III. GEOMAGNETISM

EARTH CURRENT MEASUREMENTS

J. VERŐ

The first earth current measurements were carried out in the Geophysical Observatory Nagycenk in June 1957 with quick-run type instruments, and the regular recording started on August 2, 1957, i.e. forty-five years ago. The "normal" earth current recording (speed 25 mm/hour) was continuously running, quick run records (speed 20 mm/min) were made on regular and irregular world days. The former counted three in each month, the latter were announced daily in the news, often giving at that time topic to humorists. The two instruments which were used for recording were Type GMG T9 earth current recorders, constructed by A. Ádám and produced by the Sopron plant of the Geophysical Instruments Company, originally produced for export to China. These instruments have an essentially flat frequency response down to periods of 10 s, and the eigenfrequency is at about 2.5 s.

Following the start of recording, the problem arose: how to process the records. It is not to be forgotten that at that time nearly nothing was known as compared to present knowledge about geomagnetic activity, the notions substorm, Pc and Pi-pulsations etc. were not coined, no *in situ* measurement was made in the magnetosphere (also an unknown notion at that time), the first satellite, Sputnik I was started just in October 1957. If I remember well, we obtained Dungey's basic treatment on the propagation of hydromagnetic waves in the magnetosphere and resonance there already in 1957 or in 1958, and this was a basic source for planning the processing of the recorded data.

The processing of the normal geomagnetic records has everywhere consisted of the determination of hourly averages and of activity indices, e.g. K-values, from which planetary indices, Kp, have been deduced. Thus, a rather high number of observatories followed this procedure, including several ones in the immediate vicinity of Nagycenk, as e.g. in Tihany (Hungary), Wien-Kobenzl (Austria), Budkov (Czechoslovakia), Grocka (Yugoslavia) etc. The addition of Nagycenk to this lot would not mean a significant gain. Therefore it was decided to strive at some kind of "spectral" indices both from the normal and quick-run records. A detailed description of the early processing methods was given by Ádám and Verő (1958).

In the case of the normal records, the following data were entered into the daily list in each hour:

1. average amplitude in the period range 0 to 2 min
2. the same, 2 to 6 min
3. the same, 6 to 12 min
4. the same, 12 to 24 min
5. the same, 24 to 60 min
6. maximum potential between the electrodes
7. average potential between the electrodes
8. minimum potential between the electrodes
9. potential at the 00 min of the hour
10. sum of all variations (so-called total variation).

In this list, the "total" variation is clearly a heritage from the processing of earth current exploration. Maximum and minimum values were soon substituted by range. The potential at the full hour was dropped soon, too, as it had little sense.

From the remaining values daily and monthly averages were computed, too.

The range, called T(elluric) has had till present a linear scale, as in the case of earth current records, the long period variations are more and more damped with respect to geomagnetic ones, corresponding to the magnetotelluric equations. In addition, the width of the film on which records were made, corresponded to 16 x 1.8 mV/km. Thus 10 1.8 mV/km steps covered more than the half of the film, and the signal often left by such high activity the visible area. The amplitudes in the 5 period ranges were determined for a rather long time, and among others, they enabled the publication of the first English paper on some shifts in the periods during active times (Verő 1958). As this idea did not reappear later, it is worth mentioning here, that the essence was that activity in the period ranges 2 to 6 and 24 to 60 min preceded by about one day those of the ranges between them, thus the first two were considered as "primary", the latter ones as "secondary". The range

24 to 60 min covered clearly substorms, but the earlier appearance of the range 2 to 6 min has no explanation.

In addition to the hourly values, special events were also listed, according to present nomenclature, geomagnetic storms, substorms with and without Pi-s, Pi-s without apparent substorms, SI-s, very short impulses and a few others. The list of these special events included several parameters of the events, as ratio of the amplitudes in the two components, phase lag between them, direction and so on. Details of the early list of special events are found in Ádám and Verő's cited work (1958).

Concerning quick-run records, the basic time interval was originally 10 minutes, and in each interval, the number of cycles within certain amplitude limits. The four groups were characterised by the amplitudes 0.1; 0.5 (0 to 1); 1.5 (1 to 2) and 3 (more than 2) mV/km. The counting of the amplitudes proved to be too tedious, so it was omitted soon. In addition, the activity in five period ranges (0 to 8, 8 to 15, 15 to 30, 30 s to 1, 1 to 2 min was characterised by an index between 0 and 3.

The processing of the quick-run records was in this first form much less successful than that of the normal records, therefore it was soon substituted by an improved method. It is to be mentioned that quick-run records run only three to seven days a month, as mentioned, on world days. As the primary aim of the observatory was from the very beginning the study of geomagnetic pulsations, a continuous recording seemed to be inevitable.

Simultaneously with the start of the activity of the Nagycenk Observatory, the interest for geomagnetism in general and for geomagnetic pulsations in special significantly arose. The International Geophysical Year brought an immense amount of data from all regions of the Earth, including the polar regions, which led in some years to the development of the notion "substorm". In pulsations, Voelker discovered the latitude dependence of pulsation periods, Troitskaya the simultaneous appearance of certain pulsation trains, Kunetz carried out measurements at distant sites and found simultaneous events, Jacobs studied both theoretically and observationally the latitude dependence etc. IAGA accepted soon the classification of pulsations. After later modifications, these classification introduced the Pc (pulsation continues) and Pt (pulsation trains) names, the latter was later substituted by Pi (pulsation impulse). A strong influence was exerted by on the Nagycenk activity by Angenheister's ideas (1955). In a lecture given at the Geophysical Laboratory in the early sixties, he explained his idea on "spectral" and "energetic" indices of pulsation activity. Spectral indices reflect somehow the spectrum, energetic ones the amplitude of the pulsations. He considered also the existence of a lowest level of the signals what meant that in spite of increasing scale value of the instruments, in certain intervals no signals can be found within given period limits.

The difficulties of producing pulsation spectra from the early analogue records is well illustrated by a paper by Cz. Miletits and Verő (1965), where the analysis is based on a few hundred data points taken continuously from the analogue records, then Fourier analysis was made using different lengths of the series to obtain "realistic" spectral peaks. The aim was to find harmonics in the spectrum. Nevertheless, due to the very tedious method, results proved to be unsatisfactory, partly due to the limited extent of the samples (around ten minutes), partly due to computational problems (without computers at that time).

On the basis of own experience and of the cited authors, the processing of the quick-run records was changed twice. The first change was due to the inadequacy of the original method, the second meant a simplification necessary due to the enormous quantity of the processing needed for the intermediate method. This was the more so as in 1965, the continuous recording of the pulsations with a speed of 6 mm/min started (the instrument used was similar to T9, called GMG 14A, they were of smaller dimensions, used 100 mm wide paper instead of the 160 mm wide recording paper used previously; only the recording speed was changed with respect of the instruments produced for exploration purposes). Nevertheless, during world days, this continuous quick-run recording was substituted by the 25 mm/min records. Thus, slightly different but comparable methods were necessary for the two kinds of records.

The intermediate processing method included a characterisation of the activity at a very high number of periods (up to 30 s, for each full s, then up to 60 s, for each 2 s, and so on). The basic interval was 15 min. Within this interval, a shorter section was chosen which seemed to be characteristic for the whole interval; this interval consisted of 5 to 10 individual cycles. (This is clearly the most subjective part of the processing). A "weight" was attributed to each interval, being $10 \cdot P_{\text{upper}}/P_{\text{lower}}$. This weight intended to characterise the shape of the spectrum: the more enhanced a peak is, the higher this weight. Moreover, the "regularity" of the pulsations was also noted on this basis, as "O" (oscillations, very regular sinusoids with periods differing less than 10 percent), "Q" (quasi-oscillations, period differences up to 50 percent, but still smooth sinusoids), "W" (waves, smooth without period limits), "T" (irregular). This processing method meant the first approximation of the later idea of a "Pulsation Catalogue" which should include as many characteristics of the pulsations in each interval, as only possible.

The final processing method, used for the continuous quick-run records is rather similar to the intermediate method, as it is based on a "catalogue", too. Nevertheless, here the number of period ranges was reduced to 12:

P1	1	to	5 s	P7	30	to	40 s
P2	5	to	10 s	P8	40	to	60 s
P3	10	to	15 s	P9	60	to	90 s
P4	15	to	20 s	P10	90	to	120 s
P5	20	to	25 s	P11	2	to	5 min
P6	25	to	30 s	P12	5	to	10 min.

The number of possible weights was also significantly reduced, namely to 1 for irregular and 2 for regular pulsations. After 1971, the amplitudes in the ranges, where the presence was noted, were also kept. The rules were else not changed, that means that the subjective element, the choice of a characteristic section from which the values introduced into the catalogue were determined, remained the same.

This classification remained rather fine in the range of the most often occurring pulsation with periods around 25 s, at very short and very long periods, the limits are farther away from each other. Moreover, most O, Q and W type variation occurred in the central part, in the ranges P4 to P7, too. Values (presence and amplitudes) were noted in each 30 min interval, these values were averaged for 3-hour intervals and for the day, too. On the basis of the daily sums, daily indices were deduced for each period range. It is important to remark, that the daily indices were determined so, that the values 1 to 5 should have as uniform distribution as only possible. When the person making the processing changed (this happened several times during the years to follow), these limits had to be changed. Even if the person remained the same, the limits were changed after a few years to follow changes in the personal limits set by this person. Therefore index averages for different years must not be compared, however, activities in different ranges or on subsequent days/months can be very well compared. Such daily indices could be produced both from occurrence (spectral type) and amplitude (energetic) data.

It is to be remarked here, that due to the needs of the regional earth current measurements made in Hungary, so-called station ellipses were determined for the same period ranges as used in the processing of the continuous quick-run records. These ellipses express the activity of the corresponding ranges (average amplitudes), as well as their direction characteristics (direction of the greatest activity). Early results of the statistics obtained from station ellipses and results of the processing of the 25 mm/min quick-run records were presented by Verő (1961), the intermediate method was described by Verő (1963).

Based on a significantly greater amount of data, Holló and Verő (1967) compared daily indices in the different period ranges with overall geomagnetic activity (at that time, no interplanetary data were yet available). It was found that the activity is connected with the activity in the range 5 to 10 s, as well as with the position of the maximum in the 20 to 30 s range, and these two factors express practically the complete information concerning overall geomagnetic activity of the pulsations.

The noise level in the Nagycenk Observatory was initially extremely low. Neglecting high frequency (several kHz) noise of unidentified origin, possibly connected with the then extremely strong border protection, the border of the communist world, noise sources were restricted. Sometimes the diving-pump of the nearby (about 1.5 km) cattle farm caused slight disturbances, but the responsible leaders of the farm learned soon that some noise appeared in the observatory, the insulation of the pump got faulty and a repair was imminent, thus having experienced the noise we told them, let's repair.

A peculiar source of noise is also worth mentioning. Originally the energy in the observatory was taken from alkaline accumulators. Later the electric network was built up, and current reached the observatory through a 2 km long sideline air cable from the next village Fertőboz. The cable crossed partly a forest with young oak trees. Slowly the trees got higher and reached the level of the cable, thus a cleaning of the cutting was necessary in every second year. Especially winter rime-frost caused serious troubles, as sometimes a continuous connection was established by ice between the branches of the trees and the cable. The only remedy was naturally to cut the branches of the trees in the vicinity, especially above the cable.

Another experience is even more closely connected to the electric network. Namely typical noise was found after some reparations in the buildings. This noise appeared as sudden "jumps" in the potential between the electrodes, and the shifted potential value remained for some time, several hours during which repeated smaller-bigger jumps were apparent, then the quiet conditions returned. This noise appeared mostly during the evening hours, from 6 to about 10 p.m. As a close connection was found between the transmission time of the Hungarian TV (e.g. no noise was found on Mondays, being then without transmission, and on Sunday mornings the noise was present, together with transmission), this noise was called "TV-noise". However, the next TV-set in the house of the forester, lying rather close to the W-electrode proved to be not the source of this noise, as it appeared more characteristically in the N-S component. Finally the following explanation was found: the three-phase cable from the village was a symmetrically loaded there, and the zero lead had an AC voltage of about 5 V during the disturbance. This voltage was then "demodulated" by the soil with an efficiency of about 0.1 percent, resulting in a DC voltage of a few mV-s on the N-electrode, being nearest to the earth of the network connection. Having disconnected this earth from the network, the noise disappeared. Later we had again serious troubles with similar noise. At that time, no earth connection was approved in the observatory area, only life protecting relays were used. A rather lengthy measurement series has shown that the source of the noise was at that time in the astrogeodetic hut near to the geophysical part of the observatory. As it was found an electrician worked there who did not know about our prescriptions, and he connected the motor moving the top window of the hut with the earth. Again, after eliminating this connection, the noise ceased. This trouble shooting is described in the 1969 Observatory Report (Märcz and Verő 1969).

Noise, more correctly, disturbances could also be due to meteorological effects. Namely lightning strokes hit several times during thunderstorms the observatory. Perhaps the fracture indicating the Western boundary of Alpine rocks, some km to the West of the observatory causes the high lightning activity. Curiously enough, the very sensitive galvanometers used in the recording instruments were never damaged, either the motor for the film transmission or the cable heads, sometimes the network cables, including the watt-meter were hit. A most curious experience was that the potential between the electrodes changed due to the lightning stroke quite significantly, by some tens of mV/km, and the level remained for an extended interval of time, up to ten hours or one day, when it slowly returned to the previous level. The same experience was also made during the regional earth current measurements at several other localities, too. It is as if static charge would build up in the vicinity of the electrodes and this charge would remain for a rather long time. This is, however, impossible due to the conductivity of the soil. Thus the phenomenon remained unexplained.

Another meteorological effect is due to very strong precipitation or to very quick melting of snow. If the precipitation was more than 40 to 50 mm in two days, then flowing water reached the E-electrode, which is above a layer of impermeable rocks. As the surface of this layer is sinking toward North, toward Lake Fertő in a depth of about 2 m, i.e. in the depth of the electrodes, the water inundated the electrodes and in the flowing water the potential jumped. Such disturbances lasted several days, the change was quick, and the potential returned slowly to the pre-disturbance level. Once following very heavy snowfall in winter (snow height reached 2 m), the melting of the snow masses caused similar disturbances in early spring.

The "Observatoriumsbericht" 1968 included a short description of the observatory, the recordings made there, as well as the processing methods used. This description included information about the geological-tectonic setting of the observatory. As it is situated on the western boundary of the Little Hungarian Plain, geophysical exploration of this Plain covered several times the vicinity of the observatory. It is interesting to note that gravimetric data are very unclear in this description due to the fact that such data were at that time strictly confidential, thus numerical values could not be given. It is remarked that the gravity anomaly at the observatory corresponds to a final member of the series of negative anomalies starting from the Little Carpathians toward the foot of the Sopron Mts. The boundary of the crystalline rocks at the surface is a few km-s to the west from the observatory, at a fracture which is well indicated in the very strong canalisation of the earth currents as well as in the earliest magnetotelluric (MT) measurements. Seismic refraction measurements have shown that the site is on the southwards dipping northern slope of a deep being about 2000 m deep, while the Observatory is underlain by about 1700 m of sediments. The sediment complex is rather simple, it consists of sand and clay with a specific resistance of about 20 Ωm, interrupted between 5 and 20 m depth by a gravel layer of 90 Ωm, being the same which caused water to flow toward the lake after heavy rain. MT measurements confirmed the rather strong anisotropy (the ratio of the apparent resistivities ρ_y/ρ_x is about 1.5, the MT ellipse is quite exactly E-W oriented. The MT sounding indicated below the 1.5 Ωm layer (MT resistivities are generally less than those from geoelectric soundings) a 13 km thick layer with 60, below it the conducting astenosphere with a thickness of about 10 km, underlain by the high resistivity zone. The higher E-W resistivity adds to the predominance of the Ey-component in the pulsation range.

This description closed the first section of the activity of the observatory. As mentioned earlier, in 1965 the continuous pulsation recording was started, geomagnetic data were afterwards used for the determination of activity indices and "special phenomena", the processing was simplified, values which proved to be superfluous were deleted from the reports, and also the language of the reports switched from German to English, indicating a slow change in the international connections. Nevertheless, it was not to easy to get such a change accepted in that time. In such problems, the reputation of Professor Tárczy-Hornoch as director was a serious help.

After 6 years of use of the new processing method of pulsation records a series on the method and its results was started (Holló et al. 1972, Holló and Verő 1972, Verő 1972, Tátrallyay and Verő 1973, Takács 1975, Cz Miletits et al. 1978). The first part of the series described all processing methods used in Nagycenk with details and examples for the processing are also given.

Part III of this series deals with the connection geomagnetic activity-pulsation activity, at the end, however, a short reference is made to connections with the parameters of the interplanetary medium. The study is based partly on daily indices in the 12 period ranges, partly on the values in the catalogue. Results are not discussed here, only the results in connection with the original aim of the papers, namely with the study of the applicability of the Nagycenk indices and other parameters are shortly surveyed. Concerning the daily indices, it was found that the geomagnetic activity of complete days can be estimated rather exactly based on the three (P3, P4, P6) daily indices, i.e. of the periods 15–20, 20–25 and 30–40 s while the inverse task, estimation of the pulsation activity from the geomagnetic activity is impossible. That means that in addition to geomagnetic activity, other factors have to play a significant role in the formation of the pulsation spectrum. The connections with Pi-type pulsations is less close. Concerning results obtained from the catalogue, the dependence of the actual activity on previous geomagnetic activity should be mentioned. Namely the activity on a certain day is the higher in the range 30 to 60 s, the higher the previous activity was. The situation is just the opposite in case of periods around 3 s and 2 min; here the activity is the lower, the higher the previous geomagnetic activity was. This situation was later studied in more details as non-Markovian character of the series of daily pulsation indices (Verő 1974). Daily pulsation indices were found to be clearly non-Markovian, especially in the range of the field line resonance, i.e. around 25 to 30 s, and in the range of Pi, 1 to 2 min.

In Part IV, comparisons are made between results obtained from 20 mm/min and 6 mm/min records, using the slightly different processing methods described previously. It is perhaps interesting to repeat the list of causes for differences in the two sets.

Random differences can be caused:

1. Subjective choice of the pulsation series the parameters of which are estimated
2. 20 mm/min records are made on world days which include about 10 percent of days, among them more disturbed days, thus in this sample disturbed days have too great weights

Systematic differences are caused:

3. Short periods (below 10 s) cannot be well distinguished on 6 mm/min records
4. The weights are obtained in different methods (see earlier)
5. The bandwidths for which occurrence/amplitudes are estimated, are not the same.

Concerning the last item, experiments are presented for the correction for bandwidth, however, these experiments were not fully successful. The most important point concerning the processing was that comparisons of the activities in certain period ranges are rather satisfactory, while absolute levels are much less reliable.

Part V dealt with comparisons between two mid-latitude stations (Nagycenk and Niemegk) and an auroral zone station (Sodankylä), where data of the stations were processed using similar methods. It was found that correlations e.g. between Nagycenk and Sodankylä activities are high in the period ranges below 20 s and above 1 min, indicating that in the field line resonance range correlations are poor, else reach values up to 0.5.

The final, VI. Part of the series summarised the experiences with the characterisation. The first part is concerned with the comparison of energetic (E) and spectral (S) indices, geomagnetic activity, and the difference of the energetic and spectral (E-S) indices. The E and S indices are rather highly correlated (correlation coefficients 0.7 to 0.8), nevertheless the effect of the geomagnetic activity is rather different on the different period ranges. That is why geomagnetic activity can be estimated from pulsation indices.

The other question attacked in this summary is the correlation between pulsation activities at distant observatories (Nagycenk – Memambetsu, Nagycenk – College). It was found both in the case of great latitudinal and longitudinal differences that activities are highly correlated for short intervals (some minutes) and for complete days. Between the two extremes, the correlation is poor (e.g. for Sodankylä, it is about 0.15 for hours, 0.5 for 5 min intervals and 0.9 for days).

In addition to the (earth current) pulsation records, some other developments took also place in the field of geomagnetism in the observatory. In connection with pulsations, two perpendicular vertical coils were constructed on the wall of the absolute hut, and a corresponding horizontal coil was put in the shrubs behind the observatory area. In spite of rather high effective areas (many windings in the case of the vertical coils, large area for the horizontal coils), these brought about no significant gain. The signal coming from the horizontal coil (dZ/dt) was recorded for a rather long time together with the 20 mm/min earth current records. Game caused, however, often interruptions, as they crossed the cables, so this experiment was finally unsuccessful.

There were long-lasting experiments to record Pc1 (pearl-type) pulsations, too. The first idea was to record them on analogue tape, then following an earphone survey, records without Pc1 were deleted, Pc1-events recorded on analogue way. This system seemed to be effective, nevertheless, the continuous necessity of supervision and hearing of the records meant a severe burden on the few people working in the observatory or with observatory data. Therefore we switched over to continuous analogue recording on paper, then data obtained were processed similarly to pulsation records, substituting the shortest period range, 1 to 5 s by more reliable data. Namely below 10 s, the oil immersion galvanometers used for pulsation recording are severely damped, therefore only the strongest Pc1 events were seen in the records. The sensors of the recording were high permeability core coils with about one million windings. The instrument used and the processing was published in the 1976 Observatory Report (Ádám et al. 1976). In this connection it is interesting to note that in the first days of the continuous Pc1 recording disturbances were quite often seen on the records. It was observed that these disturbances occurred during strong wind. At first it was supposed that the wooden house is shaken by the wind. Thus the sensors were put outside of the house, but the disturbance remained. In a next step sensors were dug into the soil near the house, the disturbance remained. By putting the sensors far away from the house, the disturbance ceased in some cases, while at other places it was present. At last it became clear that the shakes are transmitted by trees to the soil, therefore we looked for a treeless site, where the sensors were dug about 1 m deep into the soil into subsurface channels. With this system, wind caused no disturbance.

In the seventies, digital recording became more and more necessary. In the then political situation, taking the embargo for high-tech instruments into account, experiments were made to construct own digital instruments. This experiment failed, not due difficulties with the construction, but due to the lack of parts which could endure continuous, long-lasting functioning. That is why digital recording was introduced comparatively late in the Nagycenk Observatory.

As a result originating from the processing method presented in the series mentioned previously, some papers from the late seventies are to be mentioned here, which discussed the influence of interplanetary parameters on the pulsation activity. Such investigations became possible as soon as interplanetary data were available, as the continuous processing, catalogue and daily indices offered possibilities for comparison with any available data set.

The first paper (Verő 1975) used daily pulsation indices in the 12 ranges for the estimation of the solar wind velocity. The basis were products in which each factor expressed the probability of the occurrence of the given index in the given range for a certain solar wind velocity (simplified form of Bayes' law). The highest product of the probabilities was then used as most likely solar wind velocity. This method yielded solar wind velocity estimates superior to those estimated from Kp. It should be mentioned that here the indices were used separately, not in combinations. Using combinations, the estimates could be surely made even more accurate.

The second paper (Verő and Holló 1978) used catalogue (hourly) data to confirm the connection between interplanetary magnetic field and pulsation periods and amplitudes. Based on data of the year 1972, the reciprocal connection discovered earlier by Gringauz, Troitskaya and Gul'elmi between interplanetary magnetic field magnitude and pulsation periods was confirmed. In this respect the new factor was the very large amount of data used. The connection between pulsation amplitudes and cone angle was also confirmed, including Kovner's theoretically deduced optimum cone angle 30°, differing from that generally supposed (0°).

Finally the third paper (Verő 1980) presented a survey of pulsation amplitudes vs. Kp, solar wind velocity, interplanetary magnetic field. In this paper, the effects due to two sources of pulsations, upstream waves coming from the interplanetary medium and geomagnetic field line resonance in the magnetosphere, are evaluated, too. For the study of the field line resonance, which was an important part of the activity from the early seventies on, the processing presented here is not applicable, as in that case precise period values are needed, to be obtained by direct determination (be it by the measurement of periods on analogue records, as made initially, or from Fourier transformation, digital filtering and dynamic spectra, as made later.

In the eighties, several problems emerged in connection with the observatory. The first of them was connected with financial and personnel problems. The amount of data produced previously could not be followed, there were several reductions in the published data.

The second problem was rather inexplicable. In the Observatory Report 1985, a detailed description is given on an explicable change in the earth current activity. The events are listed as follows:

1980, December: the cables which were used from the beginning of the observatory get damaged. They had a lifetime of 25 years, nevertheless, forest machine transporting cut trees from the forest behind the observatory turned at an unfavourable place, made a deep hole in the soil reaching the cables, they were damaged, thus they had to be substituted by new ones.

1985, October: the component E_y starts to increase with respect of the component E_x. Simultaneously with the scatter, the dispersion of the transfer coefficients between the H and E-components increases significantly.

1986, March: Unambiguous detection of the change. Magnetotelluric digital measurements by the GKV (Geophysical Exploration Company) in the observatory.

1986, December: parallel recording with an independent systèm, other types of electrodes, special cables.

1987, January: conclusion drawn from previous experiments: there is an inexplicable change in the electric components with respect to the geomagnetic components.

As repeated tests and experiments could not find any cause for the change, all scale values, cable resistivities etc. were several types checked and found being correct, and MT measurements also did not offer an explanation, the change had to be accepted as an inexplicable one. The increase amounted to about 10 percent in the (more influenced) component E_y. Not only the normal, but the pulsation records were influenced by this inexplicable change, the connection between average pulsation amplitudes and solar wind velocity confirmed this 10 percent change. The simultaneous increase of the scatter in the parameters of the H $\rightarrow$ E transfer function remained also unexplained.

This change in the transfer function was, however, soon put in shadow by a much more important problem. Namely the railway line Győr-Sopron-Ebenfurt being one of the few international companies existing during the communist era, wanted to electrify the line. Previously, the 16 2/3 Hz frequency from Austrian electrified railway lines was present in the observatory, disturbing e.g. the records of Schumann resonance. The nearest point to the observatory is about only 1.5 km away, thus it was expected that serious noise would result. The railway company was rather co-operative, thus a provisional line with a length of about 2 km was constructed in the part nearest to the observatory, and a locomotive supplied current into the rails along the line. Several temporary MT-instruments and the observatory recorded simultaneously. In spite of the fact that this experiment proved to give no noise, the concern about the future of the observatory remained. That fear was well founded, as with the start of the electrified fraction, the noise level significantly increased in the earth current records. Pc1 recording became simply impossible, and was stopped. Following several discussions with railway experts, an experiment was carried out during which the traffic of the railway line was controlled from the observatory. In addition, observatory records are compared to the current consumption from the Sopron power station.

The results of these experiments were the following: there were two distinguishable noise forms in the observatory. One of them was due to trains leaving or approaching a station. Detailed comparisons have shown that these impulses lasting a few fractions of one second (with maximum at about 5 Hz) were due to crossing of points. Perhaps the small jerk disrupted the power supply, more exactly, it was sustained by an electric arch, and this sudden change influenced the currents flowing in the soil. The other type of noise was simultaneous with high current consumption from the Sopron power station. In such cases heavy goods trains circulated between the fracture bordering the Alps, between the city Sopron and the observatory near the village Kópháza and the next power station in Dőr. In such events the 50 Hz current in the soil was so strong that the highly damped galvanometers etc. could detect it. As the section of the railway next to the observatory was built keeping all possible restrictions to avoid currents in the soil, no remedy could be found. As compensation, the railway company paid a compensation from which a digital geomagnetic system, enabling connection to the Intermagnet network was purchased.

The loss due to the electrification of the railway was quite serious. Pcl recording had to be stopped, and earth current records had an increased noise level, making period determinations below 10 s very unsure. Most likely due to slow changes in the resistivity between rails and soil, the disturbance level increased slightly, but continuously in the following years, and this increase led to the stop of the processing of analogue pulsation records. Sometimes the noise level was high, especially during winter fog, when humid objects caused leakage currents flow into the soil. A few most curious events were explained accidentally. Namely sometimes, mainly during the night strong disturbances appeared without any evident cause. Sometimes the railway experienced simultaneous problems, too. In one such case a burnt owl was found near to the railway line. It was supposed that similar disturbances are also due to owls taking off from the cables, but no bird was found as cats ate them.

Not only the observatory, but also the observatory reports changed significantly. The state-owned Sopron printing office became a private office, too, in the transitional time emergency solution were necessary.

The events of the last years, the decrease of the personnel, problems with material necessary for recording (e.g. recording paper, spare galvanometers etc.) and the nearly exclusive use of digital methods led to severe changes in the observatory reports in general. Even their complete substitution by data carriers other than paper is imminent. Thus, it seemed to us necessary to summarise the past of the observatory reports, the data published there and the methods to obtain them, also explaining the ideas lying behind the different parameters published there. In the digital era, some kinds of disturbances cannot be detected any more, or the source of the detected noise can be discovered with more difficulties. Together with a strongly increasing noise level, all these factors justify a closing act in the series of Nagycenk observatory reports.

1957–1959	Observatoriumsberichte (in German) as reprints from Acta Technica Hungarica. Content: earth current data, processed with the initial method (activity indices, daily variation of amplitudes in several period ranges, special phenomena etc.), pulsations only from 20 mm/min records
1960–1966	separate booklets in German, printed at the Sopron printing office
1961	geomagnetic data started, processed similarly to earth current data
1962	reductions in the content. atmospheric electricity data started
1966	description of the observatory: geology, instrument, processing methods
1967–1985	separate booklets, now in English, printed at the Sopron printing office
1967	reductions in amount of data published, e.g. geomagnetic data about the period ranges less than 6 min are omitted, the list of special phenomena is common from geomagnetic and earth current records; ionospheric absorption data started
1969	technical paper on the elimination of a noise source
1971	daily pulsation indices in 12 period ranges included
1972	geomagnetic data reduced, no data on amplitudes in period ranges; ionospheric absorption data lacking due to the construction of a new equipment
1975	average pulsation amplitudes in 12 period ranges included; data of ionospheric absorption re-started
1976	Pc1 data included together with description of the instrument; ionospheric absorption data lacking due to maintenance of the transmitter
1978	ionospheric absorption data re-started
1980	special phenomena now include Pc1 events
1985	report on an unexplainable change in the earth current activity

1986–1987	home-made volume containing data of two years, earth current data for the frequency ranges 2 to 20 min dropped, activity indices common from earth current and geomagnetic records, pulsation amplitudes omitted, simplified form of the parameters of special phenomena; Pc1 recording stopped due to noise from electrified railway line near the observatory
1988–1989	again booklet with two years' data, printed at the printing office of the Sopron University (EFE)
1990–1993	booklets printed at the Hillebrand's printing office
1990–1991	re-arrangement of the data
1992–1993	daily averages of the geomagnetic elements included

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