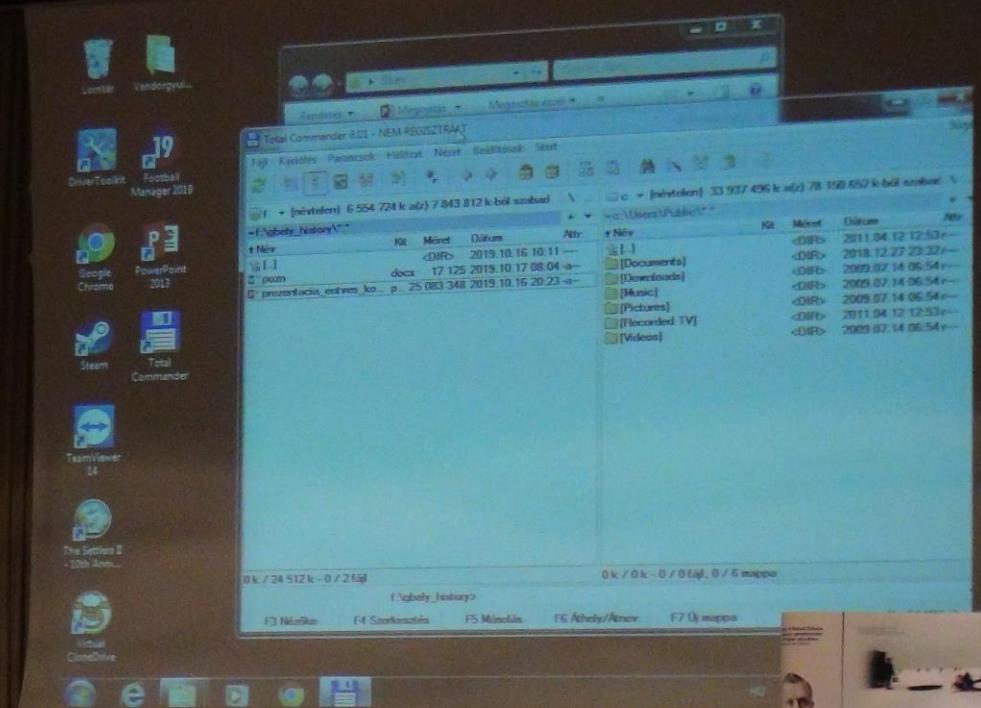
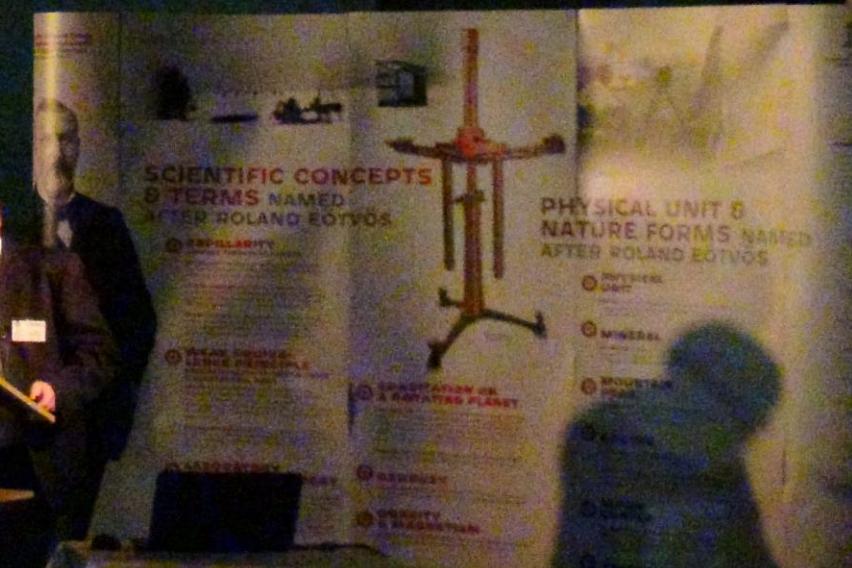
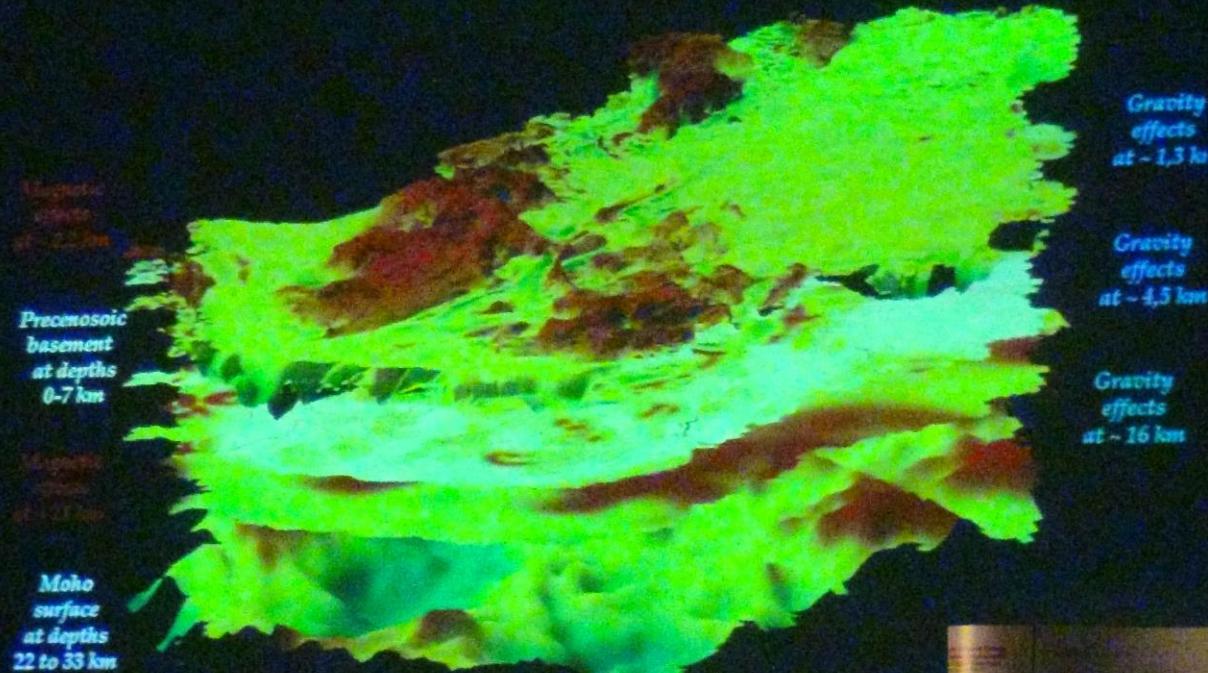


Fotogaléria Egbell  
Photo Galery Gbely  
2019.10.17



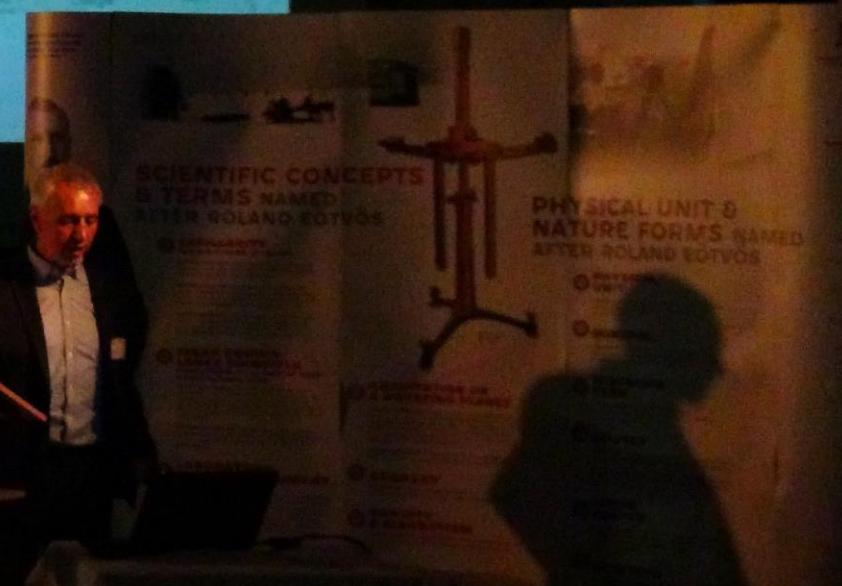
*Gravity and magnetic sources of different depths  
in the Pannonian basin*



## EXPLORATION

- Exploration in the first half of 20th years was performed mainly based on oil&gas seepage on the surface and occurrence hydrocarbons in the water wells and shallow exploration wells drilled up to 200 m.
- Geophysical methods start to be implemented to exploration
  - 1926 – 1927 geoelectric measure Sundberg method (swedish american company AEM)
  - Gravity measure – indicate elevation structure in the vicinity of Gbely
  - 1939 – 1945 first seismic measure (refraction) Germany company Gesellschaft fur praktische Lagerstättenforschung
  - Well log measure (Schlumberger) SP and RaG implemented to wells (1942) which brings significant improvement in oil&gas horizons identification
- Exploration works expanded from Gbely area to other Vienna Basin parts like Šaštín, Brodské, Závod, Kuklov, Gajary and pioneers wells were drilled up to 1 000 m.

12.11.2019



## Vermilion Energy / CEE business unit



### Central and Eastern Europe

- Established assets and position in under investment basin
- JV interests (operator) in Croatia
- Concessions in Hungary
- Entered termite agreement in Slovakia

### Ukraine

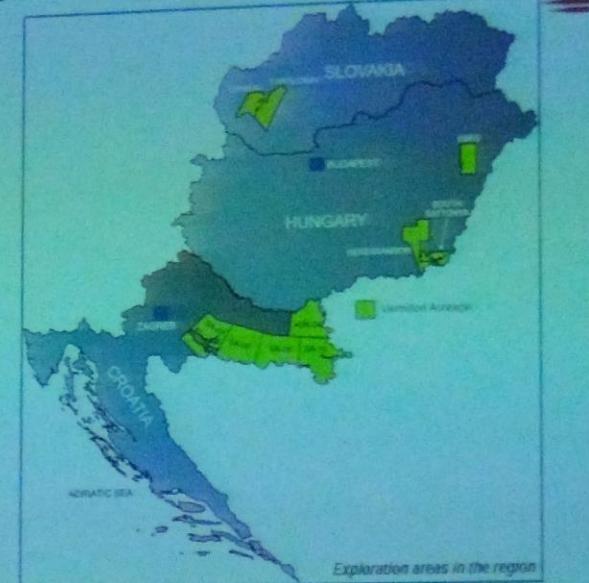
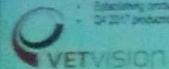
- Comb fed concessions - 95% of Russia's gas producer
- Q4 2017 production: 3,372 bwpd

### Hungary

- 40% interest oil producer
- Q4 2017 production: 11,215 bwpd

### Slovakia

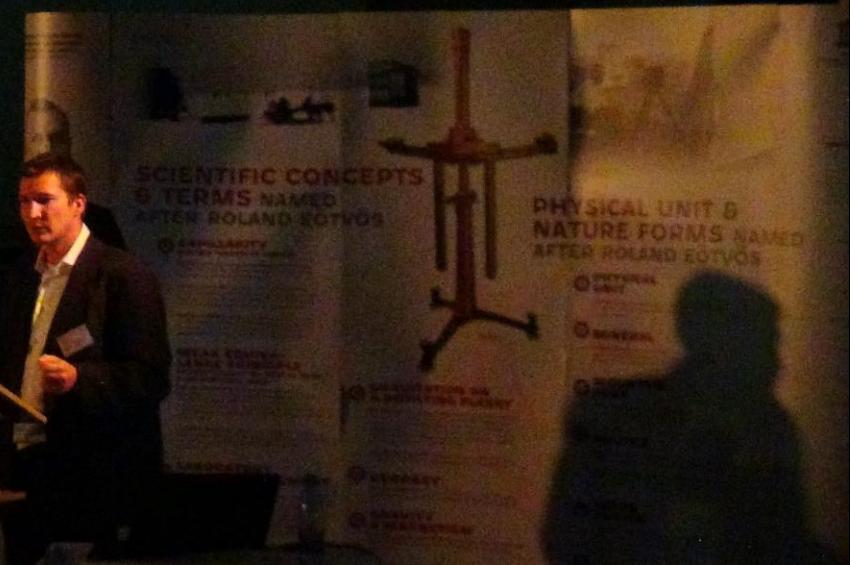
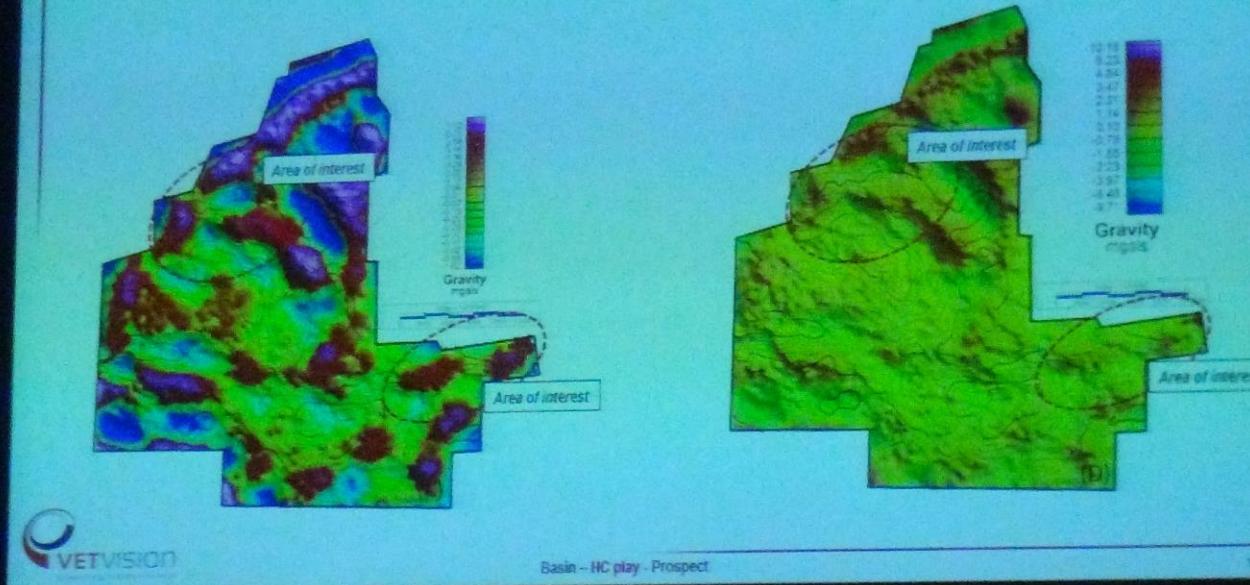
- Establishing production operations and successful exploration and position in North German Basin
- Q4 2017 production: 4,410 bwpd

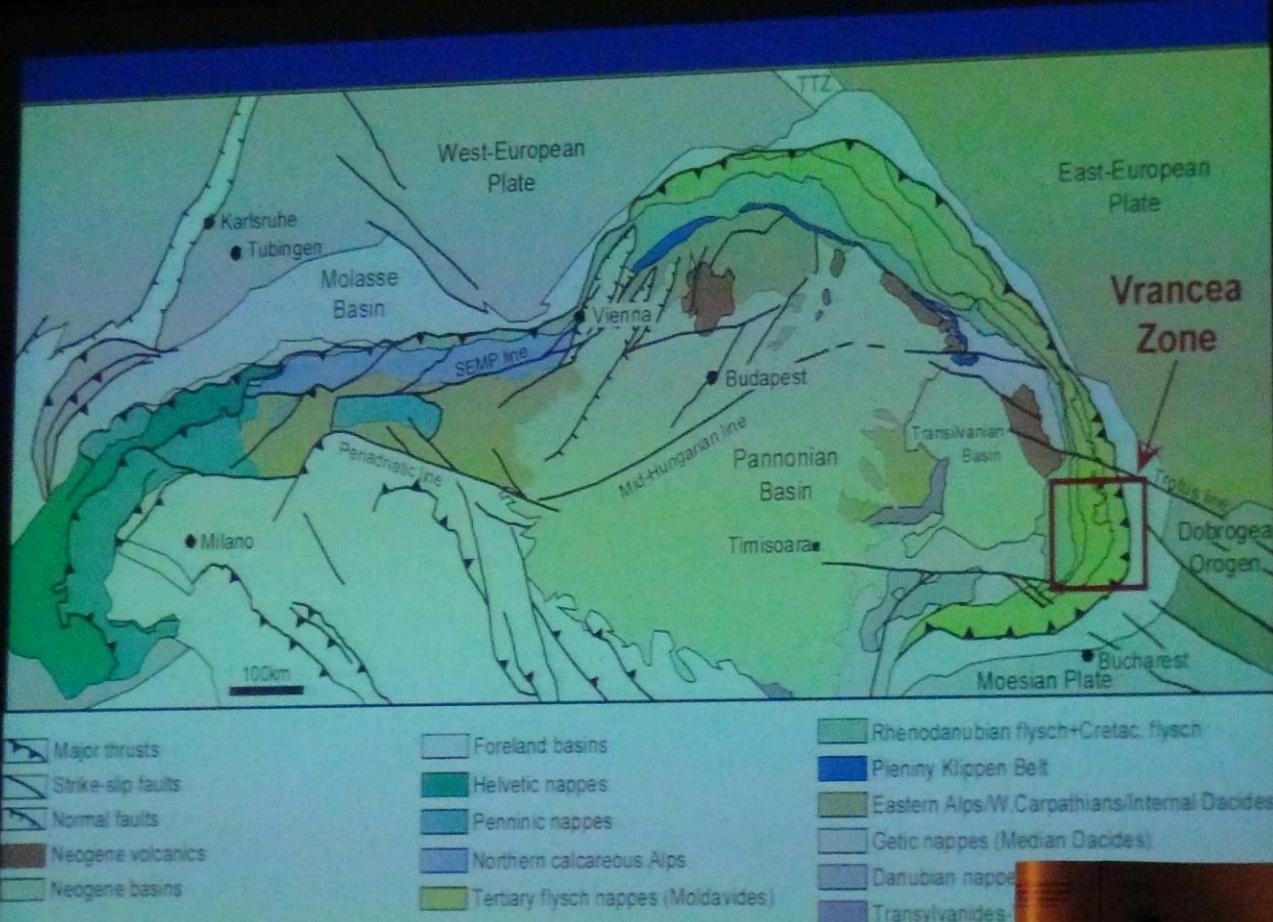


VERMILION  
ENERGY



Residual Gravity 10km (C) and Gravity (D) with TWT contour of the Base Pannonian





SCIENTIFIC CONCEPTS  
TERMS NAMED  
AFTER ROLAND KÖTVOSS

• TERRANE

• TECTONIC

• TECTONIC PLATE

• TECTONIC CYCLE

PHYSICAL UNIT &  
NATURE FORMS NAMED  
AFTER ROLAND KÖTVOSS

• PHYSICAL UNIT

• MINERAL

• MOUNTAIN PEAK

• RIVER

• LAKE

• FOREST

• HILL

• CANYON

• GORGE

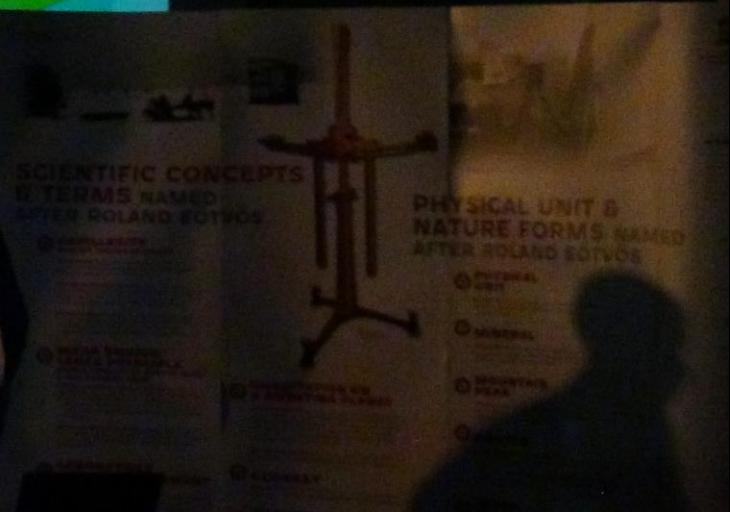
• CREEK

• CREEK

$$E = \begin{bmatrix} W_{xx} & W_{xy} & W_{xz} \\ W_{yx} & W_{yy} & W_{yz} \\ W_{zx} & W_{zy} & W_{zz} \end{bmatrix}$$

- interpolation of deflection of the vertical
- determination of local geoid forms
- determination of gravity and gravity anomalies mainly for geophysical purposes
- determination of vertical gradients

*inversion based reconstruction  
of the 3D potential function*





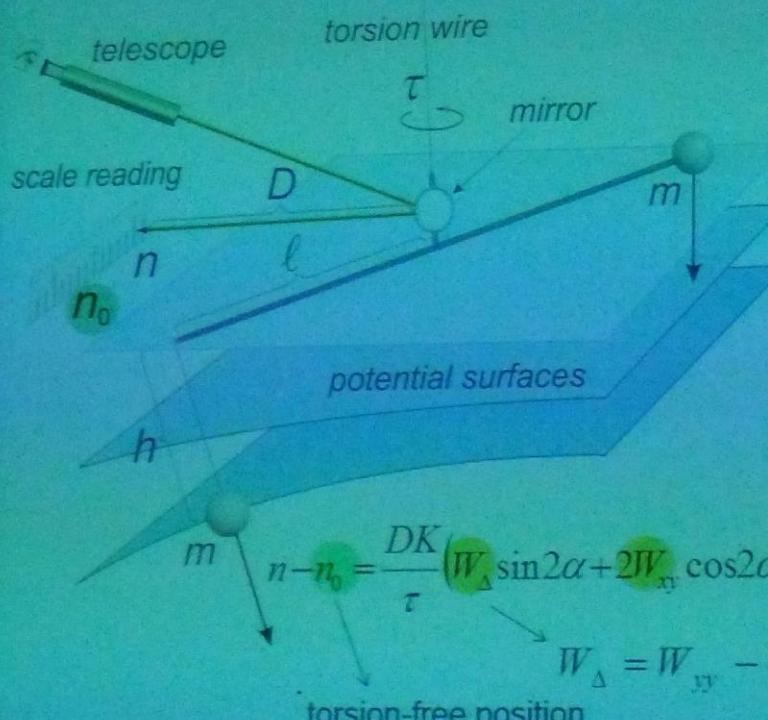
## Contents



- *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*



## Horizontal variometer



$$\mathbf{E} = \begin{bmatrix} W_{xx} & W_{xy} & W_{xz} \\ W_{yx} & W_{yy} & W_{yz} \\ W_{zx} & W_{zy} & W_{zz} \end{bmatrix}$$

$$m \quad n - n_0 = \frac{DK}{\tau} (W_{\Delta} \sin 2\alpha + 2W_{xy} \cos 2\alpha) + \frac{2Dhlm}{\tau} (W_{xy} \cos \alpha - W_{xx} \sin \alpha)$$

$W_{\Delta} = W_{yy} - W_{xx}$

torsion-free position

Theory of Stereoscopy : Sir Charles Wheatstone (1838)

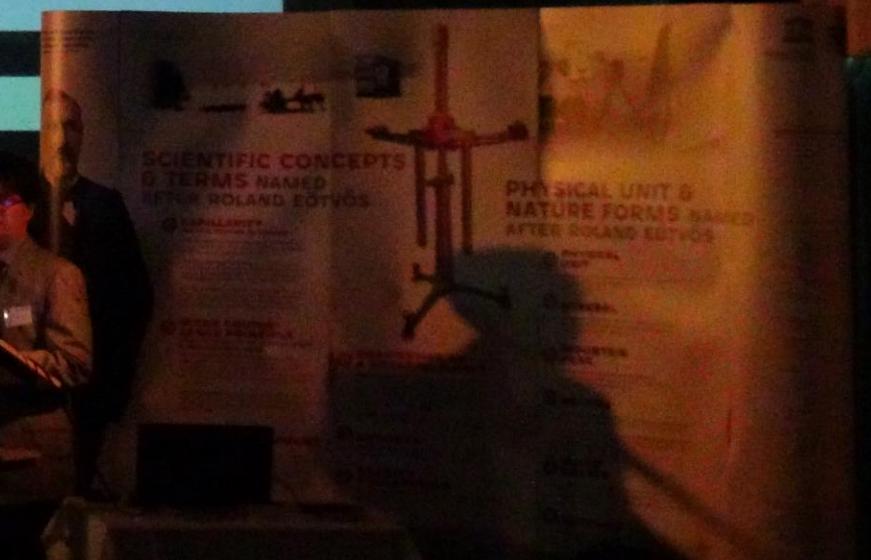
Lenticular Stereoscope : David Brewster (1851)

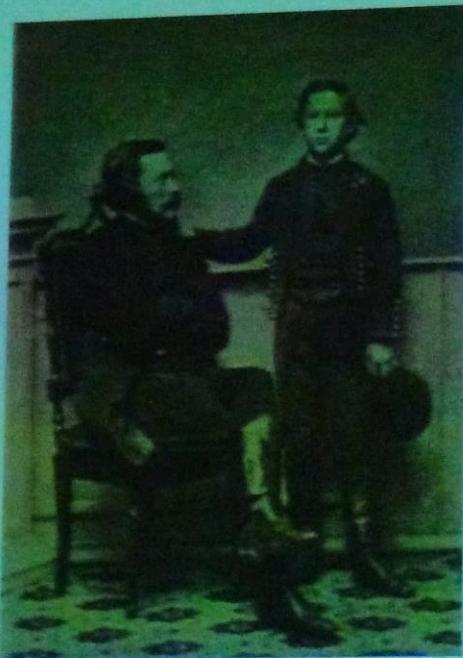
Description of the Anaglyph technology: Wilhelm Rollmann (1852)

1<sup>st</sup> Anaglyph image (colour printing): Louis Ducos du Hauron (1891)

D. Brewster

Lenticular stereoscope





József Eötvös with his son  
Vasárnapi Újság (Sunday News), 1860



Loránd was born  
Buda, 27 July, 1848

*„Ambition and sense of duty, which binds not only a privileged nation, but to the whole of mankind, were born with me. To satisfy these two aspirations and to satisfy my individual independence is my goal; and at least so far I've found that I can answer it the most if I enter the scientific career.”*

From the letter of Roland Eötvös to his father  
28 March, 1868





1858 (by Gusztáv Keleti)



Student in Heidelberg



Young professor

Married in 1876 with Gizella Horváth (1853–1919)

Daughters: Jolán (1877–1879), Rolanda (1878–1952), Ilona (1880–1945)

Eötvös did not have any grandchildren

Roland EÖTVÖS Loránd  
(1848–1919)



1896



1905



1912



1919



# 8 TERMS NAME AFTER ROLAND EÖTVOS

CAPILLARITY  
TENSION OF LIQUIDS

of capillarity) The Eötvös rule  
surface tension of an arbitrary  
temperatures.





# & TERMS AFTER ROLAND EÖTVÖS

## CAPILLARITY SURFACE TENSION OF LIQUIDS

**EÖTVÖS RULE** (Eötvös law of capillarity) The Eötvös rule enables the prediction of the surface tension of an arbitrary liquid pure substance at all temperatures.

**EÖTVÖS CONSTANT** The Eötvös constant is a constant  $2.1 \times 10^{-7} \text{ J/(K-mol}^2\text{)}$  in the Eötvös rule, connecting the surface tension, the molecular weight, and the specific volume with the temperature deviation from the critical temperature.

**EÖTVÖS NUMBER** The Eötvös number is a dimensionless number measuring the importance of gravitational forces compared to surface tension forces, characterizing the motion of bubbles or drops moving in a surrounding fluid.

## EQUIVALENT PRINCIPLE

### PRINCIPLE OF INERTIAL MASS

experiment, Eötvös-type experiment that measured the equivalence of inertial mass and gravitational mass, and the same, something demonstrated with the

is a measure of gravitational forces of two sets

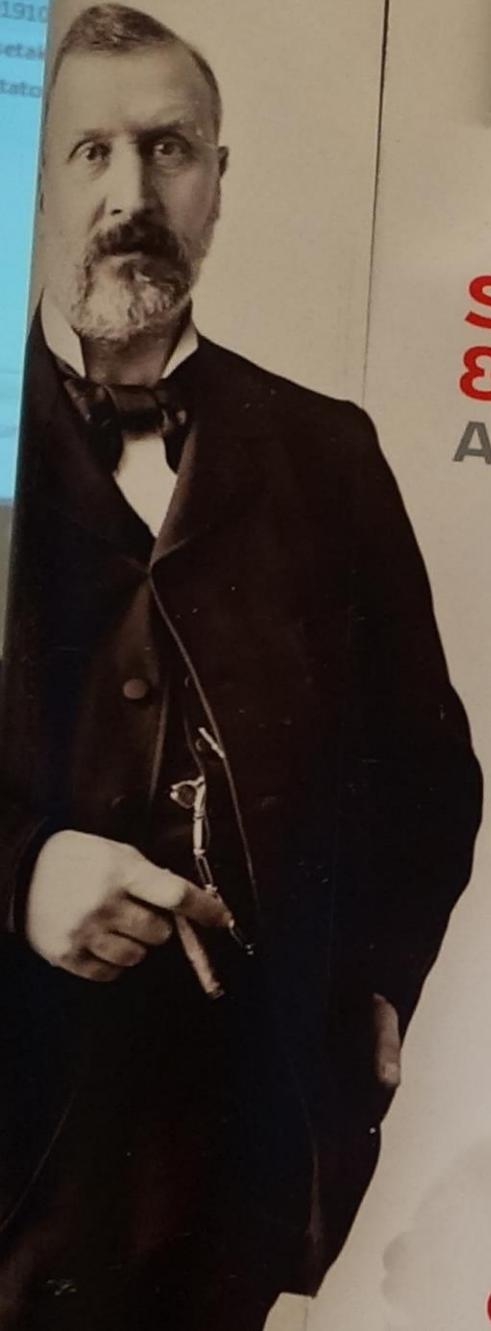
## ENT

possible to accuracy, meter by light bar, rail bar, bounded by two

S







## SCIENTIFIC CONCEPTS & TERMS NAMED AFTER ROLAND EÖTVÖS

### CAPILLARITY

SURFACE TENSION OF LIQUIDS

**EÖTVÖS RULE** (Eötvös law of capillarity) The Eötvös rule enables the prediction of the surface tension of an arbitrary liquid pure substance at all temperatures.

**EÖTVÖS CONSTANT** The Eötvös constant is a constant  $2.1 \times 10^{-7} \text{ J/(K-mol)}^2$  in the Eötvös rule, connecting the surface tension, the molecular weight, and the specific volume with the temperature deviation from the critical temperature.

**EÖTVÖS NUMBER** The Eötvös number is a dimensionless number measuring the importance of gravitational forces compared to surface tension forces, characterizing the shape of bubbles or drops moving in a surrounding fluid.

### WEAK EQUIVALENCE PRINCIPLE

PROPORTIONALITY OF INERTIAL MASS & GRAVITATIONAL MASS

**EÖTVÖS EXPERIMENT** (EPF experiment, Eötvös-type experiment) a famous physics experiment that measured the correlation between inertial mass and gravitational mass, demonstrating that the two were one and the same, something that had long been suspected but never demonstrated with the same accuracy.

**EÖTVÖS PARAMETER** The Eötvös parameter is a measure in the Eötvös experiment (a difference of the ratios of gravitational and inertial masses divided by their average for the two sets of test masses).

### LABORATORY & FIELD INSTRUMENT

### GEODESY

**EÖTVÖS TENSOR** The Eötvös tensor is a  $3 \times 3$  ( $x,y,z$ ) symmetrical gravity gradient tensor, and its elements are the gravity gradients.



### GRAVITATION ON A ROTATING PLANET

**EÖTVÖS EFFECT** It is the change in perceived gravitational force caused by the change in centrifugal acceleration resulting from eastbound or westbound velocity. When moving eastbound, the object's angular velocity is increased (in addition to the earth's rotation), and thus the centrifugal force also increases, causing a perceived reduction in gravitational force.

**EÖTVÖS CORRECTION** This is the correction necessary if the instrument is on a moving platform, such as a ship or aircraft.

## PHYSICAL UNIT & NATURE FORMS NAMED AFTER ROLAND EÖTVÖS

### PHYSICAL UNIT

**EÖTVÖS** (unit) The eötvös (or eotvos) is a unit of acceleration divided by distance. The symbol of the eötvös unit is E.  
 $1 \text{ eötvös} = 1 \times 10^{-8} \text{ s}^{-2}$

### MINERAL

**LORÁNDITE** Lorándite is a mineral (thallium arsenic sulfosalt), being used for detection of solar neutrino. It was discovered in 1894 and named after Roland Eötvös.

### MOUNTAIN PEAK

**EÖTVÖS PEAK** (Cima di Eötvös, Eötvösspitze) The Eötvös Peak is the second highest, or south-western, Cadin peak in the Dolomites (3037m).

### ROUTES

**VIA EÖTVÖS** (Via Eötvös Dímai) This classic route tackles a central line through the complex South Face of the Tofana (Dolomites).

**EÖTVÖS-ÚT** (Eötvös Loránd-turistaút, Etveska, Eötvösova cesta) A hiking trail above Banská Štiavnica (Seimerebanya, Schenitz), named after Roland Eötvös in 1896.

### MOON CRATER









 Virtual  
CloneDrive



## SCIENTI & TERM AFTER RO

### CAPILLA SURFACE TENSIO

EÖTVÖS RULE (Eötvös law) Enables the prediction of the surface tension of a liquid pure substance at all temperatures.

EÖTVÖS CONSTANT The constant  $\kappa = \text{N} \cdot \text{K}^{-1} \cdot \text{mol}^{-1}$  in the Eötvös rule. It is the ratio of surface tension to the molecular weight times the temperature deviation.

EÖTVÖS NUMBER The Eötvös number measuring the importance of gravity compared to surface tension in determining the shape of bubbles or drops.

### WEAK E LENCE PI PROPORTIONAL & GRAVITATION

EÖTVÖS EXPERIMENT (Eötvös experiment) A famous physics experiment demonstrating that the two masses had long been suspected to have the same accuracy.

EÖTVÖS PARAMETER In the Eötvös experiment, the ratio of the two masses divided by the mass of the test masses.

### LABORATO & FIELD IN

EÖTVÖS TORSION BALANCE (Eötvös pendulum) The instrument used to measure gravity gradients in the Eötvös torsion balance. Two test masses were attached to a horizontal beam and carried a vertical rod. The main feature of the torsion balance was that the beam was free at the center.



1E01VOS

Wim Eijk  
Managing Director  
Service of Integrity



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&  
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Ján M. Štefunko

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# SCIENTIFIC & TERMS AFTER ROLAND

## CAPILLARITY

SURFACE TENSION OF LIQUIDS

**EÖTVÖS RULE** (Eötvös law of capillarity) enables the prediction of the surface tension of a liquid pure substance at all temperatures.

**EÖTVÖS CONSTANT** The Eötvös constant ( $c$ ) is a proportionality factor ( $c = 2.1 \times 10^{-7} \text{ J}/(\text{K} \cdot \text{mol}^2)$ ) in the Eötvös rule relating the surface tension, the molecular weight, and the temperature deviation from the melting point.

**EÖTVÖS NUMBER** The Eötvös number ( $E$ ) is a dimensionless number measuring the importance of gravitational forces compared to surface tension forces. It is used to predict the shape of bubbles or drops moving in a gravitational field.

## WEAK EQUIVALENCE PRINCIPLE

PROPORTIONALITY OF GRAVITATIONAL & GRAVITATIONAL MASS

# SCIENTIFIC & TERMS AFTER ROLAND

## CAPILLARITY

SURFACE TENSION OF LIQUIDS

**EÖTVÖS RULE** Eötvös law of capillarity states the prediction of the surface tension of liquid pure substance at all temperatures.

**EÖTVÖS CONSTANT** The Eötvös constant ( $\gamma_0$ ) is the value of the surface tension of a liquid pure substance at the reference temperature.

**EÖTVÖS NUMBER** The Eötvös number is a dimensionless number measuring the importance of the gravitational force compared to surface tension forces in determining the shape of bubbles or drops moving in a fluid.

## WEAK EQUIVALENCE PRINCIPLE

PROPORTIONALITY OF GRAVITATIONAL AND ELECTROMAGNETIC FORCES



# SCIENTIFIC & TERMS AFTER ROLANDA man with short brown hair, wearing a dark suit jacket over a white shirt, stands at a podium. He is gesturing with his right hand while speaking. A gold-colored microphone is positioned to his left. The background is dark, and a large projection screen is visible behind him. A projection screen to the right of the speaker displays the text "SCIENTIFIC & TERMS AFTER ROLAND".

## CAPILLARITY

SURFACE TENSION OF

**EÖTVÖS RULE** (Eötvös law of capillarity) enables the prediction of the surface tension of liquid pure substance at all temperatures.

**EÖTVÖS CONSTANT** The Eötvös constant ( $2.1 \times 10^{-7} \text{ J/(K} \cdot \text{mol}^2\text{)}$ ) in the Eötvös rule, where  $T$  is the temperature, the molecular weight, and  $\sigma$  the temperature deviation from the critical point.

**EÖTVÖS NUMBER** The Eötvös number is a dimensionless number measuring the importance of gravitational forces compared to surface tension forces, shape of bubbles or drops moving in a fluid.

## WEAK EQUIVALENCE PRINCIPLE

PROPORTIONALITY OF GRAVITATIONAL MASS

# SCIENTIFIC & TERMS AFTER ROLAND

## CAPILLARITY

SURFACE TENSION OF

**EÖTVÖS RULE** (Eötvös law of capillarity) A rule that enables the prediction of the surface tension of a liquid pure substance at all temperatures.

**EÖTVÖS CONSTANT** The Eötvös constant ( $\gamma_0 = 2.5 \times 10^{-7} \text{ J/(K} \cdot \text{mol}^2\text{)}$ ) in the Eötvös rule, where  $\gamma$  is the surface tension, the molecular weight, and  $T$  is the temperature deviation from the reference point.

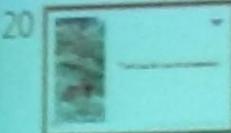
**EÖTVÖS NUMBER** The Eötvös number, a dimensionless number measuring the importance of gravitational forces compared to surface tension forces, such as of bubbles or drops moving in a fluid.

## WEAK EQUIVALENCE PRINCIPLE

PROPORTIONALITY OF GRAVITATIONAL MASS



19  
VETVISION



DIA 20 / 20 MAGYAR



JEGYZETEK

Dr. Roland Eötvös  
Hungarian physiologist,  
higher education  
Minister (1920)

## SCIENTIFIC CONCEPTS & TERMS NAMED AFTER ROLAND EÖTVÖS

### CAPILLARITY SURFACE TENSION OF LIQUIDS

**EÖTVÖS RULE** (Eötvös law of capillarity) The Eötvös rule enables the prediction of the surface tension of an arbitrary solid-pure substance at all temperatures.

**EÖTVÖS CONSTANT** The Eötvös constant is a constant (value) (1/km²) in the Eötvös rule, connecting the surface tension, the molecular weight, and the specific volume with the temperature deviation from the critical temperature.

**EÖTVÖS NUMBER** The Eötvös number is a dimensionless number measuring the importance of gravitational forces compared to surface tension forces, characterizing the shape of bubbles in drops moving in a rotating fluid.

### WEAK EQUIVALENCE PRINCIPLE PROPORTIONALITY OF INERTIAL MASS & GRAVITATIONAL MASS

**EÖTVÖS EXPERIMENT** (EPP experiment, 1890–1904) experiment: A famous physics experiment that measured the equivalence between inertial mass and gravitational mass, demonstrating that the Sun's gravitational pull was stronger than the centrifugal force it exerted on the Earth.

**EÖTVÖS PARAMETER** The Eötvös parameter is a measure of the effect of the Sun's gravitational pull on the Earth's rotation period.

### ORATORY FIELD INSTRUMENT

**EÖTVÖS TENSOR** The Eötvös tensor is a 3x3 symmetric, quasi-symmetric tensor and its elements are the gravity gradient.

### GRAVITATION ON A ROTATING PLANET

**EÖTVÖS EFFECT** It is the change in perceived gravitational force caused by the change of centripetal acceleration resulting from rotational or translation velocity. When moving eastbound, the effects of rotation are increased (in addition to the earth's rotation), and thus the centrifugal force also increases, causing a perceived reduction in gravitational force.

**EÖTVÖS CORRECTION** This is the corrected measure of the gravitation on a moving platform, such as a ship or airplane.

### GEODESY

**EÖTVÖS TENSOR** The Eötvös tensor is a 3x3 symmetric, quasi-symmetric tensor and its elements are the gravity gradient.

### GRAVITY

**EÖTVOS  
AFTER R**

**CAPILLARITY**  
SURFACE TENSION

**EÖTVÖS RULE (EÖTVÖS)**  
enables the prediction of the surface tension of liquid pure substances

**EÖTVÖS CONSTANT**  
 $\gamma = \frac{RT}{M} \left( \frac{1}{2} \left( \frac{\partial P}{\partial r} \right)_{T, M} \right)^{-1}$   
tension, the molecular interaction with the temperature deviates from Raoult's law

**EÖTVÖS NUMBER**  
number measuring the effect of the interaction of the molecule with the surface compared to surface tension of bubbles or droplets

**WEAK  
LENCE**  
PROPORTIONAL  
TO GRAVITATION

**EÖTVÖS EXPERIMENT**  
experiment) a famous experiment demonstrating that the gravitational force of attraction between the Earth and the Sun is proportional to the mass of the Sun and the mass of the Earth, and inversely proportional to the square of the distance between them, demonstrating that the Sun's mass is much larger than the Earth's mass.

**EÖTVÖS PARAMETER**  
in the Eötvös experiment, the ratio of the mass of the test masses to the mass of the Sun.



00 Scientific Meeting  
20 October

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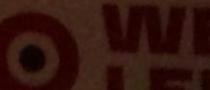


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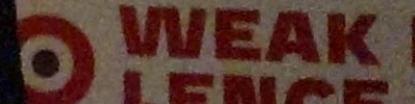
**CAPILL**

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**EÖTVÖS RULE** (Eöt  
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**EÖTVÖS CONSTANT**  
 $2.1 \times 10^{-7} \text{ J}/(\text{K} \cdot \text{mol}^{1/2})$  in  
tension, the molecular  
the temperature devia

**EÖTVÖS NUMBER**  
number measuring the  
compared to surface tension  
shape of bubbles or droplets



**WEAK LENS**





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## **Magyar Olaj- és Gázipari Múzeum**

**A Magyar Olaj- és Gázipari Múzeum országos szakmúzeum, melyet 1969-ben alapítottak azvalon a céllal, hogy gyűjtse, feldolgozza, kiállításain és kiadványaiban bemutassa Magyarország, a Kárpát-medence szénhidrogéniparának több mint száz éves történetét. 1993-ban átvette a Zsigmondy Vilmos Gyűjteményt, azóta nem csak a szénhidrogénipar, hanem a vízbányászat történeti emlékeit is gyűjti, őrzi, bemutatja.**

**A múzeum a gyűjteményeibe (műszaki emlék gyűjtemény, történeti gyűjtemény, fotó- és filmtár, képző- és iparművészeti gyűjtemény, archívum, adattár, könyvtár, ásvány- és kőzetgyűjtemény) került anyagot rendszerezi, nyilvántartja, tudományosan feldolgozza és kiállításán, kiadványaiban bemutatja.**

**Zalaegerszegen, a több mint 30 000 m<sup>2</sup>-es állandó szabadtéri kiállításon a szénhidrogénipar (bányászat, kőolajfeldolgozás, gázszerelés, szállítás) műszaki emlékeivel, állandó kiállításain az iparág technológiai folyamataival, történetével ismerkedhet meg a látogató. Különtörökben ásvány- és kőzetkiállítás is található. Szabadtéri szoborparkjában kiemelkedő műszaki szakemberek mellszobrai láthatók.**

**Gyűjteményei, valamint Dr. Papp Simon geológus, egyetemi tanár emlékére berendezett kis kiállítás és a Zsigmondy emlékszoba, a múzeum központi épületében található.**

**Külön kell kiemelni a Budapest melletti Vecsésen 1995-ben megnyílt állandó kiállítást, ahol a kőolaj és földgáz csővezetékes szállításának eszközeit, dokumentumait tekinthetik meg az érdeklődők, szerény szabadtéri kiállításon és az ízlésesen berendezett 200 m<sup>2</sup>-es kiállítási teremben. Lovásziban az LT-3 jelű ipari műemlék tankállomást működteti a múzeum.**

**Régebben a RT 2 jelű mérőállomás kezelőépületében ipartörténeti kiállítás és Buda Ernő**

Gyűjteményei, valamint Dr. Papp Simon geologus, egyetemi tanár emlékére berendezett kiállítás és a Zsigmondy emlékszoba, a múzeum központi épületében található. Külön kell kiemelni a Budapest melletti Vecsén 1995-ben megnyílt állandó kiállítást, ahol a kőolaj és fölgáz csővezetékes szállításának eszközeit, dokumentumait tekinthetik meg az érdeklődők, szerény szabadtéri kiállításon és az ízlésesen berendezett 200 m<sup>2</sup>-es kiállítási teremben. Lovásziban az LT-3 jelű ipari műemlék tankállomást működteti a múzeum. Bázakerettyén a BT-2 jelű mérőállomás kezelőépületében ipartörténeti kiállítás és Buda Ernő bányamérnök emlékére berendezett emlékszoba várja a látogatókat.

A múzeum 1974 óta rendszeresen jelentet meg kiadványokat.

A Múzeumi Közlemények sorozatnak évente egy-két kötete jelenik meg.  
A múzeumot 1991-től a Magyar Olajipari Múzeum Alapítvány működteti.

**A központi épület címe: Magyar Olaj- és Gázipari Múzeum**

**H-8900 Zalaegerszeg,**

**Wlassics Gyula u. 13.**

**Tel.: (+36) 92 313 632**

**Fax: (+36) 92 311 081**

**Web: [www.olajmuzeum.hu](http://www.olajmuzeum.hu)**

**E-mail: [moim@olajmuzeum.hu](mailto:moim@olajmuzeum.hu)**

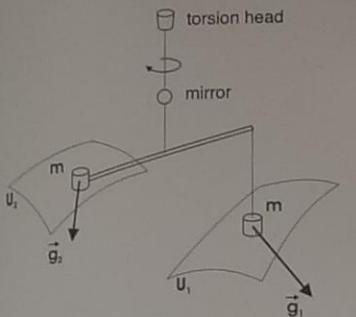
**A szabadtéri kiállítás címe: H-8900 Zalaegerszeg  
Falumúzeum u.**

**Nyitva tartás: Április 01-től október 31-ig, hétfő kivételével naponta  
Egyéb időpontban csak előre bejelentett csoportokat fogad.**



# ARTH,

slow motions of masses or fluid masses can be followed by the change in shape of potential surfaces detected by the Eötvös balance. The sensitivity for such changes can be increased by the use of the gravitational compass, although in practice such measurements are rare. Changes in the water level of the Danube could also be detected from a cellar way with a cm precision, but measurement was not automated.



Coulomb torsion balance  
the Coulomb torsion balance

torsion balance

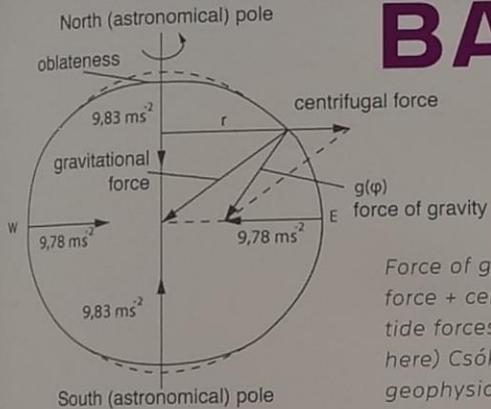
Budapest, 1890

doubled big + 1907

horizontal variometer,  
1889

Eötvös torsion pendulum measures tiny local variations in the force of gravity with a precision of 1 eötvös.  
Pethő G. - Vass P. (2011): Gravimetry.

Eötvös started to experiment with gravity and the torsion balance around 1885. His first instruments were similar to those of Coulomb, and served mainly for demonstration purposes. Eötvös soon realized the potentialities of this simple device for measuring the difference between the two main curvatures of the very local equipotential surface, i.e. of the surface perpendicular in each point to the combined effects of gravity and the centrifugal force due to earth rotation.



Force of gravity = gravitational force + centrifugal force (+ earth tide forces, which is not shown here) Csókás J. (1993): Applied geophysics

## OTHER INSTRUMENTS

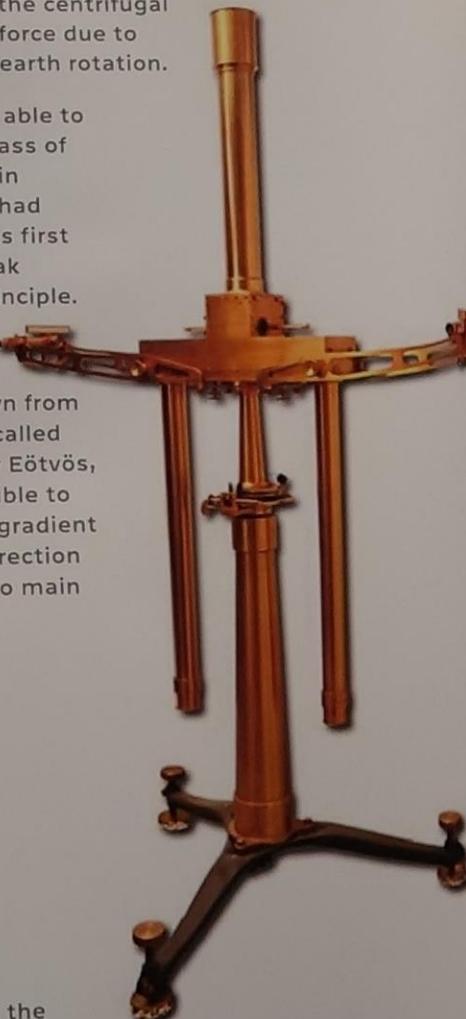
While Eötvös dedicated most of his time and ingenuity to improving the precision and stability of the torsion balance, he also developed several other innovative instruments as gravitation-

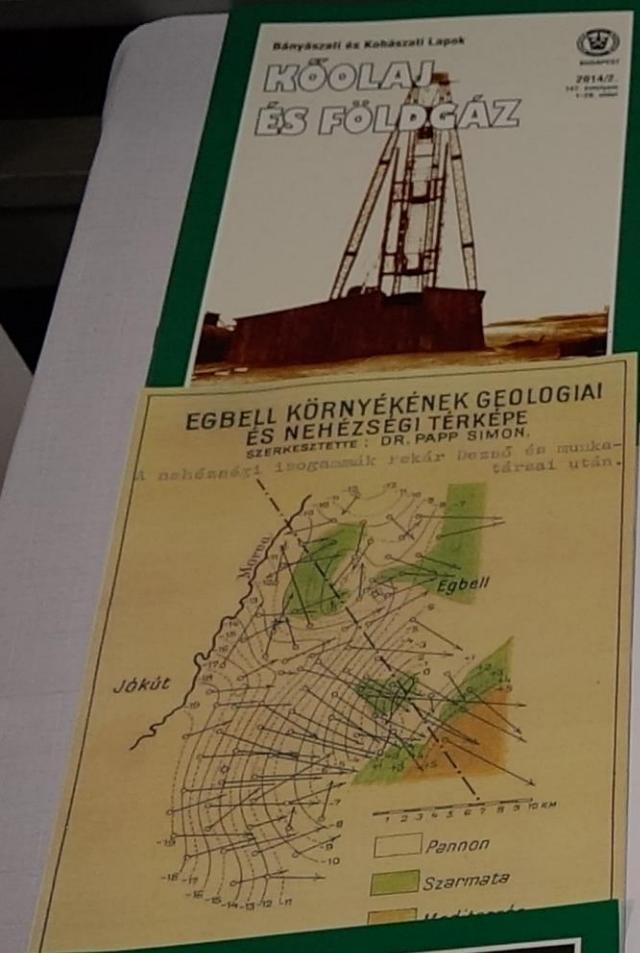
## FUNDAMENTAL ISSUES

### WEAK EQUIVALENCE PRINCIPLE

Eötvös carried out a series of experiments on the proportionality of inertial and gravitational masses.

It was a very subtle idea that any deviation from the proportionality of gravitating and inertial masses could be best checked by detecting tiny differences in the direction of the acceleration of different substances, and that those differences might be



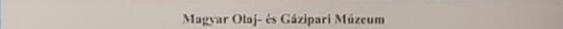








ZÁKAZ  
FAJCÍT!



#### Magyar Olaj- és Gázipari Múzeum

A Magyar Olaj- és Gázipari Múzeum országos szakmúzeum, melyet 1969-ben alapítottak azáltal a céllal, hogy gyűjtse, feldolgozza, kiállításán és kiadványaihoz bemutassa Magyarország, a Kárpát-medence szénhidrogéniparának több mint száz éves történetét. 1993-ban átvette a Zsigmond Vilmos Gyűjteményt, azóta nem csak a szénhidrogénipar,

hamen a vízhányasztat történeti emlékeit is gyűti, őrzi, bemutatja.

A múzeum a gyűjteményeibe (műszaki emlek gyűjtemény, történeti gyűjtemény, fotó- és filmár, képző- és iparművészeti gyűjtemény, archívum, adattár, könyvtár, ásvány- és körzetgyűjtemény) került anyagot rendszerezni, nyilvántartja, tudományosan feldolgozza és kiállításán, kiadványaihoz bemutatja.

Zalaegerszegen, a több mint 30 000 m<sup>2</sup>-állában szabadtéri kiállításon a szénhidrogénipar (bányászt, kőolajfeldolgozás, gázzolgáltatás, szállítás) műszaki emlékeivel, állandó kiállításain az ipari (technológiai) folyamatával, történetével ismerkedhet meg a látogató. Különösen az ásvány- és közvetki kiállítás is található. Szabadtéri szoborparkjában

kiemelkedő műszaki szakemberek mellszobrai láthatók.

Gyűjteményei, valamint Dr. Papp Simon geológus, egyetemi tanár emlékére berendezett kis kiállítás és a Zsigmondy emlékszoba, a múzeum központi épületében található.

Külön kell kiemelni a Budapest meletti Vecsésen 1995-ben megnyílt állando kiállítást, ahol a kőolaj és földgáz csövözetek szállításának ezekről dokumentumait tekinthetik meg az érdeklődök, szerény szabadtéri kiállításon és az írásban berendezett 200 m<sup>2</sup>-es kiállítási teremben. Lovászban az LT-3 jelű ipari műemlék tankállomást működteti a múzeum.

Bázakerettyén a BT-2 jelű mérőállomás kezelőpályében ipartörténeti kiállítás és Buda Ernő bányamérnök emlékére berendezett emlékszoba várja a látogatókat.

A múzeum 1974 óta rendszeresen jelentet meg kiadványokat.

A Múzeumi Közlemények sorozatnak évente egy-két kötetet jelent meg.

A múzeumot 1991-től a Magyar Olajipari Múzeum Alapítvány működteti.

A központi épület címe: Magyar Olaj- és Gázipari Múzeum

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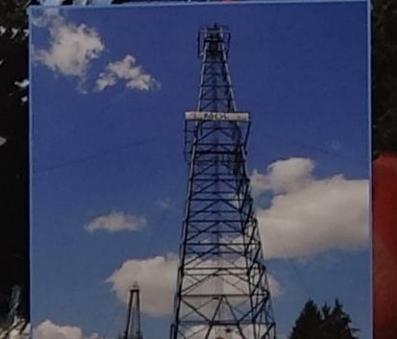
E-mail: [moim@olajmuzeum.hu](mailto:moim@olajmuzeum.hu)

A szabadtéri kiállítás címe: H-8900 Zalaegerszeg

Falumúzeum u.

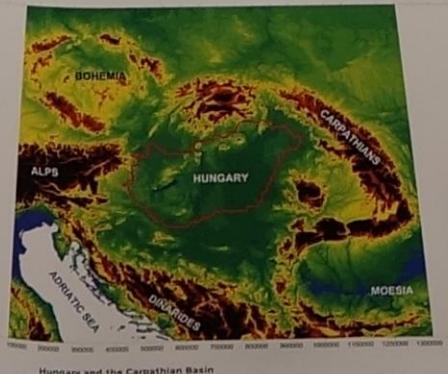
Nyitva tartás: Április 01-től október 31-ig, hétfő kivételével naponta

Egyéb időpontban csak előre bejelentett csoportokat fogad.





- 1857-1865 High School studies at the Piarists in Pest  
1865-1867 State and law studies at the University of Pest  
1866 The beginnings of his mountain climbing passion that lasted a lifetime  
1867-1870 Science studies at the University of Heidelberg  
1870 Doctorate in physics, mathematics and chemistry with highest honours  
1871 Assistant teacher at the Department of Higher Science  
(later Theoretical Physics) at the University of Pest  
1872 Full Professor, Department of Theoretical Physics, University of Pest  
1873 Elected as corresponding member of the Academy  
1878 Full Professor of the Department of Experimental Physics (successor of Jedlik)  
1883 Elected as regular member of the Academy  
1888-1891 President of Budapest Department of Hungarian Carpathian Association  
1889-1905 President of the Academy (successor of Trefort)  
1891 Leading role in the founding of the Mathematical and Physical Society  
and the launching of the journal Letters in Mathematics and Physics (Mat-Fiz Lapok)  
1891 President of the Hungarian Mountaineering Federation  
1891-1892 University rector  
1894-1895 (from June to January): Minister of Religion and Public Education.  
Act on Religious Freedom, and initiating the organization of the József Eötvös College  
1905 Resignation from the academic presidency to devote all his time to scientific research



Hungary and the Carpathian Basin

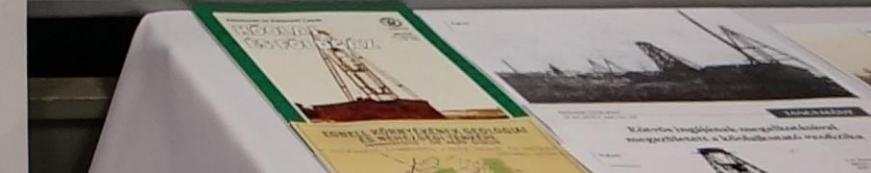
J. Eötvös, the father of R. Eötvös was a well-known poet, writer, and politician. R. Eötvös also inherited some of his talents and wrote several poems in his youth, and always held both poets and scientists in high esteem. Two of his quotes on their respective values:

"Poets can penetrate deeper into the realm of secrets than scientists."

"A scientist can soar high like a poet, but also knows how high he flies."

## MILESTONES OF HIS SCIENTIFIC ACTIVITY

- 1875-1885 Capillary-related studies: a reflection method for determining capillary laws,  
Eötvös rule, Eötvös constant  
1886-1919 Gravity- and geomagnetic studies  
1890 "Gravitational attraction of Earth to different materials" (Academy lecture, 20 January)  
1891 Curvature and horizontal variometers  
1891 The first field measurement at Ság hill  
1896 Investigations in gravity and geomagnetism (summary)



## HEIGHT & PERSPECTIVE

Mountaineering, rock climbing, and (mainly stereoscopic) photography were among the favourite hobbies of Eötvös, a pioneer of high precision geophysical physics, and a founding father of geophysics.

He spent most of his summers in Schläuderbach (now Člubná, mold. in the Dolomites). With his daughters he made the first ascent of several peaks and access routes in that region.

One of the peaks (Giant Cliffs, 280 m in the Celler range) was even named after him. Even at the age of 68, shortly before his death, he climbed some of the highest peaks of the Tatra mountains.

## SHAPE OF THE EARTH, GEODESY

The Eötvös balance was the first instrument for gravitational gravimetry, that is for the measurement of the very local properties of the shape of the equipotential surfaces of Earth. Eötvös started his measurements by comparing the local derivatives of the potential in several points of his room, then of his whole institute. Local masses substantially influence those values.

Eötvös also tried to estimate what those independent second derivatives would be if the building was not there, and he arrived at a value surprisingly close to the results of modern measurements. With the Eötvös balance four of the five independent second derivatives are measured, which were not yet incorporated only two. Eötvös gave a relationship between the local curvature  $R$  in function of gravity acceleration and the minimum and maximum curvature radius and in the function of the second derivatives of gravitational potential. A convenient unit for gravimetry ( $10^{-9} \text{ cm}$ ) was named after him. One Eötvös is the unit of gradient of gravity acceleration, which is defined as a  $10^9$  fold change of gravity over a horizontal distance of 1 centimetre.

Both the gradients and the curvature values are expressed in Eötvös units, which are about  $10^{-11}$  part of the force of gravity change over 1 centimetre.

## PURE AND APPLIED GEOPHYSICS

Gravitation is a basic nature-forming force, underestimated in everyday life, and sometimes even in geophysics. The planetary engine, operated by first of all of gravitation, is responsible for all those things that we call geodynamics at the surface: continental drift, collision of tectonic plates, mountain building, basin formation, volcanism, earthquakes. (A thought might have inspired Eötvös to study gravity: "he himself is before all things and all things are held together in him." Colossians 1:17).

Although Eötvös was always interested in the implications and possible applications of his and his colleagues' measurements, he preferred not to rush to conclusions.

He realized that the relationship between his results and the arrangement of underground density distribution was a rather complicated one.

Subterranean perturbations of the gradients and directive forces of gravity were measured by Eötvös on the ice sheet of Lake Balaton in 1901 and 1903.

Notes for compilation and instrument:  
See László Borsig's notes,  
in the background: Between the ice sheet  
and the "floating house" (wintering hut), put the net.

The first strong correlation between results of measurements made with his instrument and actually finding oil was at Egbej (now Odeberg, Norway), which is often considered as the birth of applied geophysics. In the days of Eötvös, his balance was extensively used for prospecting in many countries of the world, and proved to be very efficient under certain geological conditions such as in Texas. Eötvös balances were produced in large numbers, and several improvements were made to make the work more convenient under difficult circumstances such as in mines. He was "...the father of geophysical prospecting for oil, even if he hasn't it!" (A. O. Rankine).

Curvature variometer:  
the Coulomb torsion balance

Horizontal variometer;  
1919

Eötvös torsion pendulum measures  
tiny local variations in the force  
of gravity with a precision of 1 eötvös.

Péter G. - Vass P. (eds): Gravimetry

To the combined effects of gravity and  
the centrifugal force due to  
earth rotation.

The prime Eötvös  
torsion balance

Budapest, 1919

Eötvös torsion balance:

"modified type," 1907

Eötvös started to experiment with gravity and the torsion balance around 1880. His first instruments were similar to those of Celsius, Lomb, and Kerven, and served mainly for demonstration purposes. Eötvös soon realized the potentialities of this simple device for measuring the difference between the two main curvatures of the very local equipotential surface, i.e. of the surface perpendicular in each point

to the combined effects of gravity and the centrifugal force due to earth rotation.

## THE EÖTVÖS TORSION BALANCE

By 1890 he was able to measure the mass of the Gellér-hill in Budapest, and had also finished his first test on the weak equivalence principle.

A new version of the torsion balance, having one weight hanging down from the end of the rod, was called horizontal variometer by Eötvös, because it made it possible to measure the horizontal gradient of  $g$  in addition to the direction and difference of the two main curvatures.



## OTHER INSTRUMENTS

## FUNDAMENTAL ISSUES

### WEAK EQUIVALENCE PRINCIPLE

Eötvös carried out a series of experiments on the proportionality of inertial and gravitational masses. It was a very subtle idea that any deviation from the proportionality of gravitation and inertial masses could be best checked by detecting tiny differences in the direction of the acceleration of different substances, and that these differences might be detected by observations of a horizontal rod (known as Eötvös experiment). Eötvös (together with D. Peškár and J. Fekete) succeeded in improving the precision of the careful pendulum experiments of Bessel by a factor of one.

### CAPILLARITY

Before turning to gravity, Eötvös achieved his most important results in the field of capillarity. The generality and simplicity of the Eötvös law in that field ranks with the universal gas laws.

### GRAVITATIONAL CONSTANT

In the field of gravity, his measurements of  $G$  should be mentioned. First he used the Cavendish method, then various static and dynamical methods.

### TESTING GRAVITY

A relative precision of  $10^{-10}$  was achieved.

### TESTING FOR GRAVITY

He also tried to measure whether gravity can be shielded. One needed the gravitational compensation. The results showed that even for a lead plate as thick as the earth diameter, the screening cannot exceed  $1/100$  of the force.





any deviation from the equilibrium.







TEOTIVOS  
Stephan Tönnies



TEGIVOS  
Geophysical Field Measurements

TEGIVOS  
Geophysical Field Measurements

GEOPHYSICAL  
FIELD MEASUREMENTS

TEGIVOS  
Geophysical Field Measurements



LEOLVOS





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IEOTIVOS

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1EOTIVOS

Stefan Gavrilov  
Wolfsburg



