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

Why were the Eötvös gravity measurements made in Egbell (now Gbely in Slovakia)?

Bouguer gravity anomalies compiled during the project CELEBRATION 2000

2D and 3D integrated interpretation of gravity field
Ján Medlen (born: on January 9th, 1870, Egbell; died: June 6th, 1944, Gbely)

- He was a slovak farmer who discovered, in 1912, the first natural gas deposits near his house in Gbely.
- He brought the gas through the corridor to his house and he started to use it for cooking and heating. Until - his house exploded after burn the gas, because the concentration of gas was very high. The story happened in 1913.
- The Ministry of Finance of the Kingdom of Hungary sent the 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.
Eötvös gravity measurements in Egbell (Gbely)

Eötvös torsion-balance map
of the Egbell (Gbely) oil field (now in Slovakia)

Gravity anomaly map
of the Egbell (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$^{-1}$).

made by Eötvös’ assistants
Pekár and Fekete in 1915-16

borehole sited by Böckh in 1913

re-draft after Renner (1953).
Values of isolines are in $10^{-5}$ ms$^{-2}$
Eötvös gravimetric measurements

meant a huge success
not only for
oil industry but also for the gravimetry in Europe and the world
Bouguer gravity anomaly map


compiler in frame of International project CELEBRATION 2000
Bouguer gravity anomaly map
Bouguer gravity anomaly map

Western Carpathian Gravity Low: -70 mGal
Eastern Carpathian Gravity Low: -100 mGal
Southern Carpathian Gravity Low: -100 mGal
Source 1: Low density Sediments

Source 2: Low density Upper Crust

Bouguer gravity anomaly map

Profile 2T

Western Carpathian Gravity Low

Calculated vs. Observed

Flysch nappes (-0.20)
Neogene sediments (-0.20)

European plate (0)

Lower Lithosphere (+0.30)

Asthenosphere (+0.27)
SOURCES OF THE EASTERN AND SOUTHERN CARPATHIAN GRAVITY LOWS

Superposition

Source 1
Low density sediments
+
Source 2
Crustal roots

Bouguer gravity anomaly map
Moho depth
Bouguer gravity anomaly map

PANNONIAN GRAVITY HIGH
+15 mGal
Sedimentary thickness model
Bouguer gravity anomaly map

Pannonian Gravity High

+15 mGal
Source PGH: Elevation of the Moho
2D INTEGRATED GEOPHYSICAL MODELLING

GOAL

DERMINATION

THERMAL LITHOSPHERIC STRUCTURE AND THICKNESS
2D integrated geophysical modelling

CAGES software
(Zeyen and Fernandez, 1994)

- Surface heat flow
- Gravity field
- Geoid
- Topography

Anomalous bodies are defined:

- Heat conductivity \([\text{W.m}^{-1}\text{K}^{-1}]\)
- Heat production \([\text{W.m}^{-3}]\)
- Density \([\text{kg.m}^{-3}]\)
- Geometry \([\text{m}]\)
Input data

Topography

GTOPO30 database [Gesch et al., 1999]

Free air gravity

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

EGM96 global model [Lemoine et al., 1998]

Geoid [Lemoine et al., 1998]

worldwide data set

Surface heat flow [Pollack et al., 1993]
Profile I
Profile IX
Map of lithosphere thickness
Location of the profiles of the CELEBRATION 2000 experiment (modified after Guterch et al. 2003)
Location of the CELEBRATION 2000 seismic profile CEL01 on the background of geological map of Central Europe

(a) Surface heat flow density, (b) free-air gravity anomaly, (c) geoid, (d) topography with dots corresponding to measured data with uncertainty bars and solid lines for calculated values; (e) lithospheric structure, in the lithospheric mantle, isotherms are indicated every 200 °C; (f) crustal structure. The white dashed line indicates the expected boundary between microplate ALCAPA and European platform.
Location of the CELEBRATION 2000 seismic profile CEL05 on the background of geological map of Central Europe.

(a) Surface heat flow density, (b) free-air gravity anomaly, (c) geoid, (d) topography with dots corresponding to measured data with uncertainty bars and solid lines for calculated values; (e) lithospheric structure, in the lithospheric mantle, isotherms are indicated every 200 °C; (f) crustal structure. The white dashed line indicates the expected boundary between microplate ALCAPA and European platform.
3D INTEGRATED GEOPHYSICAL MODELLING
Lit Mod software

Finite difference method

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

combining a geophysical, geological and upper mantle petrological data is capable to study both the crust and the lower lithosphere
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
3D integrated geophysical modelling

Profile CEL01

Distribution of:

- Temperature
- Density
- Seismic velocity

in Lower Lithosphere and Asthenosphere
3D INTEGRATED GEOPHYSICAL MODELLING

Fit to the observed and modeled data for the studied area

Profile CEL01
Geophysical model of the lithosphere

- Fit to the observed and modeled data
3D integrated geophysical modelling

Sediment thickness

Moho depth

Depth of the boundary between upper and lower crust

LAB depth
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
Reflection seismic transect calibrated by well data from the southern part of the Danube Basin

Low Bouguer gravity but high magnetic anomalies above the Pásztori volcano
3D integrated geophysical modelling

- Calculated magnetic field above the Pásztori volcano
- Observed magnetic field above the Pásztori volcano
- Observed gravity 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)
Simplified sketch showing the asthenospheric sourced volcanism in the Little Hungarian Plain Volcanic Field
Thank you for your attention

and special thanks to

Baron Roland von Eötvös
Central european lithospheric transects

Location of 2-D transects
Lithospheric model for transect C

Profile C Adriatic Sea-Moldova SW-NE (14/43 - 28/48)

Vrancea 99 Seismic data (Radulescu et al., 1988)