A 100 YEARS AGO...

Birth of the first Applied Geophysical Institute

Dedication to Eötvös

Dr. Dezső Nagy

Geodetic Survey Division

10:30 AM 19 April, 2006

615 Booth Street, Boardroom

Natural Resources Canada
Ressources naturelles Canada
Canada

Baron ROLÁND EÖTVÖS

Eötvös Loránd 1848 – 1919

TOPICS

XV. International Erdmessung Konferenz

Baron Loránd Eötvös

Development of the Torsion Balance

Use of the Torsion Balance:

- Geodesy
- Exploration for oil

Name association

Torsion Balance surveys in Canada, USA

Torsion Balance surveys in Hungary

Torsion Balance surveys Worldwide

FÜNFZEHNTEN ALLGEMEINEN CONFERENZ DER INTERNATIONAL ERDMESSUNG BUDAPEST 20 - 28 September 1906

Delegations from Nineteen Countries
48 delagates attended
Hayford, Helmert, Sir George Darwin, Poincaré, Heuvelink, Hecker, Kimura, Artamonoff, von Kalmár, Gautier,...

Bestimmug der Gradienten der Schwerkraft und ihrere Niveauflächen mit Hülfe der Drehwage

Baron ROLAND EÖTVÖS
Montag, 24 September 1906
Next day talk was given in French as well

Visit to field survey at ARAD
Sir George Darwin petitioned the Hungarian Government for Financial support

Birth of first Applied Geophysics Institute

Biography

Born in Buda July 27, 1848

1867 University of Heidelberg

student of Kirchhoff, Bunsen, Helmholtz

1870 doctorate [with distinction]

1872 Chair of theoretical physics

1873 Associate Member of the Academy

1878 Director, Institute of Physics [new]

1883 Full Member of the Academy

1889 Elected President of the Academy

1894 Minister of Religion and Education

Died in Budapest April 8, 1919

Development of Torsion Balance

1888 First report for the Academy

1890 Curvature variometer

1890 First torsion balance

1891 First field measurements: Ság Hill

1896 Fundamental paper on Gravitation

1898 Single torsion balance

1900 Paris: A presentation on his research

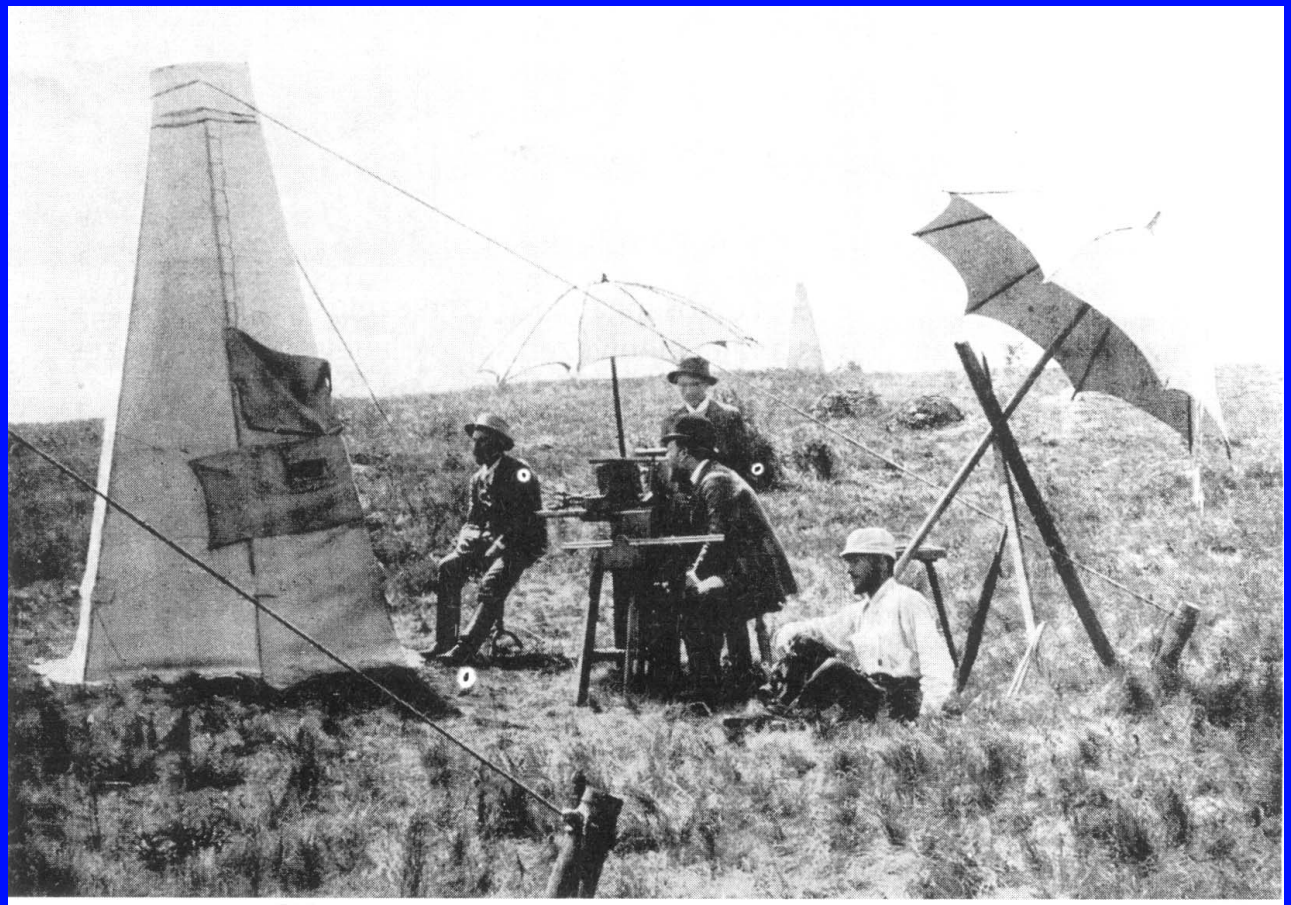
1900 Award: Paris World Exhibition

1902 Double balance

1901 1903 Measurements on Lake Balaton

1906 Budapest: XV. Konferenz

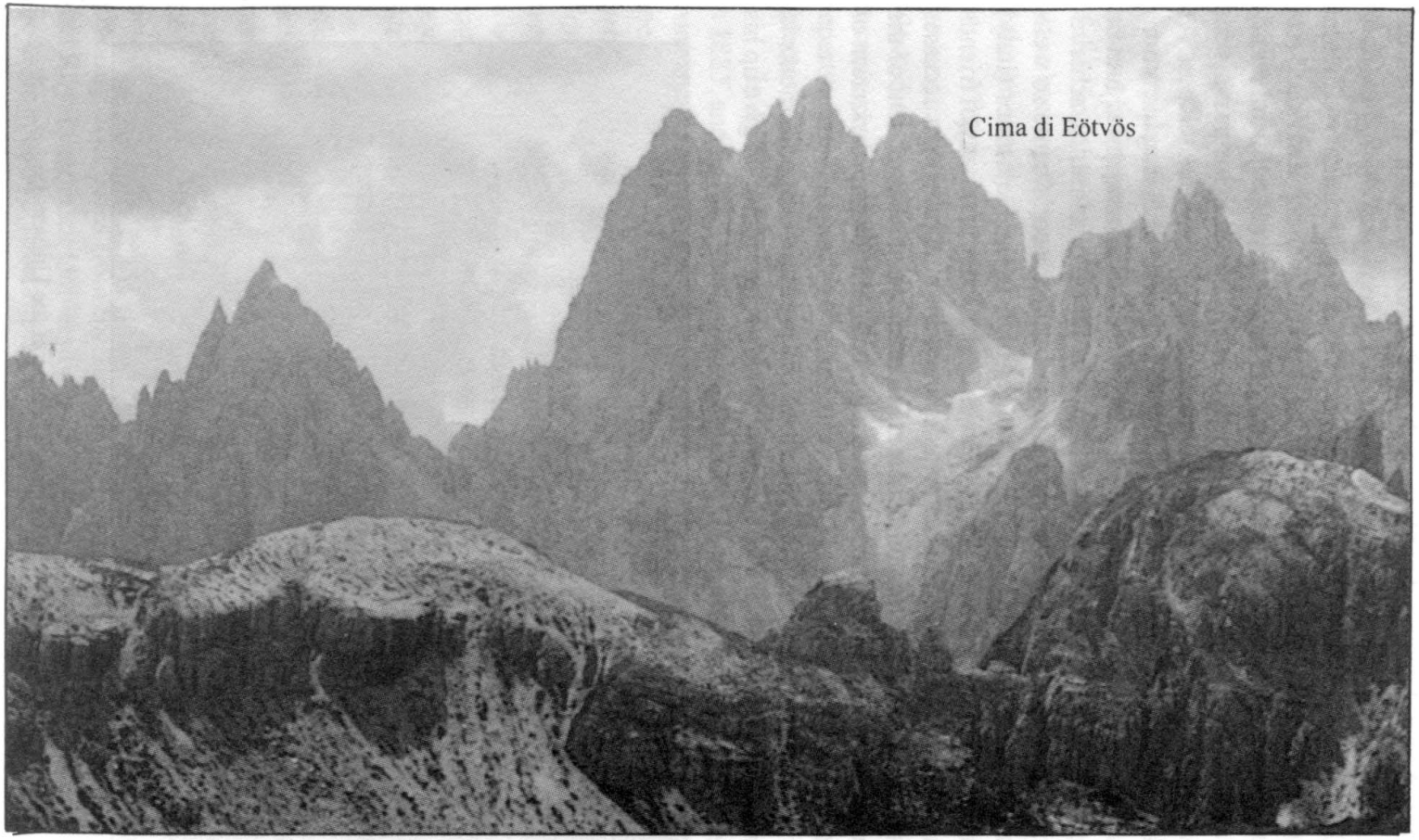
First Measurements in 1891



4. ábra. A nevezetes Ság hegyi mérés 1891-ben. A távcsövön észlel Eötvös Loránd, előtte ül Bodola Lajos, a földön Kövesligethy Radó, mögötte áll Tangl Károly

Eötvös goes to University [11 km]

Eötvös Peak (Cima di Eötvös)

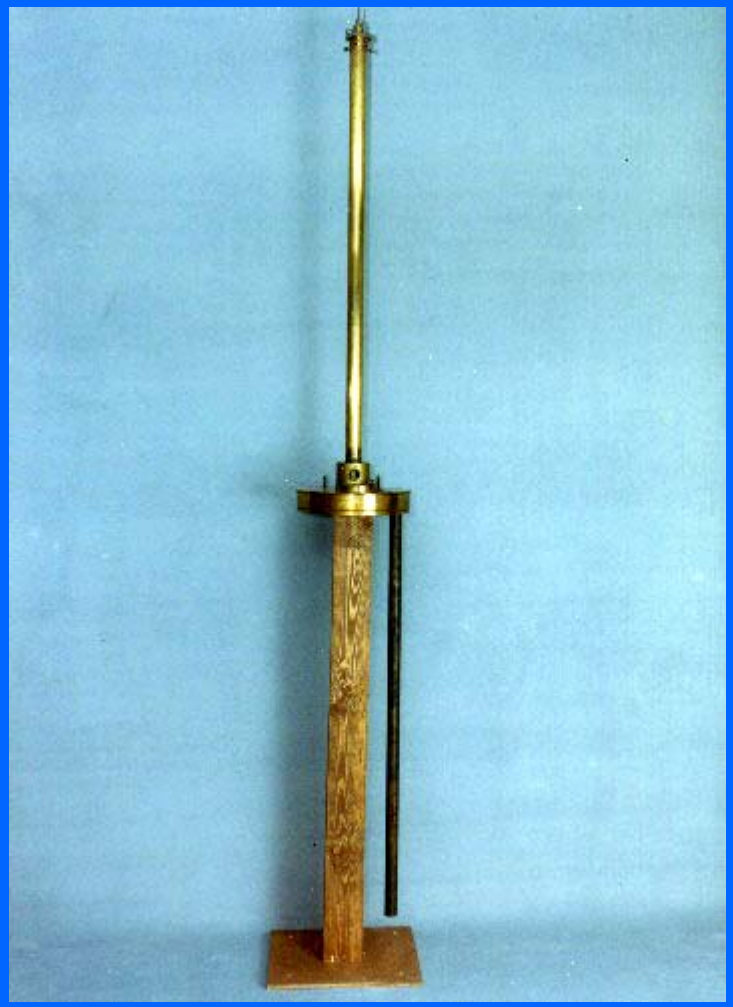


Eötvös peak (Cima di Eötvös) in the Dolomites, Italy

Stereo Photo by Eötvös

100 YEARS OF GRAVITY

Eötvös Torsion Balance



Horizontal Variometer, 1890

The first Eötvös Torsion Balance

Most important research tool for Eötvös

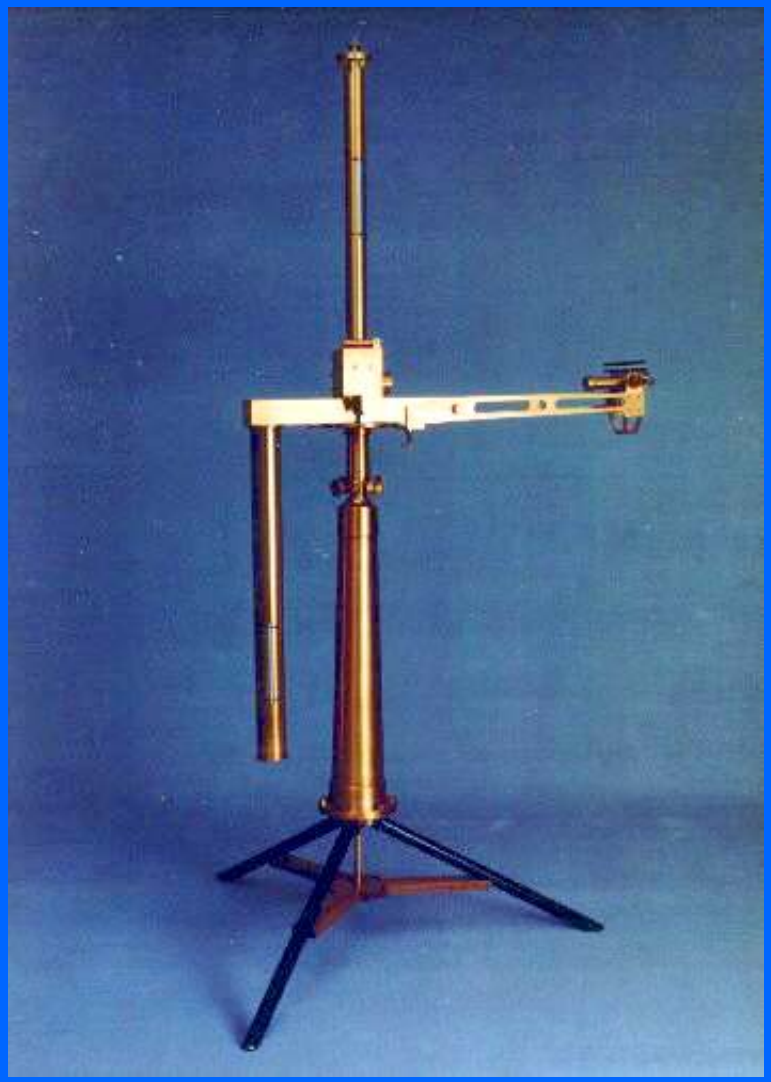
Almost unbelievable sensitivity

It gives the *gradient* of gravity

The unit of *gradient* E, is named after Eötvös

$1\ E = 10^{-6}$ mGal/cm

Eötvös Torsion Balance



The Balaton Balance, 1898

Single Torsion Balance

Designed for field work

Used on the Lake Balaton

Won an Award in 1900

[World Exhibition, Paris]

Eötvös Torsion Balance

Double Balance, 1902

Eötvös and his colleagues used this instrument in their experiments to study the

equivalence

of

inertial and gravitational mass

Eötvös Torsion Balance

Double Small Balance, 1908

Improved version of the

Double Balance

Smaller in size

Easier to handle

In the 1920s and 30s hundreds of oil fields were discovered throughout the world with the help of Eötvös' ingenious instrument

The Eötvös gravimeter

The Bifilar-type gravimeter

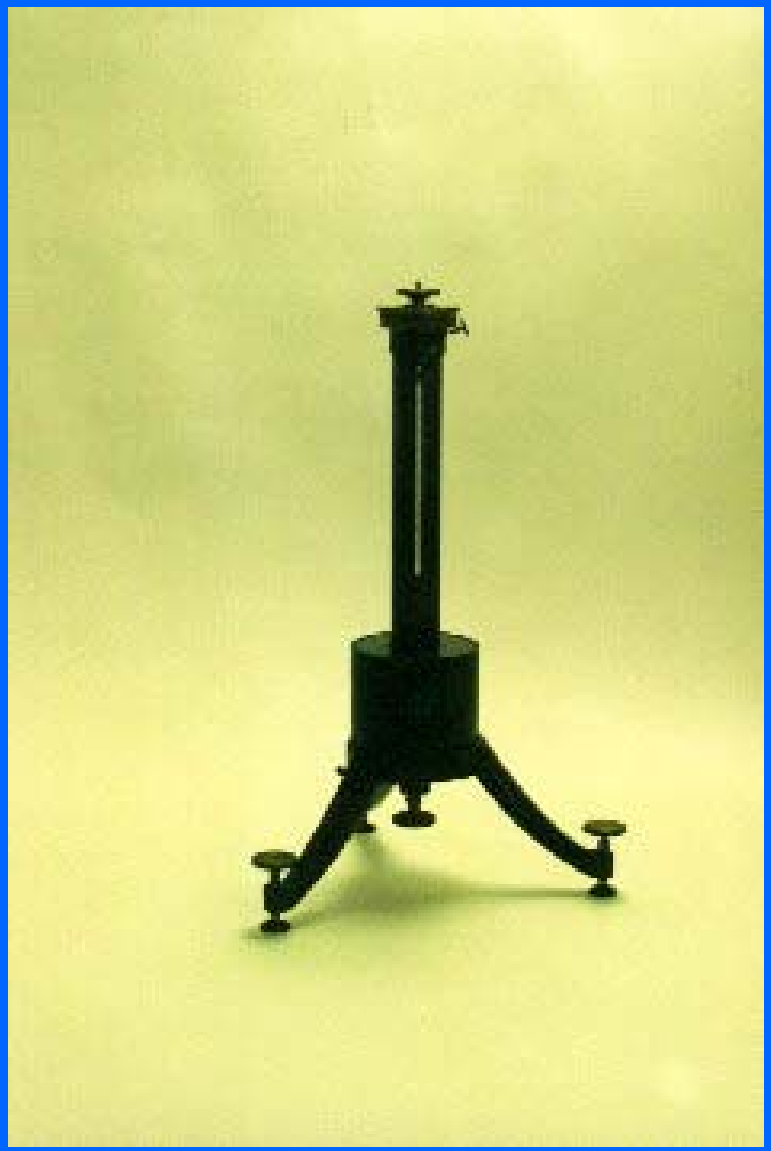
Constructed in 1901

It measures gravity instead of horizontal gradient

Its acccuracy was not high [in Eötvös' opinion]

It was not developed further

Torsion Filament Preparator



Used to prepare

Torsion wires

Most essential and delicate

part of Eötvös' instrument

to be built in balances

Detect Eötvös Effect

Used to demonstrate

the change in gravity

on a platform

moving in the East-West

direction

GRAVITY

Popular description [after Pekár]:

Prepare a wire from 1 gram of gold, such that it wraps the Earth around the equator 25 times.
If 1 millimeter is cut out from the wire, the weight of this pice correponds to 1 Eötvös!

NOTE: the instrument measures changes.

GRAVITY

HORIZONTAL GRADIENT:

Measured by Eötvös Torsion Balance

Unit is named after Eötvös

1 E = 10^{-9} gal per horizontal centimeter

980.000 000 000 gals

1 cm

980.000 000 001 gals

NAME ASSOCIATION

Eötvös Effect

Eötvös Correction

Eötvös Torsion Blance

Eötvös Unit

Eötvös Tensor $E = \begin{pmatrix} W_{11} & W_{12} & W_{13} \\ W_{21} & W_{22} & W_{23} \\ W_{31} & W_{32} & W_{33} \end{pmatrix}$

GEODESY

Interpolation deflection of the vertical

Local geoid determination

Vertical gradients from TB measurements

Gravity from horizontal gradients

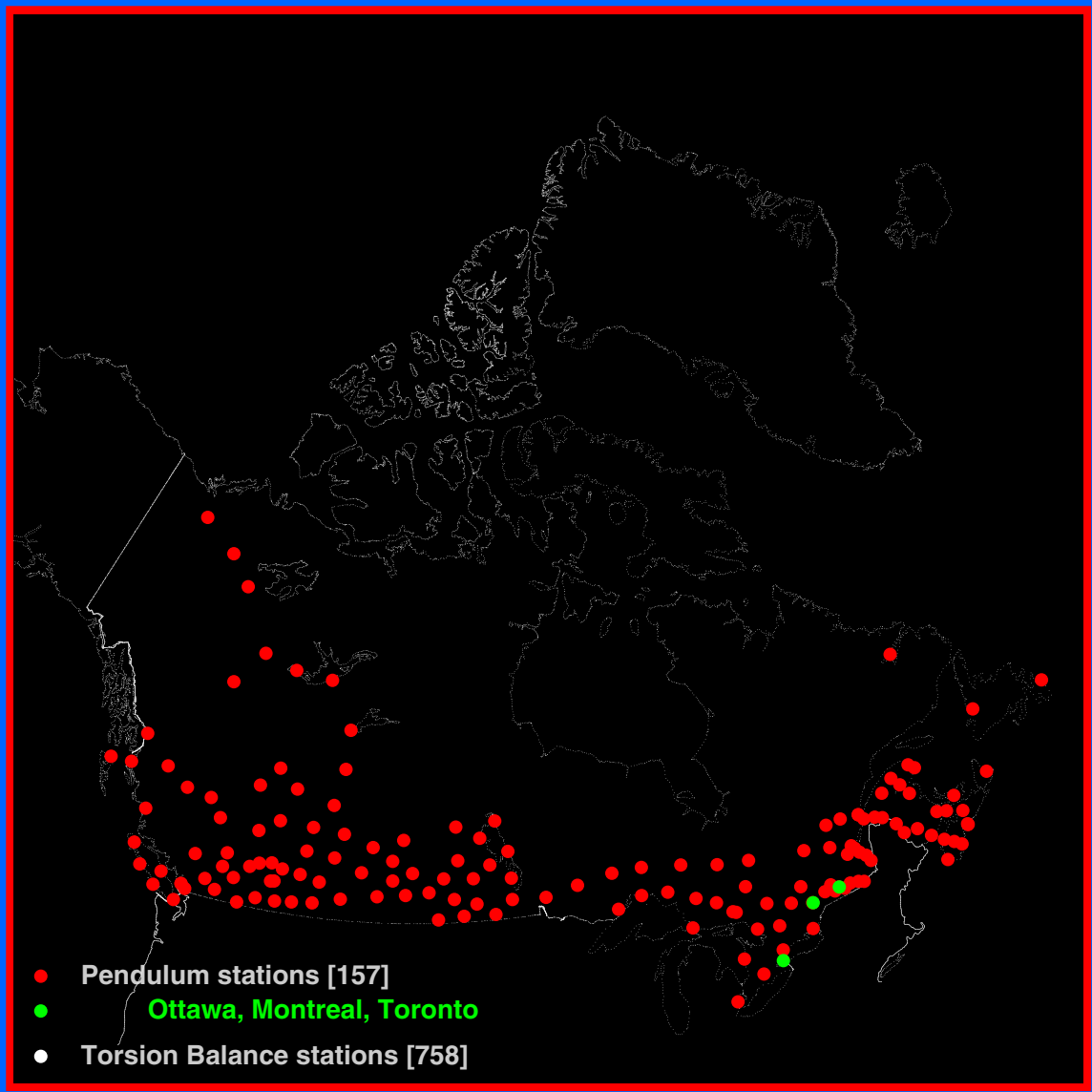
Gravity field modeling from TB

Study of equipotential surfaces

Use of Bonnet theorem:

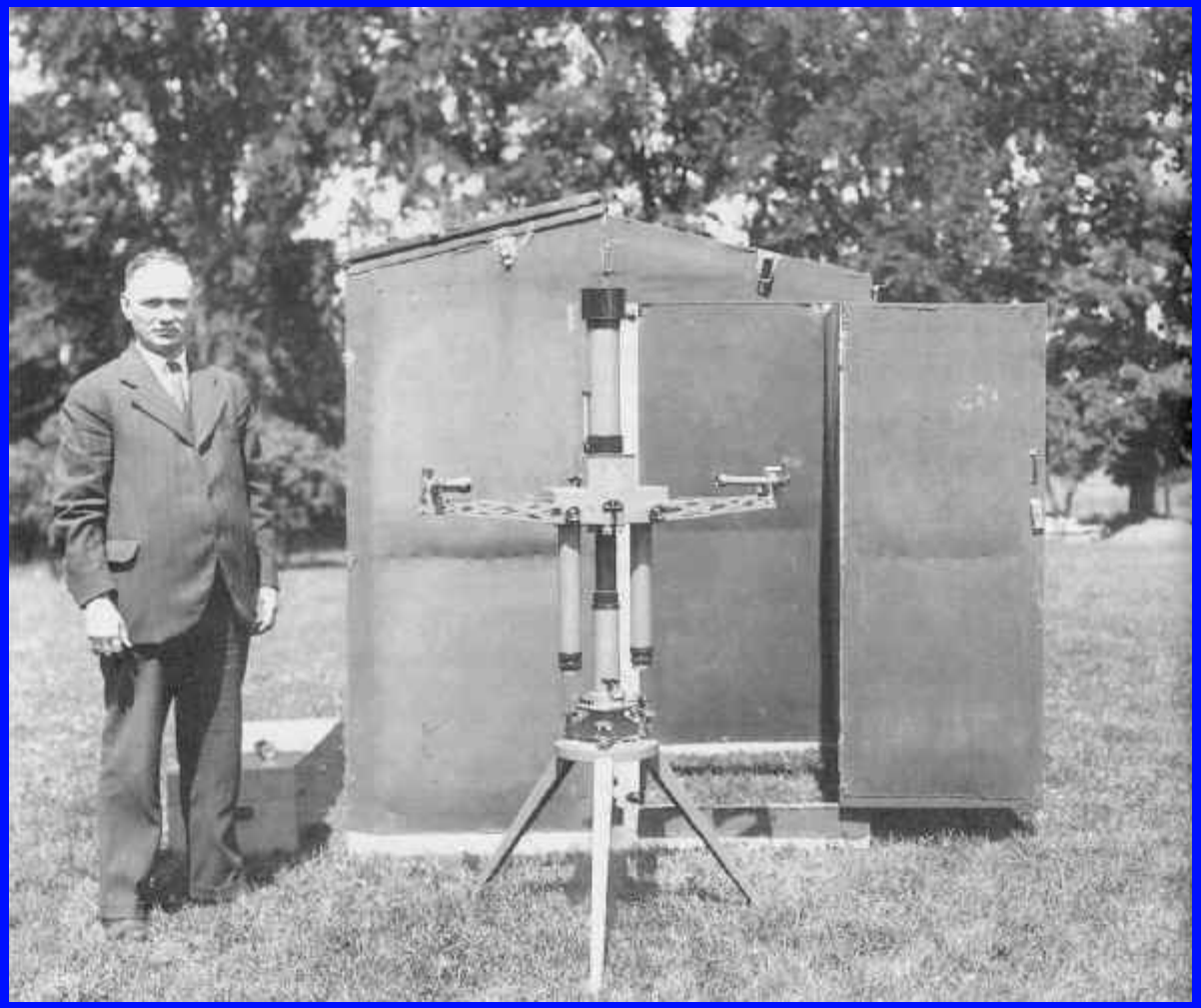
- First-order (E,F,G)
- Second-order (e,f,g)
  - fundamental quantities

Gaussian curvature


Pendulum stations [157]
Ottawa, Montreal, Toronto
Torsion Balance stations [758]

EÖTVÖS TORSION BALANCE STORED IN SCIENCE MUZEUM

EÖTVÖS TORSION BALANCE USED IN CANADA



EÖTVÖS TORSION BALANCE ORIGINAL FROM 1928

Torsion Balance Surveys in Canada

1	70	1929-30	Hull-Gloucester Fault
2	46	1929	Hazeldean Fault (A)
3	79	1930	Hazeldean Fault (B)
5	47	1930	Caldwell Pyrite Deposit
6	79	1931	Onakawana Lignite Deposit
7	73	1933	Grand Rapids Siderite
8	131	1935	Moncton Buried Granite
9	233	1934	Malagash Salt Deposit
	758 points		Miller Publ. 1940

MALAGASH SALT DEPOSIT

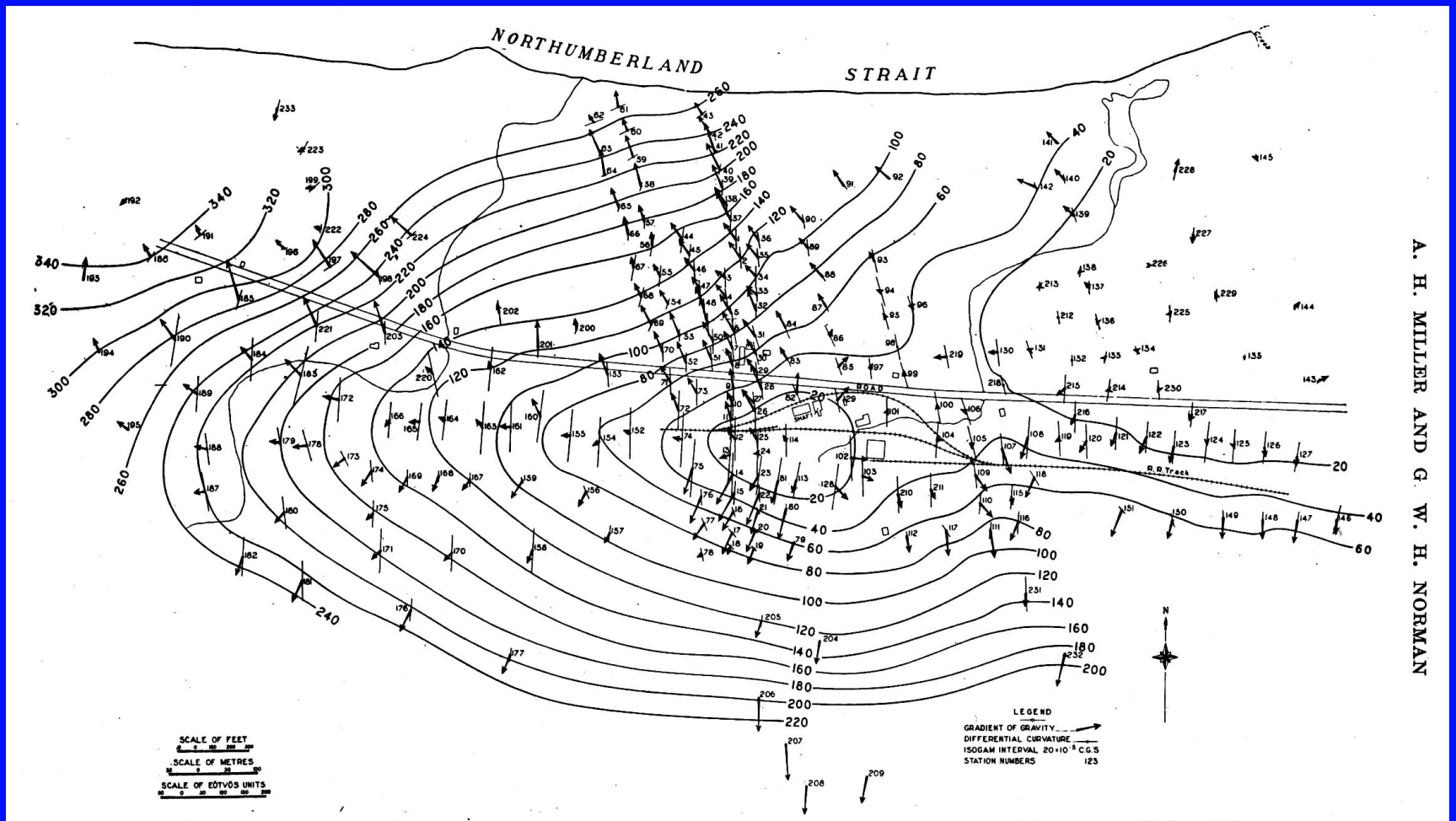
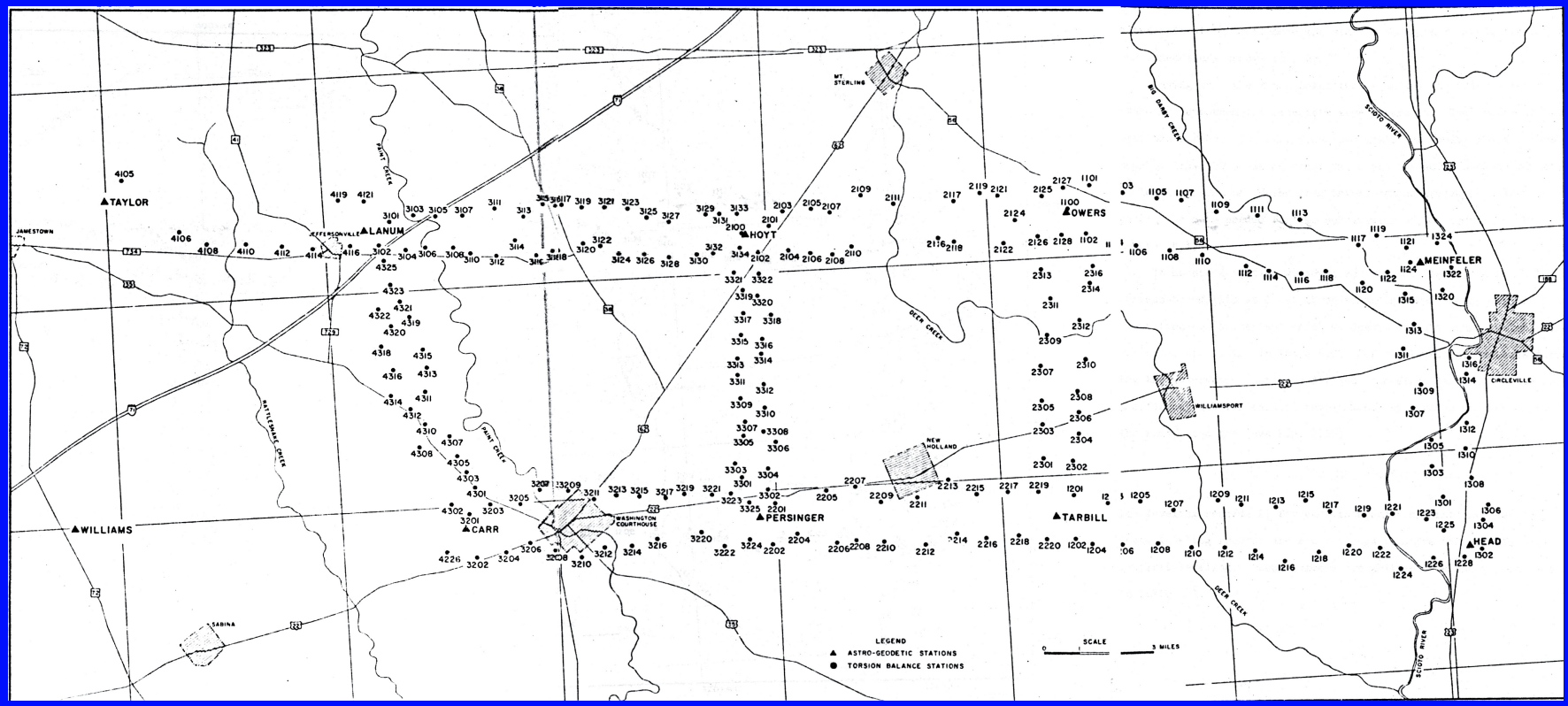


FIG. 2.—GRADIENTS, CURVATURES AND ISOGAMS FROM TORSION BALANCE SURVEY AT MALAGASH, N.S., 1934.
At stations where gradient arrows are not shown, the gradients are too small to be plotted.
Curvatures for stations close to the borders of the topographic map used are omitted because the correction for these curvatures could not be computed.

Result: "This deposit was accurately locatad by the torsion balance"...

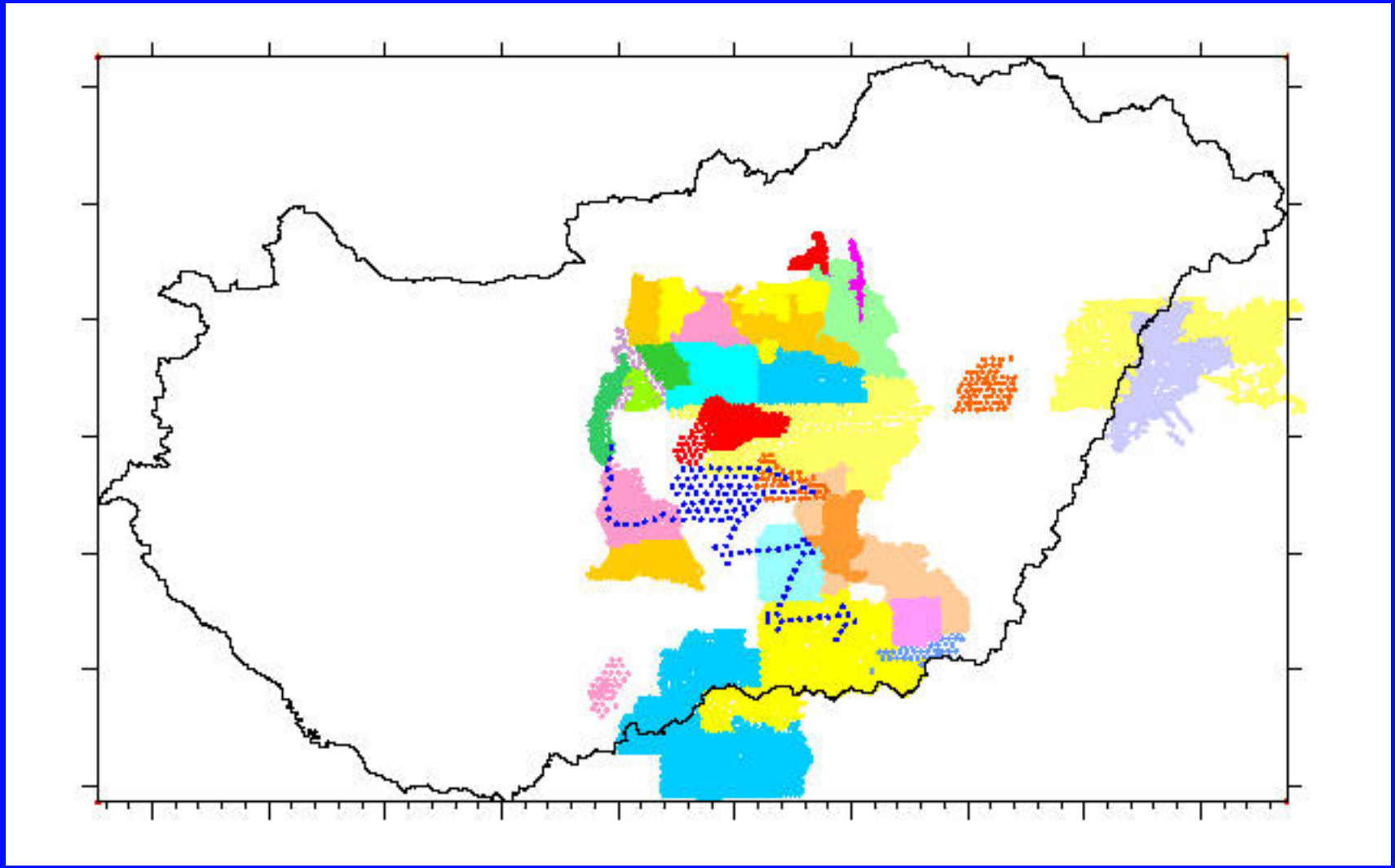
Torsion Balance measurements in Southwest Ohio



Badekas (1967) 228 measurements

Interpolated deflections: ".5 ~ 35km

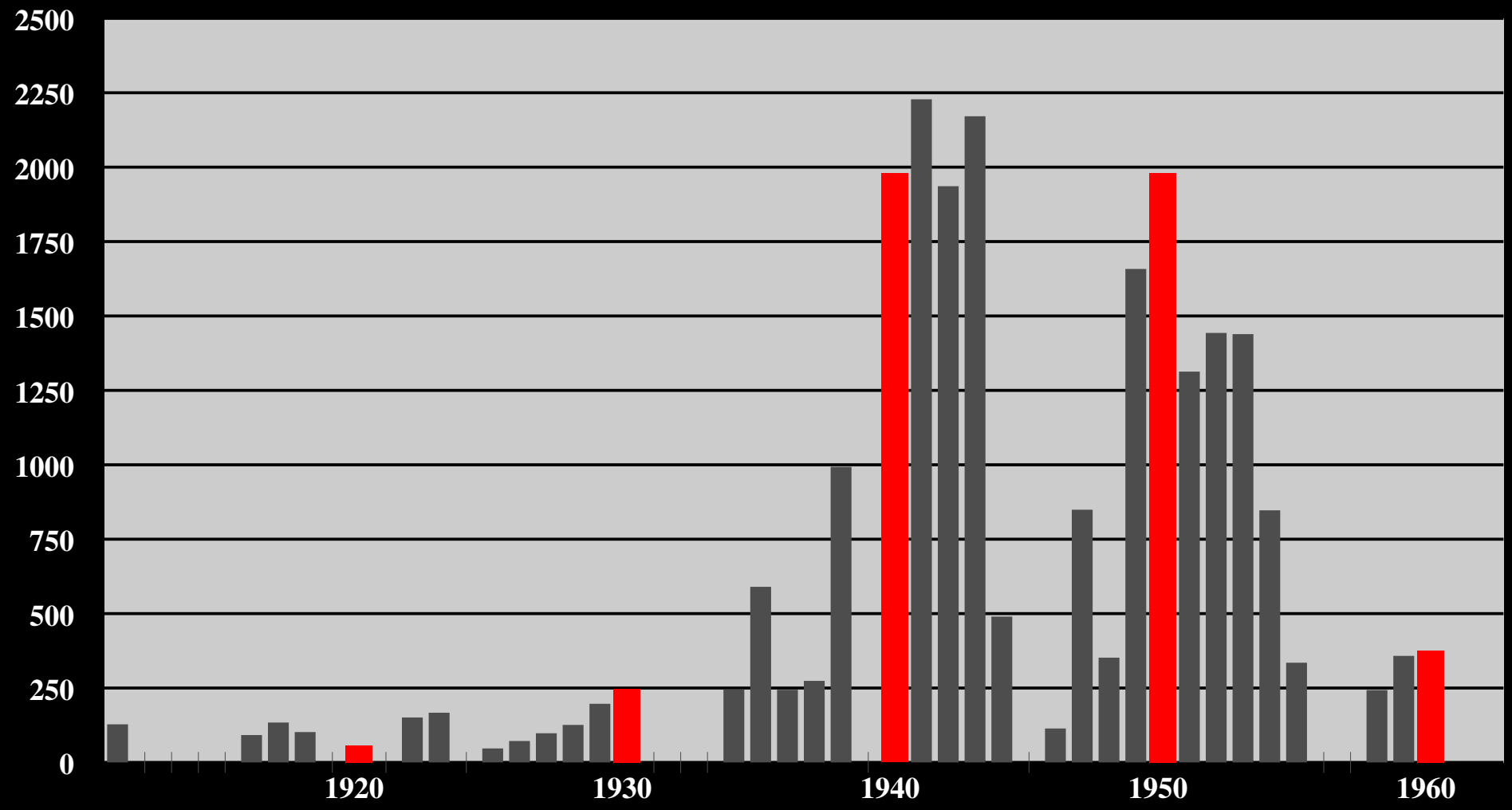
HUNGARIAN TORSION BALANCE DATA



From over 60 000 points, only 24 077 are available in digital form

HISTOGRAM

[TORSION BALANCE DATA, HUNGARY]*



TOTAL NUMBER OF POINTS: 24,077

PROVIDED BY GY. TOTH/BME

MISCELLANEOUS

1921: Klotz orders TB from Ecker

1922 Sept.15, Original ETB, New York City

1928 Original TB to Ottawa

1929: from Japan and India to America
from Europe to Africa more than 70
"Original Eötvös made in Hungary"

1923-1925: 25 TB shipped to USA every year

1926-1938: 159 Oil Fields discovered

Total of over 300 TB was made

Indus Valley, Upper Assam, Borneo, Po Plain
France, Trinidad, Tobogo, Mexico, Venezuela...