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# Geomagnetic repeat station survey in Hungary during 1994–1995 and the secular variation of the field between 1950 and 1995

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A geomagnetic repeat station survey was carried out in Hungary during the period 1994–95. The magnetic declination, inclination, and the total field were directly observed by proton-precession and DI-flux magnetometers. The network consisted of 195 sites. In most cases, the geographic coordinates of the stations and the azimuths of the reference marks were determined by a pair of GPS receivers. The direct observations were reduced to the epoch of 1995.0 using the continuous geomagnetic records of Hungary's Tihany Geomagnetic Observatory. The normal reference field in Hungary is expressed traditionally by a second-order polynomial of the geographic coordinates. In the course of the last campaign, the polynomial coefficients were computed by the method of adjustment according to the most frequent value. The normal distributions of the secular variations of the field elements were determined by second-order polynomials of latitude and longitude for the period 1950–95.

**Keywords: magnetic survey maps, secular variations, magnetometers, Hungary, GPS**

## 1. Introduction

The Earth's magnetic field is composed of several components having different origins and time variations. While the fast fluctuations are known

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to be connected mainly with magnetospheric, ionospheric phenomena (currents of charged particles), it is suggested that the long-term, so-called secular variations are caused by slow movements of magnetized materials inside the Earth's core [DE SANTIS et al. 1997]. In order to model the internal processes, one must separate the magnetic effects of several origins from the total, observable magnetic field. The part of the field that is thought to be generated mainly by sources from the Earth's interior is termed normal field.

For a great many years the temporal variation of this field has been carefully investigated at some points of the Earth, primarily at the locations of geomagnetic observatories. However, the observatory network is rather sparse and uneven for effectively mapping the spatial distribution of the field, as well as its temporal variations. The fundamental purpose of repeat station surveys is to map the geomagnetic field over a relatively dense and even network of an area of limited size and to compile normal maps of the surveyed region and date (epoch). A knowledge of the normal magnetic distribution is of great importance from two aspects: viz. (as was already mentioned) comparison between fields of different epochs can yield information about mass-flow processes of internal origin; on the other hand, because the normal map demonstrates the global behaviour of the field, it can serve as a reference for investigating local magnetic anomalies.

The results of the field measurements performed at different dates and different stations are reduced to the same epoch by eliminating the fast temporal variation of the field of mainly external origin. Corrections are carried out with the aid of the continuous magnetic records of observatories. The time-corrected field reflects the effects both of the internal magnetic sources and of the Earth's crust. To obtain the normal reference field, the anomalies caused by the surface magnetic rocks must be eliminated. For limited-size regions of the Earth (with no significant curvature), the geomagnetic field can be modelled by polynomials of latitude and longitude. The spatial wavelengths of the crust-generated magnetic changes are much smaller than those of the variation of the core-field. For this reason, the analytical magnetic model of the Earth's interior can be obtained by truncation of the polynomial at the first or second order. For determining the normal map for larger, continent-size areas, regional harmonic analyses (SCHA, TOSCA, ASHA) can yield reliable results [for a summary of these methods, see DE SANTIS et al. 1997].

The first magnetic network survey in Hungary was carried out between 1847 and 1857 (*Table I*). The most extensive geomagnetic research was led by Loránd Eötvös, who performed gravity and geomagnetic observations simultaneously, between 1902 and 1917 at 1600 stations located at several regions of the former territory of Hungary [FEKETE et al. 1918].

| | | | | |
|---|---|---|---|---|
| 1847-57 (1850.0) | K. Kreil J. Liznár | 52 | D, I, H | Magn. theodolite, Earth-Inductor |
| 1864-79 (1875.0) | G. Schenzl | 117 | D, I, H | Magn. theodolite, Earth-Inductor |
| 1892-94 (1890.0) | I. Kurländer | 38 | D, I, H | Magn. theodolite, Earth-Inductor |
| 1902-17 (1903.0, 1906.0) | L. Eötvös | 1600 | D, I, H | Magn. theodolite, Earth-Inductor |
| 1934-36 (1936.0) | J. Hofhauser | 26 | D | Magn. theodolite |
| 1949-50 (1950.0) | Gy. Barta | 290 | D, I, H, Z | Magn. theodolite, Earth-Inductor, QHM, BMZ |
| 1964-65 (1965.0) | E. Aczél, R. Stomfai | 300 | D, H, Z | BMZ, QHM |
| 1979-82 (1980.0) | T. Lomniczi, P. Tóth | 299 | D, H, F | QHM, Proton-magn. |

*Table I.* Summary of the Hungarian geomagnetic surveys carried out between 1847 and 1982. The columns show: the observational period and the date of the data reduction (in brackets); the names of the persons who directed the measurements and data processing; the number of surveyed stations; the measured magnetic components; and the equipment used. The networks of the surveys carried out before 1917 covered the former territory of Hungary

*I. táblázat.* A Magyarország területén 1847 és 1982 között elvégzett geomágneses hálózati mérések összefoglalása. Az egyes oszlopok az alábbi adatokat tartalmazzák: az észlelések időszaka, illetve zárójelben a mért adatok vonatkoztatási időpontja; a méréseket és az adatfeldolgozást irányító személyek nevei; a hálózatban résztvevő állomások száma; a mért mágneses komponensek; az alkalmazott műszerek típusai. Az 1917 előtt elvégzett kutatások hálózatai Magyarország korábbi területére vonatkoznak

The first systematic survey within the country's present boundaries was completed in 1950. Later on, detailed mapping of the Hungarian magnetic field was repeated every fifteen years [SZABÓ 1983]. The last campaign was carried out in 1994 and 1995. In this survey the magnetic declination, inclination, and the total field were directly measured by DI fluxgate and proton precession magnetometers. The data were reduced to the epoch of 1995.0. The network consisted of 195 stations located inside Hungary (184 sites), and within the borders of the neighbouring countries (11 sites).

Here, we present the repeat station network and the equipment utilized for our last geomagnetic campaign. Later on, we give a brief overview on the mathematical procedure adopted for computing the magnetic normal field, then we summarize the results obtained. Finally, the normal distribution of the mean secular variation computed for the time interval of 1950–1995 will be presented.

## 2. The magnetic repeat station network in 1994–95

Most of the stations of our last magnetic campaign were identical with the base points of the 1964–65 survey [ACZÉL, STOMFAI 1968]. In order to curtail expenses, however, the number of original stations was considerably reduced. Because the magnetic sources of the crust do not represent the global trend of the magnetic field, the network was truncated mainly in regions which are characterized by local magnetic anomalies. These areas are very well known in Hungary on the basis of former geomagnetic investigations. Unfortunately, some of the remaining points had to be omitted because of the increased artificial magnetic noise due to the development of civilization in the last three decades. In order to approach the even character of the former network, some new base points were established instead of the artificially disturbed sites, taking into account the following basic requirements:

— not close to local magnetic anomalies,
— absence of artificial disturbances,
— proximity to the original network station.

To ensure the connection between the magnetic charts of Hungary and the neighbouring countries, some of the border-area repeat stations of our neighbours were also surveyed during the last campaign.

The final form of the network consisted of 195 base points, their locations are shown in *Fig. 1.* The names of the stations and their coordinates are listed in Appendix I.

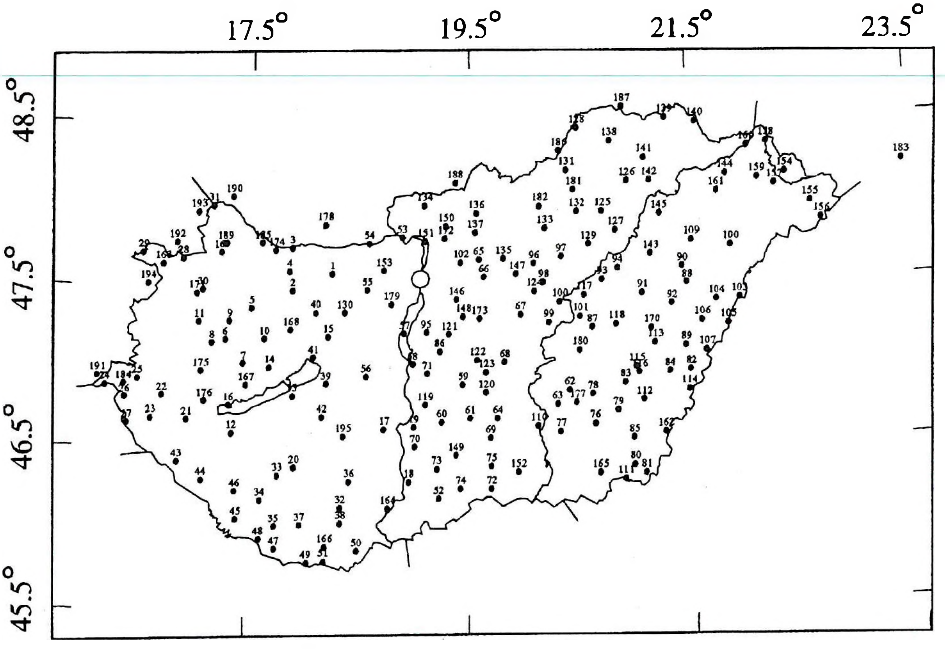


*Figure 1.* The Hungarian geomagnetic repeat station network in 1994–95. The site names are listed in the Appendix

*1. ábra.* A magyarországi geomágneses alaphálózat 1994–95-ben. Az állomások nevei a mellékletben találhatóak

## 3. Equipment and method of observations

The geomagnetic field, as a vectorial field, can be unambiguously determined at a certain point by the measurements of its three independent space components. During the course of our survey, the absolute value of the field vector, the declination (azimuth of the geomagnetic North direction with respect to the geographic North), and the inclination (the angle by which the total field vector is inclined from the horizontal plane) were observed at every site. The total value of the field (F) was measured by G856 type Proton or GSM19 type Proton Overhauser magnetometers having a resolution of 0.1 nT, and 0.01 nT, respectively.

The measurements of declination (D) and inclination (I) were carried out by the use of DIM100 or UFG1 type fluxgate magnetometers and a Zeiss Theo 020B steel-free theodolite using the conventional zero-field method [JANKOWSKI, SUCKSDORFF 1996]. The fluxgate magnetometer consists of an electronic unit and a cylindrical sensor. The equipment measures the magnetic field in the direction of the axis of the sensor. In the course of the observations, the probe is mounted on the telescope of the theodolite so that the axes of the two units should roughly coincide with each other. The azimuth of the magnetic meridian and the value of the inclination can be determined by positioning the sensor in the directions which are characterized by zero magnetic field value. Then, the magnetic line of force is just perpendicular to the axes of the sensor and the telescope at the site of observation. The resolution of the fluxgate magnetometer is 0.1 nT. The scale division of the theodolite is 1 minute of arc, but because one tenth of the scale division can be estimated, the real resolution of the theodolite is about 6–12 second of arc. Since the resolution of our theodolite is less than that of our magnetometer, the overall resolution of D and I observations falls within the specified interval of 6–12 second of arc.

The azimuth of the magnetic meridian can be read on the horizontal scale of the theodolite. This value, however, depends on the actual orientation of the zero point of the scale. In order to be able to give an absolute meaning to the relative observations, we must determine the bearing of the theodolite by making reference measurements to one or more field objects with known geographic azimuths. At some stations, we could use the reference directions that were established during the 1964–65 geomagnetic campaign. In other cases, however, where the environmental changes of the last decades had obliterated the former reference marks, a pair of ASHTECH XII type GPS receivers was utilized to mark new lines for orientation. The possibility of using GPS for determining true geodetic azimuths was checked at several sites before surveying the network. A comparison was carried out between azimuths obtained by GPS observations and other methods, i.e. observations of the Sun and measurements performed with a gyro-theodolite. As a result of the experiments the application of the GPS technique turned out to be a very powerful method in terms of accuracy and reliability of azimuth determinations [HEGYMEGI at al. 1996].

Generally, four sets of observations of the field elements were carried out at the network stations. Each measurement was corrected in time (see next section). The standard deviations of the averages of the time-corrected D, I, or F observations were considered as the determination error of the given component at a certain station. In order to evaluate the determination errors relating to the whole network, we computed the average of the standard deviations calculated for the individual sites. As a result, we obtained errors of 0.37 min., 0.15 min, and 1.26 nT for the determination of the D, I, and F magnetic components, respectively. These values represent the errors both of the field measurements and the time corrections.

## 4. Processing of measured data

The construction of geomagnetic normal maps for a given region is the primary aim of repeat station surveys. Because the normal charts must be referred to a certain date (epoch) and to a certain topographic level, the measured data must be reduced both in time and space before computing the normal parameters of the field. However, in Hungary, being a flat country, the differences between the levels of the sites are so small that the topographic corrections can be regarded as negligible.

### *4.1 Correction in time*

The aim of the time-correction of the observations is to eliminate the time-variations of the geomagnetic field taking place during the whole period of the survey. The procedure was carried out using the continuous records of the Tihany Geomagnetic Observatory (THY). We considered the 1994–95 biannual means of the individual geomagnetic components at Tihany as the reference levels for the measurements. The field data were corrected by the difference between the reference levels and the Tihany observations using the following formula:

$$B^i(1995.0,P_j)=B^i(t_j,P_j)-[B^i(t_j,THY)-B^i(1995.0,THY)] \quad , \quad (1)$$

where $B^i(1995.0, P_j)$ is the value of the $i$-th magnetic component at the $j$-th station ($P_j$) after time-correction, and $t_j$ is the time of the field measurement at the $j$-th site. The accuracy of the corrections depends on the extent of the deviations between the magnetic time variations at the observatory and at the base point to be corrected. Fortunately, in the case of quiet daily magnetic variations, due to the relatively small size of Hungary the correction error is negligible. The time-reduced field elements at the network stations are indicated in Appendix I.

### *4.2 Determination of the magnetic normal field*

In Hungary, the magnetic normal field is expressed traditionally by a second order polynomial of the geomagnetic coordinates. One of the normal components of the field (denoted by $\overline{B^i}$) at the points having coordinates of ($\phi$, $\lambda$) can then be computed as:

$$\overline{B^i(\varphi,\lambda,\underline{p})}=p_0+p_1(\varphi-\varphi_0)+p_2(\lambda-\lambda_0)+p_3(\varphi-\varphi_0)^2 \quad , \quad (2)$$
$$+p_4(\varphi-\varphi_0)(\lambda-\lambda_0)+p_5(\lambda-\lambda_0)^2$$

where the coordinates of the reference site are $\varphi_0$=45.5°, $\lambda_0$=16.0°. The latitude and longitude differences are expressed in minutes. The parameters $p_i$ are the coefficients of the fitted surface.

The parameter vector can be obtained by minimizing a merit function that measures the fitting between the observed data and a given model. The applied adjusting method depends on the statistical distribution of the input data. It means that different merit functions must be minimized in order to achieve the best model of the real physical field.

In our case, adjustment according to the most frequent value [STEINER 1988] was applied for computing the Hungarian reference field. This method requires the fulfilment of the following minimum condition from the adopted parameter vector:

$$\sum_{j=1}^{N} \varepsilon^2 \ln(\varepsilon^2 + \overline{(B_j^i(\varphi_j, \lambda_j) - B^i(\varphi_j, \lambda_j, \underline{p}))}) = \min. \qquad (3)$$

where $N$ is the total number of network stations, $\varphi_j$, $\lambda_j$ are the coordinates of the $j$-th station, and $B^i_j$ is the value of the $i$-th magnetic component at the $j$-th base point. The quantity $\varepsilon$ is termed dihesion; this quantity characterizes the scattering of the measured data around the actually computed reference field. In the algorithm, the dihesion determines a weight function according to which the individual observations are weighted with respect to their residuals from the computed model field. Because of the two unknown parameters ($\varepsilon$ and $\underline{p}$) in Eq. 3, adjustment according to the most frequent value can be solved only by an iterative procedure.

The coefficients of the normal fields of the measured D, I, F, and the computed H, and Z magnetic components obtained by the specified adjustment are collected in *Table II*, the constructed iso-line maps are demonstrated in *Figs. 2-6*.

| | $p_0$ | $p_1$ | $p_2$ | $p_3$ | $p_4$ | $p_5$ |
|---|---|---|---|---|---|---|
| D (') | 99.04 | 0.00469 | 0.21906 | 0.00027 | 0.00010 | −0.00001 |
| I (') | 3711.44 | 0.94267 | 0.07941 | −0.00022 | −0.00009 | −0.00004 |
| F (nT) | 47134.28 | 5.32541 | 1.05978 | −0.00573 | 0.00105 | 0.00012 |
| H (nT) | 22240.08 | −9.09192 | −0.46631 | −0.00177 | 0.00169 | 0.00042 |
| Z (nT) | 41575.65 | 10.84261 | 1.28384 | −0.00839 | 0.00093 | 0.00012 |

*Table II.* Coefficients of the Hungarian magnetic normal fields for the epoch 1995.0 for the D, I, F, H, and Z components. The normal values of the field elements at a given site can be computed by Eq. 2 (see text). D and I are obtained in minutes, while F, H, and Z in nT

*II. táblázat.* A geomágneses tér D, I, F, H, és Z komponenseinek 1995.0 epochára vonatkozó magyarországi normál tereit reprezentáló polinom együtthatók. Az egyes tér-elemek normál értékei egy adott ponton az együtthatók 2. egyenletbe való behelyettesítésével számolhatóak. D és I valamint F, H, és Z normál értékei percben, illetve nT-ban adódnak

Of course, different adjustment methods lead to a different second-order model of the magnetic field. In order to have a picture of the dimension of the possible deviations, we computed the normal field using algorithms of both simple and weighted least squares fittings. In the second

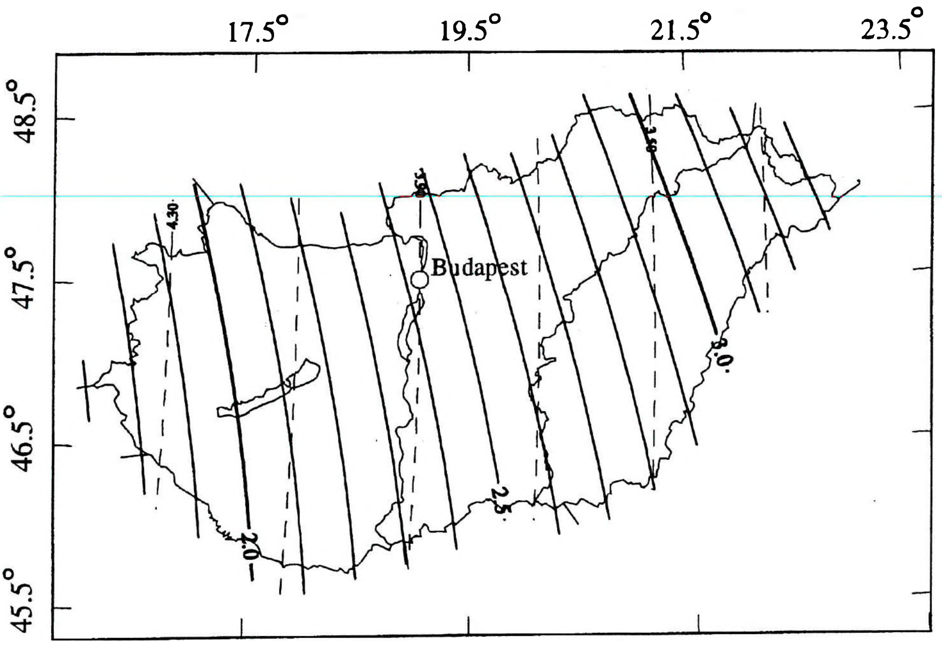


*Fig. 2.* Declination chart of the normal geomagnetic field in degrees for the epoch 1995.0 (continuous curves) and the mean yearly variation of the declination for the period 1950-95 expressed in minutes/year (dashed lines). The contour intervals are 0.1 degree and 0.2 minute/year for the isolines and the isoporic lines, respectively

*2. ábra.* A deklináció normálértékének izogon görbéi az 1995.0 epochára vonatkozóan fokokban kifejezve (folytonos vonalak), illetve a deklináció átlagos éves változási ütemének normál eloszlása 1950 és 1995 között perc/év egységekben (szaggatott vonalak). A szomszédos izovonalak közötti különbség 0,1 fok, illetve 0,2 perc/év

case, the weighting was carried out — in accordance with the Chauvenet criterion [see WORTHING and JEFFNER 1943 or MELONI et al. 1994] — using an iterative algorithm. After computing a normal field, its standard uncertainty ($\sigma$) was expressed in the following way:

$$\sigma = \sqrt{\nu / (N-6)} \,, \tag{4}$$

where $\nu$ is the sum of the squares of the differences between observed and normal values of the field, and $N$ is the number of network stations that participate in the inversion. The weight was 0 for the sites where the residual

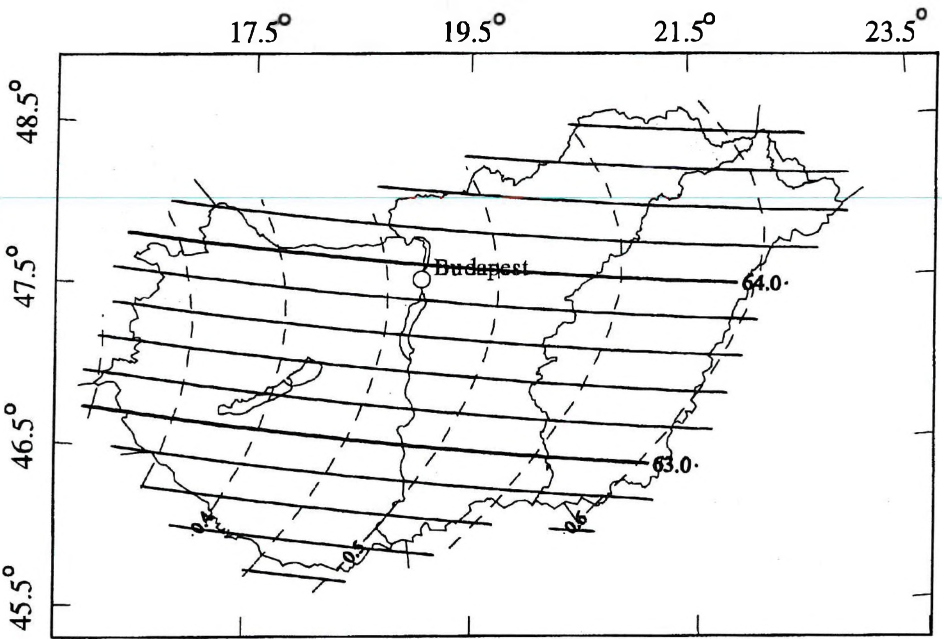


*Fig. 3.* Inclination chart of the normal geomagnetic field in degrees for the epoch 1995.0 (continuous curves) and the mean yearly variation of the inclination for the period 1950–95 expressed in minutes/year (dashed lines). The contour intervals are 0.2 degree and 0.05 minute/year for the isolines and the isoporic lines, respectively

*3. ábra.* Az inklináció normálértékének izoklin görbéi az 1995.0 epochára vonatkozóan fokokban kifejezve (folytonos vonalak), illetve az inklináció átlagos éves változási ütemének normál eloszlása 1950 és 1995 között perc/év egységekben (szaggatott vonalak). A szomszédos izovonalak közötti különbség 0,2 fok, illetve 0,05 perc/év

exceeded $2\sigma$, and 1 otherwise. Every rejection of data was followed by the computation of a new normal field and $\sigma$ until the residuals of all input data remained in the $2\sigma$ interval of the model field.

To demonstrate the deviations between the normal charts resulting from the applied methods, we calculated the differences of the normal fields at each observation point and characterized the deviations by their averages. For the directly observed declination, inclination, and total field, the mean differences fell within the order of the observational errors of the given components [KOVÁCS et al. in press]. This means — from the practi-

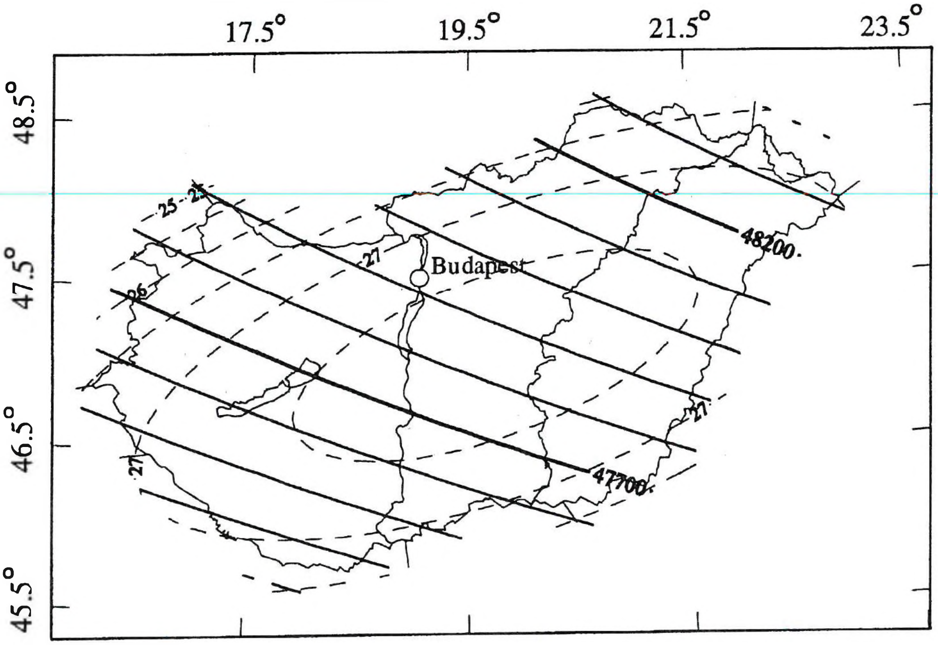


*Fig 4.* Total intensity chart of the normal geomagnetic field in nT for the epoch 1995.0 (continuous curves) and the mean yearly variation of the total magnetic intensity for the period 1950–95 expressed in nT/year (dashed lines). The contour intervals are 100 nT and 0.5 nT/year for the isolines and the isoporic lines, respectively

*4. ábra.* A totális mágneses térerősség normálértékének izodinám görbéi az 1995.0 epochára vonatkozóan nT-ban kifejezve (folytonos vonalak), illetve a totális tér átlagos éves változási ütemének normál eloszlása 1950 és 1995 között nT/év egységekben (szaggatott vonalak). A szomszédos izovonalak közötti különbség 100 nT, illetve 0,5 nT/év

cal point of view — that any set of normal coefficients obtained by the specified adjusting methods could be adopted to define the normal field for Hungary on the basis of the last geomagnetic survey.

## 5. Secular variation

At any point of the Earth, the annual mean values of the geomagnetic field elements show a successive variation which can be characterized by

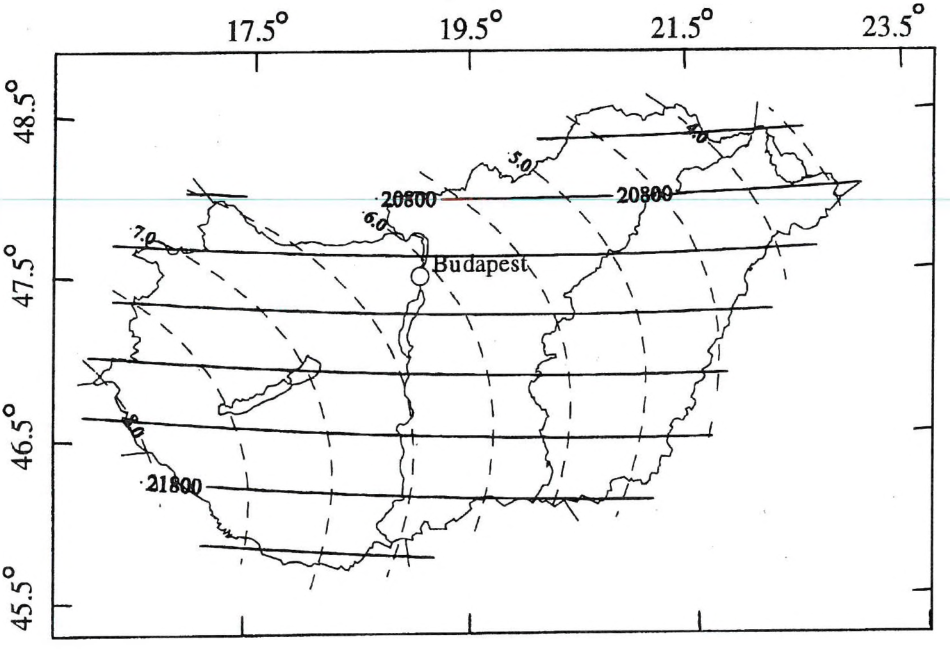


*Fig. 5.* Horizontal intensity chart of the normal geomagnetic filed in nT for the epoch 1995.0 (continuous curves) and the mean yearly variation of the horizontal intensity for the period 1950–95 expressed in nT/year (dashed lines). The contour intervals are 200 nT and 0.5 nT/year for the isolines and the isoporic lines, respectively

*5. ábra.* A horizontális intenzitás normálértékének izodinám görbéi az 1995.0 epochára vonatkozóan nT-ban kifejezve (folytonos vonalak), illetve a totális tér átlagos éves változási ütemének normál eloszlása 1950 és 1995 között nT/év egységekben (szaggatott vonalak). A szomszédos izovonalak közötti különbség 200 nT, illetve 0,5 nT/év

nearly the same trend over some decades. Because the characteristic period of these changes can be measured in hundreds of years, this type of magnetic course is called secular variation. It is suggested that this phenomenon arises from flows of magnetized materials within the Earth's core. It follows that the rate and the trend of the secular changes must vary in space over the surface. The contours of equal rate and trend of changes are termed isopor. The spatial distribution of the isopors over an area of limited size can be determined by adjusting the differences obtained between the observations of geomagnetic surveys of different epochs.

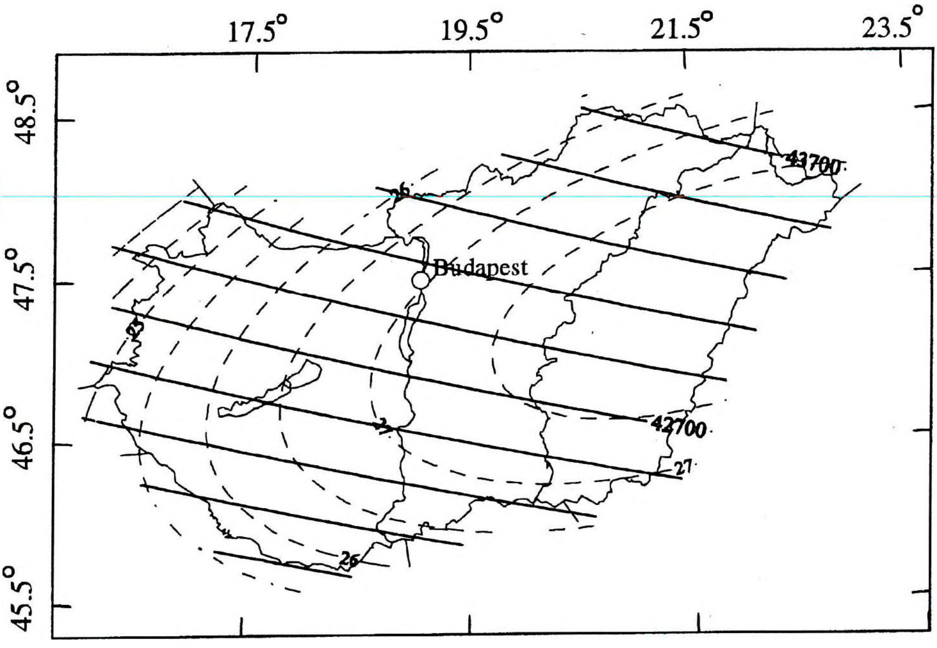


*Fig. 6.* Vertical intensity chart of the normal geomagnetic field in nT for the epoch 1995.0 (continuous curves) and the mean yearly variation of the vertical intensity for the period 1950–95 expressed in nT/year (dashed lines). The contour intervals are 200 nT and 0.5 nT/year for the isolines and the isoporic lines, respectively

*6. ábra* A vertikális intenzitás normálértékének izodinám görbéi az 1995.0 epochára vonatkozóan nT-ban kifejezve (folytonos vonalak), illetve a totális tér átlagos éves változási ütemének normál eloszlása 1950 és 1995 között nT/év egységekben (szaggatott vonalak). A szomszédos izovonalak közötti különbség 200 nT, illetve 0,5 nT/év

*Figure 7A* and *B* show the relative changes of the annual means of the geomagnetic elements at Tihany Observatory between 1955 and 96. It can be seen that the curves of the time variations of declination, vertical and total magnetic intensities continuously increase and are nearly linear. With the inclination and the horizontal intensity, however, the courses are not so evident, and the variations here are much smaller than in the other components.

As was already pointed out, detailed geomagnetic surveys were carried out in Hungary on four occasions during the period 1950–95. This means that we could compare the measured data of our last survey with that

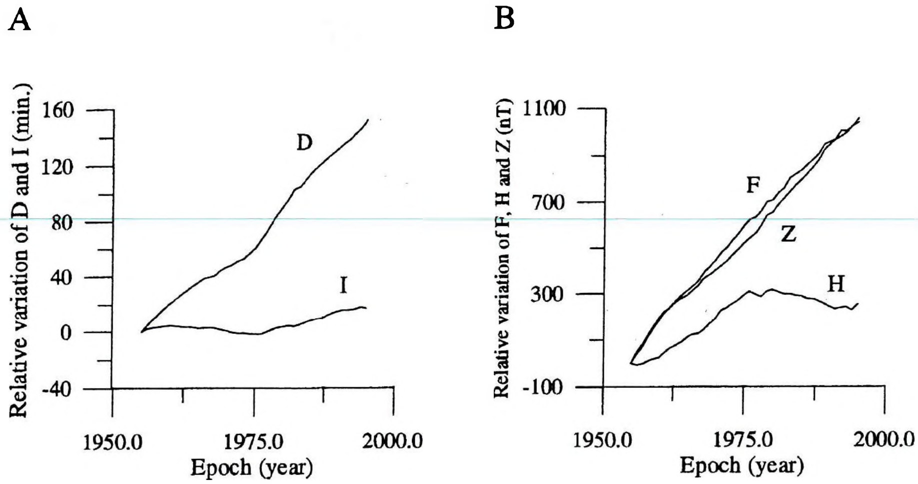


*Fig. 7.* Variations of the annual means of the D, I (*A*), and H, Z, F (*B*) magnetic field components at Tihany between 1955 and 96. To facilitate the representation, the initial values of the curves were translated to zero

*7. ábra.* A D, I (*A*), illetve a H, Z, és F (*B*) mágneses komponensek átlagos éves változási üteme Tihanyban 1955 és 1996 között. Az ábrázolás megkönnyítése érdekében a görbéket egységesen nulláról indítottuk

of three earlier ones in order to get a picture of the spatial distribution of the geomagnetic secular variations over the last 45 years. Judging by the records of Tihany Observatory the trends of the changes of the magnetic D, F, and Z components were nearly linear; the dimensions of the H and I variations were negligible in comparison with the changes of the other components over the last 45 years. For this reason, we decided to compute the secular variations for the time interval 1950.0–1995.0.

The stations of the networks in 1949–50 and 1994–95 were not identical. For this reason, we constructed a grid of 20x20 km over the surveyed area, and interpolated the measurements of the real networks to the points of this grid. Then we computed the mean annual variations of the geomagnetic field elements along the regular grid. Similarly to the normal field, the spatial distribution of the secular variation for Hungary is generally defined by the second-order polynomial specified by Eq. 2. Therefore, we adjusted the mean annual variations obtained for the constructed grid by the method of adjustment according to the most frequent value. The polynomial coefficients characterizing the secular variations of the field elements are reported in *Table III*, the adjusted isopors are presented on the maps of the normal fields (Figs. 2–6). As was expected on the basis of the magnetic records of Tihany Observatory: every field component in Hungary increased, on average, over the last 45 years. The dimensions of the annual variations in the country range between about 3.2–4.4 min., 0.3–0.65 min., 25–28 nT, 3.5-8 nT, 24-28 nT for the magnetic D, I, F, H, and Z components, respectively.

| | $p_0$ | $p_1$ | $p_2$ | $p_3$ | $p_4$ | $p_5$ |
|---|---|---|---|---|---|---|
| D ('/year) | 4.41 | 0.00033 | −0.00276 | 0.00000 | 0.00000 | 0.00000 |
| I ('/year) | 0.36 | −0.00148 | 0.00126 | 0.00001 | 0.00000 | 0.00000 |
| F (nT/year) | 25.69 | 0.02334 | 0.00399 | −0.00025 | 0.00010 | −0.00003 |
| H (nT/year) | 8.46 | 0.00314 | −0.01112 | −0.00009 | 0.00004 | −0.00001 |
| Z (nT/year) | 24.24 | 0.02610 | 0.01228 | −0.00023 | 0.00008 | −0.00003 |

*Table III.* Coefficients of the annual variation normal fields of the magnetic components for the time-span 1950–1995. The normal value of the mean annual variation at a given site can be computed by Eq. 2 (see text). D, and I are obtained in minutes/year, F, H, and Z in nT/year

*III. táblázat.* A geomágneses normál tér 1950 és 1995 közötti átlagos éves változását jellemző polinom-együtthatók értékei. Az átlagos éves változás normál értéke egy adott ponton az együtthatók 2. egyenletbe való behelyettesítésével számolhatóak. D, és I, valamint F, H, és Z változásainak normál értékei perc/év, illetve nT/év egységekben adódnak

## 6. Summary and conclusions

The spectrum of the geomagnetic field is complex both in time and space. During the course of the geomagnetic surveys, the investigations were mainly concerned with the slow spatial and temporal variations of the field.

In the preparatory phase of the last campaign we decided to complete the measurements along the network of the 1964–65 survey. After checking the quality and condition of some former points, however, it was realised that very many of the original sites had become unsuited to magnetic measurements over the last decades because of the increased artificial noise or the obliteration of the base or reference points. For this reason we had to work out a measuring procedure by which the unsuitable base points or reference marks could be substituted by new ones in the vicinity of the original ones without significant loss of time. The solution was provided by a pair of GPS receivers. These were used to determine both of the geographic coordinates of the new sites and the azimuths of new reference marks. Because the GPS and the magnetic measurements could be carried out simultaneously, the observational time was not very much increased.

During the last survey the geomagnetic normal fields that were adopted were computed by adjustment according to the most frequent value. The benefit of using this technique is the automatic weighting of the measurements with respect to their residuals from the normal field. The reference fields obtained were compared with the results of the traditional simple and weighted least squares fitting methods. The mean deviations between the reference fields obtained by the several techniques were comparable with the determination errors of the individual components (see Section 3). It was shown by STEINER [1988] that both the least squares fitting and the adjustment according to the most frequent value give a reliable result if the distribution of the input data set is of Gaussian type. We would again emphasize, that the last magnetic campaign was not extended to stations that are located on areas of local magnetic anomaly. It means — from the statistical point of view — that our set of observations does not include extreme values. It is supposed, therefore, that the probable normal distribution of the measurements around the reference field is due only to this fact.

Hungarian geomagnetic surveys have been repeated every fifteen years since 1950. Following this tradition, the next campaign is expected to be carried out around the year 2010. However, in order to follow the variation of the field during this relatively long period, we are planning to map the geomagnetic field every 5–6 years using the secular station network of Hungary, which includes 20 base points.

## Acknowledgement

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# Appendix

Names, coordinates, and magnetic field element values of the repeat stations of the last Hungarian magnetic survey. The field values are reduced to the epoch 1995.0. D, I, and F are observed, H and Z are computed. The original numbers of the stations included in the 1964–65 survey (see text) are indicated in brackets. A, SK, and UA mean Austrian, Slovakian and Ukrainian sites, respectively. For three stations the magnetic declinations were not determined.

A legutóbbi magyarországi alaphálózatmérés pontjainak nevei, koordinátái, illetve az ott megállapított mágneses tér komponenseinek az értékei. A tér értékei az 1995.0 epochára vonatkoznak. D, I, és F voltak a mért komponensek, H-t és Z-t pedig ezek alapján számoltuk. Az 1964–65-ös alaphálózatban is szereplő állomások eredeti számait zárójelben közöljük. Az A, SK, és UA jelölések osztrák, szlovák, illetve ukrán állomásokat jelentenek. Három pont esetében a mágneses deklinációt nem sikerült meghatároznunk.

| | **Station** | **Latitude** (Degree) | **Longitude** (Degree) | **D** (Deg.) | **I** (Deg.) | **F** (nT) | **H** (nT) | **Z** (nT) |
|---|---|---|---|---|---|---|---|---|
| 1 | Kocs (4) | 47.57525 | 18.26009 | 2.245 | 63.922 | 47850.0 | 21034.9 | 42978.5 |
| 2 | Bakonybánk (5) | 47.46667 | 17.89500 | 2.112 | 63.788 | 47830.6 | 21126.2 | 42912.1 |
| 3 | Gönyü (6) | 47.73389 | 17.88818 | - | 64.001 | 47878.2 | 20987.9 | 43032.9 |
| 4 | Mezőörs (7) | 47.59002 | 17.86712 | 2.133 | 63.906 | 47822.1 | 21034.5 | 42947.7 |
| 5 | Nagygyimót (8) | 47.36051 | 17.52812 | 2.005 | 63.668 | 47791.6 | 21199.2 | 42832.6 |
| 6 | Iszkáz (11) | 47.16382 | 17.29309 | 1.901 | 63.461 | 47679.5 | 21303.2 | 42655.7 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 7 | Nyírád (13) | 47.01713 | 17.46311 | 2.020 | 63.348 | 47669.8 | 21383.1 | 42604.9 |
| 8 | Kemenespálfa (14) | 47.14550 | 17.17475 | 1.926 | 63.436 | 47697.3 | 21329.9 | 42662.3 |
| 9 | Nyárád (17) | 47.27885 | 17.33143 | 1.953 | 63.563 | 47748.5 | 21258.1 | 42755.3 |
| 10 | Városlőd(18) | 47.17048 | 17.64646 | 2.051 | 63.495 | 47728.0 | 21299.5 | 42711.7 |
| 11 | Nagysimonyi (19) | 47.27515 | 17.05701 | 1.817 | 63.572 | 47695.9 | 21228.2 | 42711.4 |
| 12 | Marcali (23) | 46.58208 | 17.36810 | 2.020 | 62.977 | 47509.2 | 21585.5 | 42322.5 |
| 13 | Köröshegy (26) | 46.81112 | 17.90700 | 2.134 | 63.224 | 47623.4 | 21454.4 | 42517.0 |
| 14 | Nagyvázsony (29) | 46.99504 | 17.70089 | 2.098 | 63.348 | 47675.6 | 21385.8 | 42610.0 |
| 15 | Csór (30) | 47.18410 | 18.22754 | 2.291 | 63.577 | 47802.3 | 21272.1 | 42808.4 |
| 16 | Vonyarcvashegy (31) | 46.75150 | 17.33324 | 1.959 | 63.109 | 47556.3 | 21509.6 | 42413.9 |
| 17 | Györköny (35) | 46.60579 | 18.73529 | 2.269 | 63.125 | 47635.3 | 21533.7 | 42490.3 |
| 18 | Sükösd (37) | 46.28203 | 18.95663 | 2.263 | 62.782 | 47570.1 | 21757.6 | 42302.7 |
| 19 | Dunapataj (41) | 46.61384 | 19.00305 | 2.363 | 63.121 | 47668.1 | 21551.1 | 42518.2 |
| 20 | Taszár (42) | 46.37038 | 17.93152 | 2.078 | 62.800 | 47533.0 | 21727.5 | 42276.5 |
| 21 | Felsőrajk (44) | 46.66221 | 16.96574 | 1.877 | 62.983 | 47526.2 | 21588.9 | 42339.8 |
| 22 | Milejszeg (45) | 46.81200 | 16.74145 | 1.802 | 63.088 | 47544.6 | 21519.9 | 42395.5 |
| 23 | Nova (46) | 46.67066 | 16.64510 | 1.878 | 63.047 | 47517.1 | 21537.3 | 42355.9 |
| 24 | Kétvölgy (47) | 46.87621 | 16.22828 | 1.833 | 63.168 | 47558.6 | 21466.9 | 42438.1 |
| 25 | Felsőmarác (48) | 46.92087 | 16.51591 | 1.668 | 63.158 | 47613.5 | 21498.9 | 42483.4 |
| 26 | Bajánsenye (49) | 46.79853 | 16.40904 | 1.677 | 63.112 | 47553.5 | 21505.8 | 42412.7 |
| 27 | Szíjártóháza (50) | 46.63872 | 16.43234 | 1.535 | 62.954 | 47517.9 | 21606.7 | 42321.4 |
| 28 | Fertőd (52) | 47.66483 | 16.89555 | 1.952 | 63.880 | 47817.9 | 21051.6 | 42934.6 |
| 29 | Ágfalva (53) | 47.70015 | 16.53629 | 1.871 | 63.893 | 47800.8 | 21034.7 | 42923.9 |
| 30 | Beled (56) | 47.47395 | 17.08110 | 1.997 | 63.775 | 47786.3 | 21116.3 | 42867.6 |
| 31 | Rajka (58) | 47.98793 | 17.16121 | 2.094 | 64.205 | 47874.1 | 20832.5 | 43103.8 |
| 32 | Hosszúhetény (66) | 46.12535 | 18.34988 | 2.173 | 62.600 | 47491.5 | 21855.6 | 42163.7 |
| 33 | Töröcske (67) | 46.32156 | 17.78484 | 2.034 | 62.769 | 47519.7 | 21743.7 | 42253.2 |
| 34 | Hencse (68) | 46.17035 | 17.62814 | 2.116 | 62.598 | 47447.0 | 21836.4 | 42123.5 |
| 35 | Hobol (69) | 46.00701 | 17.76003 | 2.063 | 62.479 | 47440.5 | 21921.1 | 42072.2 |
| 36 | Váralja (70) | 46.28703 | 18.42489 | 2.209 | 62.804 | 47546.7 | 21730.5 | 42290.3 |
| 37 | Szentlőrinc (71) | 46.01700 | 17.98485 | 2.089 | 62.464 | 47429.6 | 21926.8 | 42056.9 |
| 38 | Magyarsarlós (72) | 46.02866 | 18.35155 | 2.173 | 62.536 | 47479.4 | 21896.8 | 42128.6 |
| 39 | Enying (75) | 46.88865 | 18.21177 | 2.205 | 63.286 | 47673.3 | 21431.1 | 42584.6 |
| 40 | Bakonycsernye (77) | 47.33500 | 18.10833 | 2.184 | 63.670 | 47809.4 | 21205.7 | 42849.2 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 41 | Balatonkenese (78) | 47.05361 | 18.09207 | 2.180 | 63.424 | 47719.1 | 21348.8 | 42677.2 |
| 42 | Iregszemcse (79) | 46.68122 | 18.17818 | 2.165 | 63.079 | 47669.3 | 21583.0 | 42503.4 |
| 43 | Semjénháza (81) | 46.40207 | 16.88804 | 1.849 | 62.799 | 47444.8 | 21687.8 | 42197.7 |
| 44 | Csurgó (83) | 46.29555 | 17.10630 | 1.959 | 62.726 | 47438.1 | 21738.6 | 42164.0 |
| 45 | Csokonyavisonta (86) | 46.05033 | 17.41978 | 2.026 | 62.476 | 47416.7 | 21912.5 | 42049.8 |
| 46 | Lábod (87) | 46.22536 | 17.40819 | 1.991 | 62.620 | 47433.2 | 21814.4 | 42119.4 |
| 47 | Drávafok (88) | 45.87031 | 17.76649 | 2.019 | 62.333 | 47362.6 | 21992.1 | 41947.1 |
| 48 | Potony (89) | 45.92699 | 17.62481 | 2.024 | 62.394 | 47382.0 | 21956.2 | 41987.8 |
| 49 | Kisszentmárton (91) | 45.78472 | 18.04911 | 2.105 | 62.270 | 47349.5 | 22032.2 | 41911.3 |
| 50 | Magyarbóly (93) | 45.85864 | 18.49823 | 2.204 | 62.347 | 47413.1 | 22004.8 | 41997.5 |
| 51 | Drávaszabolcs (94) | 45.79447 | 18.20478 | 2.119 | 62.292 | 47367.5 | 22024.0 | 41935.9 |
| 52 | Mátételke (98) | 46.17853 | 19.22644 | 2.349 | 62.711 | 47563.2 | 21807.0 | 42269.5 |
| 53 | Pilismarót (101) | 47.79720 | 18.89162 | 2.399 | 64.068 | 48010.1 | 20995.0 | 43176.1 |
| 54 | Nyergesújfalu (102) | 47.76096 | 18.59104 | 2.346 | 64.069 | 47932.5 | 20960.0 | 43106.9 |
| 55 | Újbarok (103) | 47.47031 | 18.57520 | 2.327 | 63.817 | 47856.4 | 21115.9 | 42945.9 |
| 56 | Sárszentágota (105) | 46.93366 | 18.57312 | 2.385 | 63.355 | 47734.3 | 21407.1 | 42665.0 |
| 57 | Ráckeve (106) | 47.20296 | 18.91651 | 2.324 | 63.598 | 47812.8 | 21261.1 | 42825.6 |
| 58 | Dunavecse (107) | 47.01091 | 18.99020 | 2.301 | 63.409 | 47797.6 | 21395.0 | 42741.8 |
| 59 | Fülöpháza (108) | 46.88140 | 19.45305 | 2.517 | 63.346 | 47750.0 | 21421.0 | 42675.6 |
| 60 | Kiskőrös (109) | 46.64804 | 19.25338 | 2.444 | 63.150 | 47697.2 | 21542.6 | 42555.1 |
| 61 | Bócsa (111) | 46.66802 | 19.51559 | 2.500 | 63.172 | 47721.2 | 21537.6 | 42584.6 |
| 62 | Öcsöd (112) | 46.83709 | 20.41013 | 2.602 | 63.378 | 47851.3 | 21442.0 | 42778.4 |
| 63 | Kunszentmárton (113) | 46.74977 | 20.29816 | 2.596 | 63.261 | 47822.9 | 21517.0 | 42708.9 |
| 64 | Bugac (114) | 46.66612 | 19.76283 | 2.528 | 63.187 | 47766.0 | 21546.1 | 42630.5 |
| 65 | Galgahévíz (117) | 47.65591 | 19.59295 | 2.629 | 64.018 | 47994.9 | 21026.0 | 43144.1 |
| 66 | Zsámbok (118) | 47.54885 | 19.63840 | 2.603 | 63.949 | 47964.3 | 21064.3 | 43091.4 |
| 67 | Tápiógyörgye (120) | 47.31548 | 19.97342 | 2.599 | 63.778 | 47950.7 | 21187.0 | 43016.0 |
| 68 | Nagykőrös (124) | 47.02045 | 19.83006 | 2.718 | 63.503 | 47842.8 | 21345.3 | 42817.2 |
| 69 | Szank (127) | 46.54547 | 19.69839 | 2.548 | 63.056 | 47732.7 | 21628.6 | 42551.3 |
| 70 | Kalocsa (128) | 46.49627 | 19.01394 | 2.386 | 62.991 | 47685.1 | 21655.1 | 42484.4 |
| 71 | Szalkszent-márton (129) | 46.94973 | 19.12535 | 2.409 | 63.380 | 47766.0 | 21402.4 | 42702.8 |
| 72 | Ásotthalom (130) | 46.23869 | 19.70672 | 2.525 | 62.829 | 47618.0 | 21744.4 | 42363.4 |
| 73 | Kéleshalom (131) | 46.36038 | 19.20832 | 2.384 | 62.873 | 47612.5 | 21709.5 | 42375.1 |

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|---|---|---|---|---|---|---|---|---|
| 74 | Mélykút (132) | 46.24037 | 19.43001 | 2.447 | 62.787 | 47639.4 | 21785.7 | 42366.2 |
| 75 | Zsana (134) | 46.37340 | 19.70419 | 2.535 | 62.905 | 47648.8 | 21702.6 | 42419.4 |
| 76 | Orosháza (135) | 46.62539 | 20.63515 | 2.691 | 63.187 | 47777.3 | 21551.7 | 42640.3 |
| 77 | Derekegyháza (136) | 46.58040 | 20.32678 | 2.582 | 63.125 | 47742.8 | 21582.0 | 42586.3 |
| 78 | Csabacsüd (138) | 46.80708 | 20.61848 | 2.683 | 63.348 | 47845.6 | 21462.0 | 42762.0 |
| 79 | Kétsoprony (139) | 46.70206 | 20.84183 | 2.757 | 63.268 | 47816.1 | 21508.7 | 42705.4 |
| 80 | Mezőkovácsháza (144) | 46.36680 | 20.98200 | 2.804 | 62.970 | 47721.6 | 21687.6 | 42508.8 |
| 81 | Battonya (145) | 46.31469 | 21.07999 | 2.788 | 62.930 | 47709.8 | 21711.4 | 42483.4 |
| 82 | Zsadány (146) | 46.94876 | 21.50359 | 2.933 | 63.500 | 47930.1 | 21386.3 | 42894.3 |
| 83 | Csárdaszállás (147) | 46.87719 | 20.90941 | 2.738 | 63.416 | 47884.0 | 21428.6 | 42821.6 |
| 84 | Vésztő (148) | 46.93861 | 21.31405 | 2.875 | 63.507 | 47915.7 | 21374.5 | 42884.1 |
| 85 | Pusztaottlaka (149) | 46.53205 | 20.97851 | 2.900 | 63.119 | 47802.4 | 21613.6 | 42637.1 |
| 86 | Kunpeszér (151) | 47.09165 | 19.23678 | 2.356 | 63.517 | 47889.8 | 21355.5 | 42864.6 |
| 87 | Kenderes (152) | 47.22726 | 20.62191 | 2.782 | 63.705 | 47919.2 | 21227.7 | 42960.8 |
| 88 | Hajdúszoboszló (158) | 47.48724 | 21.48060 | 2.977 | 63.991 | 48096.8 | 21090.8 | 43225.9 |
| 89 | Furta (159) | 47.10086 | 21.46354 | 2.930 | 63.632 | 48000.4 | 21318.9 | 43006.3 |
| 90 | Hajdúböszörmény (160) | 47.59209 | 21.44154 | 3.063 | 64.041 | 48148.9 | 21076.1 | 43291.0 |
| 91 | Nádudvar (162) | 47.43417 | 21.07427 | 2.875 | 63.928 | 48057.5 | 21121.1 | 43167.4 |
| 92 | Kaba (163) | 47.36407 | 21.34246 | 2.949 | 63.896 | 48047.4 | 21141.3 | 43146.2 |
| 93 | Tiszaszőllős (164) | 47.52382 | 20.71352 | 2.732 | 64.021 | 48068.4 | 21055.9 | 43211.3 |
| 94 | Egyek (165) | 47.59389 | 20.85480 | 2.840 | 64.089 | 48076.8 | 21008.5 | 43243.8 |
| 95 | Bugyi (167) | 47.20954 | 19.11324 | 2.453 | 63.632 | 47831.1 | 21243.4 | 42854.8 |
| 96 | Zaránk (168) | 47.63051 | 20.09678 | 2.736 | 64.068 | 48055.3 | 21014.7 | 43216.8 |
| 97 | Tenk (169) | 47.66849 | 20.34180 | 2.722 | 64.112 | 48101.3 | 21001.5 | 43274.4 |
| 98 | Jászapáti (171) | 47.51165 | 20.18266 | 2.590 | 63.982 | 48015.9 | 21062.5 | 43149.7 |
| 99 | Besenyszög (172) | 47.26492 | 20.22448 | 2.670 | 63.737 | 47924.7 | 21206.5 | 42977.5 |
| 100 | Tiszasüly (173) | 47.39048 | 20.33013 | 2.688 | 63.873 | 47964.7 | 21122.2 | 43063.5 |
| 101 | Tiszabő (174) | 47.29944 | 20.51317 | 2.644 | 63.799 | 47968.4 | 21178.9 | 43039.8 |
| 102 | Domony (176) | 47.64335 | 19.43157 | 2.543 | 64.014 | 47958.7 | 21013.2 | 43110.1 |
| 103 | Kókad (178) | 47.38828 | 21.94888 | 3.039 | 63.885 | 48112.5 | 21177.7 | 43200.9 |
| 104 | Hosszúpályi (179) | 47.38225 | 21.74328 | 3.053 | 63.888 | 48099.0 | 21169.8 | 43189.7 |
| 105 | Kismarja (180) | 47.23116 | 21.84392 | 2.995 | 63.773 | 48095.8 | 21254.7 | 43144.5 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 106 | Szentpéterszeg (181) | 47.25379 | 21.61193 | 2.921 | 63.782 | 48039.7 | 21223.4 | 43097.3 |
| 107 | Körösszegapáti (182) | 47.06627 | 21.64570 | 2.977 | 63.627 | 47994.2 | 21319.6 | 42999.1 |
| 100 | Nyíradony (190) | 47.71683 | 21.88398 | 3.100 | 64.239 | 48179.2 | 20939.5 | 43390.9 |
| 109 | Hajdúvid (192) | 47.75552 | 21.53028 | 2.973 | 64.251 | 48212.0 | 20945.0 | 43424.7 |
| 110 | Csanytelek (194) | 46.61538 | 20.12651 | 2.464 | 63.153 | 47796.3 | 21584.9 | 42644.8 |
| 111 | Mezőhegyes (197) | 46.28324 | 20.89622 | 2.741 | 62.901 | 47675.6 | 21717.5 | 42441.9 |
| 112 | Békés (199) | 46.76374 | 21.07187 | 2.838 | 63.363 | 47844.1 | 21450.5 | 42766.0 |
| 113 | Füzesgyarmat (200) | 47.12232 | 21.18313 | 2.857 | 63.649 | 48016.6 | 21313.4 | 43027.1 |
| 114 | Újszalonta (201) | 46.82520 | 21.48396 | 2.777 | 63.417 | 47880.3 | 21426.3 | 42818.7 |
| 115 | Dévaványa (203) | 46.97874 | 21.00939 | 2.736 | 63.514 | 47934.6 | 21378.1 | 42903.4 |
| 116 | Köröstadány (204) | 46.93836 | 21.03477 | 2.753 | 63.476 | 47905.9 | 21393.6 | 42863.6 |
| 117 | Tiszabura (207) | 47.42963 | 20.54707 | 2.694 | 63.862 | 48022.1 | 21155.6 | 43111.1 |
| 118 | Karcag (208) | 47.24506 | 20.83364 | 2.829 | 63.758 | 47951.1 | 21202.1 | 43009.1 |
| 119 | Dunatetétlen (210) | 46.75234 | 19.10616 | 2.390 | 63.216 | 47714.1 | 21501.1 | 42595.0 |
| 120 | Helvécia (211) | 46.82803 | 19.66105 | 2.564 | 63.317 | 47783.2 | 21457.2 | 42694.5 |
| 121 | Dabas (212) | 47.19518 | 19.32262 | 2.476 | 63.635 | 47859.9 | 21254.2 | 42881.6 |
| 122 | Lajosmizse (213) | 47.03712 | 19.58170 | 2.588 | 63.479 | 47820.8 | 21353.6 | 42788.5 |
| 123 | Kecskemét (214) | 46.95900 | 19.66009 | 2.589 | 63.434 | 47820.1 | 21386.2 | 42771.4 |
| 124 | Jászalsó-szentgyörgy (215) | 47.45883 | 20.09678 | 2.639 | 63.847 | 47981.0 | 21148.9 | 43068.6 |
| 125 | Harsány (219) | 47.94197 | 20.71961 | 2.874 | 64.343 | 48139.8 | 20844.0 | 43393.2 |
| 126 | Gesztely (220) | 48.12452 | 20.94577 | 2.909 | 64.489 | 48216.3 | 20766.4 | 43515.2 |
| 127 | Mezőcsát (224) | 47.82553 | 20.83687 | 2.962 | 64.246 | 48115.7 | 20906.5 | 43336.4 |
| 128 | Aggtelek (225) | 48.45559 | 20.49015 | 2.823 | 64.774 | 48260.2 | 20567.7 | 43658.0 |
| 129 | Egerlövő (226) | 47.74362 | 20.59257 | 2.852 | 64.193 | 48082.4 | 20932.1 | 43287.0 |
| 130 | Csákberény (228) | 47.33382 | 18.37490 | 2.286 | 63.705 | 47805.3 | 21177.4 | 42858.7 |
| 131 | Sáta (231) | 48.20057 | 20.39477 | 2.776 | 64.557 | 48179.0 | 20698.5 | 43506.2 |
| 132 | Noszvaj (232) | 47.94387 | 20.48350 | 2.812 | 64.325 | 48115.1 | 20846.4 | 43364.6 |
| 133 | Verpelét (233) | 47.84488 | 20.19328 | 2.623 | 64.181 | 48098.1 | 20948.2 | 43296.6 |
| 134 | Nagyoroszi (237) | 47.99222 | 19.09332 | 2.540 | 64.350 | 48034.3 | 20792.6 | 43300.8 |
| 135 | Csány (239) | 47.66052 | 19.81675 | 2.484 | 64.067 | 47995.2 | 20989.5 | 43162.2 |
| 136 | Cserhát-szentiván (241) | 47.94221 | 19.57004 | 2.576 | 64.277 | 48016.6 | 20840.2 | 43258.3 |
| 137 | Kisbágyom (242) | 47.82554 | 19.56172 | 2.572 | 64.167 | 48027.9 | 20928.4 | 43228.3 |

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|---|---|---|---|---|---|---|---|---|
| 138 | Szendrőlád (243) | 48.37124 | 20.78910 | 2.928 | 64.712 | 48256.9 | 20613.9 | 43632.5 |
| 139 | Zsujta (246) | 48.50727 | 21.30026 | 3.338 | 64.774 | 48316.3 | 20591.9 | 43708.6 |
| 140 | Vilyvitány (247) | 48.47894 | 21.58196 | - | 64.902 | 48150.5 | 20424.2 | 43604.2 |
| 141 | Felsődobsza (248) | 48.26662 | 21.10514 | 2.945 | 64.631 | 48259.9 | 20676.6 | 43606.1 |
| 142 | Szerencs (250) | 48.12556 | 21.14689 | 3.014 | 64.504 | 48222.6 | 20757.4 | 43526.4 |
| 143 | Tiszacsege (255) | 47.67559 | 21.15431 | 2.912 | 64.178 | 48110.4 | 20955.6 | 43306.7 |
| 144 | Beszterec (259) | 48.15270 | 21.84718 | 3.207 | 64.566 | 48289.5 | 20738.8 | 43609.4 |
| 145 | Újtikos (260) | 47.91988 | 21.23637 | 2.863 | 64.437 | 48155.1 | 20779.1 | 43441.3 |
| 146 | Gyömrő (262) | 47.41244 | 19.38765 | 2.423 | 63.815 | 47903.4 | 21138.1 | 42987.4 |
| 147 | Jászberény (263) | 47.56550 | 19.93676 | 2.731 | 63.963 | 47984.3 | 21062.7 | 43114.4 |
| 148 | Csévharaszt (266) | 47.30549 | 19.45337 | 1.541 | 63.743 | 47862.0 | 21174.3 | 42923.4 |
| 149 | Kiskunhalas (268) | 46.44160 | 19.38154 | 2.428 | 62.945 | 47653.8 | 21675.3 | 42439.0 |
| 150 | Legénd (271) | 47.86554 | 19.29001 | 2.623 | 64.186 | 48019.5 | 20910.5 | 43227.6 |
| 151 | Tahitótfalu (274) | 47.77472 | 19.09960 | 2.448 | 64.096 | 47983.2 | 20962.4 | 43162.1 |
| 152 | Zsombó (276) | 46.33432 | 19.94601 | 2.618 | 62.913 | 47654.1 | 21699.1 | 42427.1 |
| 153 | Tök (279) | 47.59051 | 18.72661 | 2.355 | 63.962 | 47911.0 | 21031.7 | 43048.0 |
| 154 | Tákos (280) | 48.14890 | 22.39538 | 3.302 | 64.573 | 48336.2 | 20753.8 | 43654.0 |
| 155 | Nagyszekeres (284) | 47.96391 | 22.61877 | 3.243 | 64.516 | 48295.5 | 20779.6 | 43596.6 |
| 156 | Csenger (285) | 47.86013 | 22.71021 | 3.211 | 64.368 | 48269.6 | 20880.9 | 43519.5 |
| 157 | Vitka (287) | 48.08012 | 22.29701 | 3.226 | 64.542 | 48314.4 | 20767.7 | 43623.2 |
| 158 | Eperjeske (289) | 48.34062 | 22.22705 | 3.336 | 64.700 | 48341.1 | 20659.1 | 43704.3 |
| 159 | Nyirkárász (290) | 48.12382 | 22.13402 | 3.285 | 64.549 | 48292.1 | 20752.8 | 43605.6 |
| 160 | Révleányvár (291) | 48.32158 | 22.04719 | 3.005 | 64.706 | 48331.8 | 20650.5 | 43698.1 |
| 161 | Kótaj (292) | 48.04511 | 21.76159 | 3.128 | 64.480 | 48222.3 | 20775.1 | 43517.7 |
| 162 | Elek (295) | 46.56294 | 21.26092 | 2.938 | 63.229 | 47873.7 | 21563.7 | 42742.2 |
| 163 | Nagycenk (301) | 47.63275 | 16.72106 | 1.568 | 63.852 | 47768.2 | 21051.0 | 42879.6 |
| 164 | Báta | 46.11768 | 18.77142 | 2.244 | 62.636 | 47531.0 | 21847.5 | 42212.3 |
| 165 | Csanádalberti | 46.31982 | 20.67189 | 2.688 | 62.920 | 47678.8 | 21704.8 | 42452.0 |
| 166 | Csarnóta | 45.88371 | 18.21726 | 2.135 | 62.349 | 47392.0 | 21993.8 | 41979.5 |
| 167 | Diszel | 46.88368 | 17.49135 | 2.014 | 63.242 | 47620.5 | 21439.8 | 42521.1 |
| 168 | Eplény | 47.22528 | 17.88528 | 2.150 | 63.542 | 47769.7 | 21283.1 | 42766.5 |
| 169 | Bősárkány | 47.70280 | 17.24286 | 2.024 | 63.942 | 47886.4 | 21035.4 | 43018.8 |
| 170 | Szerep | 47.21718 | 21.15017 | 2.890 | 63.791 | 48043.1 | 21218.0 | 43103.8 |
| 171 | Cirák | 47.45077 | 17.02713 | 2.002 | 63.800 | 47756.5 | 21085.1 | 42849.8 |

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|---|---|---|---|---|---|---|---|---|
| 172 | Penc | 47.78873 | 19.28266 | 2.475 | 64.147 | 48006.2 | 20933.9 | 43201.5 |
| 173 | Pilis | 47.28994 | 19.60027 | 2.619 | 63.796 | 47917.1 | 21158.8 | 42992.5 |
| 174 | Győrszentiván | 47.72040 | 17.74154 | 2.138 | 63.727 | 47886.8 | 21196.7 | 42940.0 |
| 175 | Türje | 46.96969 | 17.08262 | 1.894 | 63.284 | 47635.3 | 21415.6 | 42549.9 |
| 176 | Bókaháza | 46.77920 | 17.11744 | 1.925 | 63.111 | 47566.3 | 21512.5 | 42423.6 |
| 177 | Cserebökény | 46.75559 | 20.47291 | 2.620 | 63.292 | 47830.1 | 21497.1 | 42727.0 |
| 178 | Hurbanovo – SK | 47.87417 | 18.19000 | 2.196 | 64.082 | 47950.6 | 20958.2 | 43127.9 |
| 179 | Pusztazámor | 47.38362 | 18.79921 | 2.428 | 63.784 | 47852.3 | 21139.1 | 42930.0 |
| 180 | Kétpó | 47.08810 | 20.50586 | 2.825 | 63.608 | 47884.9 | 21285.5 | 42893.9 |
| 181 | Miskolc | 48.07496 | 20.45545 | 2.767 | 64.427 | 48156.5 | 20787.3 | 43438.9 |
| 182 | Pétervására | 47.98117 | 20.14853 | 2.682 | 64.314 | 48106.9 | 20851.7 | 43353.0 |
| 183 | Nizsnye Szeliscse – UA | 48.19608 | 23.45697 | 3.563 | 64.626 | 48385.7 | 20734.6 | 43717.9 |
| 184 | Kondorfa | 46.88461 | 16.39443 | 1.664 | 63.129 | 47606.0 | 21516.8 | 42466.0 |
| 185 | Vámosszabadi | 47.76388 | 17.61075 | - | 64.101 | 47919.0 | 20930.0 | 43106.4 |
| 186 | Lenartovce - SK | 48.31615 | 20.32553 | 2.726 | 64.653 | 48182.1 | 20626.8 | 43543.6 |
| 187 | Janik - SK | 48.57818 | 20.91086 | 2.960 | 64.884 | 48300.2 | 20501.4 | 43733.3 |
| 188 | Zselovce - SK | 48.12898 | 19.37348 | 2.586 | 64.462 | 48051.5 | 20715.2 | 43357.0 |
| 189 | Novy Straz - SK | 47.75888 | 17.27491 | 2.192 | 64.043 | 47897.8 | 20964.6 | 43066.0 |
| 190 | Samorin - SK | 48.04080 | 17.33922 | 2.122 | 64.305 | 47903.4 | 20770.2 | 43166.4 |
| 191 | Jennersdorf - A | 46.93565 | 16.15975 | 1.851 | 63.202 | 47535.0 | 21431.3 | 42429.6 |
| 192 | Apetlon - A | 47.76298 | 16.83944 | 1.955 | 64.024 | 47823.3 | 20946.1 | 42992.2 |
| 193 | Zurndorf - A | 47.94840 | 17.02607 | 1.968 | 64.159 | 47862.1 | 20861.6 | 43076.4 |
| 194 | Oberpullendorf - A | 47.50774 | 16.58313 | 1.911 | 63.845 | 47675.0 | 21015.0 | 42793.4 |
| 195 | Regöly | 46.56030 | 18.36881 | 2.220 | 63.069 | 47665.7 | 21588.4 | 42496.6 |

## Geomágneses alaphálózat mérés Magyarországon 1994–95 folyamán valamint a tér szekuláris változása 1950 és 1995 között

KOVÁCS Péter és KÖRMENDI Alpár

A legutóbbi országos alaphálózat-mérésünkre 1994 és 1995 folyamán került sor. Hálózatunk 195 pontot tartalmazott, amelyeken közvetlenül a mágneses deklinációt, inklinációt, valamint a tér abszolút értékét mértük DI fluxgate, valamint protonprecessziós magnetométerek segítségével. Az állomások földrajzi koordinátáit, illetve a referencia pontok irányait a legtöbb esetben GPS vevők segítségével állapítottuk meg. Az eredményeket a tihanyi geomágneses obszervatórium regisztrátumainak a felhasználásával az 1995.0 epochára redukáltuk. A tér komponenseinek normáltereit a földrajzi koordináták másodrendű polinomjaiként határoztuk meg. A polinomok együtthatóit a leggyakoribb érték szerinti kiegyenlítés felhasználásával számoltuk. A tér szekuláris változásának normál eloszlását a legutóbbi és az 1949-50-es országos alaphálózat-mérés eredményei alapján ugyancsak a földrajzi koordináták másodrendű polinomjaiként adtuk meg.

## ABOUT THE AUTHORS

**Péter Kovács** was born in Budapest, in 1969. He graduated as geophysicist in the Eötvös Loránd University, in 1994 and then joined Eötvös Loránd Geophysical Institute of Hungary. His main research interest is geomagnetism and he played a part in the last Hungarian geomagnetic repeat station survey, which was carried out in 1994 and 1995. In addition he is working towards his Ph.D. The subject of this Ph.D. research is the numerical investigation of the dynamics of the magnetosphere and solar wind using the time series of the geomagnetic field.

**Alpár Köremendi** (1944) geophysicist. Graduated from Eötvös Loránd University (ELTE), Budapest in 1968. Experienced in exploration geophysics, geoelectrical resistivity and shallow seismic measurements (Research Institute for Water Management VITUKI), seam-wave seismic and seismoacoustic research (Tatabánya Coal Mines) and in observatory practice: recording and processing the variations of the Earth's magnetic field, ionospheric phenomena, testing and developing magnetic instruments (ELGI).