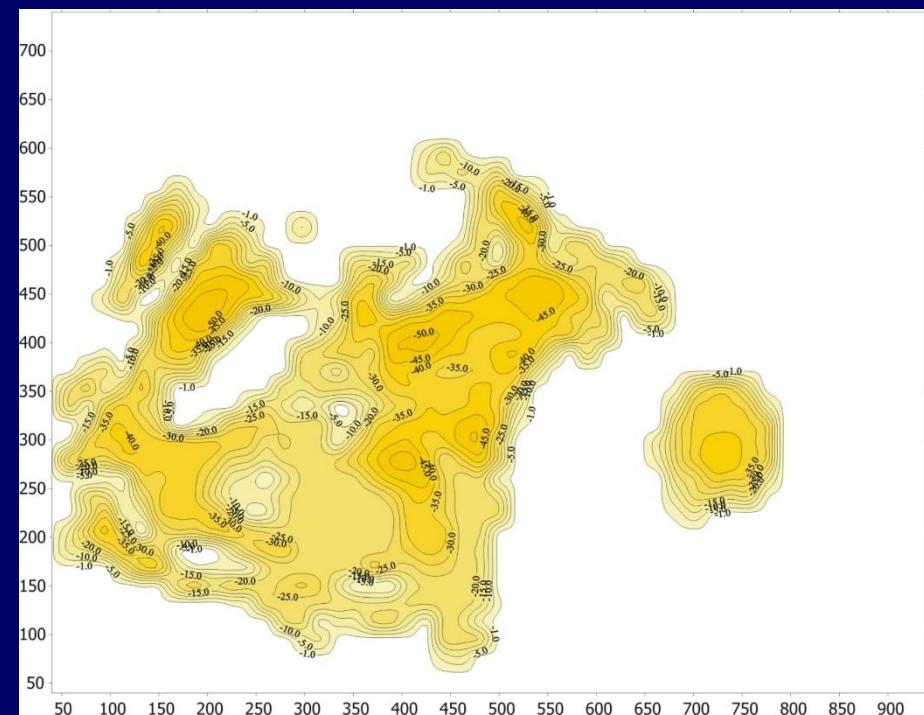


Pannonian and Transylvanian Basins

Sedimentary thickness

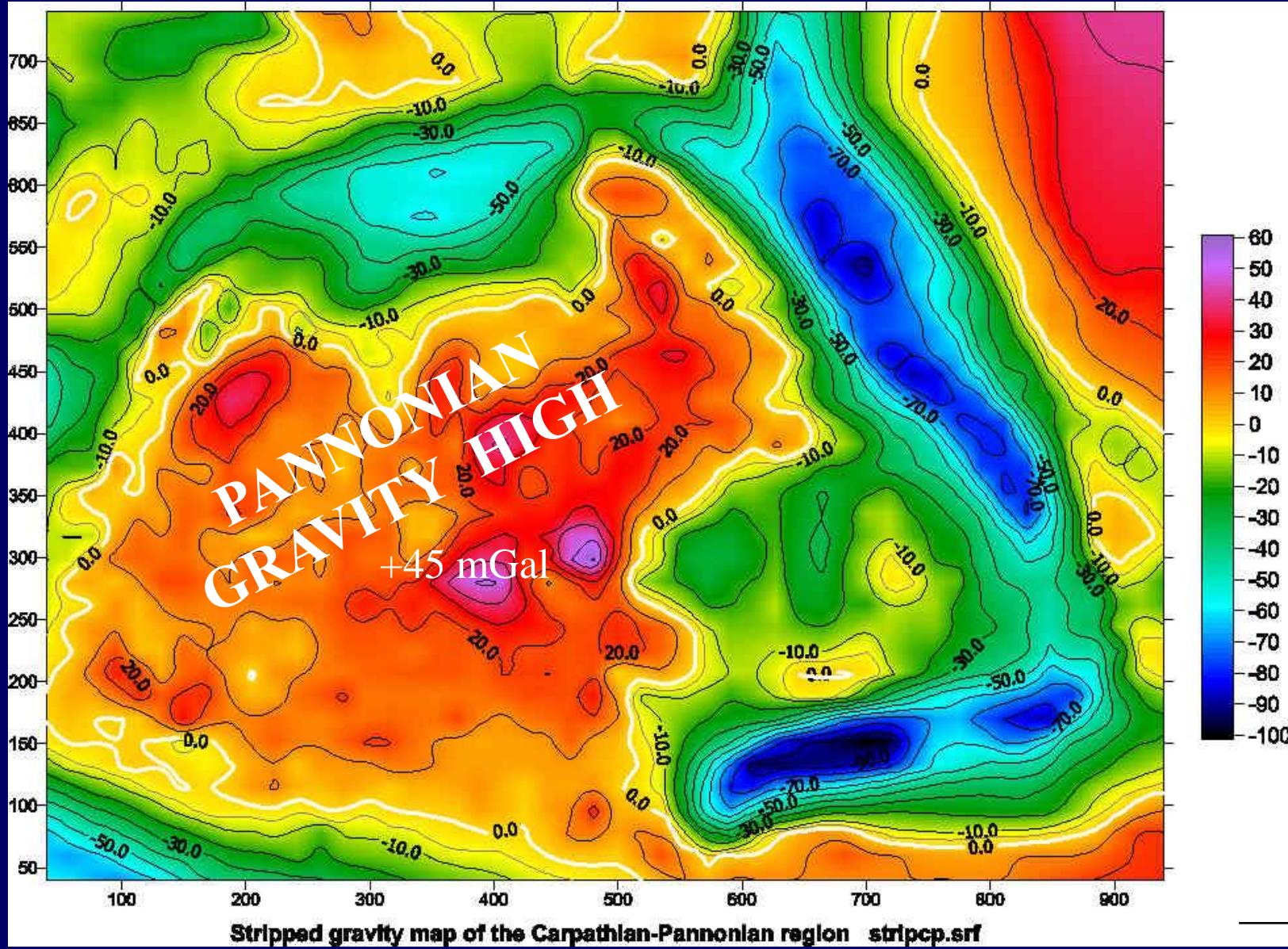
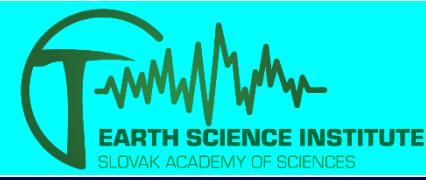


Gravity effect of Sedimentary thickness



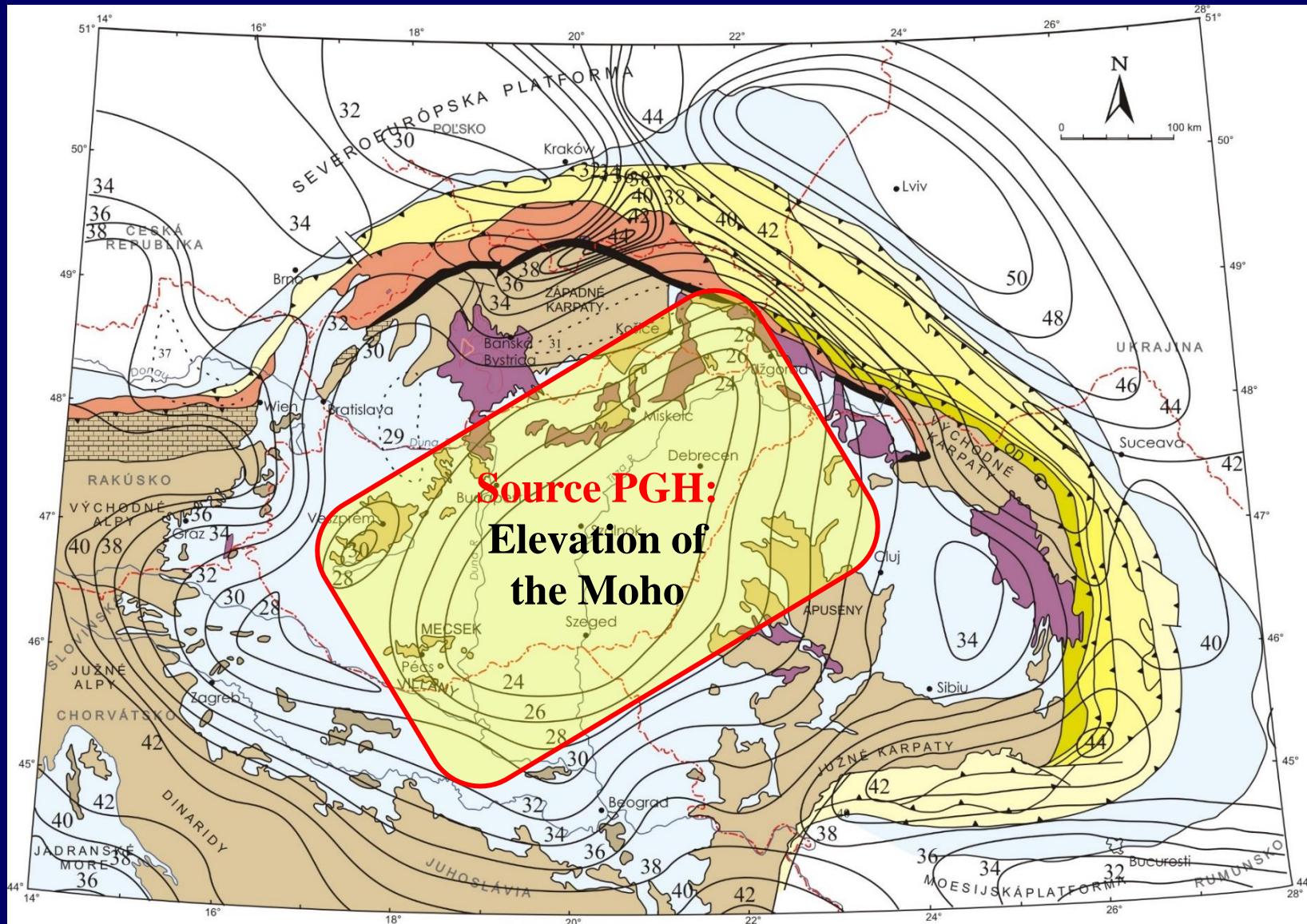


Bouguer gravity anomaly map





Moho depth





2D INTEGRATED GEOPHYSICAL MODELLING

GOAL

DERMINATION OF STRUCTURE AND LITHOSPHERIC THICKNESS (LAB)



CAGES software

(Zeyen and Fernandez, 1994)

- Surface heat flow
- Gravity field
- Geoid
- Topography

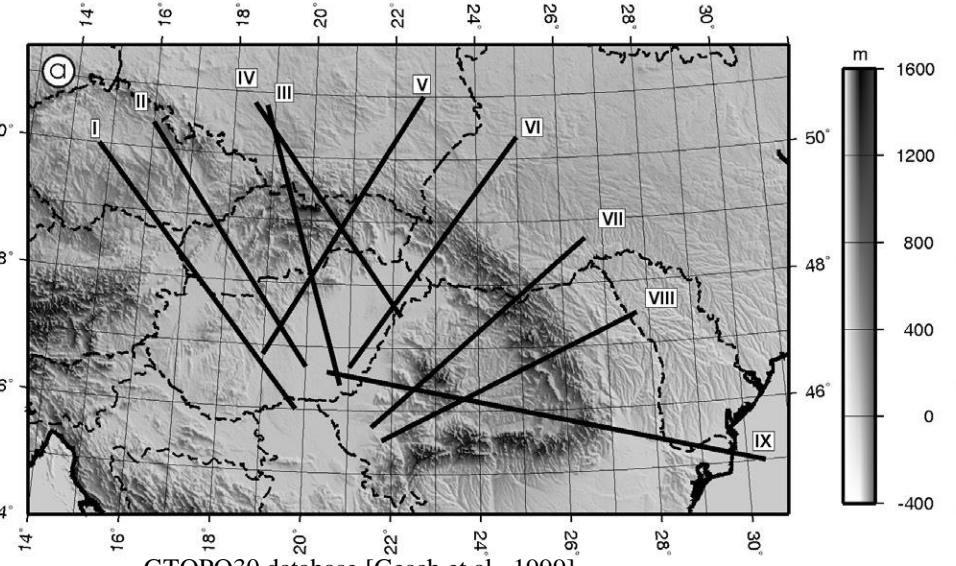
Anomalous bodies are defined:

- Heat conductivity [W.m⁻¹K⁻¹]
- Heat production [W.m⁻³]
- Density [kg.m⁻³]
- Geometry [m]



Input data

Topography

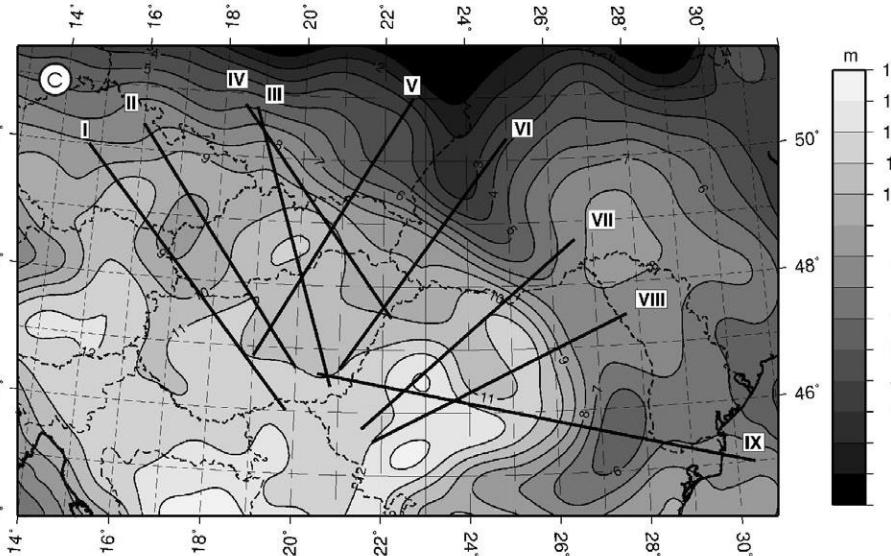


GTOPO30 database [Gesch et al., 1999]

Geoid

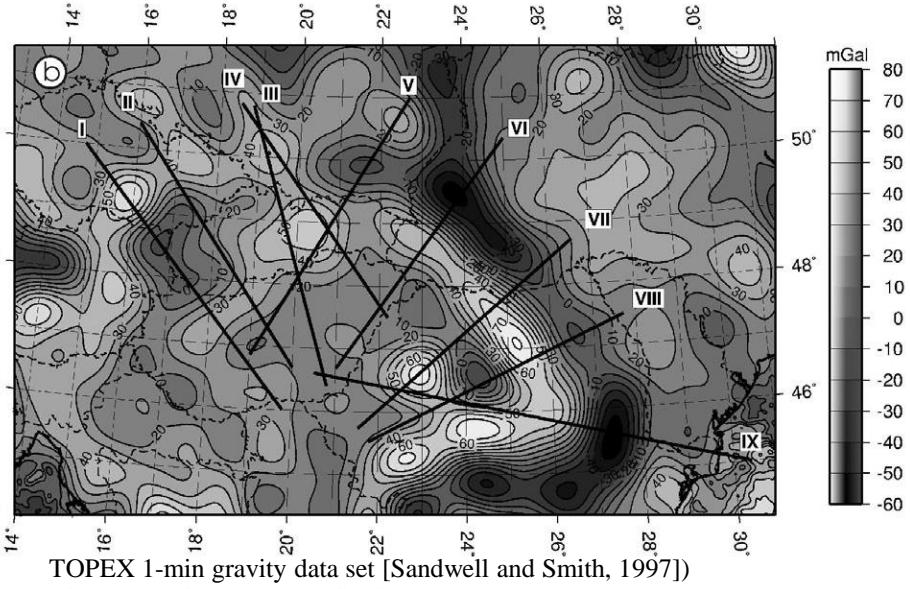
[Lemoine et al., 1998]

C



EGM96 global model

Free air gravity



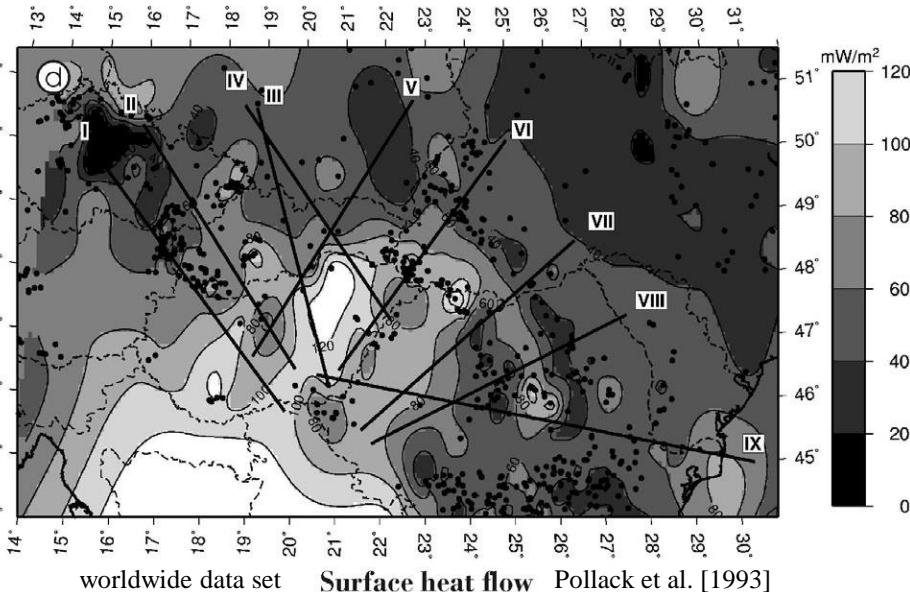
TOPEX 1-min gravity data set [Sandwell and Smith, 1997]

mGal

80
70
60
50
40
30
20
10
0
-10
-20
-30
-40
-50
-60

Surface heat flow

Pollack et al. [1993]



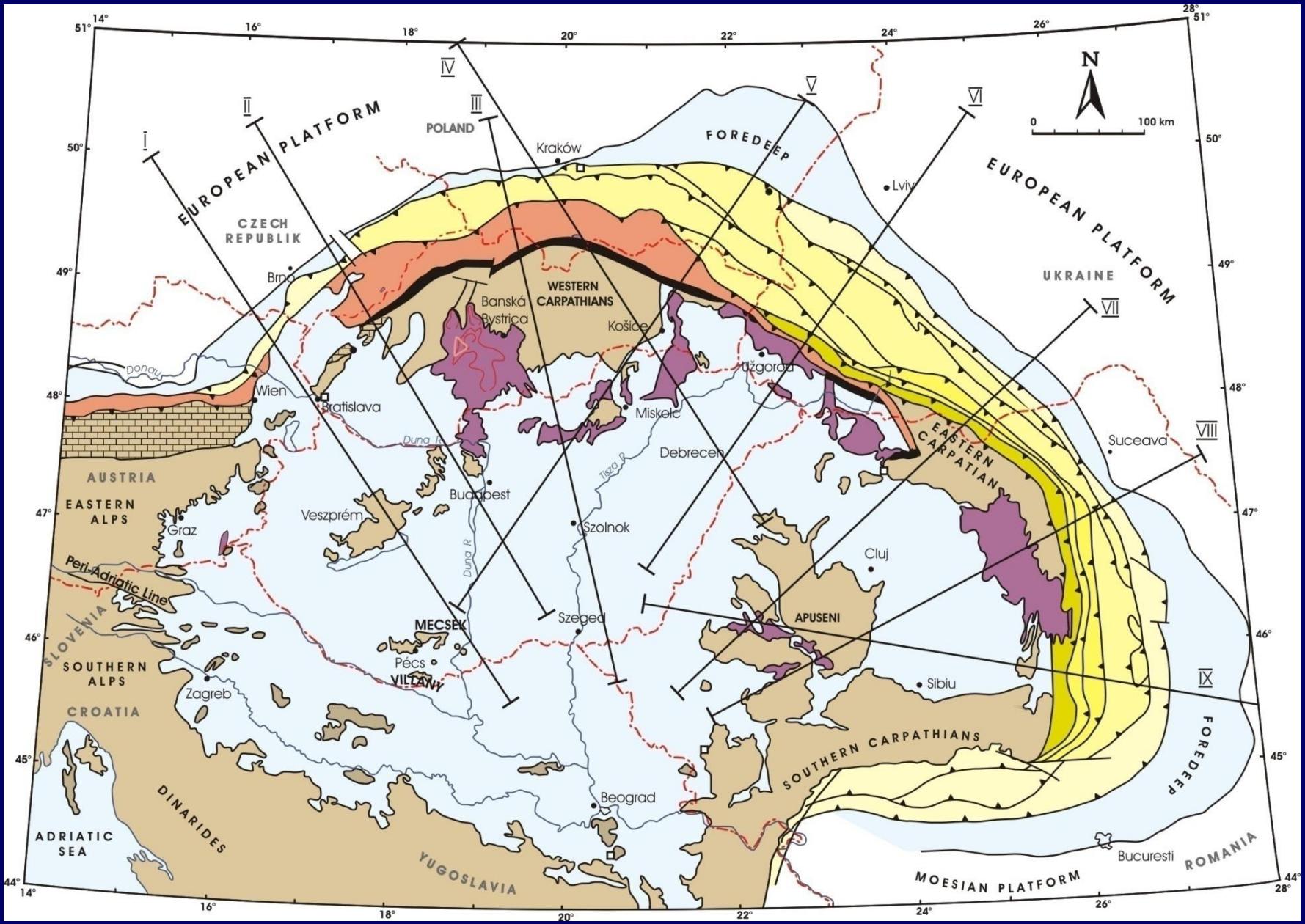
120
100
80
60
40
20
0

14
13
12
11
10
9
8
7
6
5
4
3
2
1
0

1600
1200
800
400
0
-400

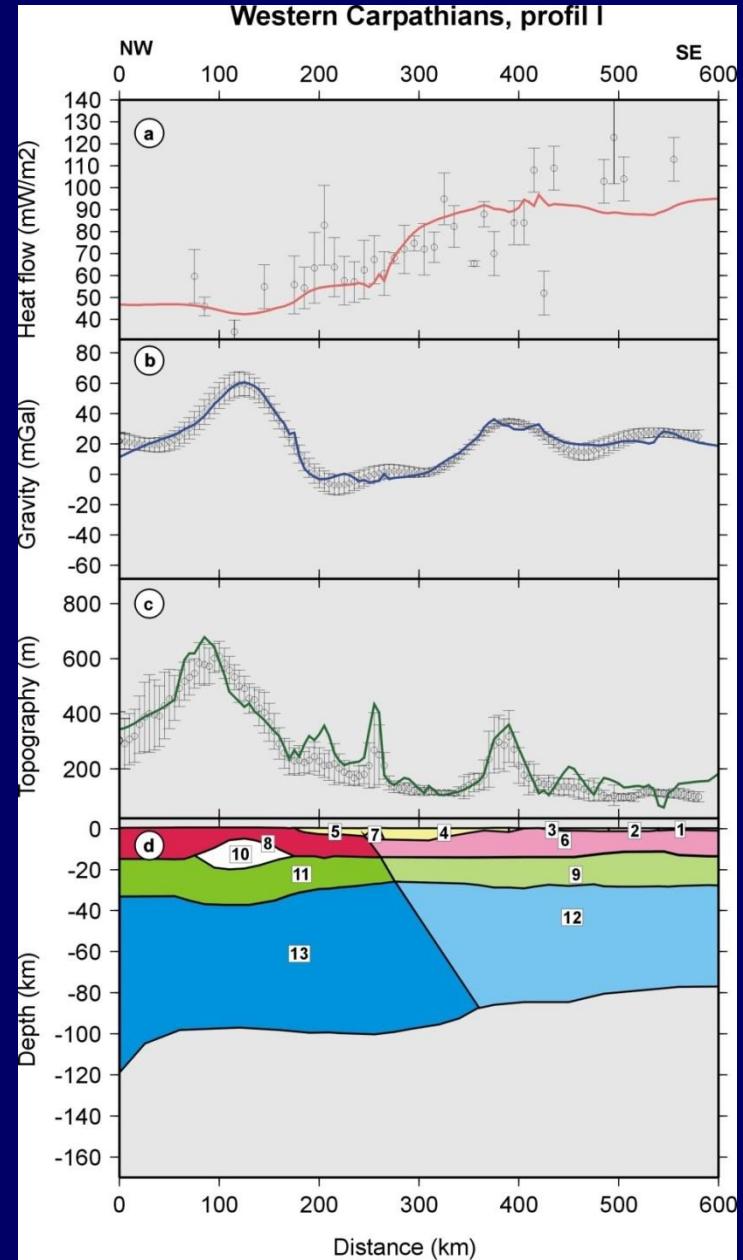
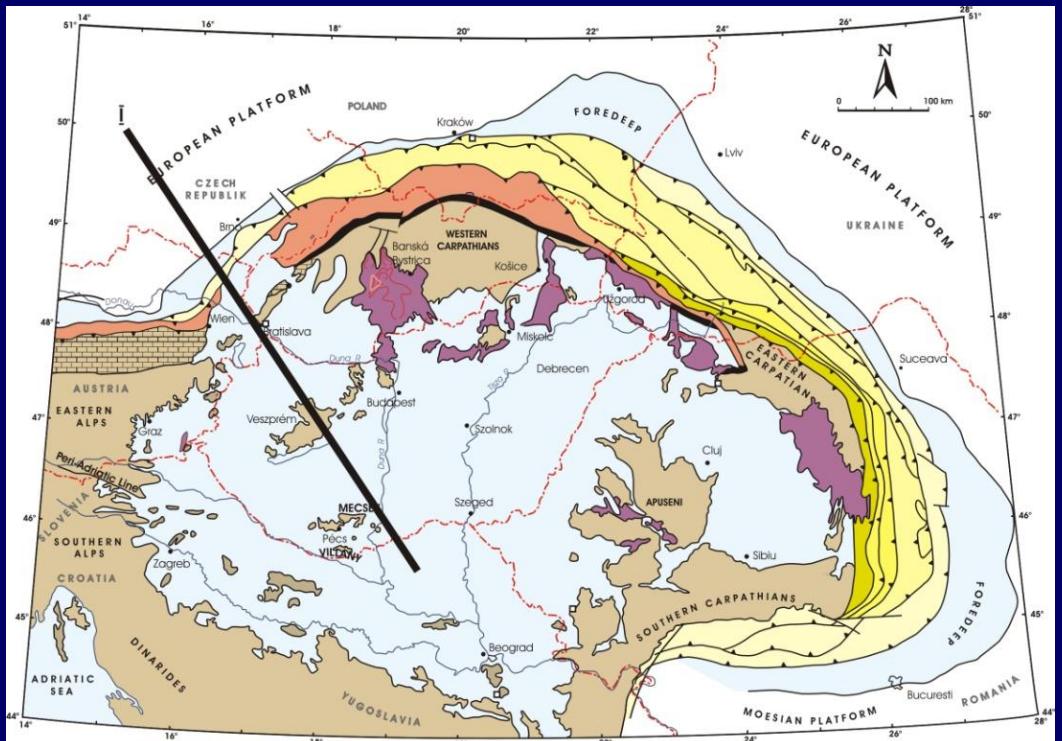


Profiles location



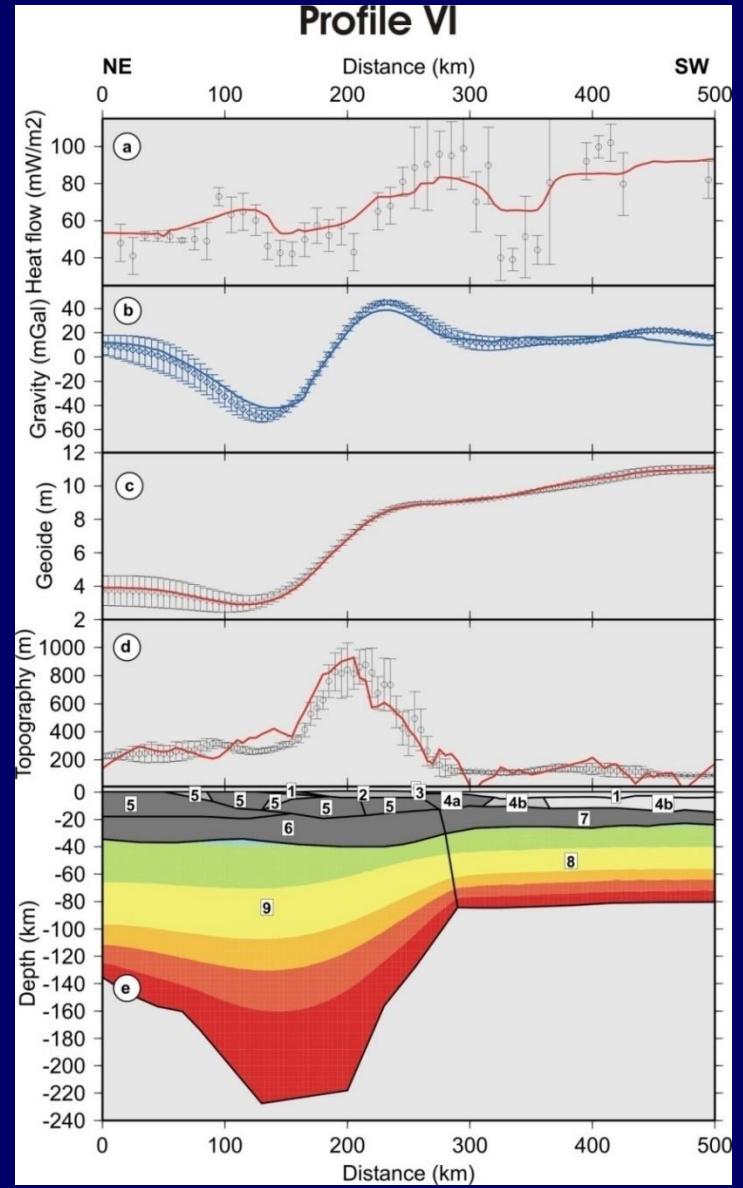
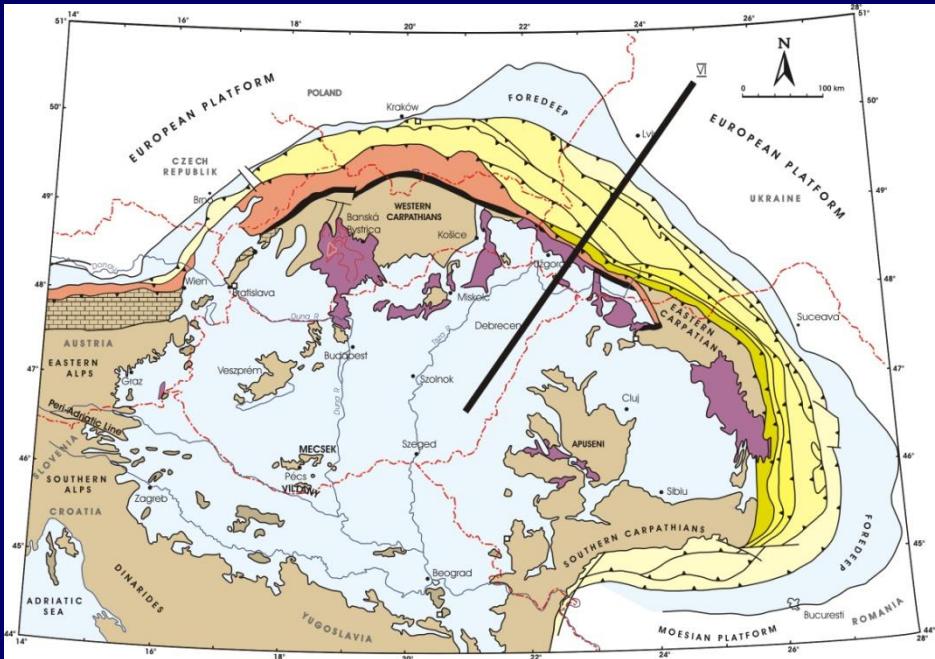


Profile I



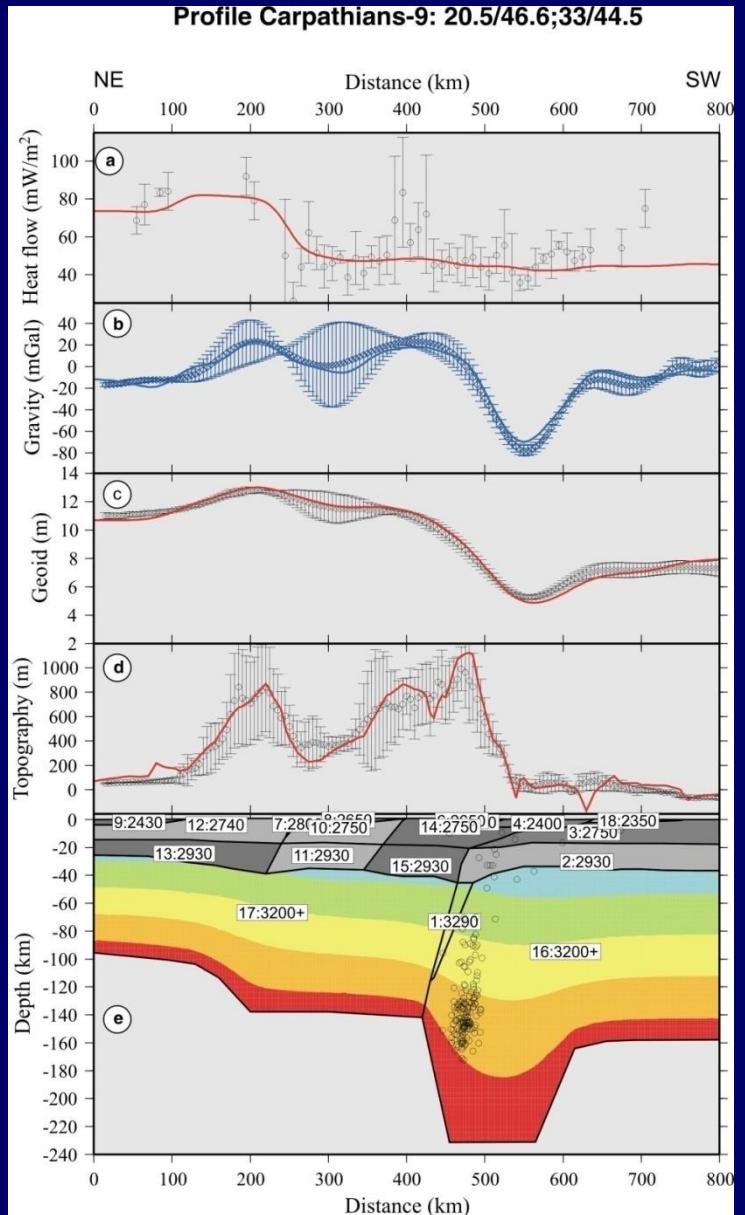
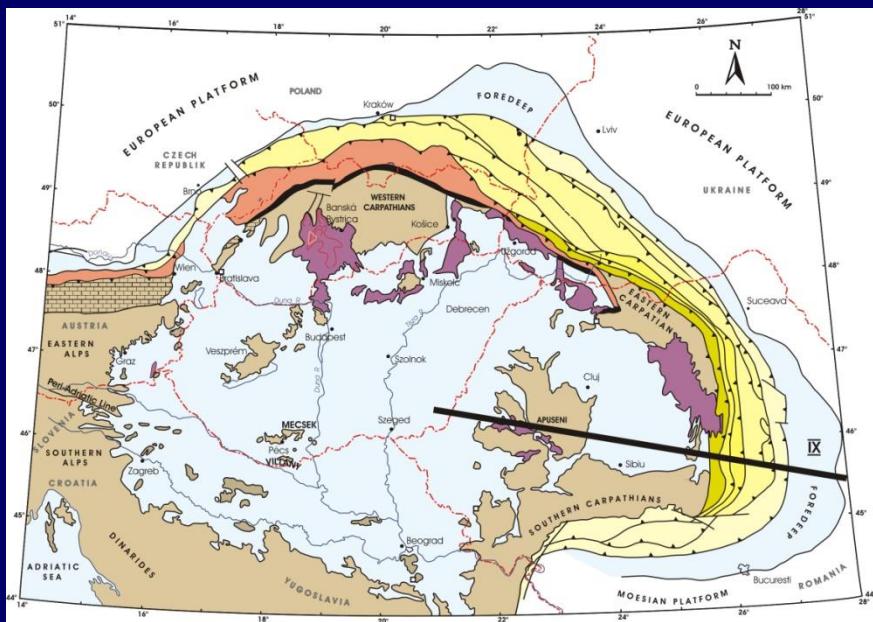


PROFILE VI



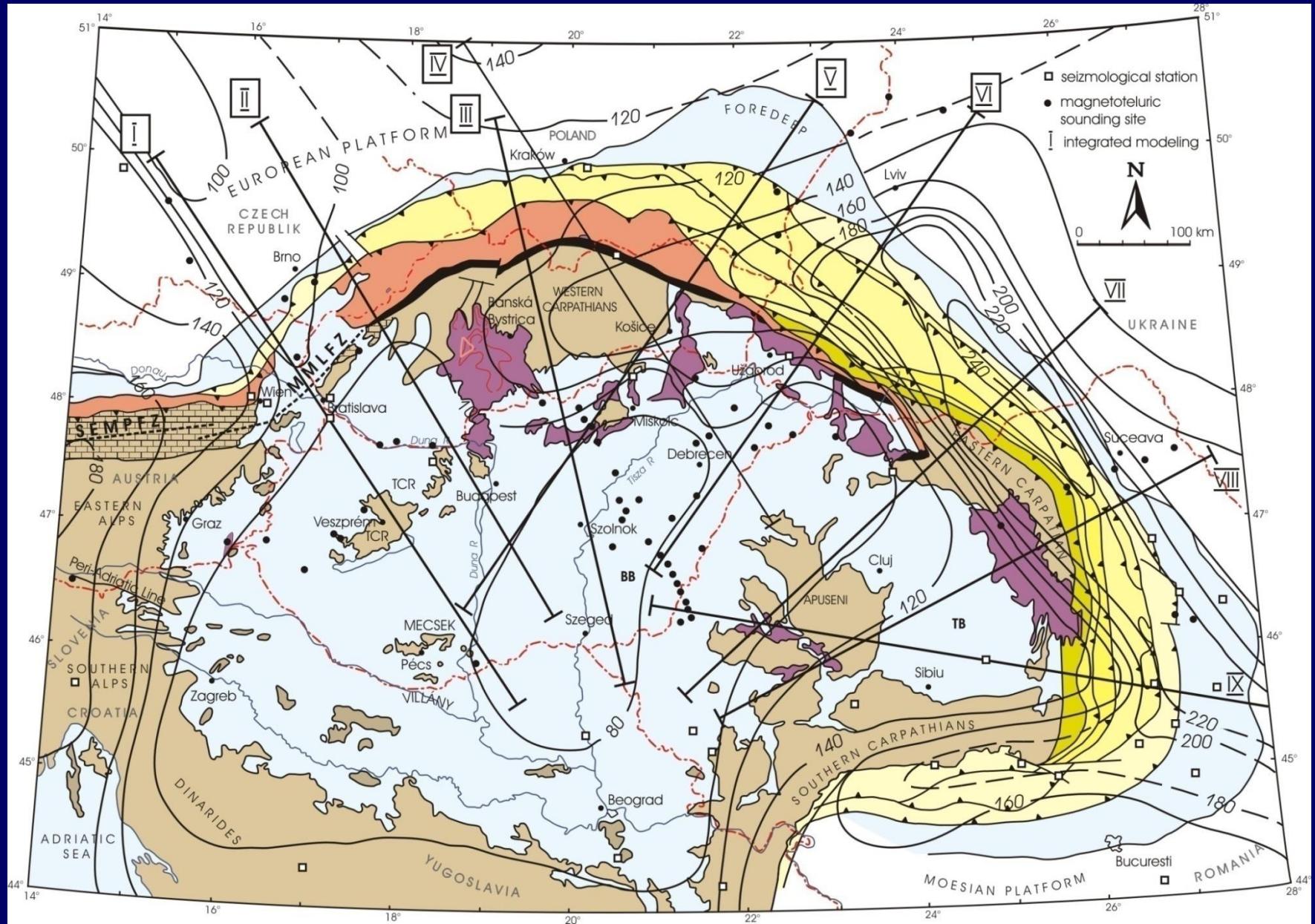


Profile IX



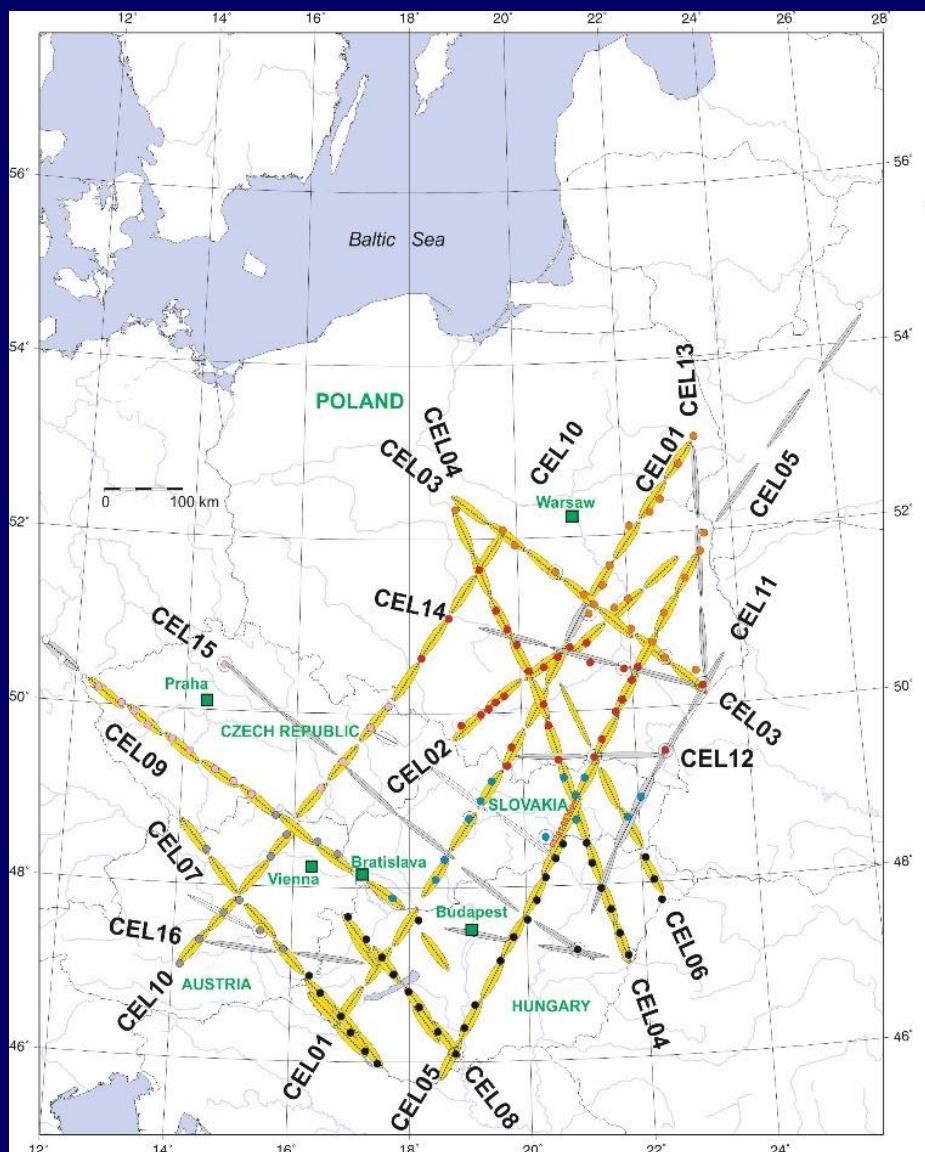


Map of lithosphere thickness

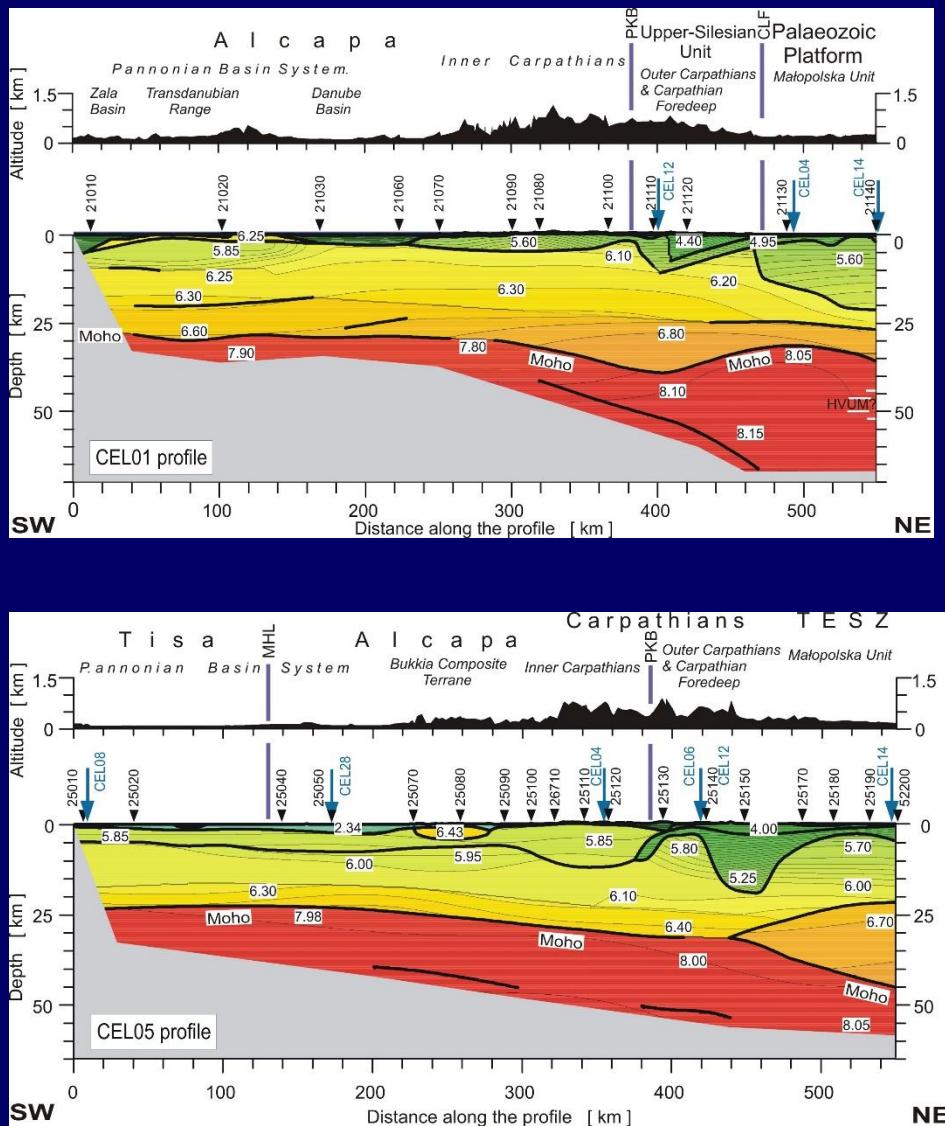




CELEBRATION 2000 seismic experiment

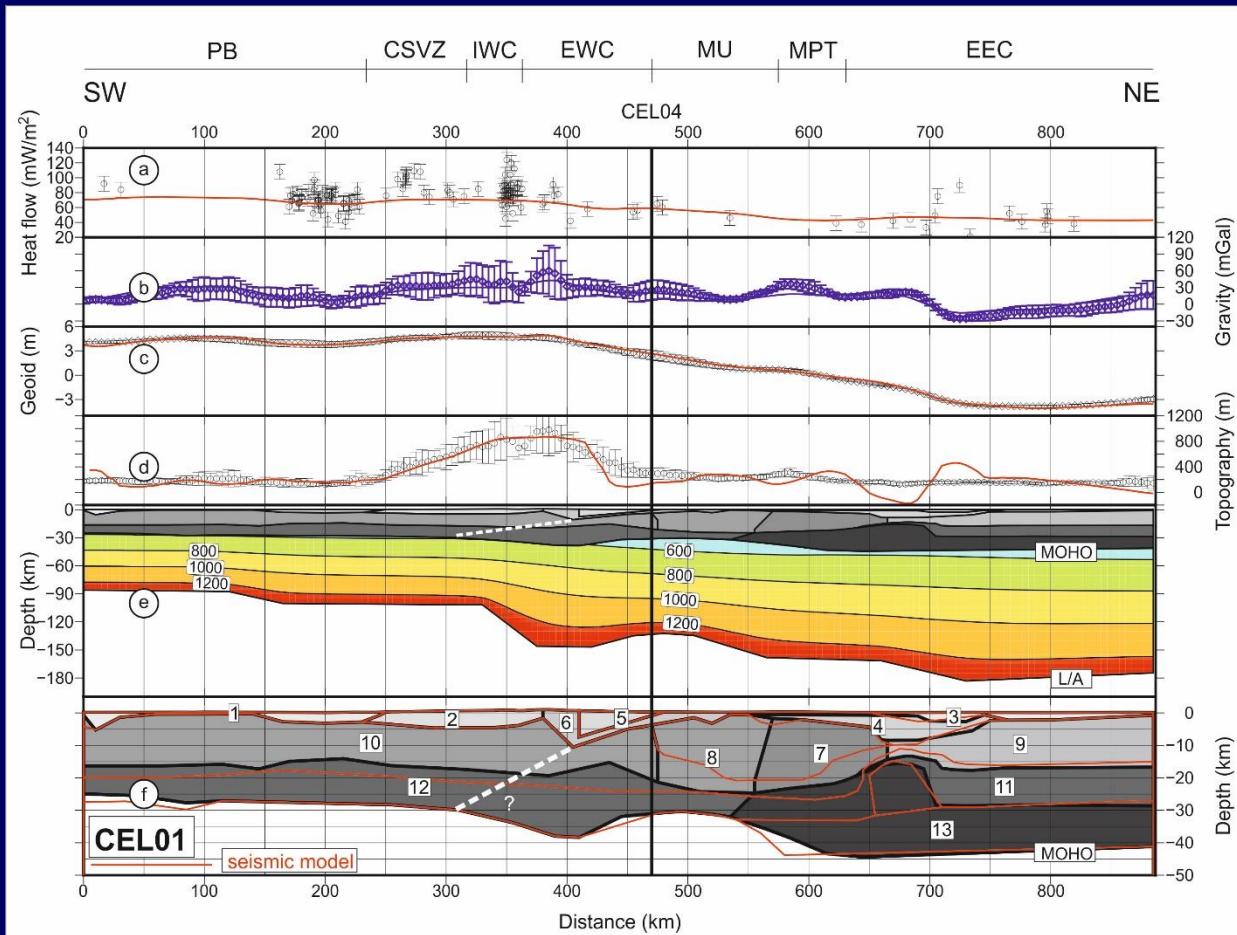
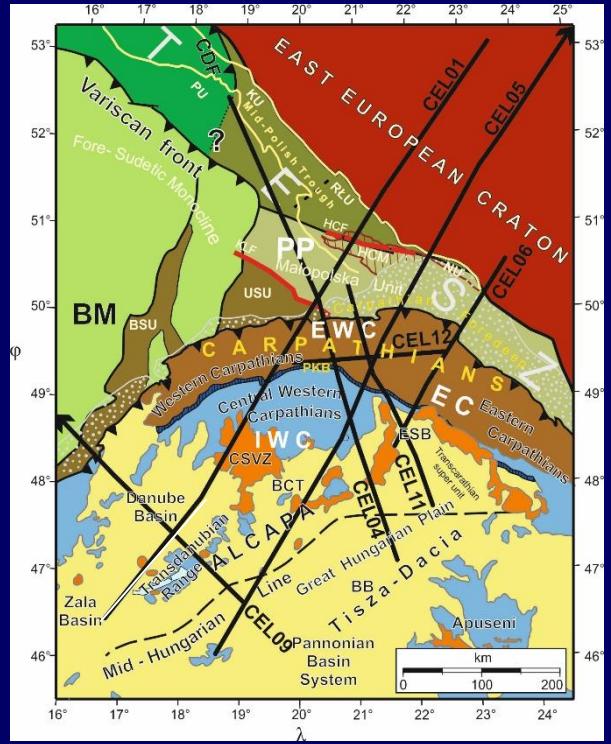


Location of the profiles of the CELEBRATION 2000 experiment (modified after Guterch et al. 2003)





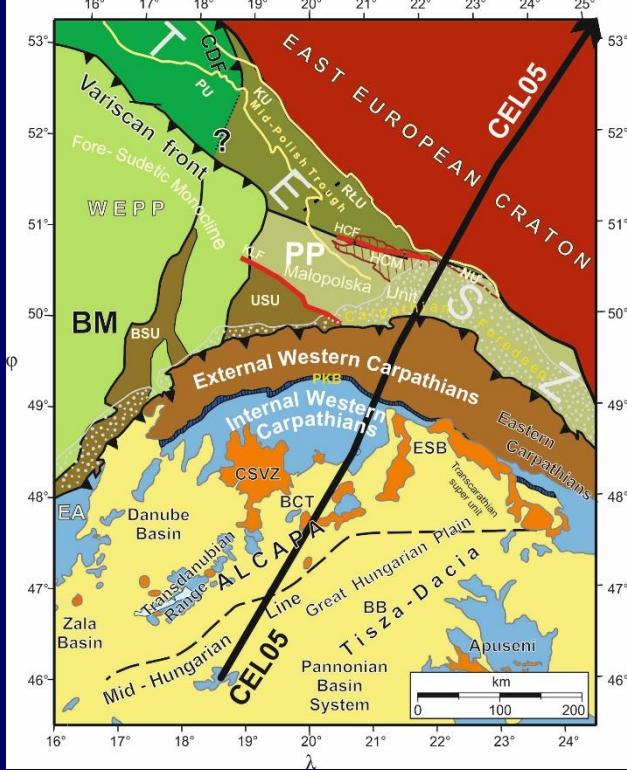
Lithospheric model for profile CEL01



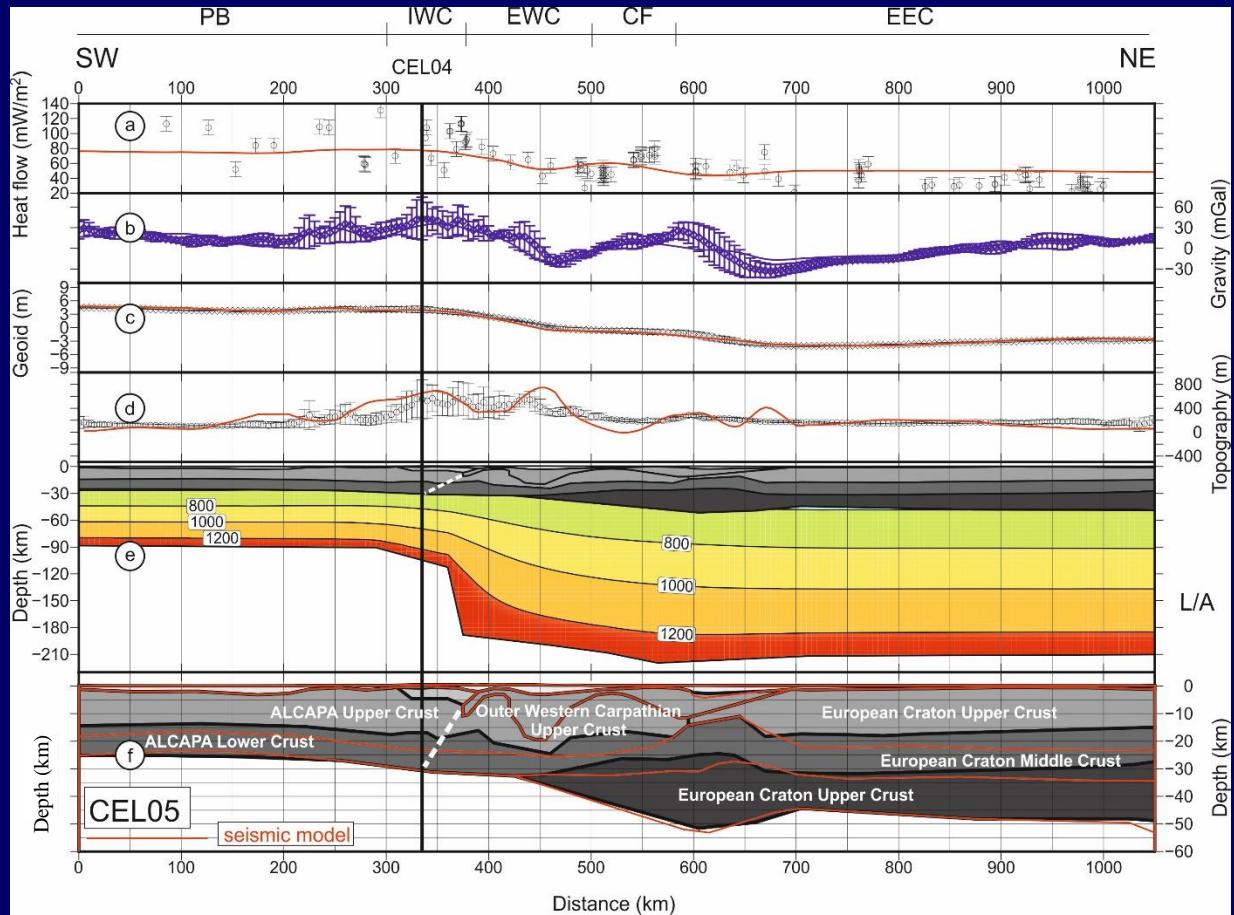
Location of the CELEBRATION 2000 seismic profile
CEL01 on the background of geological map of Central
Europe



Lithospheric model for profile CEL05



Location of the CELEBRATION 2000 seismic profile CEL05 on the background of geological map of Central Europe





3D INTEGRATED GEOPHYSICAL MODELLING



Lit Mod software

is self-consistent geophysical-petrological program

Finite difference method

Numerical implementations are given by
AFONSO ET AL. 2008 and FULLEA ET AL. 2009

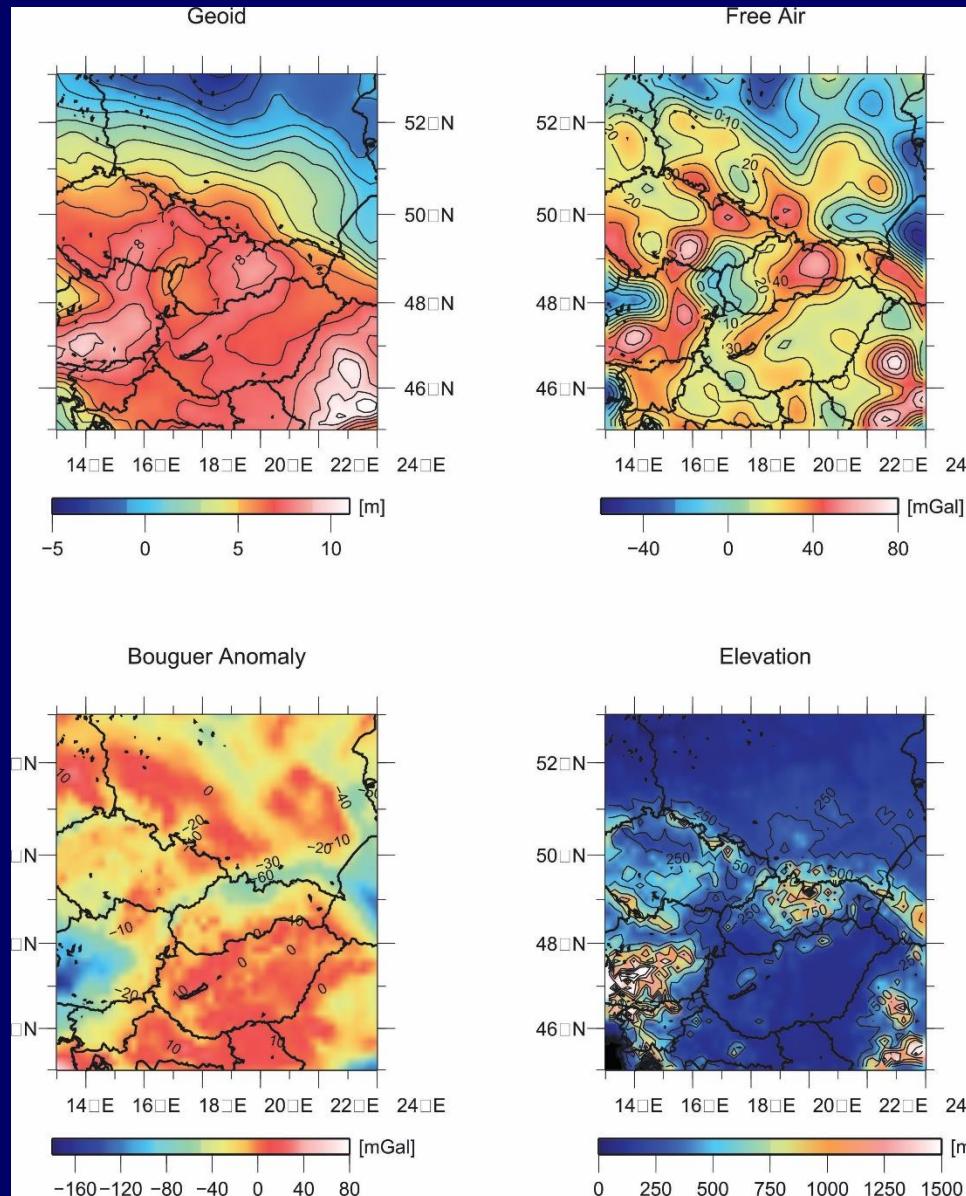
It is capable to model the lithosphere structure variations and the thermophysical properties of the upper mantle down to 410 km



3D integrated geophysical modelling

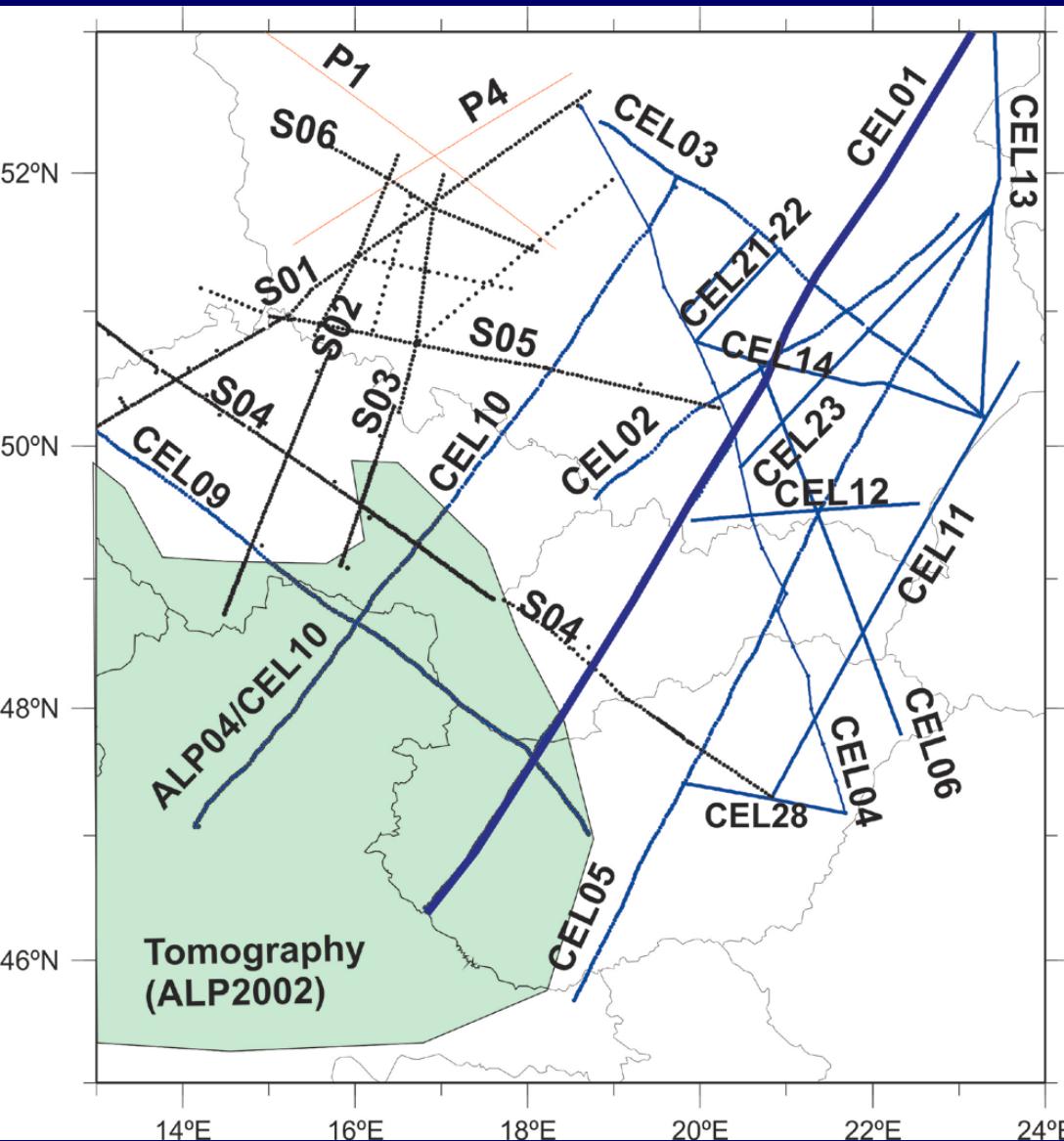


Input data





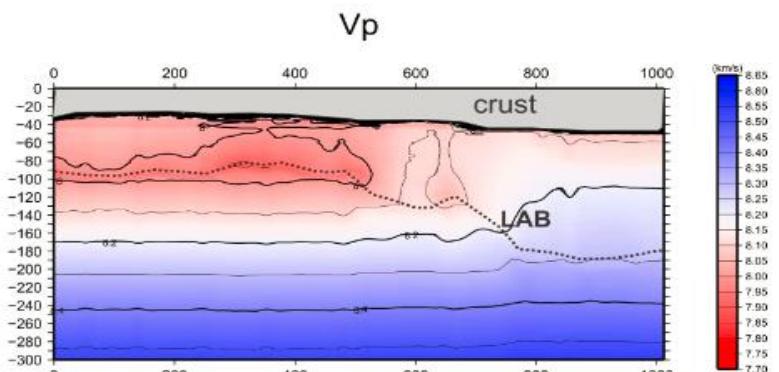
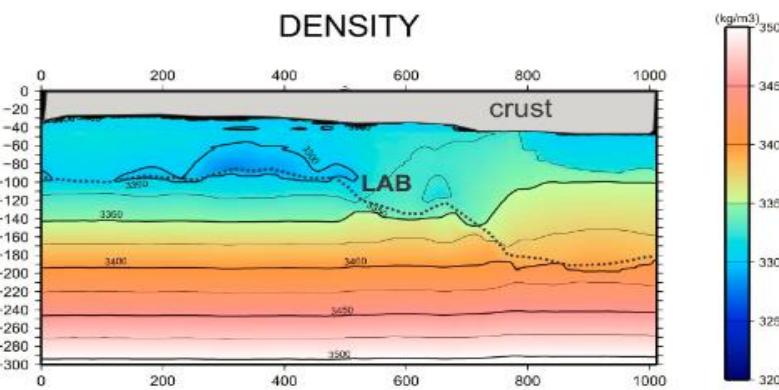
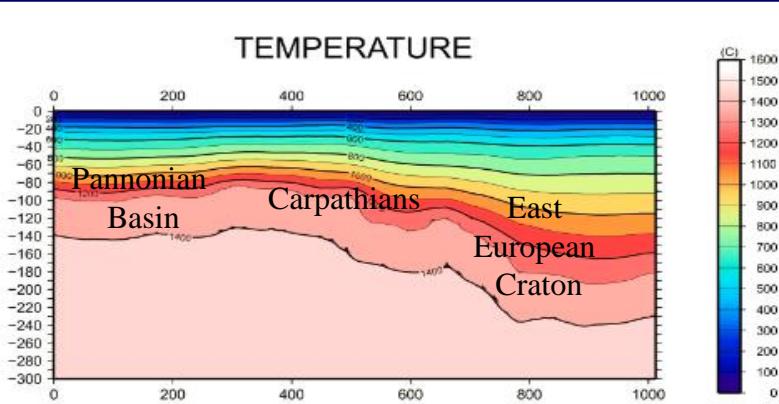
3D INTEGRATED GEOPHYSICAL MODELLING



**Robust model is based on
the results of the seismic
projects**

- POLONAISE 97
- CELEBRATION 2000
- ALPS 2002
- SUDETES 2003

Seismic study includes 18 000
profile km in total



Profile CEL01

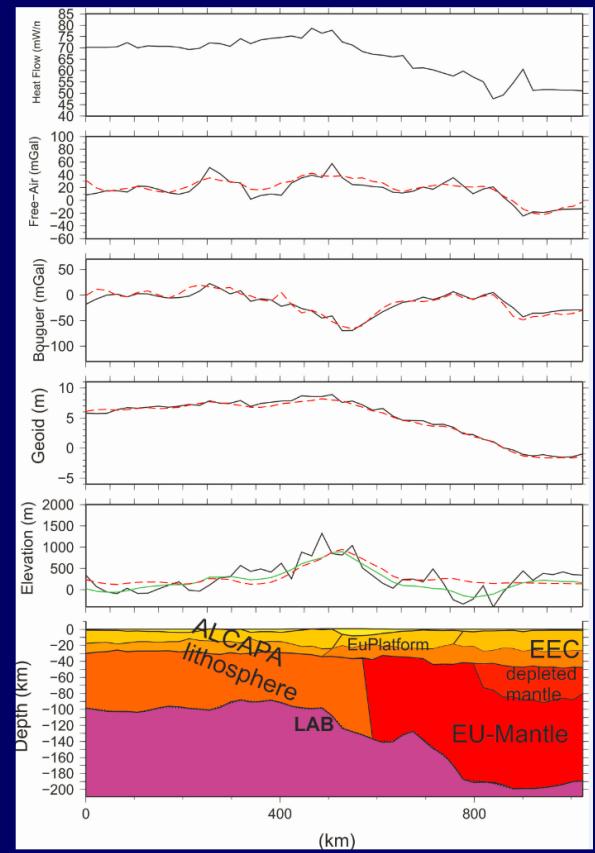
Distribution of:

- Temperature
- Density
- Seismic velocity

in Lower Lithosphere and
Asthenosphere



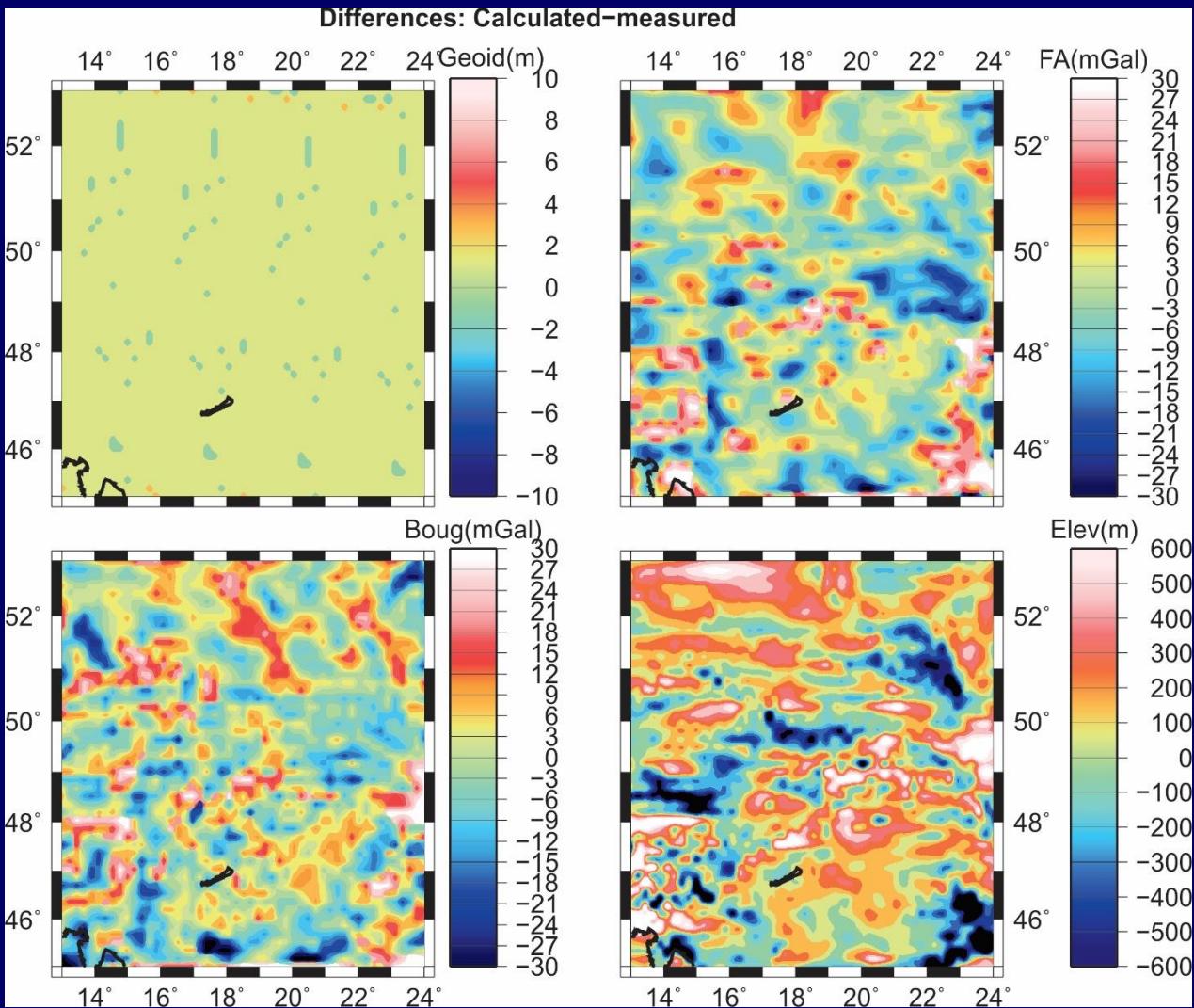
3D INTEGRATED GEOPHYSICAL MODELLING



Profile CEL01
Geophysical model of the
lithosphere

- Fit to the observed and modeled data

Fit to the observed and modeled data for the studied area

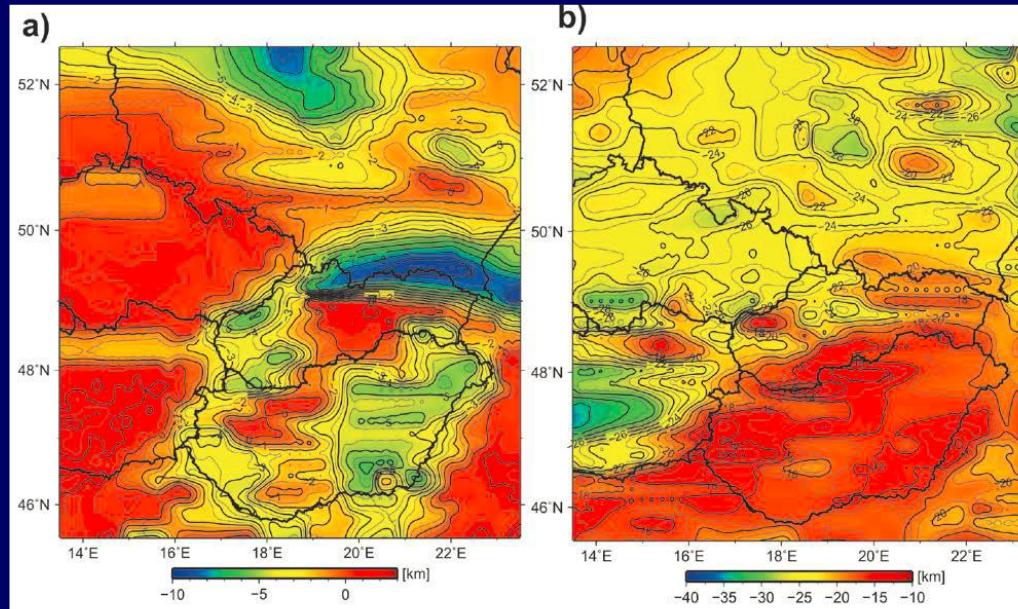




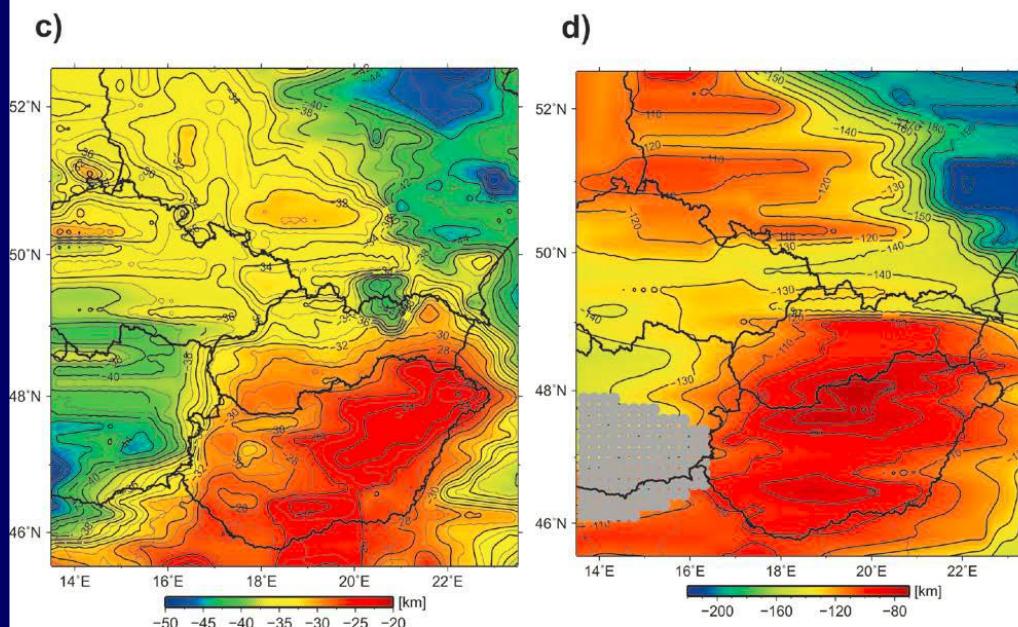
3D integrated geophysical modelling



Sediment thickness



Moho depth



Depth of the boundary between upper and lower crust

LAB depth



3D integrated geophysical modelling



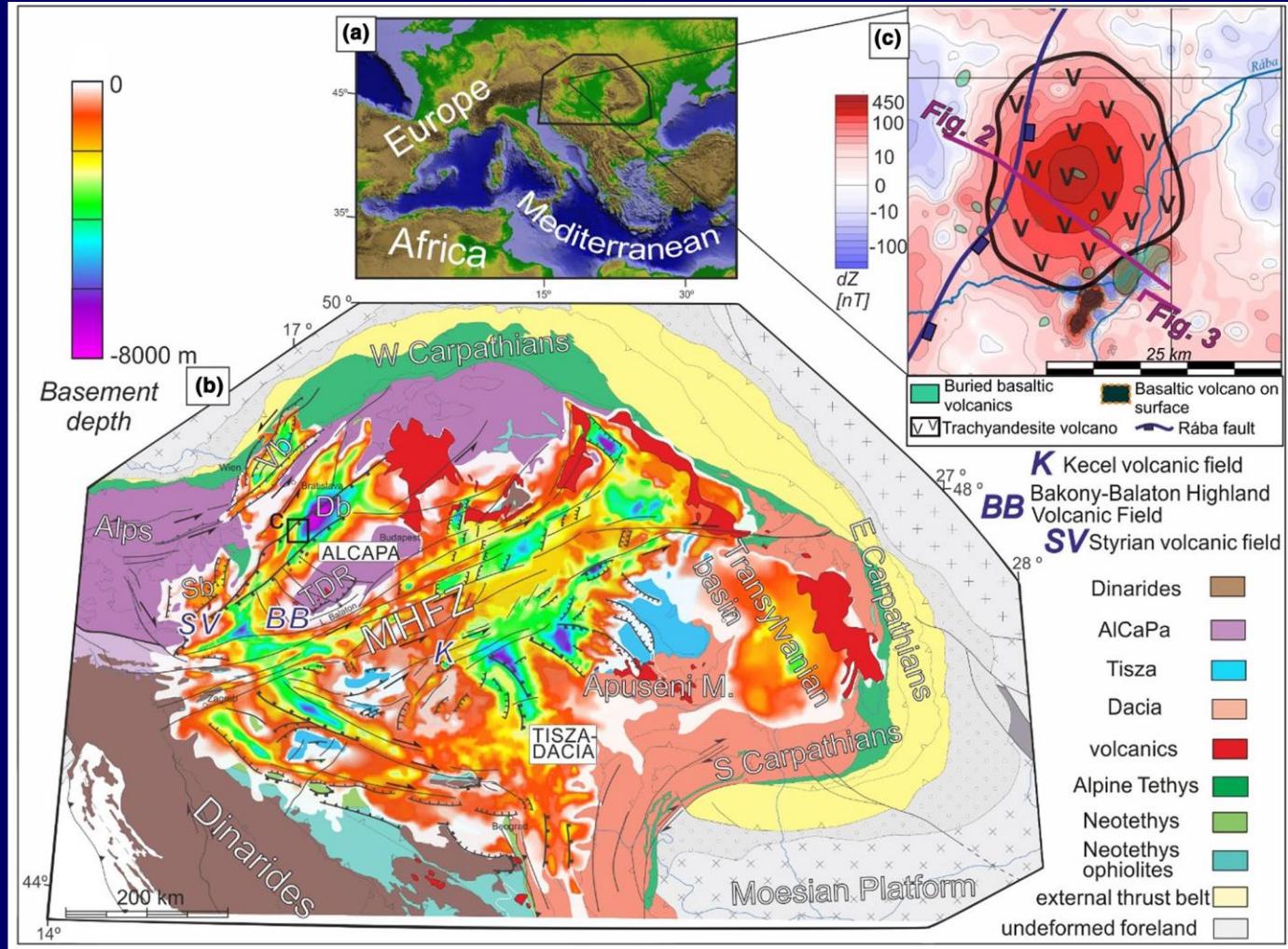
IGMAS+

3D interdisciplinary modelling approach

given by
Schmidt et al. (2015) and Götze (2014)



3D INTEGRATED GEOPHYSICAL MODELLING OF THE PÁSZTORI VOLCANO IN THE DANUBE BASIN



2018

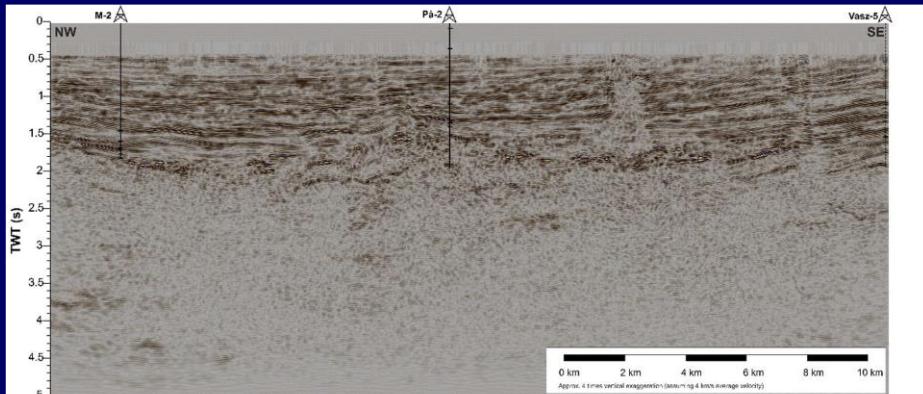


Pánisová, J., Balázsová, A., Zalai, Z., Bielik, M., Horváth, F., Harangi, S., Schmidt, S., Götz, H.J., 2018: Intraplate volcanism in the Danube Basin of NW Hungary: 3D geophysical modelling of the Late Miocene Pásztori volcano. *International Journal of Earth Sciences*, 2018, 107, 5, 1713–1730.

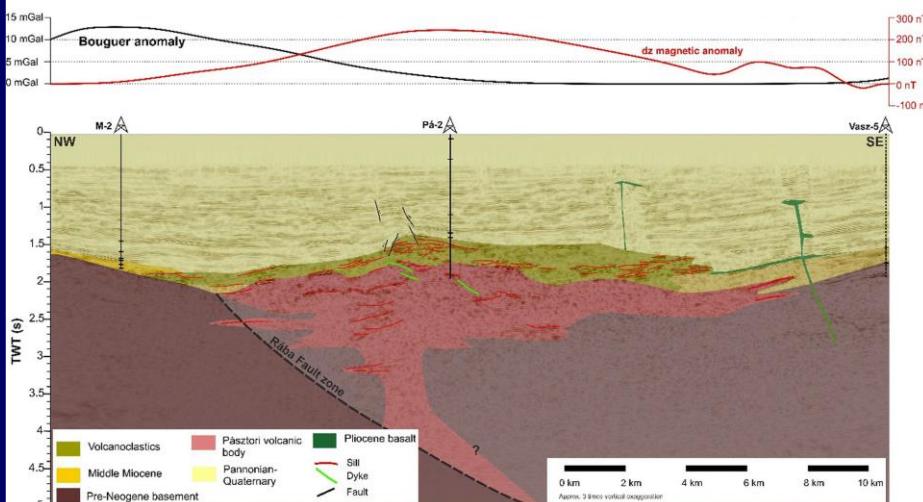


3D INTEGRATED GEOPHYSICAL MODELLING

Reflection seismic profile calibrated by well data from the southern part of the Danube Basin



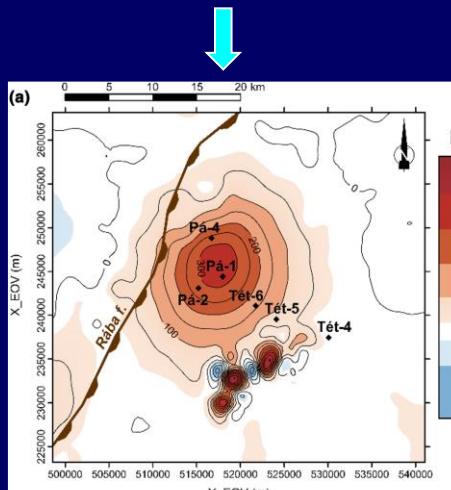
No Bouguer gravity but high magnetic anomaly above the Pásztori volcano



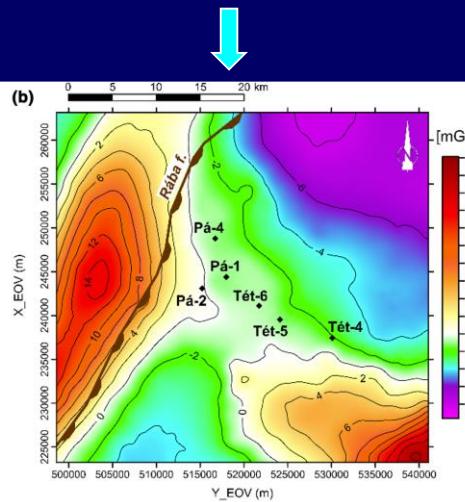


3D INTEGRATED GEOPHYSICAL MODELLING

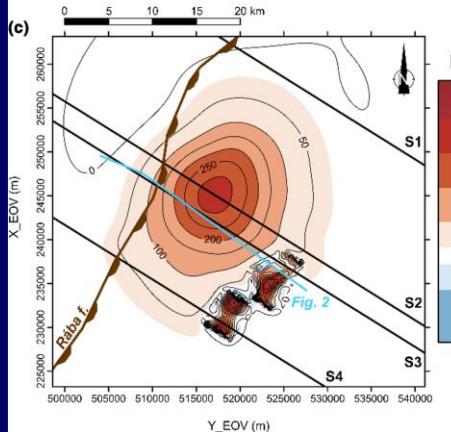
Observed magnetic field
above the Pásztori volcano



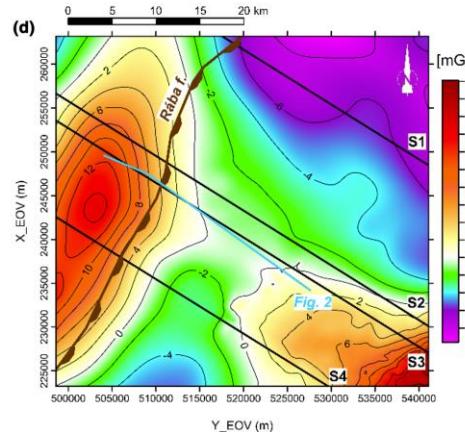
Observed gravity field
above the Pásztori volcano



Calculated magnetic field
above the Pásztori volcano

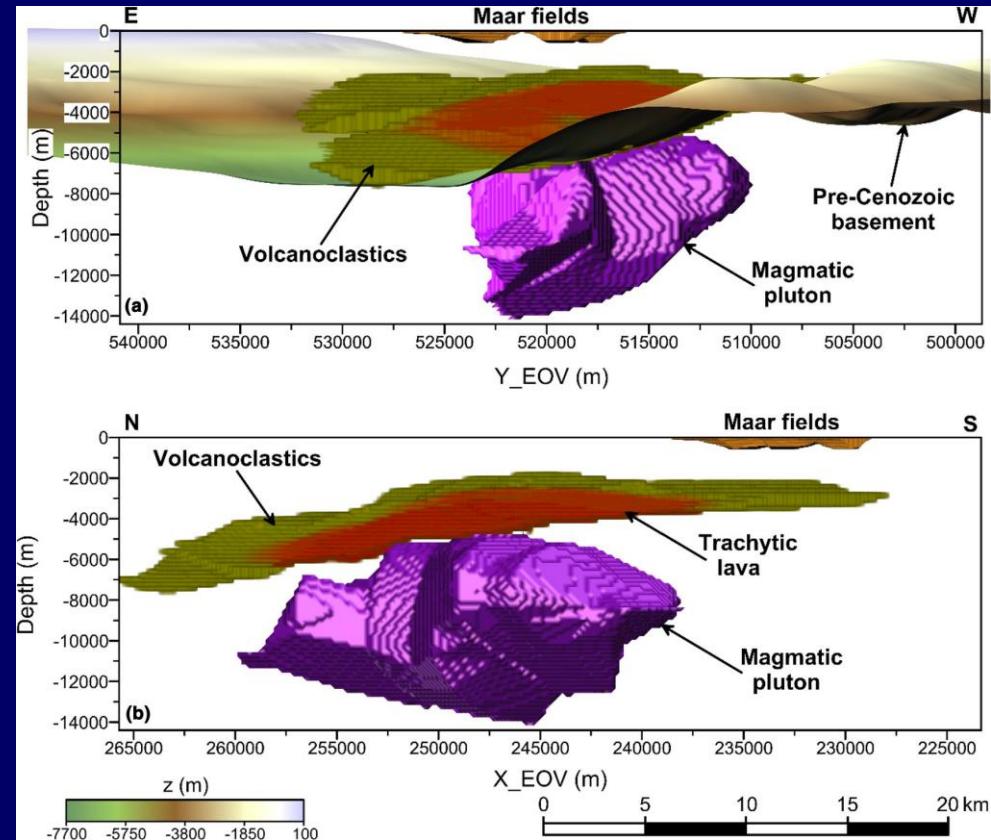
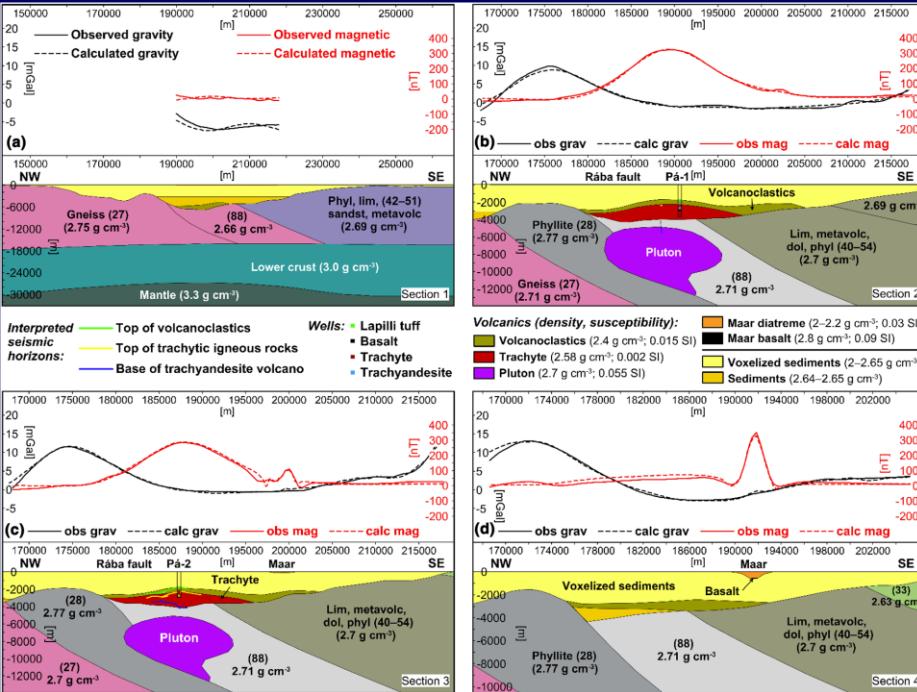


Calculated gravity field
above the Pásztori volcano





3D integrated geophysical modelling

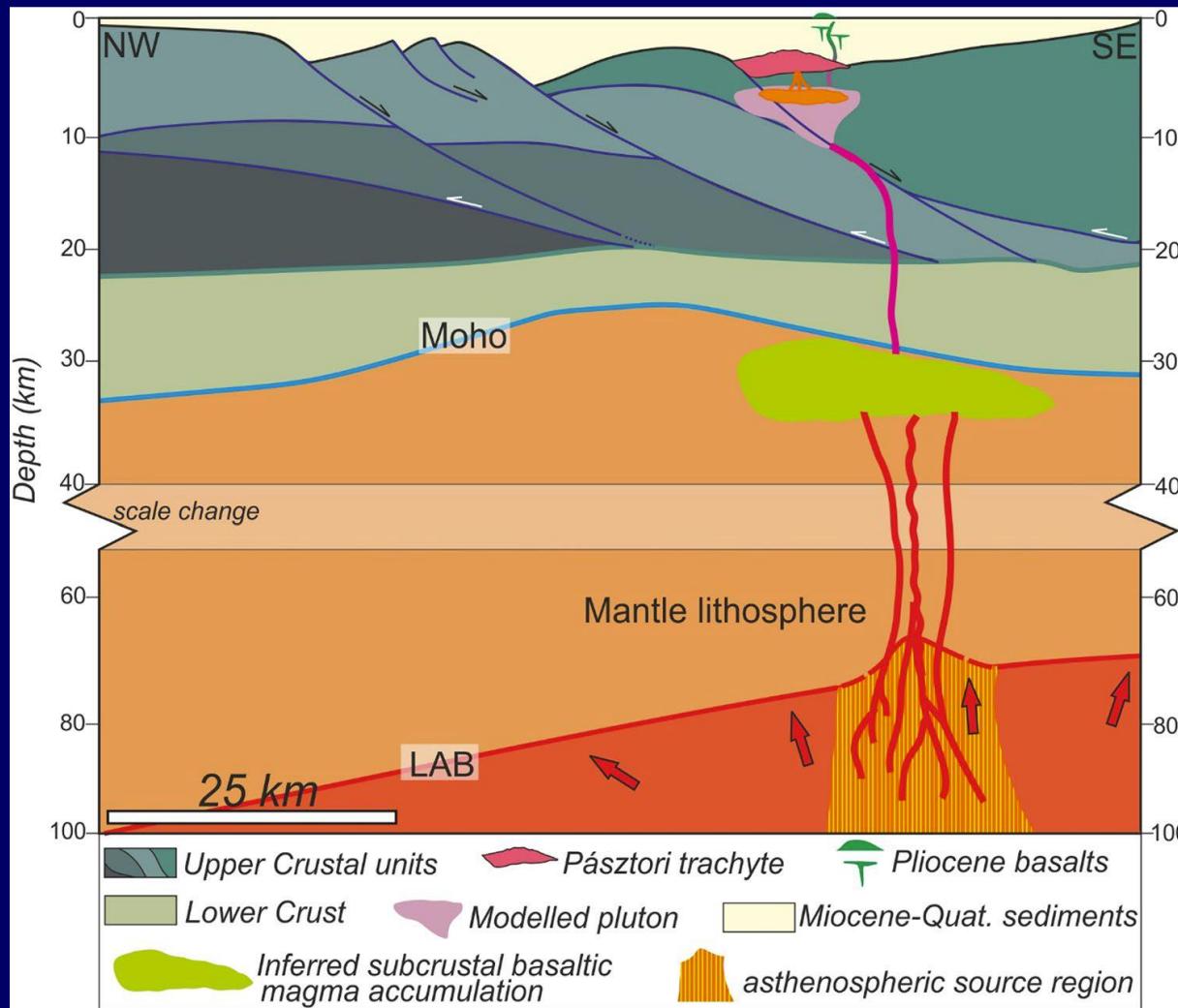


Four selected cross sections of the final Pásztori model

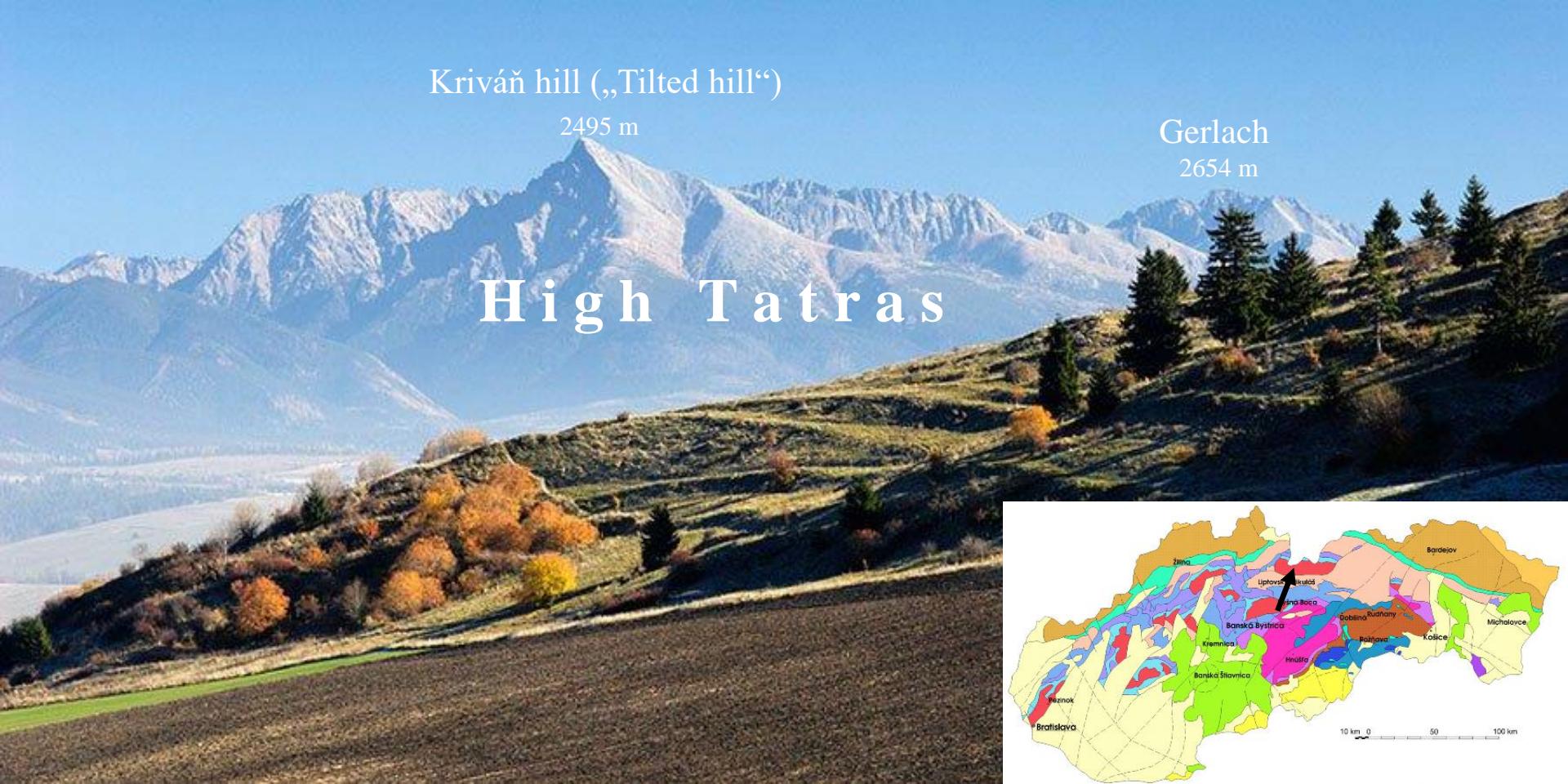
3D geophysical model of the Pásztori volcano: north view (a) and west view (b)



3D integrated geophysical modelling



Simplified sketch showing the asthenospheric sourced volcanism in the Danubian Basin Volcanic Field



Kriváň hill („Tilted hill“)

2495 m

Gerlach

2654 m

High Tatras

Thank you for your attention
and special thanks to
Baron Roland von Eötvös



Why were the Eötvös gravity measurements made in Gbely



Ján Medlen

(born: on January 9th, 1870, in Egbell-now Gbely; died: June 6th, 1944 in Gbely)

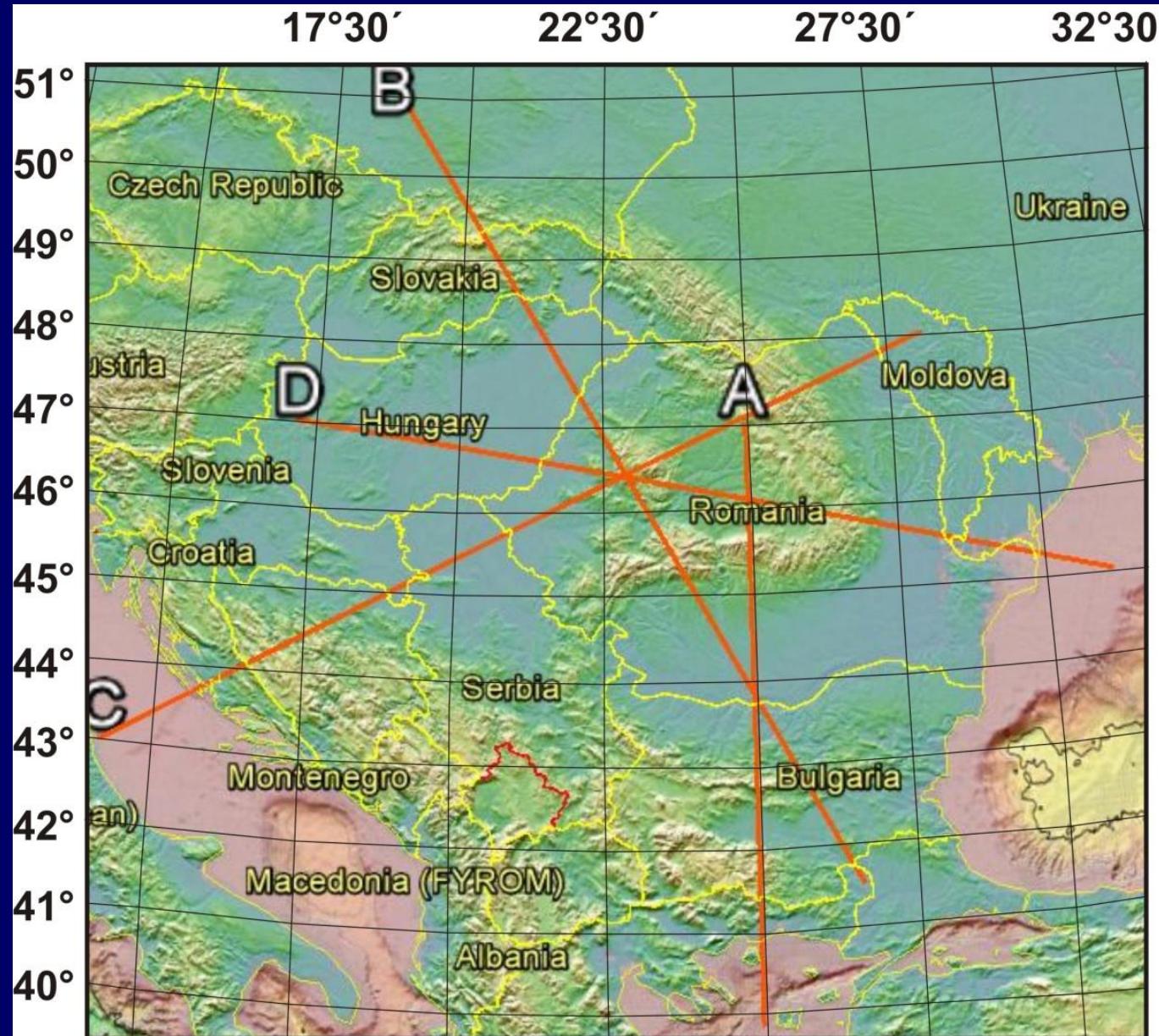
- He was a slovak farmer who discovered, in 1912, the first natural gas deposits near his house in Gbely
- The Ministry of Finance of the Kingdom of Hungary sent two geologists: Böckh and Papp to make a geological survey of this area
- In 1914, they proposed to make a borehole near Gbely, that found out at a depth of 163 meters the oil
- On January 13, 1914, Austria-Hungarian monarchy began, for the first time, to exploit oil.





Central european lithospheric transects

Location of 2-D
transects





Lithospheric model for transect C

