HUNGARY.

REPORT
ON THE ACTIVITIES
OF
THE ROYAL HUNGARIAN BARON ROLAND EÖTVÖS GEOPHYSICAL INSTITUTE DURING THE PERIOD 1936-1938.

WITH 23 FIGURES AND 8 MAPS

SUBMITTED
TO THE CONGRESS GENERAL OF THE INTERNATIONAL GEODETICAL AND GEOPHYSICAL UNION IN WASHINGTON, SEPTEMBER 1939.

BY
EUGENE FEKETE
IN CHARGE OF
THE ROYAL HUNGARIAN BARON ROLAND EÖTVÖS GEOPHYSICAL INSTITUTE.

BUDAPEST, 1939.

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Felelős kiadó: Fekete Jenő.

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Contents.

Enclosures.

I. Introduction.

Reports on the activities of the *Royal Hungarian Baron Roland Eötvös Geophysical Institute* were submitted to *the International Geodetical and Geophysical Union* on three occasions as yet.[1]

This Report submitted herewith follows the way of the previous ones and after discussing the various geophysical methods now applied by the *Geophysical Institute* the results obtained by the surveys in question are also interpreted from a practical point of view.

II. The Royal Hungarian Baron Roland Eötvös Geophysical Institute in 1936-1938.

During the period of 1936—1938 there was a great development in the *Geophysical Institute.* Up to the year 1936 the geophysical prospecting work done by the Institute was restricted only to torsion balance and terrestrial magnetic survey and first in that year the Institute was supplied with a new *seismic apparatus.* The seismic method was introduced to control the interpretation of the results of the torsion balance survey. In order to extend the practical application of the terrestrial magnetic survey *new magnetic instruments* were provided for the *Institute,* i. e. one vertical and one horizontal magnetic variometer of *Schmidt type.* Having had no magnetic observatory in *Hungary* at that time to register the daily variations of the terrestrial magnetic force, it was necessary to obtain these variations in the field by a new *registering apparatus.* In the last years there is a wide-spread use of the so called gravity-meters of various designs by which the variations of the gravity may be easily determined. The *Geophysical Institute* has got a *Haalck gravity-meter,* which though not being of the latest type, could be succesfully used still in reconnaissance prospecting work. In 1937 the *Geophy-*

[1] Travaux de la Section de Géodésie de l'Union Géodésique et Géophysique Internationale. Tome 7. Fascicule 1. Hongrie. — Tome 11. Fascicule 3. Hongrie. — Tome 13. Fascicule 1. Hungary.

sical Institute was supplied also with an *electromagnetic apparatus* and with a special *geophone to lower it in drill holes* for determination of the velocity of seismic propagation waves in the underground. In 1938 a *second seismic equipment* of the same type as the first one was put to work and at the end of the same year also an *instrument for electrical coring* was in the possession of the *Geophysical Institute.*

The *Geophysical Institute* to-day is able to put the following *field parties* at geophysical prospecting work:

A) 1 party for torsion balance survey,

B) 1 party for gravity-meter survey,

C) 1 party for terrestrial magnetic survey

a) for absolute determination of the terrestrial magnetic force,

b) for relative determination of the horizontal and vertical components,

c) for registering the daily variations of the horizontal and vertical components,

D) 2 seismic parties,

E) 1 party for electrical survey

a) for determination of the resistivity,

b) for determination of the electromagnetic force,

F) 1 party for electrical coring.

III. Geophysical prospectings in years 1936-1938.

A. Eötvös torsion balance survey.

1. Method of the torsion balance survey.

It is well known, that with the *Eötvös torsion balance* the following four quantities can be determined:

$$U_{xz} = \frac{\delta^2 U}{\delta x\, \delta z}, \quad U_{yz} = \frac{\delta^2 U}{\delta y\, \delta z}, \quad U_{\triangle} = \frac{\delta^2 U}{\delta y^2} - \frac{\delta^2 U}{\delta x^2}, \quad U_{xy} = \frac{\delta^2 U}{\delta x\, \delta y}.$$

The first two differential quotients mean the two components of the *gradients of the gravity* in the XY plane and the two second ones are significants for the *curvature of the niveau surface* of the gravity force. These quantities are extremely small being of the order of 10^{-9} CGS, which is called 1 *Eötvös unit* (1 E).

The observed values of these four differential quotients of the potential function of the gravity are composed of:

1. the effect of the *normal value* of the gravity,
2. that of the irregularity and inhomogenity of *the surface,*
3. that of the irregularity and inhomogenity of *the subterranean masses.*

From a practical point of view the effect mentioned under 3. is of greatest interest because from this effect *conclusions* as to the distribution of the underground geological formations can be drawn.

In order to obtain the effect of the underground masses, the following *corrections* have to be made on the observed values.

1. *Normal corrections.* These are taken from tables. For the torsion balance surveys of 1936—1938 which were carried out in the vicinity of the geographical latitude of 48°, *the normal values* approximately are

$$U_{xz} = +8{\cdot}1 \text{ E and } U_{\triangle} = +4{\cdot}6 \text{ E}$$

2. *Terrain corrections* are on each station determined by making a *levelling* in a circle of 100 meters radius. (Table I. Fig. 3.)

3. If the area under survey is so broken, that the gravity effect of the surface masses beyond the circle of 100 meters radius seems to be higher than 1 *Eötvös* unit, so special corrections are applied on the observed values. These *cartographical corrections* are calculated from the data of the contourlines on the maps.

Subtracting the normal gravity values, the terrain and the cartographycal gravity effects from the observed values, we obtain the *subterranean gravity anomalies.*

From the gradients of the gravity the *Δg value* between two stations can be calculated. The Δg value is the difference of the gravity force between the two stations in the XY plane. The Δg values are expressed in *milligal* units (1 mgal $= 1.10^{-3}$ CGS). Curves connecting points with the same Δg values are the *isogams.*

Interpretation of the results of a torsion balance survey is generally based on the *gradient and isogam map. The gradients* point towards the accumulation of masses or towards the increase of the specific gravity in the formations. Considering this, conclusions can be drawn from the distribution of the gradients as to the geological structures of the subterranean formations. *The isogams* can be taken for *contourlines* of the heavier formation provided, that there are only two formations and that the heavy formation is underlying the sediment of smaller specific gravity. In the case of more than two formations this interpretation of the isogams are not valid and *section calculations* are to be applied. In the section calculation the gravity effect of a supposed distribution of the underground formations i. e. the gradients have to be calculated and then to be compared with the observed gradients. It is evident, that the supposed distribution of the mass must be always in full correspondence with the known geological data and with those obtained from the well logs. If the two gradient curves, i. e. the observed and the calculated ones satisfactorily correspond, then the supposed geological section can be regarded as one possible distribution of the underground masses. Otherwise the supposition must be changed as many time as satisfactory correspondence will be achieved.

2. Results of the torsion balance surveys made in 1936-1938.

The torsion balance surveys made by the *Geophysical Institute* in years 1936—1938 were carried out with *Eötvös torsion balances of small model.* Working with three instruments simultaneously and by day only, observations could be made on nine stations in one day. (Table I. Fig. 1. and. 2.)

Torsion balance stations were located either along profiles or netlike, according to the hilly or plain ground of the areas to be surveyed.

Cartographical corrections were made on the torsion balance data obtained in years 1936 and 1937, while such corrections could be neglected in the torsion balance survey of 1938.

The results of the torsion balance surveys in these years are shown on the *enclosed Maps I. II. and III.* The subterranean gravity anomalies are represented by arrows as resultants of the U_{xz} and U_{yz} gradient components. Not to complicate these maps the curvature values U_{Δ} and U_{xy} are omitted. The isogams are also shown on these maps.

In this period the following torsion balance surveys were made by the *Geophysical Institute* in *Hungary:*

Year	Area		Number of stations	Shown on Map
1936.	*Parád and Recsk*		205	II.
	Nagybátony		147	I.
	Bükkszék		487	II.
	Füzesabony and Kál		251	II. and III.
		Total:	*1090*	
1937.	*Sóshartyán and Mátraverebély*		372	I.
	Bátor		165	II.
	Verpelét and Kál		351	II. and III.
		Total:	*888*	
1938.	*Kál and Heves*		514	II. and III.
	Kisköre, Tiszabura and Tiszanána		506	III.
	Jászberény		59	III.
		Total:	*1079*	

The number of torsion balance stations made during the three years 1936—1938 totalled 3057.

a.) Results of the torsion balance survey in the area of Sóshartyán, Mátraverebély and Nagybátony.

The results of this torsion balance survey are shown on Map I.

West of Sóshartyán there appears a *gravity maximum* indicated by the gradients as well as by the isogams. According to the geological survey *oligocene* formations are here on the surface. The flanks of this *uplift* are well defined to the N, NE, S and SW and probably are also *faulted* to the S and SW, while to the NW there is still an increase in the gravity.

SE of this gravity maximum the gravity is continually decreasing and *S of Sámsonháza* and *S of Kisterenye* there are two *depressions* with a *gravity maximum* between them, lying *N of Mátraverebély* and *S of Szúpatak.* The large gradient values on the W flank of this gravity maximum indicate the faulted structure conditions, what was ascertained also by the geological survey.

On the southern part of Map I. we find a large *gravity maximum* lying *E of Nagybátony.* This is the gravity indication of an *uplift* found also by geologists which is — however — somewhat displaced to the E. The flanks according to the torsion balance results are *faulted* to the W and to the E and are undetermined on the southern side on account of the unsuitable terrain conditions.

b.) Area of Parád, Recsk, Bátor and Verpelét.

Map II. shows the results of the torsion balance survey made in the area of *Parád, Recsk, Bátor* and *Verpelét.*

In the vicinity of Parád the regular southern direction of the gradients are caused by the northern *subterranean slope of the Mátra mountain.*

SW of Parádóhuta some gradients turn to the North, indicating the southern flank of an *anticline* of W—E direction. The hilly area, however impeded us to carry out the torsion balance survey farther to the South.

Between Parádfürdő, Mátraderecske and Recsk the gravity results indicate the underground masses of the *Hegyes-hegy,* which is the watershed between the basins of Parád and Recsk.

In the area lying *between Recsk and Bátor* the most outstanding feature is the gravity indication of a mighty *fault line* running in SW—NE direction.

SE of this fault line two *uplifts* in the basement are indicated by the gravity anomalies, separated by a *cross fault* in the valley of *Tarna* between the villages *Szajla* and *Sirok.* One of these uplifts appears where the *Darnó-hegy* is situated. The gravity indication of this uplift is incomplete to the SE on account of the hilly country side. The second uplift farther to the NE is clearly indicated by the isogams in the vicinity of *Felsőrozsnaki tanya* and of the *valley of Nagyasszó.* It is entirely possible, that according to the observed gravity values to the E there are other gravity maxima in the vicinity of *Egerbakta,* but no further observations were made in this area.

NW of the big fault line there is a gravity indication of an *anticline* of *SSW—NNE* direction just W of *Bükkszék.* The axis of this anticline can be traced from *Terpes* up to *Fedémes.* Near *Bükkszék* a small uplift is on the axis, where at present there is an oilfield of small extent and of moderate capacity.

On the southern part of the Map II. in the vicinity of *Verpelét, Kisnána* and *Domoszló,* the gravity anomalies clearly indicate the southern *subterranean flank of the Mátra mountain.* The *regional effect* of this southern flank extends farther to the S just to the southern end of the Map II.

On several places *secondary gravity effects* appear to be superposed on this regional effect, which have then the responsibility for the somewhat irregular character of the gradients. Such secondary gravity maxima can be found between *Tarnaszentmária and Kisnána,* between *Domoszló and Vécs* and between *Feldebrő and Kerecsend,* where the gradients and the convexity of the isogams show the presence of uplifts in the sediments and probably also in the basement.

c.) Area of Eger, Maklár and Füzesabony.

The big gradients of NNW direction *between Eger and Maklár* (Map II.) indicate the steep faulting condition of the basement. This *fault line* of SW—NE direction is the continuation of the fault line found farther to the NE *between Bogács and Tard,* discussed in the *Report 1936* of the *Geophysical Institute* submitted to the *Edinburgh Congress.*

Between Maklár and Füzesabony the gradients point to the big *gravity maximum of Mezőkövesd* shown on Map II. and discussed also in the *Report* just mentioned.

d.) Area of Kál, Heves and Tiszabura.

The torsion balance results obtained on this area are given on Map III.

A very important feature on the N side of this Map is that the general northern direction of the gradients in the line *Kál—Füzesabony* changes into S and SE forming a *depression* of W—E direction in the gravity anomalies.

From this line of the depression the gravity anomalies are continually increasing up to the *Tisza river,* where in the vicinity of *Kisköre and Tiszabura* they change their direction again and form a *gravity maximum* SW of *Tiszabura.* There is another gravity maximum ESE of *Tiszaroff,* the Δg value of which is smaller than that of the above described ones.

On the western part of the Map III. *near Heves a small secondary gravity maximum* appears in the isogams, which, however, seems to be of no importance from a practical point of view.

e.) Vicinity of Jászberény.

The gravity-meter survey, which will be discussed in the next paragraph, discovered a maximum in the gravity anomalies *S of Jászberény.* Because of the uncertainty in the gravity-meter results, a torsion balance party was sent to *Jászberény* in order to resurvey this area with the torsion balance. Results of this work confirmed the discovery made by the gravity-meter as this can be seen comparing the *gravity maximum of Jászberény* in the SW corner of Map III. with that on Map IV. showing the gravity-meter results.

B. Gravity-meter survey.

1. Description of the Haalck gravity-meter.

In the last years a new kind of gravity instrument found a world-wide use in the geophysical prospectings. This new instrument is the *gravity-meter,* by the aid of which the variation in the gravity can be directly measured. The gravity-meter does not mean a new method because the gravity and its variation could be determined with pendulum apparatus and could be calculated also from the results of the torsion balance survey.

The advantage of the *gravity-meter in comparison with the pendulum or torsion balance* is that with it the survey can be made *rapidly* and at very *low cost,* moreover the *accuracy* of the gravity-meter is equal to or perhaps even higher than that of a pendulum survey. On the other hand a torsion balance survey furnishes us with more data for interpretation (i. e. gradients, curvature values and isogams), than a gravity-meter survey (isogams).

There are several *types of gravity-meters,* the best of which are those based on the determination of the *lengthening of a spring* in the gravitational field. Another gravity-meter is the *barometric type* made by *H. Haalck.* The *Geophysical Institute* has been supplied with a *Haalck gravity-meter.* (Table I. Fig. 4.)

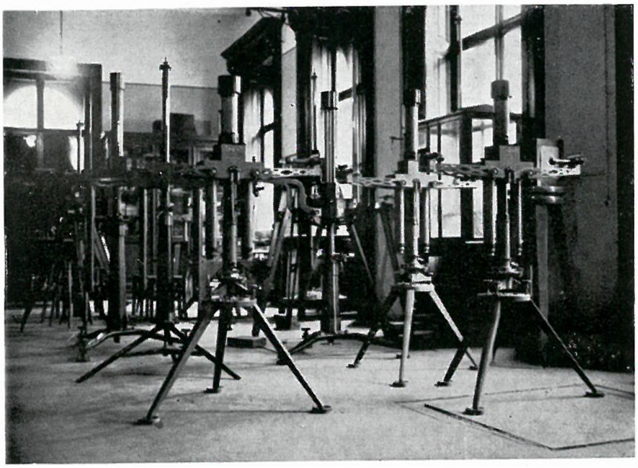

Fig. 1.
Eötvös torsion balances
in the laboratory.

Fig. 3.
Measuring the terrain
effect.

Fig. 2.
Eötvös torsion balance
in the field.

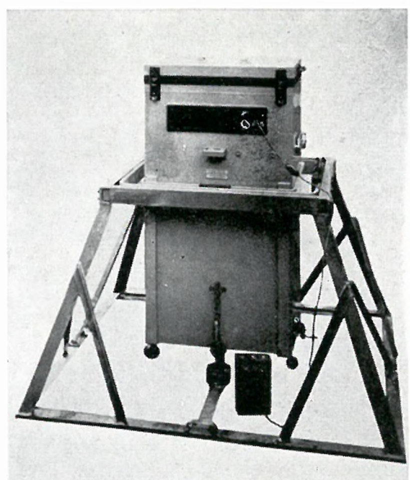

Fig. 4.
Haalck gravity-meter.

This type of gravity-meter is based on the following *theory*. We suppose that the pressure of a gas in volume V_1 is p_1 and that in volume V_2 is p_2. The two pressures are balanced by a column of mercury of height h and of specific gravity σ. Then

$$p_1 - p_2 = h \cdot \sigma \cdot g$$

where g is the force of gravity. If the temperature is constant so $p_1 - p_2$ and σ are also constant and by the variation of g only the value of h changes. From the variation of h the Δg value can be determined.

The formula for the Haalck gravity-meter is

$$\Delta g = C \cdot dx$$

where C is a constant of the instrument, dx the shifting of a drop of some liquid.

Most important is to keep the inside of the instrument on *constant temperature*, for this reason the whole instrument is in an *ice box*.

The *accuracy* of the Haalck gravity-meter is not sufficient to replace the torsion balance, but properly it can be used for a *reconnaissance* prospecting work.

Before using the Haalck gravity-meter in the field, the Δg values obtained by it *near Budapest* were compared with those determined with the pendulum apparatus by Prof. *Oltay* and with torsion balance. The following table shows this *comparison*.

	Δg values obtained with		
Station:	pendulum	torsion balance	gravity-meter
Budapest, Techn. Univ.	+ 44	—	+ 46
Budapest, Geoph. Inst.	+ 36	—	+ 41
Budapest, Geol. Inst.	+ 37	—	+ 38
Rákosfalva	+ 35	+ 35	+ 37
Mátyásföld	+ 47	+ 45	+ 39
Cinkota	+ 44	+ 43	+ 38
Nagytarcsa	+ 39	+ 38	+ 38
Gödöllő	+ 35	+ 32	+ 31
Pécel	+ 24	—	+ 25
Mogyoród	—	+ 44	+ 46
Fót, Castle	+ 32	+ 37	+ 29

The highest *accuracy* attained by the *Haalck* gravity-meter is ± 1 mgal in comparison with the accuracy of ± 0.1 mgal, claimed for the accuracy of the spring gravity-meters.

In the *field-work* with the *Haalck* gravity-meter several *difficulties* arose mostly on account of the transport of the instrument. Surveying could be made along roads only, where the heavy instrument of 700 klgr. could be carried by a truck. As a consequence of the insufficiency of suitable roads in the *Great Plain* of *Hungary* large areas remained unsurveyed. Along the roads — *profiles* — gravity-meter stations were chosen at *intervals* of 500—1000 meters, and after finishing a line, this was resurveyed on the same day. Moreover, on the next day, the survey along the whole line was repeated again, so that the Δg value on each station had been determined *four times*.

The observed values obtained with the *Haalck* gravity-meter must be also corrected similarly to the torsion balance results in order to calculate the subterranean gravity anomalies. The necessary *corrections* are as follows:

a) All observed values have to be corrected on account of the *differences in the altitude* of the stations.

b) From the observed values the *normal Δg value* valid for the station has to be subtracted.

c) There is a correction — called *Bouguer correction* — to be applied on the values observed with the gravity-meter. This is the attraction of the masses lying between the real and corrected level of the station in the vertical direction.

d) *Terrain correction,* i. e. the attraction of masses lying around the station. This is small and can be neglected, when the survey is made on a level country, but has to be applied in a hilly area.

2. Interpretation of the results of the gravity-meter surveys.

The first field-work made with the *Haalck* gravity-meter was the survey in the vicinity of *Mezőkövesd.* This was contemplated for checking the results of the torsion balance surveys carried out in this area in the years 1933 and 1934.

The results, i. e. the *isogams* obtained by the *gravity-meter* survey of *Mezőkövesd* are shown on Map IV. while the isogams calculated from the *torsion balance* results can be found on the SE corner of the Map II. The comparison of the two kinds of isogams favourably decides upon the applicability of the gravity-meter, but only in reconnaissance work.

After this trial of the *Haalck* gravity-meter a large area (Map IV.) encircled by the following villages: *Füzesabony — Kömlő — Tiszasüly — Szolnok — Cegléd — Nagykáta — Vámosgyörk — Füzesabony* was surveyed with it.

The isogam map of the gravity-meter survey can undoubtedly be used for locating gravity maxima and minima, but no or very little details appear on the gravity-meter map regarding the form and composition of the underground structures.

The eastern part of Map IV. was surveyed with both *gravity-meter* and *torsion balance* (Map III.). The distribution of the gravity is in general the same on both Maps, but there are discrepancies in the course of the isogams obtained by the two methods.

On Map IV. we find in the results of the gravity-meter survey very clear indications of *gravity maxima,* which are enumerated herewith:

1. E of *Jászfényszarú* and S of *Csány,*
2. on the western part of the surveyed area in the vicinity of *Tóalmás,*
3. S of *Jászberény* a large *gravity maxima* appeared in the isogams of the *gravity-meter survey,* which was confirmed also by the *torsion balance,*
4. S of *Zagyvarékás,*
5. on the northeastern side of *Abony.*

From a practical point of view it seems to be worthwile that all of this gravity maxima should be examined by the torsion balance and also by the seismic method.

In the cities of *Szolnok* and *Cegléd* several years ago there were made relative pendulum stations according to the results of wich

$$\Delta g\text{Cegléd} - \Delta g\text{Szolnok} = -5.0 \text{ mgal},$$

while the gravity-meter has given:

$$\Delta g\text{Cegléd} - \Delta g\text{Szolnok} = -3.7 \text{ mgal}.$$

C. Terrestrial magnetic surveys.

1. Application of terrestrial magnetic survey in prospecting.

The problem of the terrestrial magnetic survey in prospecting work is to draw conclusions from the magnetic anomalies determined on the surface as to the presence and distribution of masses of magnetic effects.

The determination of the terrestrial magnetic anomalies can be made in different ways.

Generally three *elements* of the terrestrial magnetic force are determined, i. e. the *horizontal intensity* (H), the *declination* (D) and the *inclination* (I). From these elements the three rectangular components X, Y, Z can be obtained. For practical purposes it is not necessary to determine the *absolute values* of the three components, valuable conclusions can be drawn also from their *variations.* Generally the *variations of the horizontal component* (ΔH) and those *of the vertical component* (ΔV) are measured.

For the determination of these variations the following instruments are used by the *Geophysical Institute. Schmidt vertical and horizontal variometers* (Table II. Fig. 5.) *and Kohlrausch horizontal variometer.* (Table II. Fig. 6.)

The observed *magnetic variations* — however — must be properly corrected, if we want to know the *magnetic anomalies* only, i. e. those variations, which are caused by *underground masses* of magnetic effects.

The first correction to be applied on the observed values is necessary on account of *the daily variations* of the terrestrial magnetism. If a standard magnetic observatory is in activity near the area to be surveyed, this daily variations can be taken *from the data of the observatory.* Between 1919 and 1939 there was no such observatory in *Hungary,* therefore the *Geophysical Institute* was obliged *to register* the daily variations with a *special registering instrument.* (Table II. Fig. 7.)

The normal distribution of the magnetic force in a given point of the earth can be represented by formulae in which the magnetic components are the functions of the geographical latitude and longitude. These formulae are valid — howewer — only for an area of small extent and will be derived from terrestrial magnetic values observed in in the area. For *Hungary Baron Roland Eötvös* calculated the following formulae:

$$\Delta H = -0.000\,077\,10\ \Delta\varphi + 0.000\,007\,83\ \Delta\lambda$$
$$\Delta V = +0.000\,107\,49\ \Delta\varphi + 0.000\,003\,82\ \Delta\lambda$$

where $\Delta\varphi$ and $\Delta\lambda$ are the differences in geographical latitude and longitude of the stations from a basis station and are expressed in minutes.

Applying these two corrections on the observed values we obtain the *magnetic anomalies.*

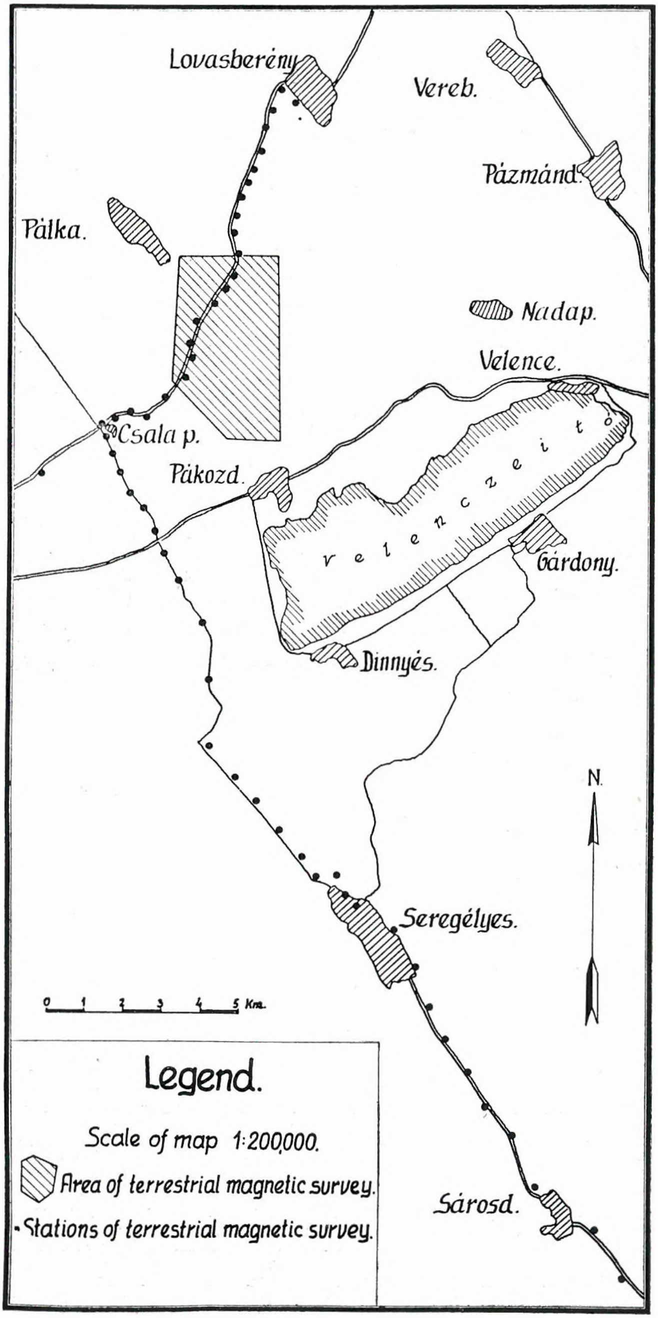

Fig. 8.
Map of terrestrial magnetic survey in the vicinity of *Pátka.*

As the variations in the ΔH and ΔV values are the highest along the magnetic meridian, we locate the *magnetic stations* generally along *S—N profiles.* The *intervals* between the profiles and between the stations are chosen according to the magnitude and extent of the magnetic anomalies.

For the proper *interpretation* of the magnetic results it is entirely necessary to know the *magnetic susceptibility* of the various underground formations These values are determined on samples by the aid of special instruments of different types. The *Geophysical Institute* is using for this purpose the so called *Eötvös magnetic translatometer.*

2. Results of magnetic surveys made in 1936-1938.

a.) In the vicinity of Pátka.

The terrestrial magnetic survey of *Pátka* (Fig. 8.) was made to investigate this area by the magnetic method because geological research work and a superficial survey with a „magnetometer" made many years ago in this area, found some indication of the presence of magnetic iron ore.

The magnetic anomalies obtained in the vicinity of *Pátka* did not indicate the presence of such magnetic masses. The small magnetic anomalies in the vertical intensity are originated probably from formations of *eruptive* origin. On the other hand along the profile, which was extended far to the South, large vertical anomaly was found near the village *Seregélyes.* According

Fig. 5.
Schmidt magnetic variometers.

Fig. 6.
Kohlrausch horizontal variometer.

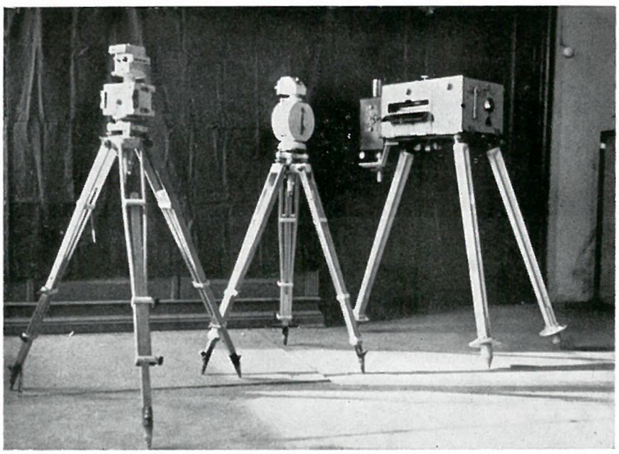

Fig. 7.
Apparatus for registering the daily variations.

Fig. 16.
Car with seismic equipment.

geological information this anomaly is due also to rocks of *eruptive* origin.

b.) In the vicinity of Nézsa.

In the same year 1936 the area near *Nézsa* (Fig. 9.) was also investigated by terrestrial magnetic survey. In this area limonit can be found, the magnetic susceptibility of which was determined and found to be 480.10^{-6}CGS. Having supposed a mass of 1000 m wide, 60 m thick, 60 m below the surface and of about 500.10^{-6} CGS magnetic susceptibility, *theoretical calculations* gave an anomaly in the vertical intensity

$$\Delta V = 65\,\gamma$$

which if present could be reliably determined in the observed magnetic anomalies. *The results of the survey* have shown that no larger than 30—40 γ anomalies were found in the vertical and in the horizontal intensity. Accordingly it can be supposed that limonit of considerable quantity can not be found in the investigated area.

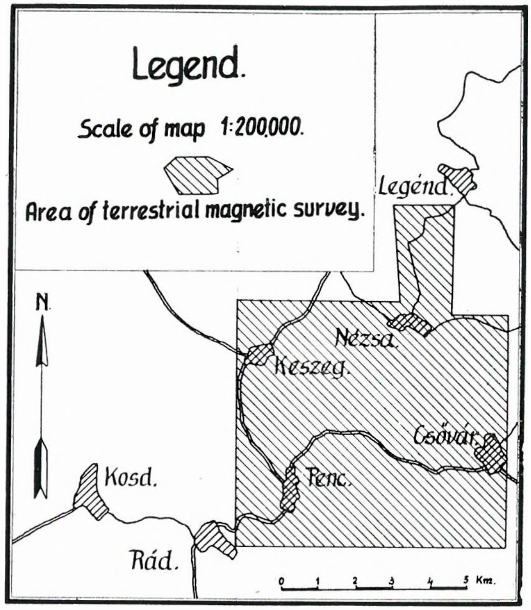

Fig. 9.
Map of terrestrial magnetic survey in the vicinity of *Nézsa.*

c.) In the Mátra mountain.

Together with torsion balance survey some terrestrial magnetic profiles were surveyed in the *Mátra* mountain and northeast of it. (Fig. 10.) ΔH and ΔV were determined in the profile of

1. *Felsőhuta—Kisterenye—Mátraszele,*
2. *Parádóhuta—Parád—Bodony* (the ΔV values only),
3. *Sirok—Pétervására—Istenmezeje,*
4. *Bükkszék—Tarnalelesz—Szederjestanya,*
5. in the vicinity of *Bükkszék.*

The surveys of these profiles do not give large anomalies in the vertical component, where from it can be concluded that the observed anomalies of the order of 70—100 γ are due to various rocks of small magnetic susceptibility and not to iron ore in quantities of practical value.

d.) In the vicinity of Füzesabony.

In the year 1935 a S—N profile was surveyed in the line of *Kömlő—Füzesabony—Andornak* and a regular magnetic anomaly was found along this profile. We have discussed this results in the *Report 1936* of the *Geophysical Institute* submitted to te *Edinburgh Congress.* In 1936 the survey was repeated on the occasion of the torsion balance survey made in this area. The results obtained in the two years correspond in general and the small differences are due to the corrections of the daily variations.

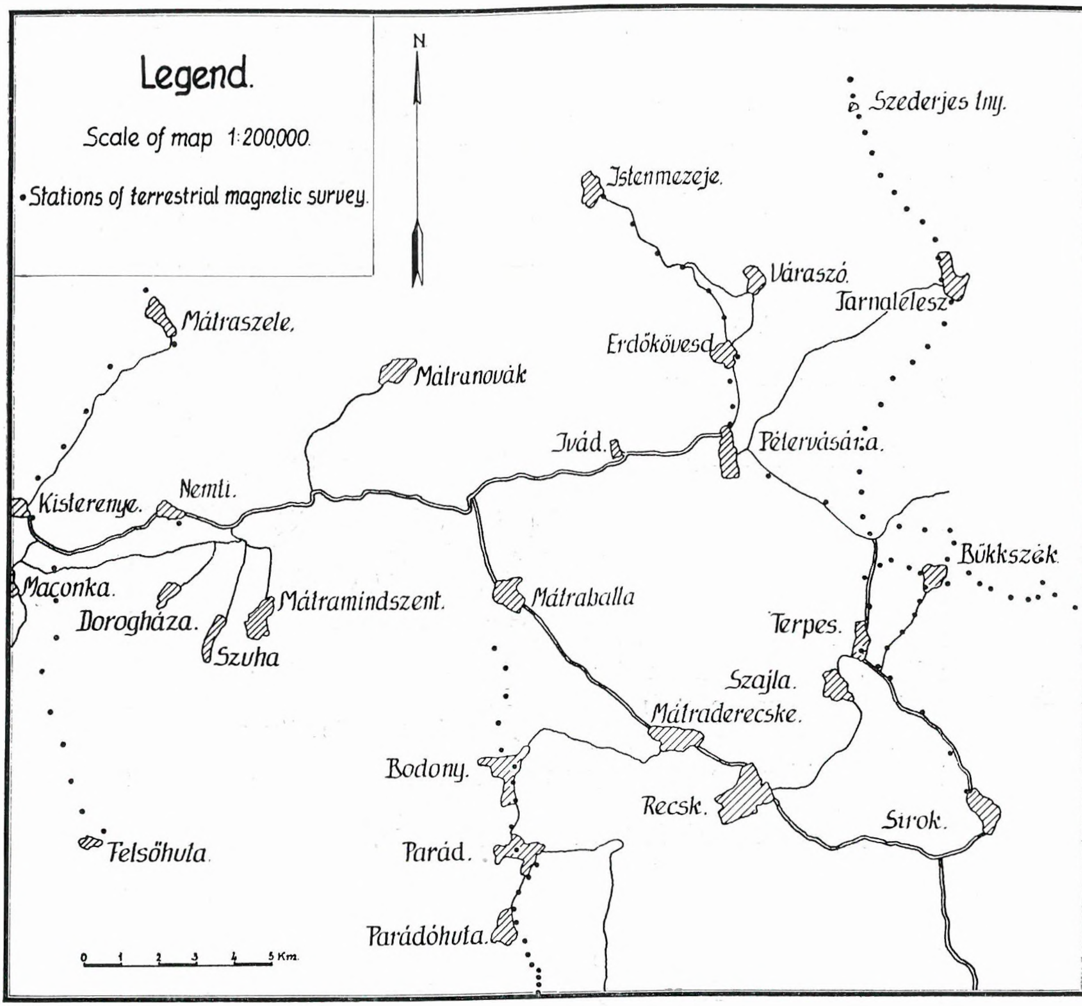

Fig. 10.
Map of terrestrial magnetic survey in the *Mátra* mountain.

e.) Terrestrial magnetic survey in Borsod and Abaúj-Torna Counties.

In the year 1938 a very extended magnetic survey was made by the *Geophysical Institute* in the vicinity of the villages *Szalonna, Martonyi (County Borsod)* and of *Tornaszentandrás, Bódvarákó, Perkupa, Komjáti* and *Tornakápolna (County Abaúj-Torna)*. The map of the surveyed area is shown on Fig. 11.

In this area 31 long and 19 short profiles of S—N direction and with intervals of 500 meters were laid, along which the ΔH and ΔV anomalies were measured on stations lying at 150 meters distances. In total ΔV value on 1067 stations and ΔH value on 976 stations were determined.

The results of the terrestrial magnetic survey made in this area are in general demonstrated on two different ways as follows:

a) by *curves* representing the *ΔH and ΔV anomalies* respectively,

b) by connecting the points of equal ΔV anomalies, i. e. constructing *vertical isodynam maps.*

In the *interpretations* of the magnetic results based on the *anomaly-curves* the following rule is of the greatest importance. If there is an underground mass of considerable magnetic effect lying in W—E direction, and crossing it on the surface by magnetic *profiles in S—N direction,* magnetic anomalies will be

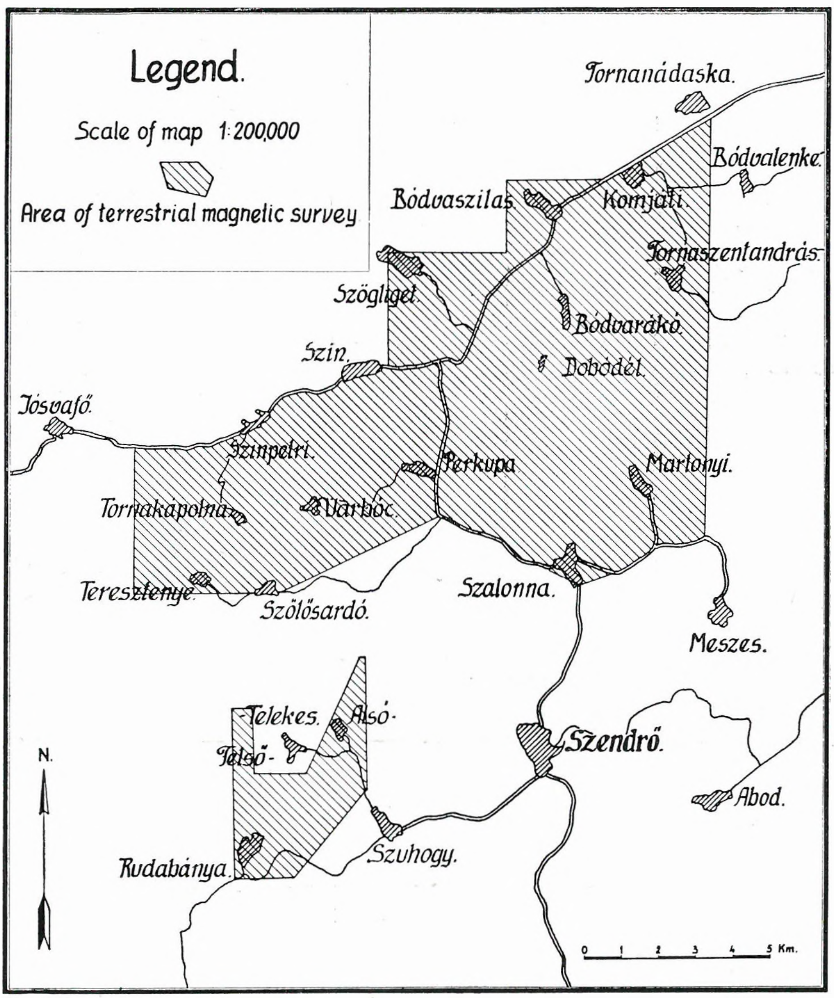

Fig. 11.

Map of terrestrial magnetic survey in the *Borsod and Abaúj-Torna Counties.*

obtained above the mass. These anomalies are so distributed, that in the *ΔH anomalies* a *maximum* appears on the S end, a *minimum* on the N end and *zero value* above the central part of the mass, while in the *ΔV anomalies maximum* value will be found just above the centre of the mass and small negative anomalies on the S and N end.

On the *isodynam maps closed isodynam lines* of the highest ΔV anomalies indicate the presence of the subterranean masses of magnetic effect.

It is possible *to draw conclusions* from the magnetic anomalies as to the depth and extent of the magnetic masses provided that the *magnetic susceptibility* of these masses in question is known.

On the surveyed area several places were found with considerable and mostly very regular magnetic anomalies.

In the *vicinity of Komjáti* the anomaly-curves (enclosed Map V.) in four profiles, as well as the isodynam map (Fig. 12.) indicate a mass of magnetic effect.

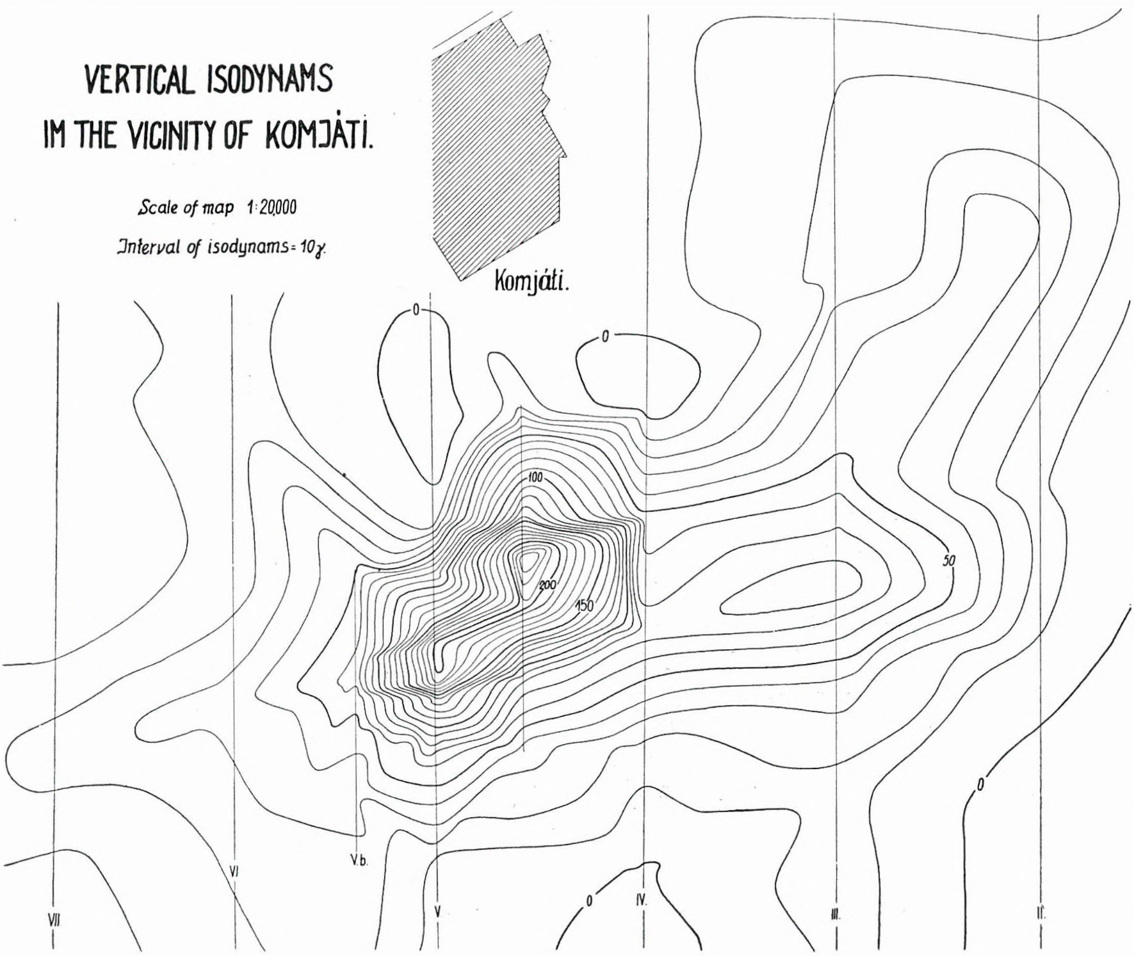

Fig. 12.

Very big anomaly was found *near Bódvarákó* ($\Delta V = 891\gamma$) but the extent of this anomaly is small.

Regular magnetic anomalies appear in the vicinity of *Bódvaszilas, Szögliget* and *Perkupa.*

Magnetic anomaly of large extent was found in the *vicinity of Tornakápolna.* The curves of this anomaly in 19 profiles are shown on the enclosed

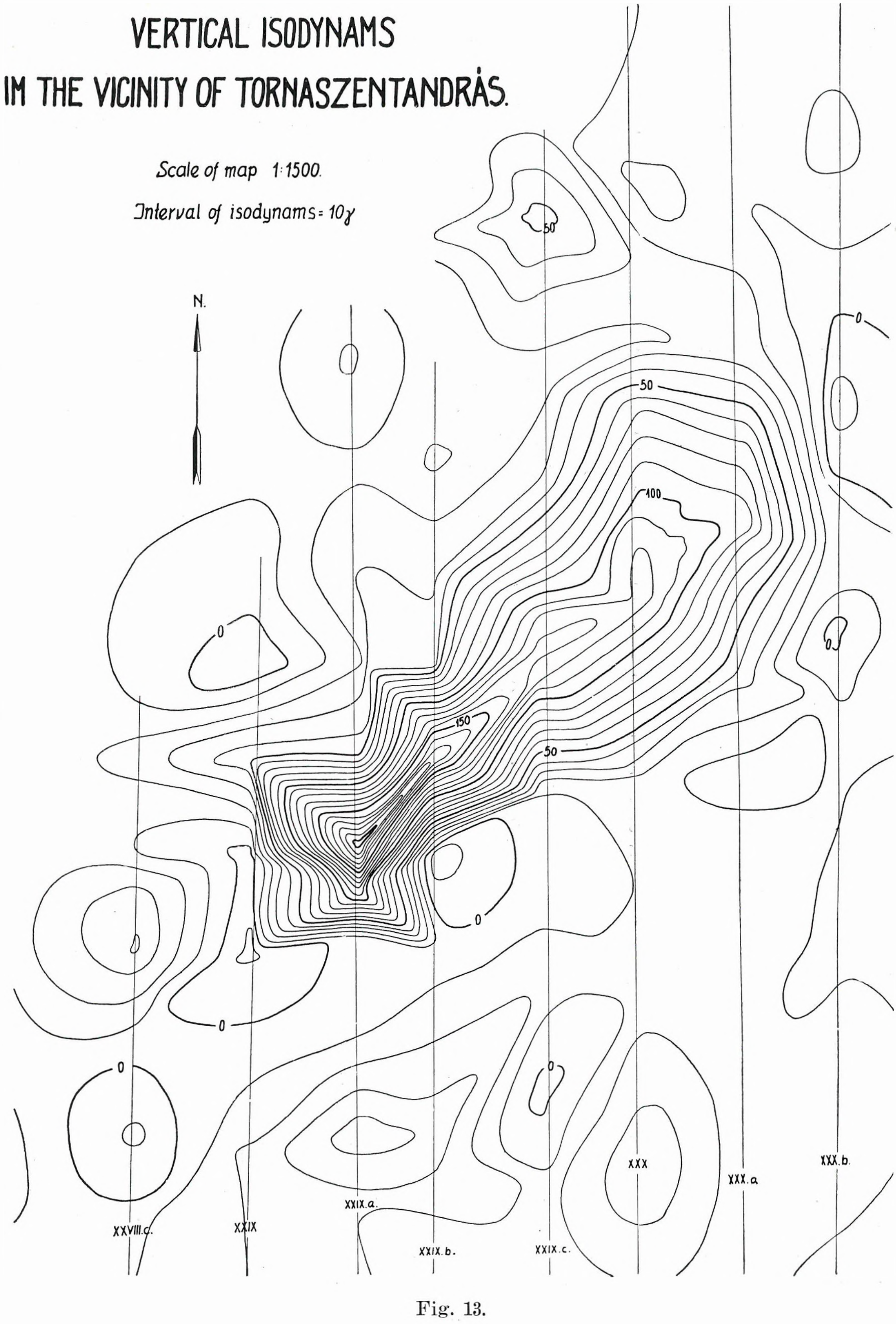
VERTICAL ISODYNAMS
IM THE VICINITY OF TORNASZENTANDRÁS.
Scale of map 1:1500.
Interval of isodynams = 10γ
N.
50
0
50
100
0
150
50
0
0
0
0
XXVIII.c.
XXIX
XXIX.a.
XXIX.b.
XXIX.c.
XXX
XXX.a
XXX.b.

Fig. 13.

Map V. and the isodynams on Map VI. The maximum value of ΔV is $357\,\gamma$ and the area encircled by the closed isodynams is 5 km long and 3 km wide. *A hole was drilled* here about 10 years ago but this was located at 1.5 km SW of the maximum ΔV value. The drilling went into limestone and reached a depth of 480 meters in schist. Determination of *magnetic susceptibility* made on samples from the surface of this area have given values as follow

susceptibility of limonit $k = 240.10^{-6}$ CGS.
„ „ hematit $k = 230.10^{-6}$ „
„ „ schist $k = 460.10^{-6}$ „

It is evident that these values are insufficient to cause the magnetic anomalies obtained near Tornakápolna, therefore we have to suppose either the presence of iron ores of higher susceptibility than actually were measured, or of rocks of eruptive origin.

In the area of *Martonyi* a very detailed magnetic survey was made near the *mine of Jóremény.* In 61 profiles with intervals of 25, 50, 100 meters and on stations of 12.5, 25, 50 meters distances 1921 ΔV and 1832 ΔH values were determined. The results are shown partly on Fig. 13. (vertical isodynams near *Tornaszentandrás)* and partly on the enclosed Map V. (anomaly-curves in profiles near *Tornaszentandrás).* Determination of the *magnetic susceptibility* on samples from this area resulted the following values:

susceptibility of limonit $k = 933.10^{-6}$ CGS.
„ „ hematit $k = 816.10^{-6}$ „

Such a big magnetic effect can give magnetic anomalies as high as $200\,\gamma$, which were actually obtained *between Martonyi and Tornaszentandrás.* Attention must be called to these anomalies, which are most probably due to buried *iron ore* at shallow depth.

Terrestrial magnetic survey was carried out also in the *iron mine of Rudabánya* in order to study the appearance and course of magnetic anomalies *above known iron ores,* limonit, siderit and ankerit. The survey was handicapped by the many disturbing masses of magnetic effects which can be always found in an active mine, for instance, electrical transmission lines, railroads, etc.

On this area in 18 profiles ΔV values were determined on 512 and ΔH values on 494 stations. The iron ore-bearing zone generally appears also in the observed magnetic anomalies, but on account of the irregularity in the magnetic susceptibility of the iron ore (limonit, siderit, ankerit), the indications of the magnetic masses are faint and uncertain.

D. Seismic method.

1. Application of the seismic method.

In the geophysical prospecting the seismic method to-day takes a very prominent part. According to this method *artificial seismic waves* are originated by *explosions* in the underground which spread in every directions with different velocity in the various formations. If these seismic waves arrive to the contact surface of two formations, they are partly *refracted* and penetrate into the new medium, partly are *reflected* and come back to the surface.

There are two kinds of seismic methods, the one is using the refracted and the other one the reflected waves. Accordingly the methods are called *refraction seismic method* and *reflexion seismic method.* In the present time the reflexion seismic method is more widely used in the geophysical prospecting works, than the refraction method.

The propagation of seismic waves in the reflexion seismic method is shown in Fig. 14. In A explosion will be made and the waves originated by this explosion are spreading in every direction. In C they are reflected and arrive to instruments called *geophones* in B, which react on the reflected seismic waves and register their arrival. If we determine the time elapsed between the explosion and arrival of the reflected waves *(T)*, the distance between the point of explosion and geophon *(AB = X)* and the velocity of the seismic waves in the sediment *(V)*, then *the depth of the reflecting surface (Z)* can be calculated with the following formula

$$Z = \frac{1}{2}\sqrt{V^2 T^2 - X^2}$$

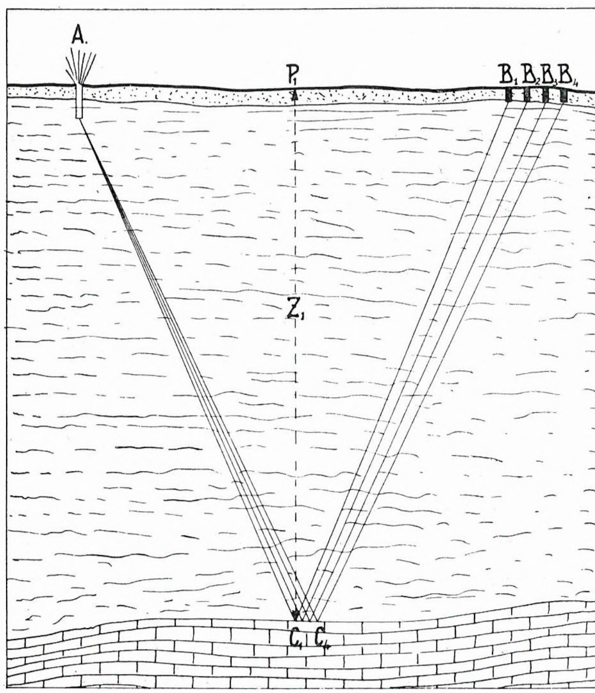

Fig. 14.
Propagation of reflected seismic waves.

In the reflexion seismic method always more than one, generally *six geophones* are used along the profile at intervals 25—50 m, in order to identify the arrival of the reflected waves on the seismograms.

The velocity of the seismic waves can be determined in different ways. Using the *refraction method* the velocity of the seismic waves can be obtained at various depths. A thoroughly accurate determination can be made when there is a well available in the area to be surveyed. *Lowering a geophone into the well* to different depths and making explosions on the surface the velocity of the seismic waves can be directly obtained.

In calculating the depth of the reflecting horizon we have to take into account *the low velocity in the surface layer,* where the geophones are placed, while the explosion will be made always below this layer of low velocity.

On Table III. Fig. 15. shows three *reflexion seismograms,* each registered by six geophones. In the lower seismogram „*A*" indicates the moment of explosion, while „*C*" the first arrival of the seismic waves which are — however — refracted waves. The arrival of the reflected waves are marked by B', B" and B'".

It is interesting to note, that while a considerable shifting appears in the *first arrival* of the refracted waves to the geophones, there is no or little difference in the arrival of the reflected waves.

The elapsed time can be directly measured on the *time marks*, which appear on the low part of the seismogram.

2. Equipment and elaboration of the seismic survey.

The *Geophysical Institute* in the seismic work was using an *electrical seismograph* made by Prof. *B. Pogány* of the *Technical University* Budapest. The parts of this electrical seismograph are as follows (Table II. Fig. 16. and Table III. Fig. 17. and 18.):

a) six geophones of condensator type,
b) six small amplifiers,
c) six large amplifiers,
d) an oscillograph with six galvanometers,
e) accumulators,
f) cables,
g) an instrument for registering the moment of the explosion,
h) an instrument to ignite the explosive.

From 1938 *two seismic equipments* were simultaneously used by the Geophysical Institute. This was advantageous from an economic standpoint, because the seismic waves generated by *one explosion* could be contemporarily registered by two instruments.

For the explosions of the reflexion seismic survey *dynamit* was used in different quantities, the amount of which for one shoot differed from *20 g* up to *2000 g,* according to the sedimentary beds, in which the explosion occured. Moreover in wet weather, when the sensitivity of the geophones decreased, more dynamit was used, than in dry atmosphere.

The reflexion seismic survey is carried out along *profiles* the direction of which should be *perpendicular* to the axis of the supposed geological structure. Where torsion balance survey was made, *the isogam map* has given valuable informations in regard of the direction of the seismic profiles. Along these profiles the *intervals of the shoot points* may vary in general from 250 up to 1000 meters. In case of a *detailed survey* several profiles were run parallel to one another. Sometimes cross-profiles were also surveyed so that a *net* of seismic results was obtained.

The results of the reflexion seismic survey are shown along the profiles by marking the *depths of the reflecting surfaces* calculated from the reflexions, by connecting them and thus preparing the reflecting surfaces. Such a map is enclosed under VIII.

If reflecting points from the same reflecting surface are available not only along profiles but on the whole surveyed area, then connecting the re-

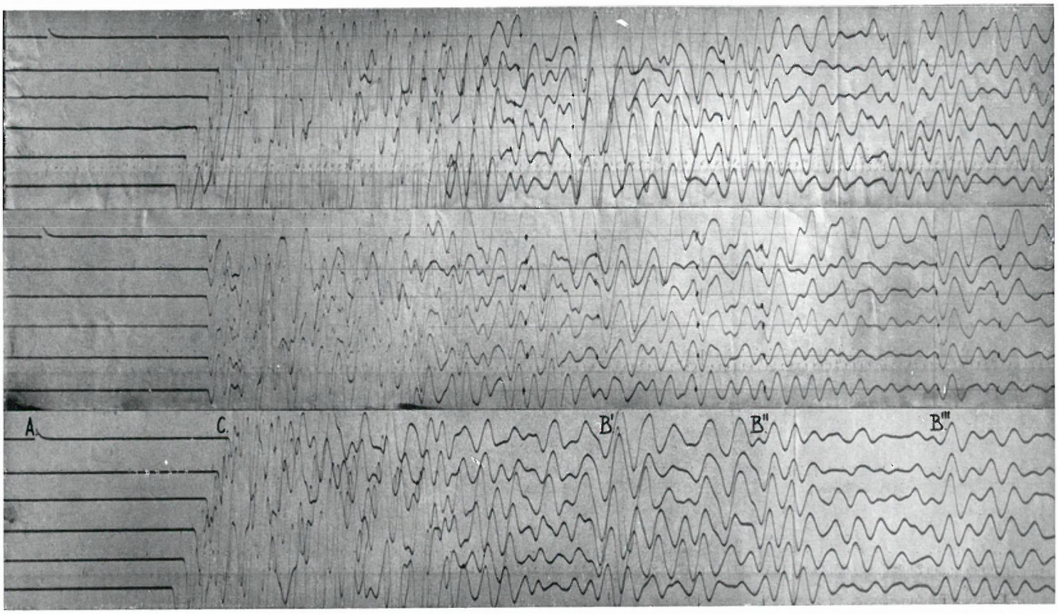

Fig. 15. Reflexion seismograms.

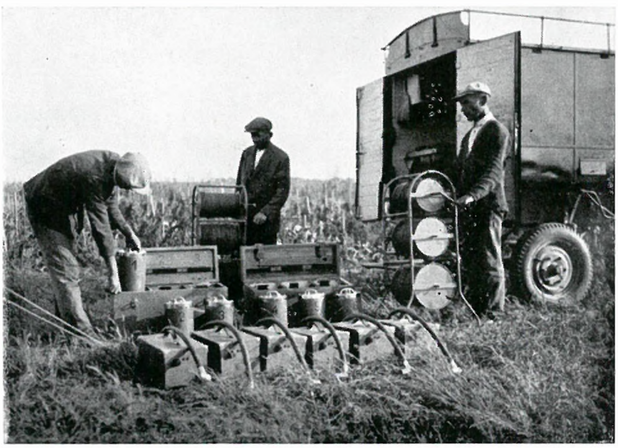

Fig. 17.
Geophones
and amplifiers.

Fig. 19.
Car with equipment
for resistivity survey.

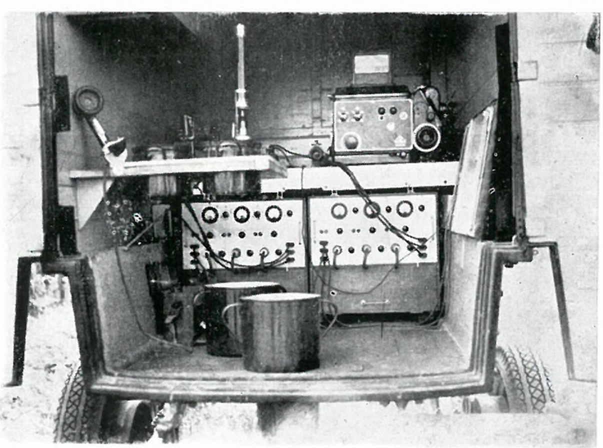

Fig. 18.
Oscillograph and amplifiers.

flexion points of the same depths a map will be obtained showing the *contourlines of the reflecting surface.* Enclosed Map VII. contains such a contourline map based on the results of the seismic survey of *Mezőkövesd.*

There are always more than one reflecting points obtained in each profiles. It is a very difficult task to connect correctly those reflecting points, which belong to the same reflecting surface. *The uncertainty in the proper connection of the reflecting points* is a serious shortcoming of this method.

3. Results of seismic prospecting made in 1936-1938.

In order to study the new seismic equipments *trial survey* was made with the instrument in *Őrszentmiklós, near Budapest* in the year 1936, where the geological conditions seemed to be favourable for reflection seismic work. The actual survey has — however — shown, that no reflexion in this area could be obtained. Another preliminary seismic survey with the new instrument *near Kapuvár* has given excellent results, i. e. clear reflexions on the seismograms so that the usefulness of the instrument was proved.

In the same year some seismic profiles were surveyed *near Fót* and *Sikátorpuszta,* where the torsion balance results indicated the presence of an *uplift.* On the seismic profiles there appeared the same structure, however with small alteration from that indicated by the gravity results.

In 1937 the areas of *Nagybátony* and *Bükkszék* were surveyed in details by the reflexion seismic method. In both cases *contourline maps* of the reflecting surfaces were prepared from the depth-determination. The determinations of the reflecting surfaces were — however — much handicapped by the uncertainty in connecting the corresponding points.

During the winter of 1938 in the vicinity of *Vásárosnamény* a profile was surveyed through a *gravity minimum* area in order to decide the question whether this gravity minimum is due to a *saltmass* or to a depression in the outcropping *andezit.* The results of the seismic survey proved the validity of the second supposition.

In 1938 a very *detailed seismic survey* was carried out *in the vicinity of Mezőkövesd.* The purpose of this survey was to decide on the existence of the *uplift* the indication of which was found as a large *gravity maximum* in the torsion balance results made here in years 1933 and 1934. These gravity results were discussed in the *Report* of the *Geophysical Institute* submitted to the *Congress General of the Union* held in *Edinburgh* in 19136. This *gravity maximum of Mezőkövesd* is shown 1. on the enclosed Map II. determined by torsion balance results, 2. on the enclosed Map IV. where gravity-meter results can be found.

The seismic survey of Mezőkövesd was made along six profiles crossing in WSW—ENE and NNW—SSE directions the gravity maximum found in this area. The *seismic contourline map of the uplift,* which corresponds to the gravity maximum, can be seen on the enclosed Map VII.

Comparing the results obtained by the three different geophysical methods, i. e. by the torsion balance, gravity-meter and reflexion seismic method, it is to be seen, that the presence of *an uplift is clearly indicated* by all of these three methods, but there are discrepancies in the details of the structure. For instance the apex of the uplift in the seismic results is displaced to the North of the highest value of the gravity maximum.

Since then the presence of this uplift was proved by a *drill* strucking the basement at *840 meters.*

In order to study the underground conditions in the *Great Plain of Hungary* a long seismic profile was surveyed *from the Bükk mountain through the Great Plain of Hungary until Debrecen.* The course of this survey is shown on the enclosed Map VII. and the results obtained in the profiles on the enclosed Map VIII. The 305 surveyed profiles are altogether 163 km long and 1579 reflecting points were determined.

The survey on the northern end went through the *well I. of Tard,* where the following *reflecting surfaces* could be identified: *a)* between *pannonian strata and tuff,* b) *tuff and oligocene,* c) and the most important between *oligocene and eocene limestone.*

In the course of the seismic profiles the following *wells* can be found:

1. the well of *Tard,*
2. „ „ „ *Tiszaőrs,*
3. „ „ „ *Karcag,*
4. „ „ „ *Hajduszoboszló,*
5. „ „ „ *Debrecen.*

In regard of the *depth of the basement* the following comparison can be made:

Well	Depth of the basement	
	according to the well log	according to the seismic survey
Tard	1781 m	1840 m
Tiszaőrs	Stopped in 1940 m in pannonian strata.	2440 „
Karcag	Stopped in 1224 m in pannonian strata.	2000 „
Hajdúszoboszló	1556 m	1556 „
Debrecen	1477 „	1393 „

The perfect correspondence in the depth of the basement in the well and survey of *Hajdúszoboszló* is due to the fact, that the velocity of the seismic waves valid for this area was calculated from the data of *well I. of Hajdúszoboszló.*

E. Electrical method.

1. Resistivity method.

In the interpretation of the results of the *terrestrial magnetic survey* made by the *Geophysical Institute* in 1938, discussed in paragraph C. of *this Report,* it was mentioned that although the observed magnetic anomalies at several places indicated the presence of *masses of magnetic effect,* it could not be decided upon the *material substance* of these masses. An *electrical survey* measuring the electrical resistivity of the underground may give informations in regard of the question whether the masses indicated by the magnetic anomalies are either *iron ores* and metalliferous or of *eruptive* origin.

The electrical survey was carried out with an *instrument* constructed by Prof. *Pogány.* (Fig. 19.) The *method* of electric resistivity measurements will be made as follows. Four *iron electrodes* will be put into the ground along a line at equal intervals. Through the two outside electrodes an *electric current* of I ampère will be introduced into the ground and the *electromotive force* — V volt — between the two inside electrodes will be measured.[2] If s is the distance between the two inside electrodes, the *mean specific electric resistivity* of the ground from the surface to a depth of s is

$$R = 2\pi s \frac{V}{I} \text{ ohm meter}$$

If the sedimentary beds in the *horizontal* direction of large extent are *homogeneous,* then by gradually increasing the intervals of the electrodes the *variation of the electric resistivity of the ground with the depth* can be determined.

The resistivity method for practical purposes can be succesfully used only when there is a *considerable difference* between the specific electric resistivities of the *ore bearing beds* and the other *sediments* or *rocks.*

2. Results of the resistivity method and their interpretation.

Because of the complexity of the problem to be solved it seemed to be profitable to begin the electric survey on areas where the *underground conditions* are more or less *known.* For this reason contemporarily with the magnetic survey electric resistivity method was used *in the iron mine of Rudabánya.* In the mine of *Rudabánya* iron ores are at many places outcropping and therefore this area is well suitable for a *preliminary electrical survey,* but on the other hand the formations in the horizontal direction are *not homogeneous* and are irregularly *folded of faulted.* These circumstances considerably disturbed the application of the resistivity method.

Before all the specific electric resistivity of the various rocks and iron ores of this area were determined and found that:

for the limonit R = 60—70 ohm m
„ „ siderit R = 70—80 „

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[2] Report on the Imperial Geophysical Experimental Survey by A. G. Broughton Edge, p. 246.

and

for the pannonian strata R = 15— 20 ohm m
„ limestone, dolomit R = 700—800 „

Resistivity surveys carried out at several places have shown, that if iron ore, *limonit or siderit*, was *overlaid by pannonian strata* only, then the presence of the iron ore of smaller conductivity did not make a sudden change in the resistivity curve, only a constant increase appeared in it. If *iron ore* was *overlaid by limestone or dolomit*, on account of the great differences in the resistivity of these formations, there was a sudden change in the resistivity curve at a depth of the iron ore.

The resistivity curves obtained in these two cases are given in Fig. 20. and 21.

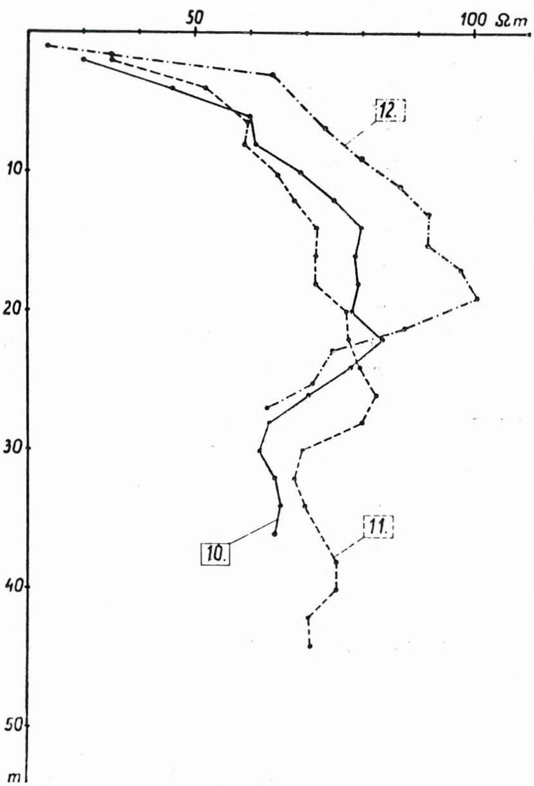


Fig. 20.
Electric resistivity curve.
Limonit
overlaid by pannonian strata.

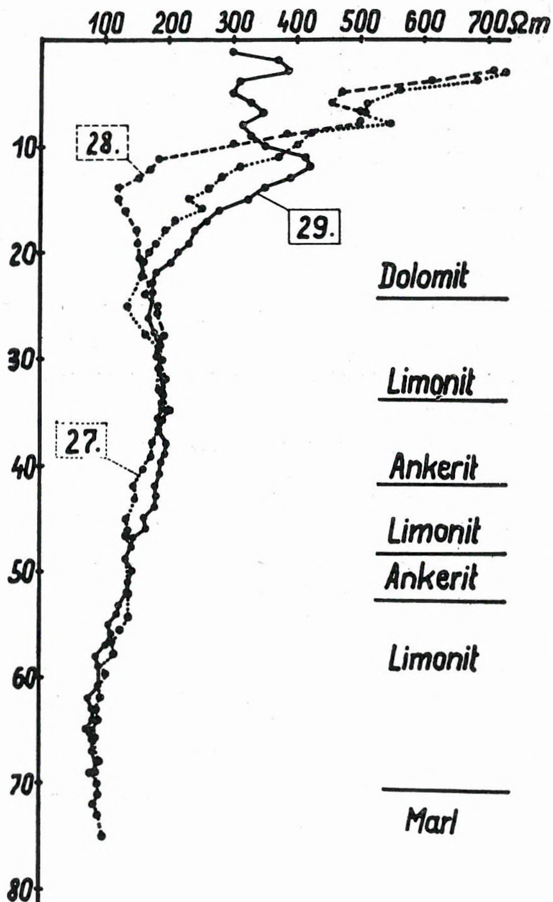


Fig. 21.
Electric resistivity curve.
Limonit and ankerit
overlaid by dolomit.

The electrical resistivity method was first applied *in the vicinity of Bódvarákó and Komjáti,* where also magnetic survey was made. The geological conditions of these areas — however — were very *unsuitable* for the application of this method.

In the area of Martonyi resistivity electric survey was made based on the experiences obtained in the mine of *Rudabánya.* Here the *specific electric resistivity* of the sediments and outcropping rocks was also determined, for wich similar values as obtained in *Rudabánya* were found.

In the vicinity of *Martonyi* the ores are to be located along *fault lines* of SW—NE direction. The surface is covered with *shale* and on one side of the fault there are *iron ores* with *campili limestone* of high and the other side of the fault *grey limestone* of small electric conductivity. These clearly appear in the resistivity curves.

Fig. 22. shows some resistivity curves obtained in one part of the surveyed area *(Tilalmas parlag).* The curve No. XIII. indicates the presence of limonit where the resistivity has a value of 70—80 ohm m.

On the surveyed area there were a great number of different resistivity curves obtained, from which — however — conclusions could be drawn only in those cases when great differences occurred between the specific electric resistivity of iron ores and the surrounding sediments and rocks.

In the *application* of the electric resistivity method for exploring limonit and other iron ores *the most favourable* condition is, if *the iron ore* is encircled by *rocks of high resistivity.* If the surface is covered by sediments of *small resistivity,* the indication of the presence of iron ores is *uncertain.*

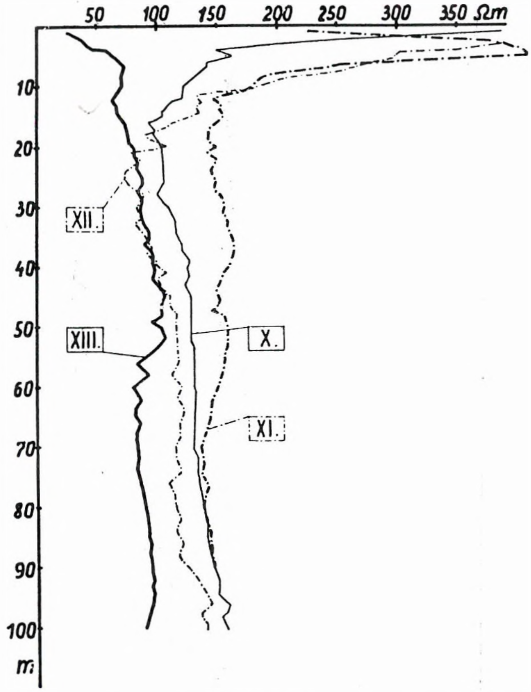


Fig. 22.
Electric resistivity curves made on *Tilalmas parlag.*

F. Electrical coring.

The various geophysical prospecting methods described in the previous paragraphs are applied in most cases for *locating* oil or gas wells. The purpose of the *electrical coring* is to study the conditions of the sedimentary beds *in the drill hole* by measuring the electrical *resistivity,* the *porosity,* the *temperature* of the beds at various depths and the contents of the *drillwater.* This method was invented and first applied for practical purpose by *M. Schlumberger.*

The electrical coring will be carried out by *lowering* a suitable *cable* into the drill hole, at the end of which three *electrodes* at some meter intervals are applied. Separate wires inside the cable are connecting these electrodes with the *registering instrument.*

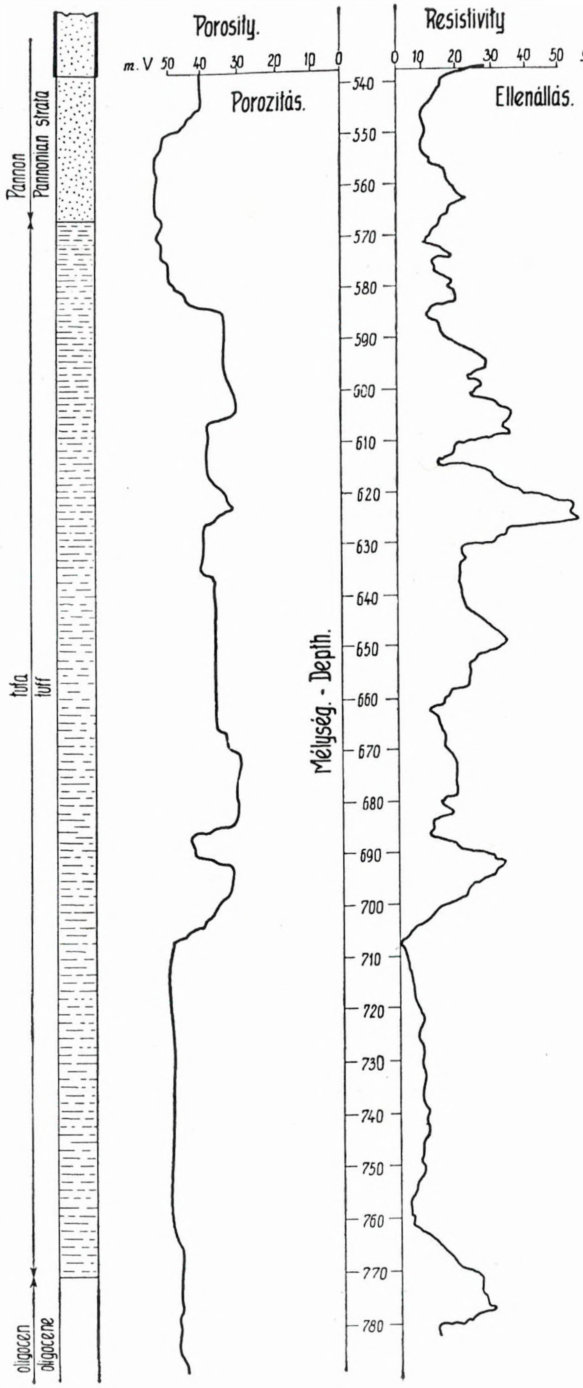


Fig. 23.
Curves
of the resistivity and porosity
obtained
in the drill hole of Mezőkövesd.

To determine the *resistivity* a *current* of constant intensity will be introduced between the casing, as one electrode and the other electrode at the end of the cable. Then an *electromotive force* is generated between the two other electrodes. This force is proportional with the electrical *resistivity* of the beds between the two electrodes. By lowering the cable into the drill hole this electromotive force can be registered alongside those parts of the drill hole, where *no casing* was yet made.

To measure the *porosity* of the beds in the drill hole the *natural electromotive force* will be registered, which exists between a non polarized electrode on the ground and that at the end of the cable.

The different geological formations are in general *non conductive* mediums, but they can become more or less *conductive* on account of their *water* contents. Beds of small resistivity are generally saturated with *salt-water,* while rocks of no porosity or porose rocks saturated with non conductive fluidity, for instance with *oil,* are of high resistivity. Therefore from the resistivity and porosity curve conclusion can be made as to the *presence of oilbearing* beds. The following cases can be taken into consideration:

1. Small resistivity and small porosity: conductive non porose rocks.

2. High resistivity and small porosity: non conductive non porose rocks.

3. Small resistivity and high porosity: formations saturated with *salt-water.*

4. High resistivity and high porosity: *oilbearing formations.*

The determination of the *temperature* in drill holes is made by lowering a *thermo-element* applied to the end of the cable into the hole. The change of the temperature in the drill hole alters the *electromotive force* generated in the thermo-element and this will be registered.

The water in the drill hole will be changed and examined to eliminate the *natural* electromotive forces originated by *electro-osmose* disturbing the porosity curve.

Fig. 23. shows the curves of electrical resistivity and porosity obtained *in the drill hole of Mezőkövesd* along a 240 m long section between the depths of 540 and 780 m. In these depths the drill went through *pannonian strata, tuff* and beds of *oligocene shale.* No temperature curve was made, the instrument being not yet adapted for measuring the temperature in the drill hole.

Although the curves show considerable changes in the resistivity and porosity, *no* horizonts are indicated with *oilbearing sediments.* In fact from a depth of 875 meters a great quantity of *hot water* broke out.

The Royal Hungarian Baron Roland Eötvös Geophysical Institute is subordinated to the *Department X. of the Ministry of Industry,* the chief of which *Dr. Ch. Telegdi Róth, University* professor and ministerial councillor, supervises *the Institute.*

The submission of this Report is made possible through *the kindness of the Ministry of Industry* by permetting the publication of the results and by granting an allowance of the press expenses.

Dr. B. Pogány, professor of the *Technical University* and his staff, *Dr. R. Schmid, B. Krekó, Dr. R. Gerő* and *St. Doktorics* rendered great and valuable services to the *Geophysical Institute* by constructing *new instruments* and taking a prominent part also in the *field work* especially in the seismic and electric surveys.

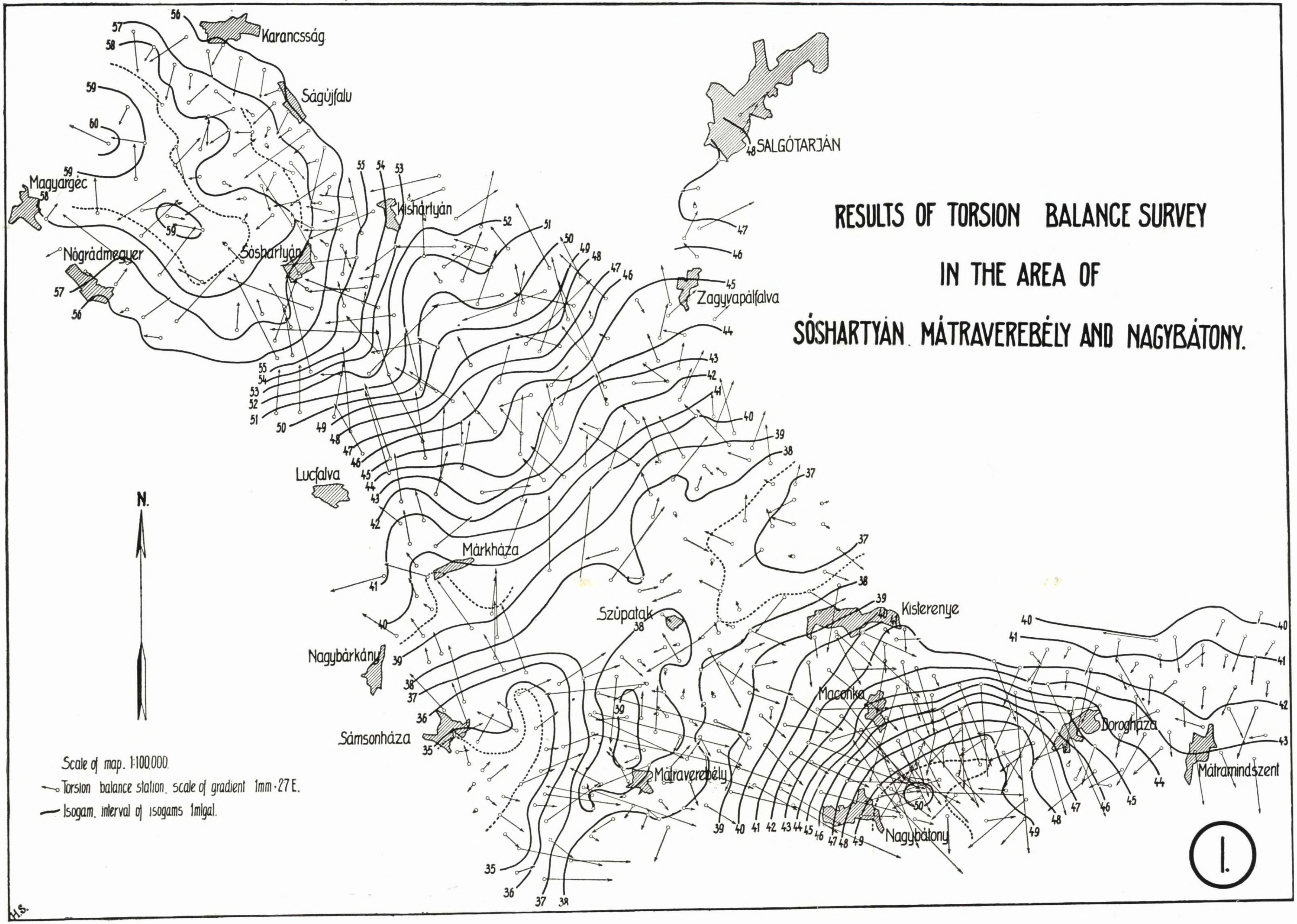
The prospecting work of the *Geophysical Institute* was made under the personal control and direction of the *writer* by the following *collaborators:*

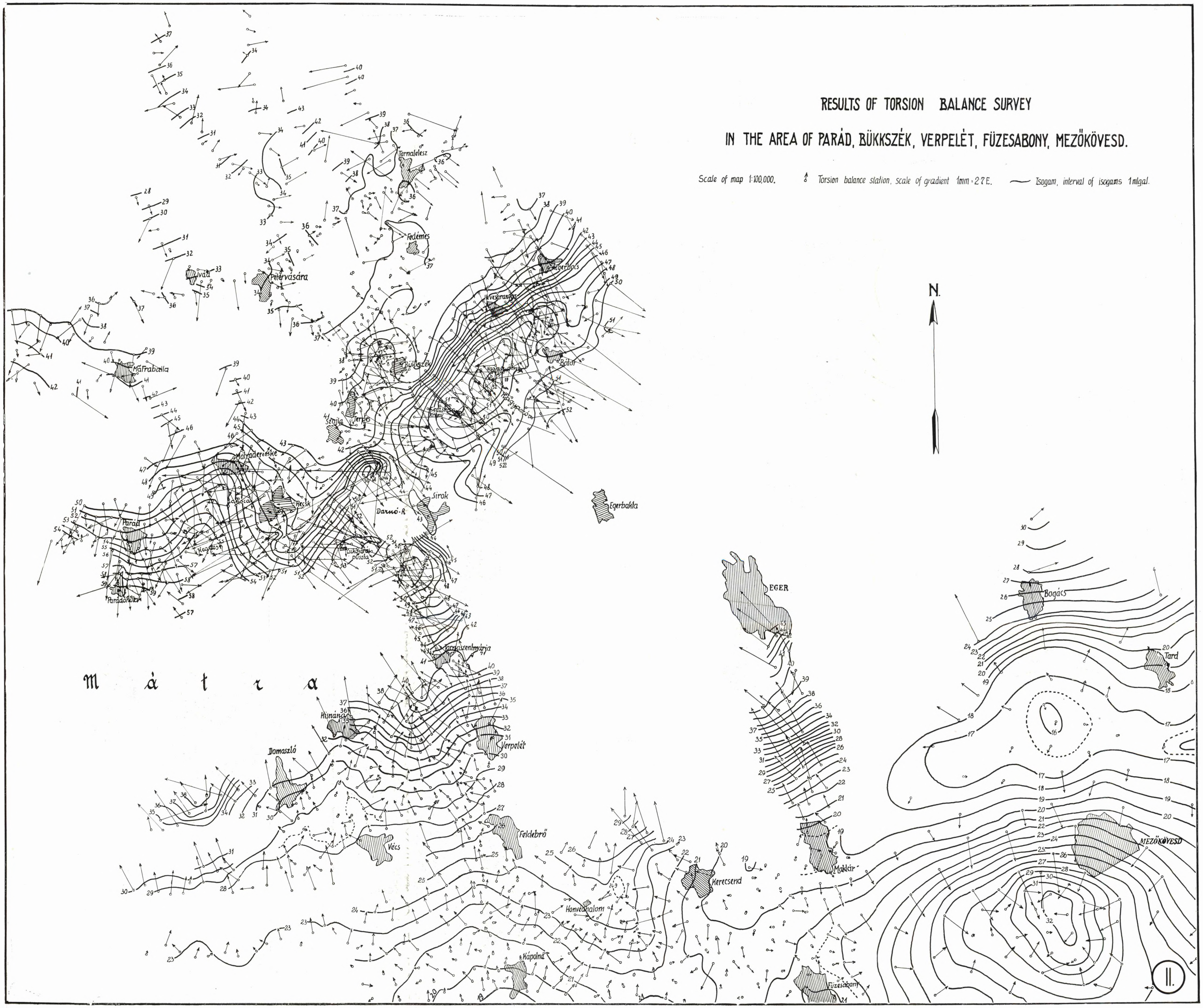
the torsion balance survey	by N. *Szecsődy,*
the gravity-meter survey	by E. *Ács,*
the terrestrial magnetic survey	by St. B. *Haáz,*
the seismic survey	by E. *Bassó* with T. *Tafner* and J. *Ország,*
the electrical survey and electrical coring	by St. *Jeney.*

HUNGARY

In the composition of this Report all members of the *Geophysical Institute* have taken part, but especially *E. Bassó* and *St. B. Haáz* must be mentioned. The electrical survey is discussed according to the Report of *Dr. R. Schmid. The drawings* were made by *J. Ország* and *A. Holczer.* In the *administration of the Institute L. Németh* was working.

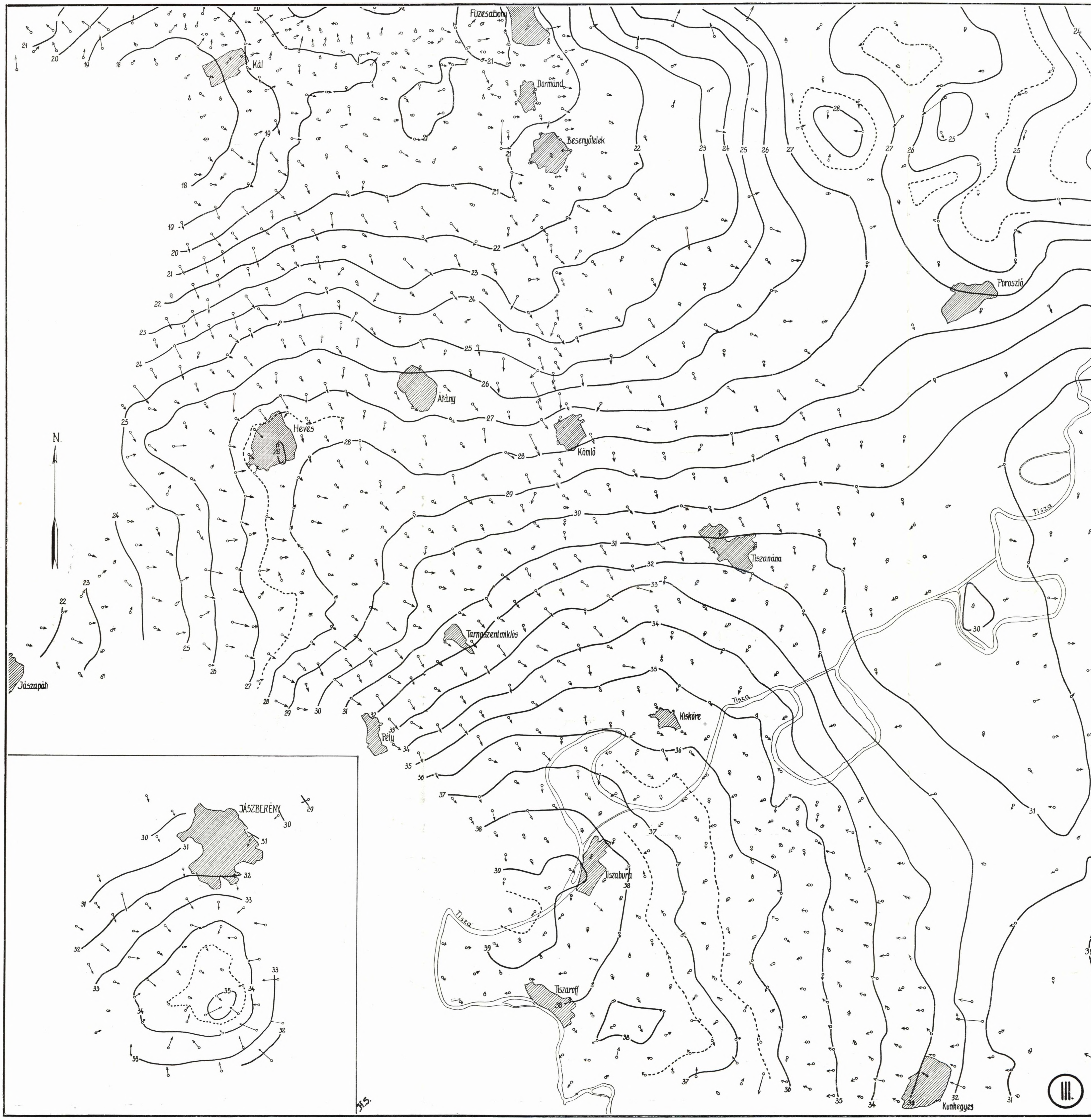
The writer wishes to acknowledge his indebtedness and to express in the name of the *Geophysical Institute* his gratitude towards everyone above mentioned for having participated in the work of the *Institute* during the period of 1936—1938.


RESULTS OF TORSION BALANCE SURVEY
IN THE AREA OF
SÓSHARTYÁN, MÁTRAVEREBÉLY AND NAGYBÁTONY.
Scale of map. 1:100.000.
Torsion balance station, scale of gradient 1mm = 27 E.
Isogam, interval of isogams 1 mlgal.
N.
Karancsság
Ságújfalu
SALGÓTARJÁN
Magyargéc
Kishartyán
Nógrádmegyer
Sóshartyán
Zagyvapálfalva
Lucfalva
Márkháza
Szúpatak
Kisterenye
Nagybárkány
Maconka
Dorogháza
Sámsonháza
Mátraverebély
Mátramindszent
Nagybátony
H.S.
1.


RESULTS OF TORSION BALANCE SURVEY
IN THE AREA OF PARÁD, BÜKKSZÉK, VERPELÉT, FÜZESABONY, MEZŐKÖVESD.
Scale of map 1:100,000.
Torsion balance station, scale of gradient 1mm = 2.7 E.
Isogam, interval of isogams 1 mlgal.
N.
Tarnalelesz
Fedémes
Ivád
Pétervására
Egerbocs
Hevesaranyos
Bükkszék
Bátor
Mátraballa
Mátraderecske
Recsk
Parád
Parádfürdő
Darnó-R.
Sirok
Szajla
Terpes
Egerbakta
EGER
Bogács
Tard
Tarnaszentmária
Mátra
Kisnána
Domoszló
Verpelét
Feldebrő
Vécs
Kerecsend
Maklár
MEZŐKÖVESD
Honvédhalom
Kápolna
Füzesabony
II.

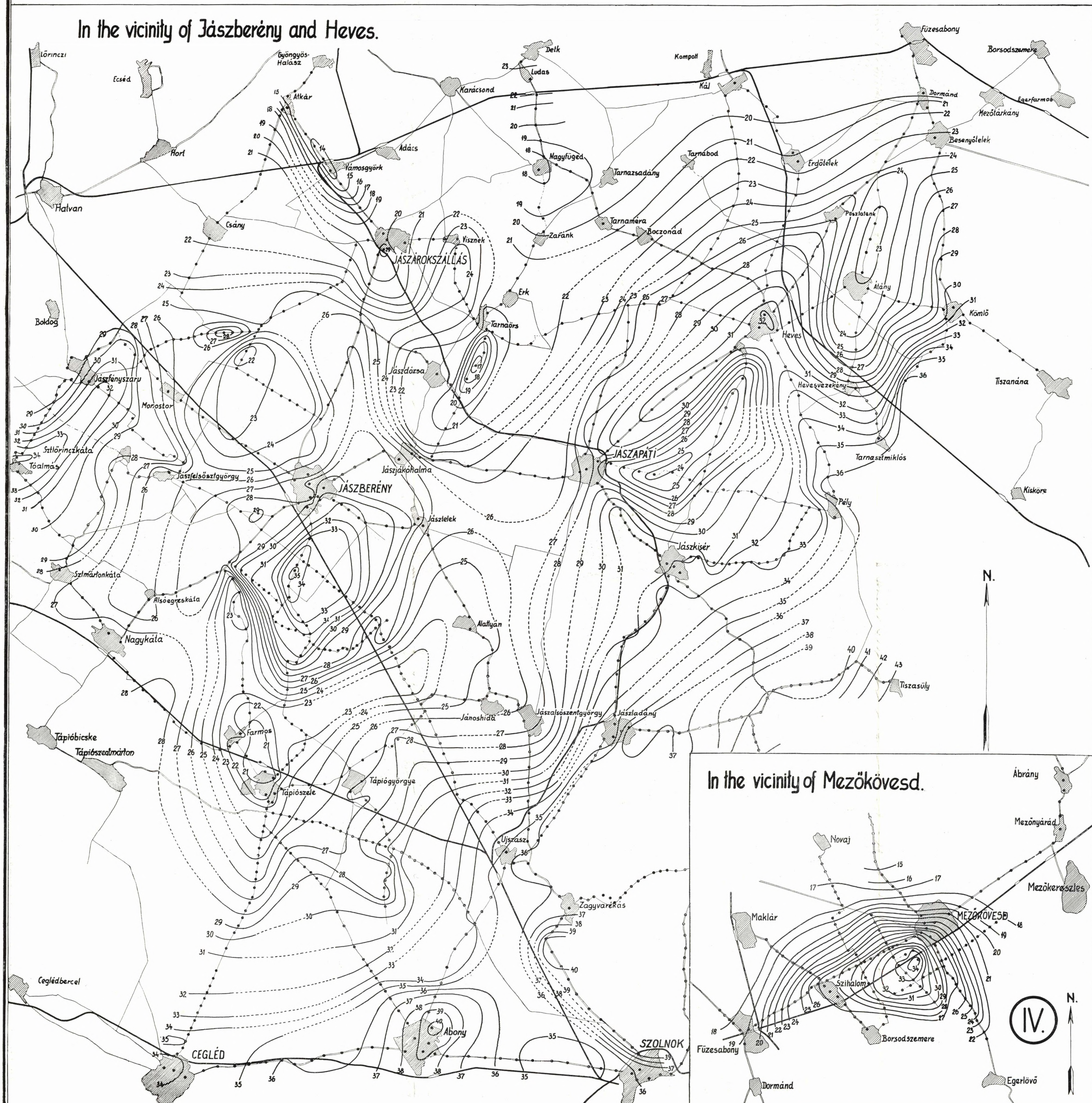
RESULTS OF TORSION BALANCE SURVEY IN THE AREA OF KÁL, HEVES, TISZABURA AND JÁSZBERÉNY.

Scale of map 1:100,000. Torsion balance station, scale of gradient 1mm = 27E. Isogam, interval of isogams 1 mlgal.



Isogam map from the results of gravity meter survey.

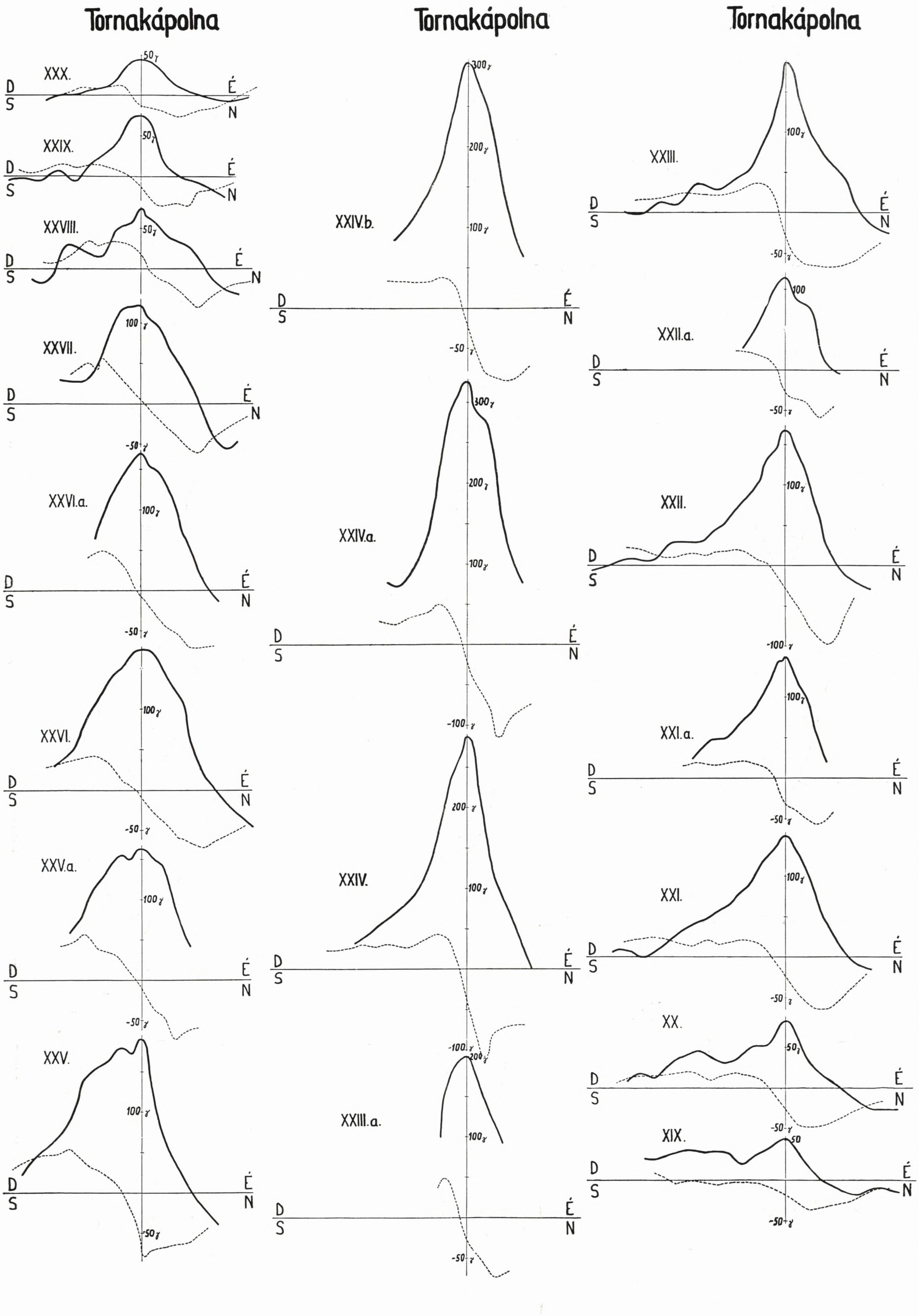
• Gravity meter station. Scale of map 1:150,000. —20— Isogam interval 1 mlgal = 1.10^{-3} C.G.S.

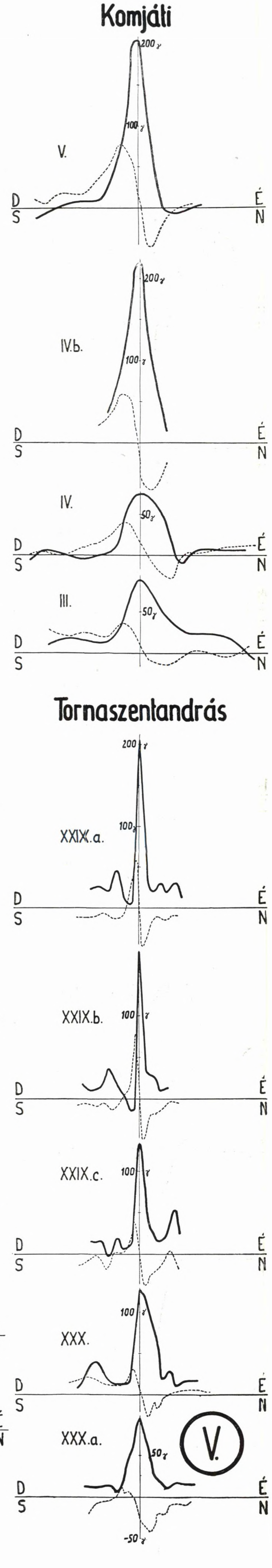


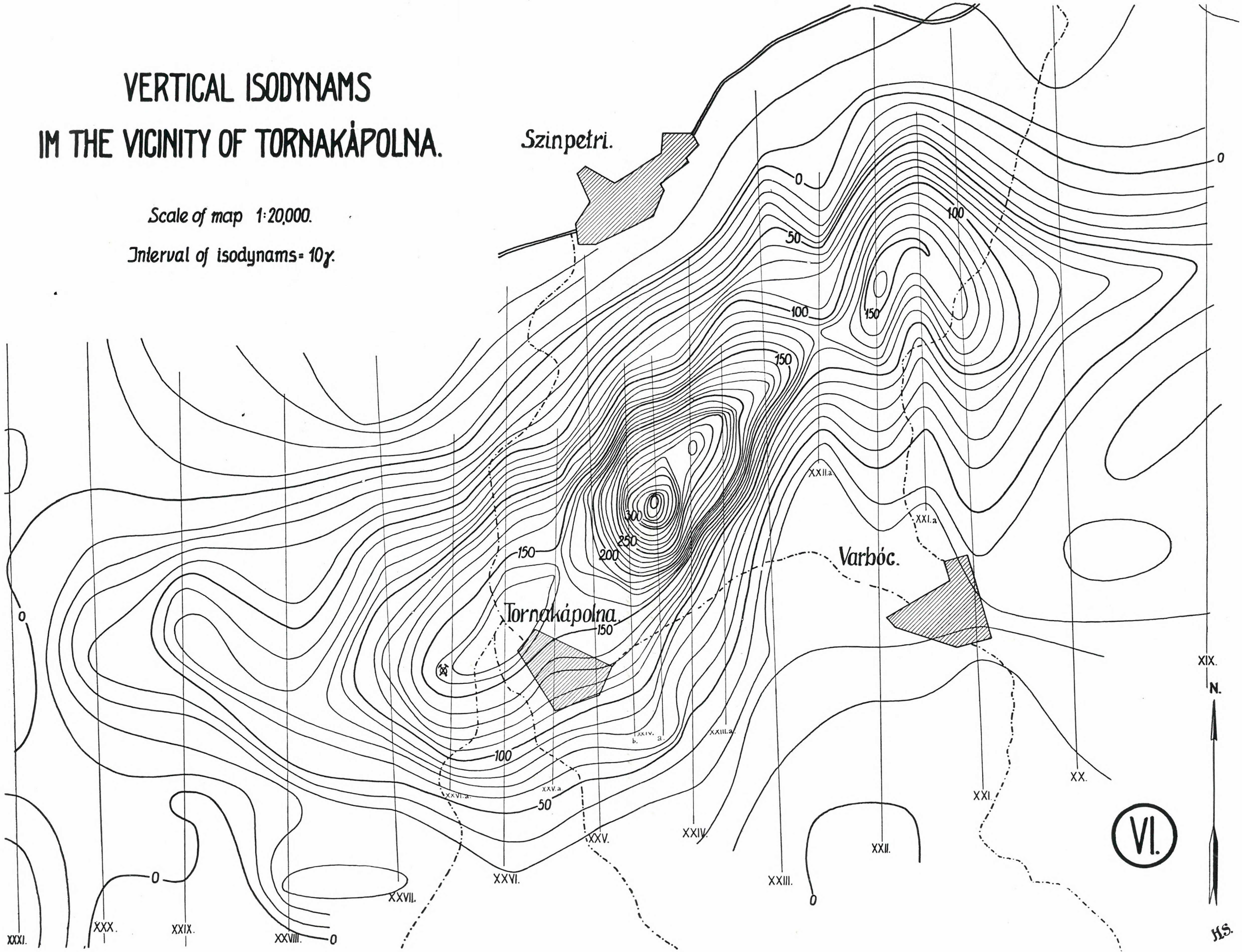
VERTICAL AND HORIZONTAL ANOMALIES OF TERRESTRIAL MAGNETISM

LEGEND:

Curve of vertical anomalies, curve of horizontal anomalies
Scale of anomalies: 1mm=4 γ
Scale of map:
of Tornakápolna and Komjáti 1:50000, of Tornaszentandrás 1:10000



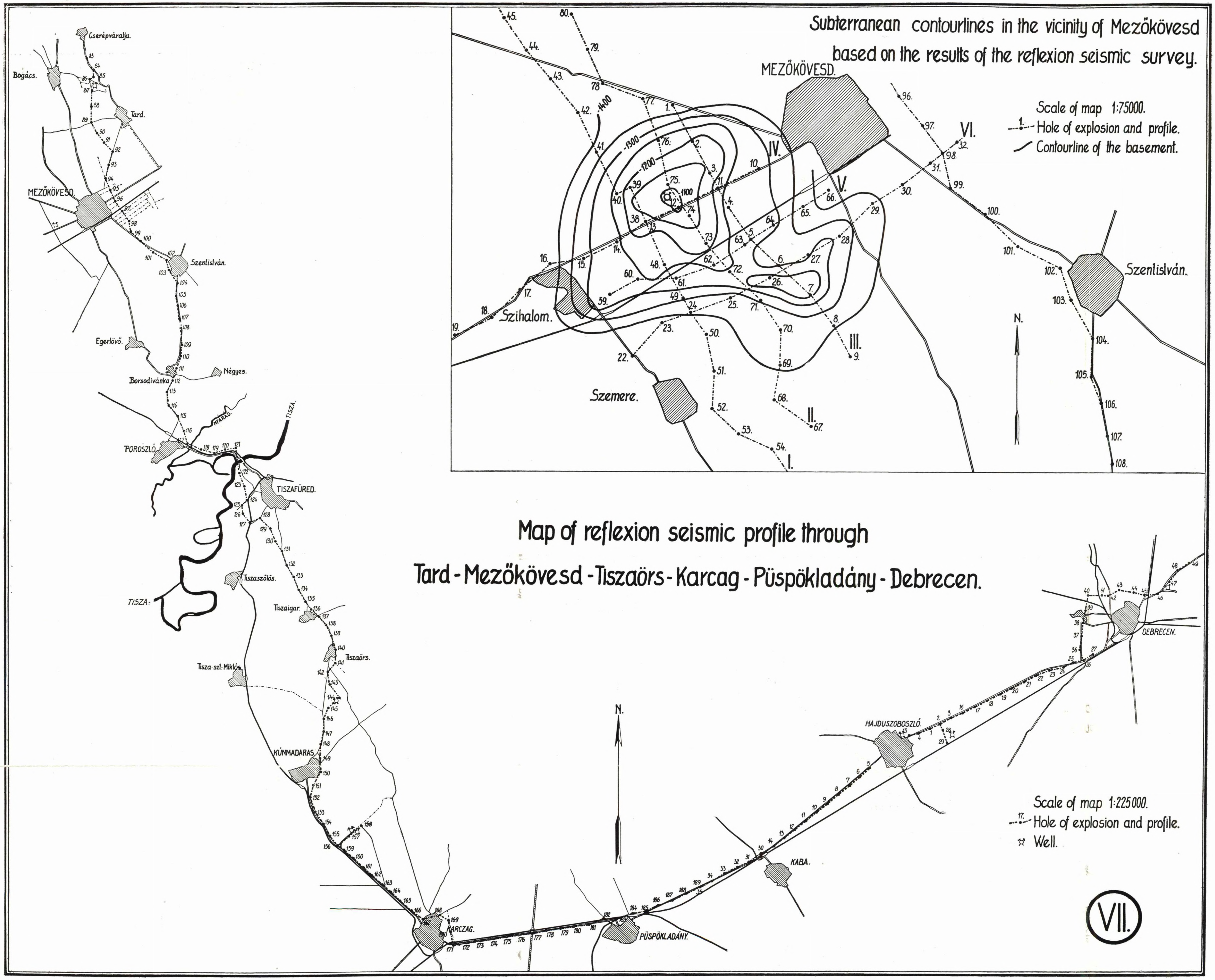




VERTICAL ISODYNAMS
IM THE VICINITY OF TORNAKÁPOLNA.

Scale of map 1:20,000.

Interval of isodynams = 10γ.

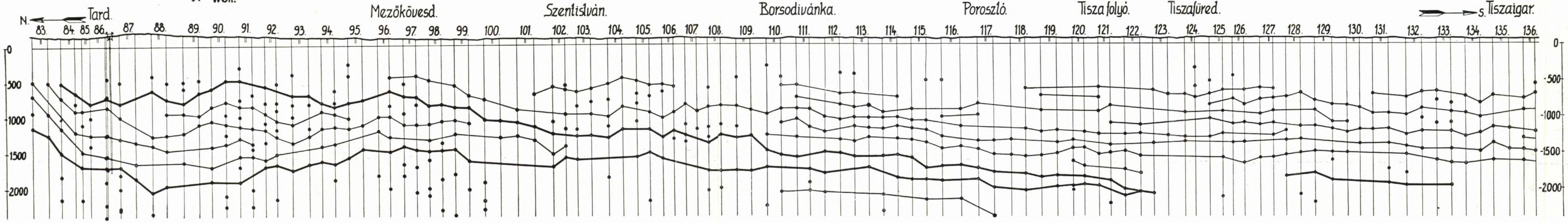


Subterranean contourlines in the vicinity of Mezőkövesd
based on the results of the reflexion seismic survey.
Scale of map 1:75000.
Hole of explosion and profile.
Contourline of the basement.
MEZŐKÖVESD.
Szentistván.
Szihalom.
Szemere.
N.
I.
II.
III.
IV.
V.
VI.
1400
1300
1200
1100
Map of reflexion seismic profile through
Tard - Mezőkövesd - Tiszaörs - Karcag - Püspökladány - Debrecen.
Cserépváralja.
Bogács.
Tard.
MEZŐKÖVESD.
Szentistván.
Egerlövő.
Négyes.
Borsodivánka.
POROSZLÓ.
TISZA.
TISZAFÜRED.
Tiszaszőlős.
Tiszaigar.
Tiszaörs.
Tisza-szt.-Miklós.
KUNMADARAS.
KARCZAG.
PÜSPÖKLADÁNY.
KABA.
HAJDUSZOBOSZLÓ.
DEBRECEN.
Scale of map 1:225000.
Hole of explosion and profile.
Well.
VII.

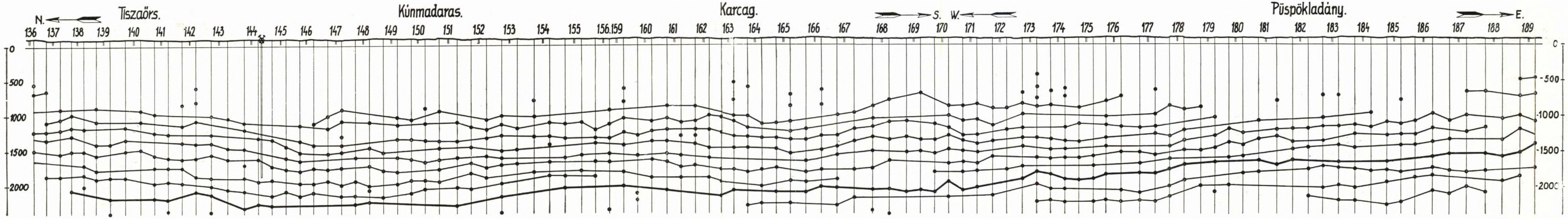
Point and profile of reflexion.
Hole for explosion.
Well.

Reflexion seismic profile through well I of Tard and Tiszaigar.

Scale of map
Horizontal 1:150000.
Vertical 1:60000.

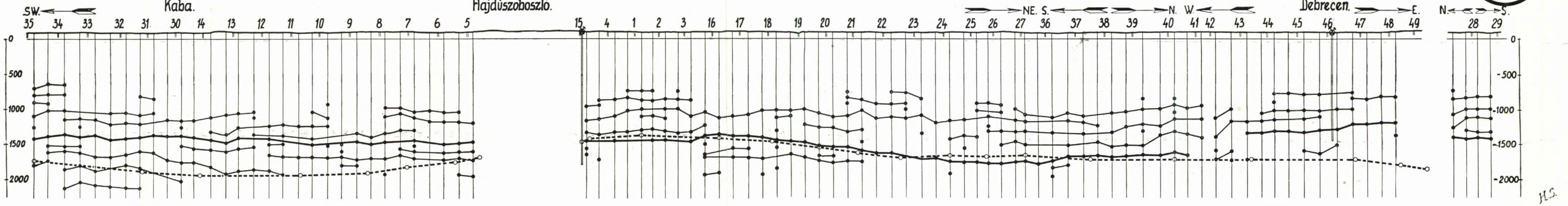


Reflexion seismic profile through Tiszaörs and Püspökladány.



Reflexion seismic profile through Püspökladány and Debrecen.

VIII



H.S.