3 EARTH PHYSICS RESEARCH

3.1 INVESTIGATION OF THE GEOMAGNETIC FIELD*

Tihany Observatory has continuously performed its tasks in recordingrelative variations of the intensity of the geomagnetic field components and in determining systematically its absolute level, as well as forwarding data obtained from the records to users in Hungary and to international data acquisition centres.

Preliminary annual mean values based on the absolute measurements in Tihany for the epoch 1984.5 are

$$D=1^\circ\ 26.0'$$
$$H=21\ 460\ nT$$
$$F=47\ 421\ nT$$
$$Z=42\ 290\ nT$$

In order to check the geomagnetic level of the Tihany Observatory comparative measurements were performed at several stations of the international network, viz. in the Nagycenk Observatory of MTA GGKI, and the Hurbanovo (Czechoslovakia) and Grocka (Yugoslavia) observatories. The measurements at Tihany were conducted by researchers of the Nagycenk, Grocka and Rude Skov (Denmark) observatories, the last with IAGA standard instruments within the scope of an IAGA programme to standardize the network of observatories.

Our measurements of declination (D), horizontal and total intensity (H, F) at Tihany were in good agreement with values measured by the IAGA instruments.

Within the framework of a comprehensive study of hourly mean values of the observatory a DFT program and a recursive algorithm for realizing a notch filter have been compiled, which provide an acceptable running time for a window of several days and, in case of the daily processing of the hourly mean values, permits one to analyse the S_q phenomena continuously *(Fig. 75)*.

The S_q filtering was used in the comparison of electron densities within the plasmasphere as determined from the local whistler receptions with the data

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arrays of H intensity measured at Tihany: for the majority of charging processes investigated by Gy. Tarcsay (ELTE, 1981) dominant frequencies estimated from the filtered magnetic time series follow flux variations with a good correlation *(Fig. 76)*.

For Tihany Observatory — in cooperation with the Department for Microwave Communication Technics of Budapest's Technical University — an automatic digital VLF signal detecting and analysing apparatus (FULGUR) has been designed. The instrument detects automatically whistlers from an aerial attached to its input, then it determines the frequency–time (f–t) value pairs characterizing the whistler curve and records them on the digital magnetic tape recorder connected to the apparatus.

FULGUR is composed of four essential units *(Fig. 77)*:

— input circuits, providing amplification and digital conversion of the low amplitude signals arriving from the aerial in the range of 1–16 kHZ;
— memory, which is able to store digitized signals for two seconds for each block;
— digital signal detector, which determines the fact and time of a whistler's arrival by correlating the arriving signals with a theoretical whistler function previously entered in FULGUR;
— analyser, which determines the f–t value pairs of whistlers stored in the memory.

The apparatus works in the following way: the A/D converter continuously samples the signals arriving from the aerial. The digitized signal is stored in the memory which can store two seconds of information, and always keeps the digits of the last two seconds. The detector continuously examines the arriving signals. When a whistler is indicated, the loading of the memory block is automatically terminated and subsequent signals will be loaded into another block. The processing of the stored information commences simultaneously. The pairs of f–t values together with their identification will be recorded on magnetic tape.

The apparatus may also work off-line when disconnected from the aerial in order to process earlier records observed and stored in analog form.

3.2 GEODYNAMIC INVESTIGATIONS*

Gravimeter observations and their processing

In recent years gravity earth tide observations were carried out on 11 stations in various countries of Europe including Hungary with the recording gravimeter (type BN–07) of ELGI. The results are shown in *Table IV*. Amplitude factors corrected for oceanic tide effects are a subject for geophysical interpretation: it can be stated that our results show a fairly good agreement with Model II of Molodensky [MOLODENSKY, KRAMER 1961] (his amplitude factor being 1,164) and significantly differ from the results of Wahr, who suggests that the static elastic earth tide can be characterized by an amplitude factor of 1,152 [WAHR 1981].

— the available observation data are not enough to study the lateral distribution of amplitude factors in detail. The distribution of amplitude factors obtained from observations that can be regarded as most reliable (Potsdam, Pecny, Tihany, Graz, Budapest) shows a homogeneous pattern and are in a good agreement with results obtained in Western Europe (Strasbourg, Brussels, Zurich). Only the amplitude factors of Frankfurt show deviating values, which is somewhat surprising since the measurements here were carried out with the most up to date instruments *(Fig. 78)*;

— our observations permit us to reveal unambiguously the resonance effect caused by the liquid core of the Earth. This is illustrated in *Fig. 79* where data measured by ELGI's instrument are compared with the data of other authors. To eliminate the possible calibration errors the curve of core resonance is presented as a relative value (the amplitude factor of the O_1 wave is not affected by resonance so it is used as a unit).

Since 1982 gravity Earth tides have been recorded at the station in Mátyás cave so a continuous observation series for more than 3 years is available for investigation. The data array of observations obtained using an extensometer is of about the same length.

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Elastic stresses in the Earth's interior due to external forces

Two kinds of external forces have been studied:

— stresses due to lunisolar effects;
— stresses caused by normal loads.

Figure 80 shows the functions of normal and tangential stresses caused by tides. In order to characterize the effects of the Earth's structure on the distribution of stresses of lunisolar origin along the radius, results obtained for the Gutenberg-Bullen model are presented together with two extreme (and irrealistic, as well) models of the Earth.

It can be established that the distribution of normal and tangential stresses within the upper mantle is practically independent of the Earth's structure. Their value is very low at the surface ($\leq 10^2$ N/m^2), while at a depth of 500–600 km it reaches 10^3 N/m^2. The distributions of normal and tangential stresses along the Earth's radius were determined for an external load of 100 N/m^2 exercising its influence over the segments $10° \times 10°$ and $1° \times 1°$ *(Fig. 81)*. The hydrostatic and maximum shear stresses are obtained from these distributions *(Fig. 82)*.

Results presented in Figs. 80–82 can be used to examine the extent of the influence of external forces on the time distribution of earthquakes. Since a relationship of this kind may come into question for shallow focus earthquakes only, the probability of earth tides exerting any influence on the triggering of earthquakes is rather small. Since earthquakes can be related mainly to shear stresses, their outburst is conditioned first of all by the maximum shear stress. Thus, oceanic tides in coastal areas, where they may generate stresses of the order 10^4–10^5 N/m^2, probably affect the distribution of quakes in time [Varga 1985].

Interpretation of extensometer measurements

A 21 m long quartz rod extensometer has been at work in the Mátyás cave since the beginning of 1981. From the results so far it could be ascertained that the long period components of extensometer measurements are only slightly influenced by meteorologic and hydrological changes. Thus, the long period variations can be related to changes that have taken place in the rocks. This assumption is rendered more probable by the fact that at stations where two or more extensometers are operated simultaneously, the records show a similar pattern versus time. The value of average relative deformation obtained at the Budapest station ($2.0 \cdot 10^6$/year) was compared with the value of average "secular" variation for 28 stations working at various places all over the world *(Table V)*. It can be seen that the value obtained in Budapest can be regarded as typical. It is, however, important that—in contradiction to the generally accepted opinion—no connection can be detected between the tectonic situation of the station and the "secular" component. The evaluation of data has also shown that the components measured with the extensometer exceed changes that have taken place in reality. This conclusion is based on the phenomenon that the value of maximum elastic stresses in rocks is $p = 10^7$ N/m^2, while the shear module is $\mu = 3 \cdot 10^{10}$ N/m^2 on average. If the lapse of time between two earthquakes is $t = 100$ years then the maximum deformation is $(p/\mu t) \leq 3 \cdot 10^{-6}$/year. Thus it can easily be seen that the value of $2.1 \cdot 10^{-6}$ year for "secular" variation as deduced from the observations must be an exaggeration since this should mean that the deformations observed on the Earth approximate the possible maximum everywhere.

Magnetostratigraphy of the Late Jurassic—Early Cretaceous basic sections at Borzavár and Hárskút

Oriented samples were drilled from each bed and both the remanent magnetization and the susceptibility of every sample were measured in the natural state. In order to determine the most economic cleaning procedure, pilot specimens were subjected to detailed demagnetization. The pilot specimens during cleaning behaved like those from the Sümeg section, so 500 °C was selected as the optimum temperature.

Virtual geomagnetic poles (VGP) that characterize the polarity of the ancient geomagnetic field were calculated for each sample from the characteristic magnetization *(Figs. 83 and 84)*. The VGP latitudes provide a clear pattern of polarity change with very few intermediate directions and correspond to the palaeomagnetic zones of *Fig. 85.*

The standard Calpionellid zones tied to the polarity zones at Borzavár and Hárskút were determined by J. Knauer (pers. comm.) By correlating the polarity zones corresponding to the oceanic magnetic anomalies M16–M17 at Borzavár with those at the Sümeg and the Foza sections, the Calpionellid zones correlate well (*Fig. 86*, columns 1, 2, 3 and 5).

The magnetic zones at Hárskút are not characteristic at the top of the column containing Calpionellids. The most likely explanation for this seems to be the extremely slow apparent sedimentation rate.

Palaeomagnetic measurements on basalts and basalt tuffs from the Balaton Highlands (cooperation programme between ELGI and the Geomagnetski Institut, Grocka, Jugoslavia)

The first palaeomagnetic results on basalts from the Balaton Highlands were published in the late sixties [Márton and Szalay 1968, Dagley and Ade-Hall 1970]. Based on the then available geological information the palaeomagnetic directions obtained were thought to be characteristic of the Late Pliocene–Early Pleistocene.

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As a result of detailed geological mapping and drilling activity [JÁMBOR et al. 1981] and K/Ar isotope age determination [JÁMBOR et al. 1980, BALOGH et al. 1982], the geological model has changed.

Palaeomagnetic measurements on samples from previously not studied localities were needed mainly for checking and calibrating the K/Ar isotope ages by comparing the palaeomagnetic polarity for a lava body of known K/Ar age with the reference polarity time scale.

The localities sampled for the Hungarian–Yugoslavian joint work are mainly situated in the Kabhegy area *(Fig. 87)*. Each core was oriented with both magnetic and Sun compass. The natural remanences were cleaned by heating or in an alternating field of increasing peak value. The results compiled in *Table VI* may serve as a basis for a new synthesis of the palaeomagnetic results, K/Ar ages, and the stratigraphic observations.

Measurement of horizontal and vertical gradients in the environment of the fundamental gravity base point

In recent years the value of gravity acceleration has been determined by the absolute method at an increasing number of points. The reliability of these measurements is ± 10–10^{-8} m/s² ($1 \cdot 10^{-8}$ m/s² = 1 μgal). In view of the fact that the absolute measurements are carried out as a rule in buildings of great volume with an uneven arrangement of masses or in caves, high anomalies of horizontal and vertical gradients of gravity can be expected.

The gradient anomalies affect the accuracy of gravity measurements in three cases:

1. In case of repeat measurements if the positioning of the instrument is not exact.
2. Comparison of the results of different types of absolute gravimeters since their reference points are at different heights.
3. Reduction of the absolute gravity value to the surface of the pillar to serve as a base point for relative gravimeter measurements.

In order to determine the gravity field within the close environment of the Budapest absolute point (Mátyás cave), first of all a microgravimetric network was established *(Fig. 88)*. The mean error of the network after adjustment was $\pm 4 \cdot 10^{-8}$ m/s². Later on the horizontal gradients were determined by torsion balance for the points of profile A–A′ laid near the direction of the highest "g" variations over point No. 82 on the central pillar (the top plane of which is level with the floor). The reliability of the gradient values is ± 1 E ($1\ \mathrm{E} = 1 \cdot 10^{-9}\ \mathrm{s}^{-2}$). It can be seen from Fig. 88 that the horizontal gradient changes by the value 70 E between points of 1 m interval only, therefore in repeated absolute measurements the apparatus has to be set up in the same position with an accuracy of ~ 1 cm in order to keep the effect of the horizontal gradient lower than $1 \cdot 10^{-8}$ m/s².

The vertical gradient was determined over a basis of 1,400 mm according to the formula

$$\partial g / \partial z \cong \Delta g / \Delta z \ [\mathrm{E}] \tag{1}$$

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for three points of the profile A–A′ (points marked by 15, 82 and 20). The value of the vertical gradient along the profile varied from 2,260 to 2,360 E which means that its deviation from the normal value was about 800 E.

Measurements over the gravity base network of the II^{nd} order

The measurement over the gravity base network of the II^{nd} order started in 1980 was continued. In 1984 the Δg values of 140 ties were determined in the northeastern part of Hungary. The network of measurements is composed of triangles, the closing error of Δg values within the individual triangles is less than 0.05 mgal.

The Bouguer anomaly map of Hungary

The Bouguer anomaly map calculated with a density of $\sigma = 2.4$ g/cm^3 in the scale of 1:100,000 for the whole territory of Hungary has been completed. The map was plotted on the basis of the regional survey performed over an irregular network of 1.3 station/km^2. The calculations and the plotting of contour maps were made by an R-35 computer and a VERSATEC plotter, respectively.

Gravity effect of two-dimensional bodies

To the purpose of interpreting gravity anomalies a program was compiled to determine the structure of bodies that can be regarded as having two dimensions only. The calculation is based on the Talwani relationship. The two-dimensional version of the inverse gravimetric solution can be regarded as the determination of the extreme values of a function with many variables. The unknowns to be determined are the coordinates of the corners of bodies, as well as their density so that the square sum of the difference of measured and calculated anomaly curves should be a minimum. It was postulated that the density of bodies varies within the range defined by the geological conditions of the investigated area on the one hand, and that the sides of bodies may not intersect one another, on the other.

To calculate the extreme values of functions of many variables the so called "hill climbing" method was used, having a very fast convergence at the outset and permitting the boundary conditions to be handled too.