III. REMEMBERINGS

MY RESEARCH (DEVELOPMENTS) CONNECTED TO THE OBSERVATORY

A. ÁDÁM

1. An appropriate place is looking for the electromagnetic observatory

Professor K. Kántás, the director of the Geophysical Research Laboratory of the Hungarian Academy of Sciences in Sopron and head of the Department for Physics and Geophysics at the Technical University also in Sopron planned to built up an electromagnetic (EM) observatory near Sopron to participate at the joint research works of the in-coming International Geophysical Year in 1957. It was our task (Antal Ádám, Pál Bencze, Ákos Wallner) in 1955 to find an electromagnetically noise free, and geologically quiet place for the observatory. Professor Kántás was thinking about the nearby area of the Hungarian-Austrian border in the Sopron Mountains where nobody could disturb the measurements being an area severely guarded by the military. We selected the surrounding of the Muck peak and started with magnetic measurements with Schmidt-type magnetometers. Meantime, we have to ask the frontier guards to check us with their (iron) arms at a distance far away enough, not disturbing the measuring results. At the second step a horizontal loop of great surface has been laid out to measure the time variations of the vertical magnetic field to detect the electric inhomogeneities of the subsoil. (It was a very hard work to use a lot of cable drums for building up a great loop.) From geophysical point-of-view this area could satisfy our requirement, nevertheless, it has to be rejected being closely guarded border region and therefore entering it always needed special permission from the frontier guards.

To eliminate these inconveniences Pál Bencze continued to search for a more appropriate place and he found it at the southern shore of the Lake Fertő in a calmly ascending hill (terrace) near the linden-tree alley of the famous Széchenyi family. Later P. Bencze looked after the observatory building here in 1956–1957.

The telluric recording started in August 1957 according to the programme of International Geophysical Year.

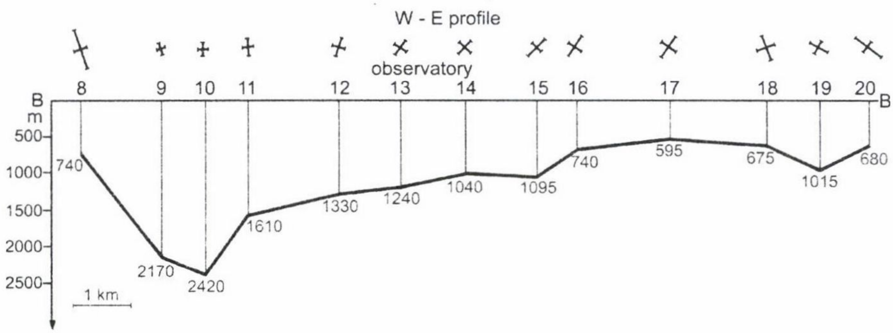

Fig. 1. Basement depth (or thickness of the sediment) deduced from telluric measurements along a profile south of Lake Fertő (Wallner 1977)

2. The geological and geophysical structure of the observatory as it has been described – among others – by Ádám et al. (2000)

A short summary is cited here from this paper: The crystalline schists of Sopron Mountains are thrust into a depth of about 2000 m along NE-SW striking fault towards SE from Sopron in the line Balf-Kópháza-Harka. The deep range beginning here is closed toward E by a high corresponding to the Mihályi gravitational maximum. The crystalline basement has an amphitheatre-like structure open towards SW in the vicinity of the village Nagycenk. The observatory lies on the northern slope of this local deep. The thickness of sediments is here about 1500 m.

This structure was originally determined by gravity and reflection seismics (report has been given by Szénás, 1957), later by detailed telluric (Wallner 1977) and magnetotelluric measurements (e.g. Ádám 1963, Ádám and Verő 1967). (An E-W telluric profile is shown in Fig. 1 (Wallner 1977).) (See later the magnetotelluric results.)

3. Early instrumentation of the observatory and start of the pulsation research

The first recording instrument of the observatory was the T9 type telluric recorder (Fig. 2) (Ádám 1958, Ádám and Verő 1958) manufactured in the section of the Geophysical Instrument Factory (Budapest) allocated to our Laboratory to provide those 60 instruments of our design ordered by the Chinese Geological Ministry Peking after a successful exhibition and field test telluric measurements in China in late 1955 and early 1956.

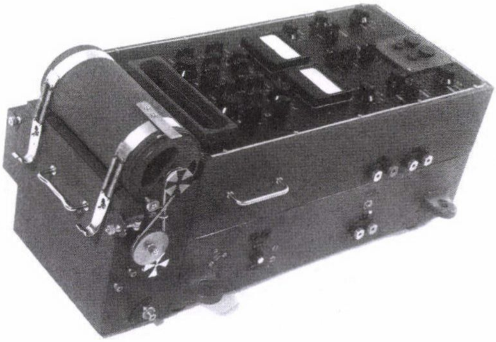

Fig. 2. Photo of the T9 telluric recorder (Ádám 1958)

During my stay in Peking Prof. Kántás initiated a synchronous telluric measurement between Peking and Sopron between January 9 and 14. I measured with Ernő Takács in the Peking Geomagnetic Observatory. My colleagues in the Laboratory and in the Geophysical Department of the University did it near Sopron. By comparing of the recordings we stated that the day-type Pc pulsations have a very large dimension (in our case the longitude difference between the measuring sites was almost 100°). These results were published by Prof. Kántás (1956) in a Chinese geophysical journal, and we also referred them e.g. by Ádám et al. (1966). A figure from this paper (Fig. 3) shows the parallel variation of the total telluric field and their correlation. — This experiment can be taken as the beginning of the long research of the electromagnetic pulsations in our institute.

4. Study of the inhomogeneities of the basement structure of the Pannonian Basin by telluric currents using the observatory as the basic station

The lot of telluric instruments manufactured in the Sopron section of the Geophysical Instrument Factory (Budapest) had to be tested by field measurements. We used this occasion and/or possibility to carry out synchronous measurements with these instruments in different parts of the country. In addition we collected the telluric recordings made by partner institutions/companies (e.g. ELGI, OKGT, MU) in their base stations in countryside. All data obtained by this way have been referred to those of our Nagycenk observatory where the continuous recording of the telluric field ran since August 1957.

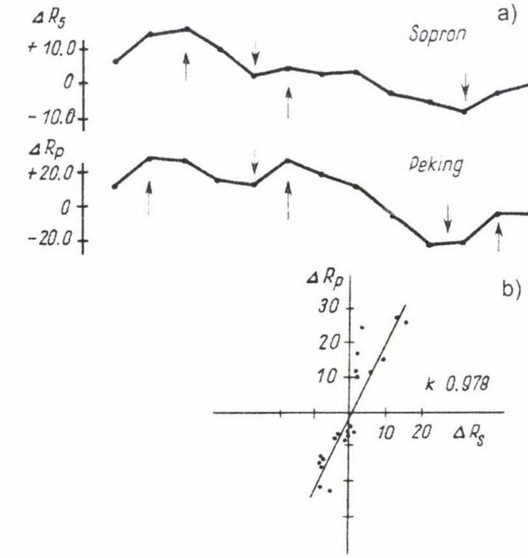

Fig. 3. a) Time variations of the total telluric field measurement simultaneously in Peking and Sopron in January 1956. b) The relation between the above values (Ádám et al. 1966)

The data processing of the recordings has been by determination of the telluric absolute ellipses (using Verő's gradient method (1960)) after separation corresponding to dominant period ranges of the telluric field. We got by this technique relative telluric frequency sounding curves for more than 60 stations in the country. These enabled us to construct different telluric maps reflecting the deep structure of the Pannonian Basin as follows:

- The first telluric isoarea map of the whole country at 25 s showing the main features of the basement of the Pannonian Basin (Fig. 4). This was the base of early tectonic speculations of V. Scheffer on the Vardar threshold in the Pannonian Basin.
- Relative frequency sounding maps constructed from the different segments of the curves corresponding to period differences, e.g. 10–25 s, 25–100 s, 100–500 s, 500–1000 s. The map of 25–100 s clearly shows with the negative values the – later very detailed studied – Transdanubian Conductivity Anomaly (Fig. 5).

About this results we published papers in Hungarian and in German, too, especially in the *Freiberger Forschungshefte* (Ádám and Verő 1964, 1965, 1967).

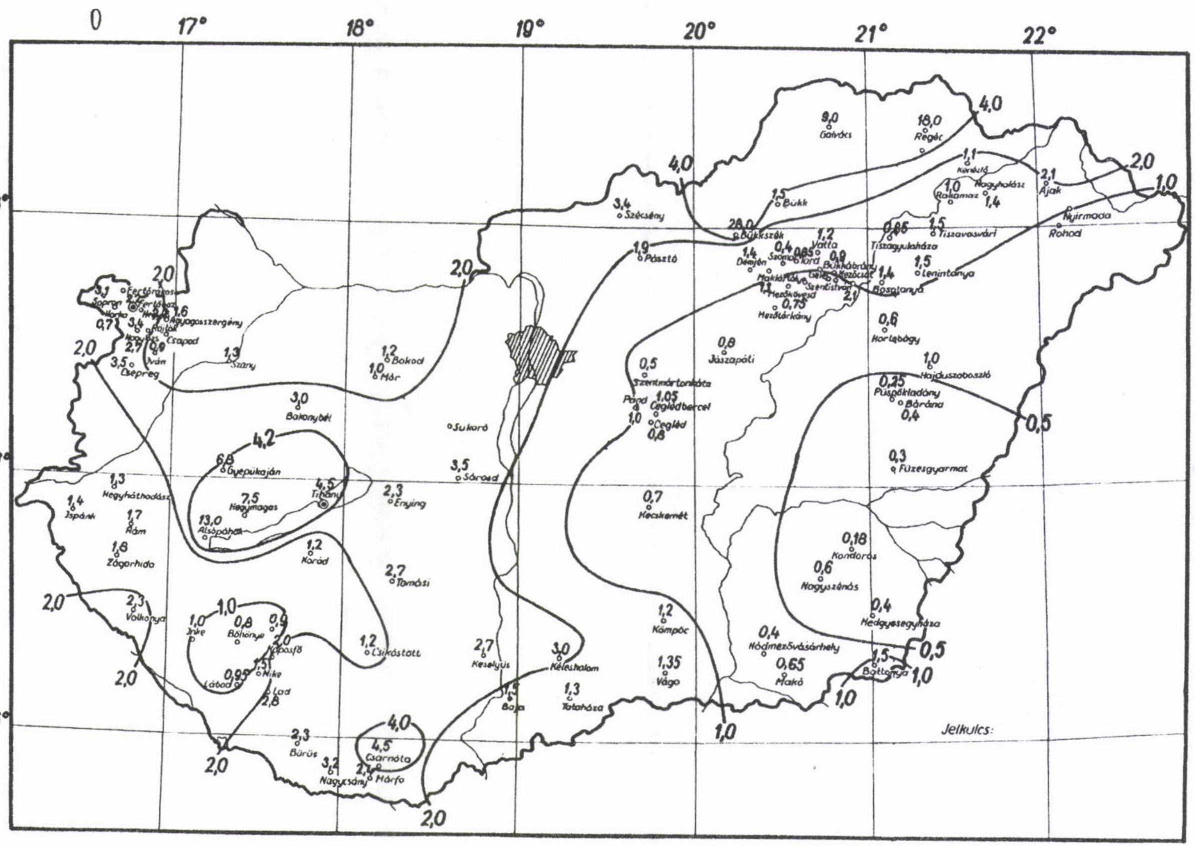

Fig. 4. Telluric isoarea map of Hungary determined with 25 s variations (Ádám and Verő 1967)

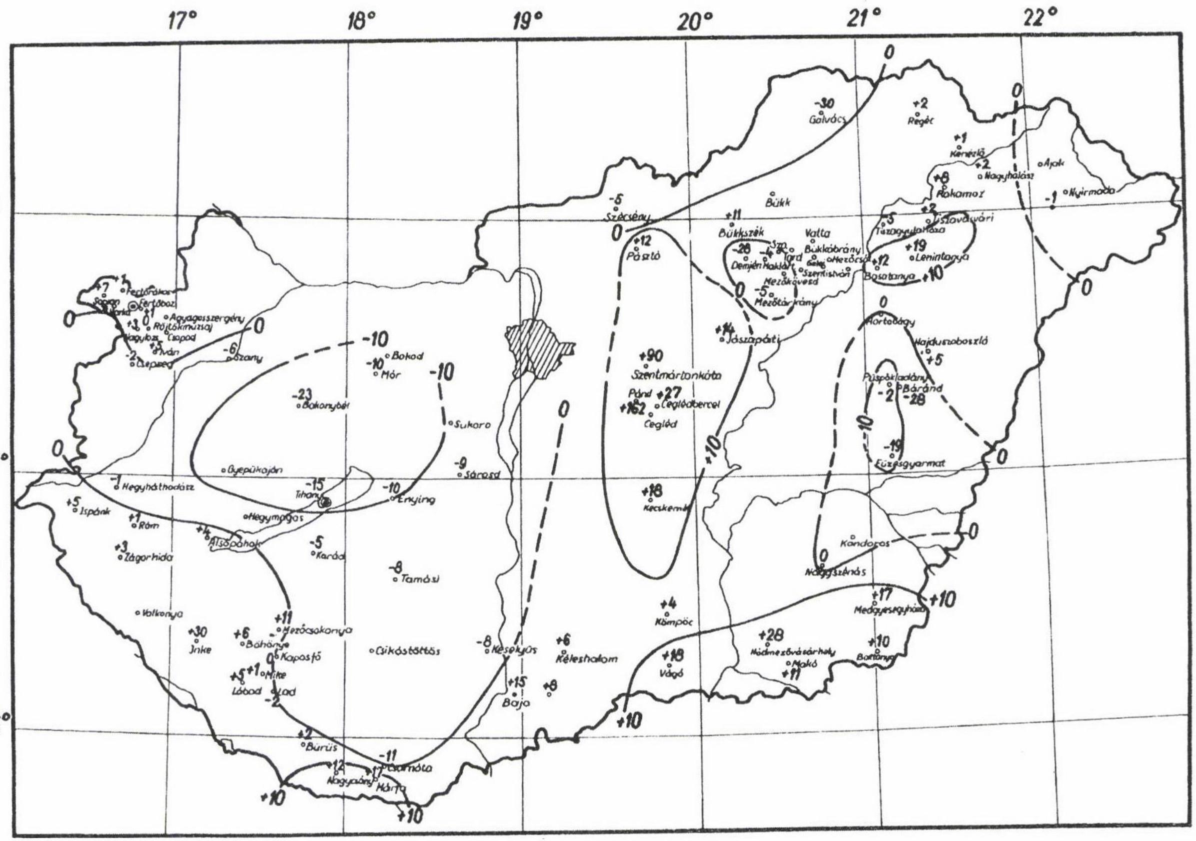

Fig. 5. Map t_{25-100} of Hungary on the basis of relative telluric frequency soundings (Ádám and Verő 1967)

5. Instrument developments based on the experiments got in the observatory

The first results we obtained by the magnetotelluric (MT) method and the automatization of the telluric measurements required new instrument developments. First the T9 telluric recorder —manufactured in great series in Sopron — was updated. More simple and reliable switches and film/paper rolling mechanism were used in the new T14 instrument which also got a more attractive designed form. This new recorder served for a long time in our observatory for the so-called "quick recording of pulsations". This recorder served in the partner institutions not only for the telluric/magnetotelluric measurements, but for the very long range geoelectric soundings (in some cases AB > 10 km) too, having a very special isolation system between the current and high voltage circuits in it.

To determine the telluric absolute ellipses (Ádám et al. 1962) in a more simple way we designed a so-called "total-variation counter" (Fig. 6). "Total" means sum of the absolute values of all variations. This instrument measures the total variations of the 3 components of the telluric fields by optically digitizing them with help of a cylinder mirror with surface divided by 0.5 mm wide reflecting or not reflecting parts. In the focus of the mirror there is a phototransducer connected to the counter through appropriate electronics. The time variation of the 3 telluric components — represented by the deviations of the galvanometers — can be counted in unites of 0.5 mm for any time interval. About successful experiments in the observatory has been reported by Ádám et al. (1968). This was the first digital geoelectric instrument. The idea of this instrument had been realized by ELGI in its TEM80 which is already fully electronized.

Great efforts have been done to develop highly sensitive magnetic instruments for MT. We opened into two directions. A fluid damped static variometer has been designed following the principle of the Schlumberger galvanometers. In this respect our partners were in the Geophysical Instrument Factory - Aurél Ponori Thewrewk and L. Major. This basic instrument has been built into a phototransducer to get high sensitivity (in scale value 0.01 nT on the recorder) (Ádám and Major 1967) (see Fig. 7). This variometer served a lot in our almost all long period magnetotelluric soundings before buying the digital MT instrument from the Polish Geophysical Institute (Warsawa).

Fig. 6. Photo of the total variation counter

For recording magnetic variations of higher frequency than 0.1 Hz different types of induction coils have been developed partly for our observatory (e.g. for the pearl type pulsations and ELF signals) partly for our partners (ELGI, OKGT, etc.) who had to study the layer structure of the sediments by magnetotellurics not only the total thickness of the sediment cover. (The pearl type pulsations record in the observatory was later strongly disturbed by the electrification of the nearby railway.)

Our induction coil consisted of 2 m long supermalloy core with a coil of 500.000 turns. Its scale value could reach the μT (Ádám and Horváth 1976). ELGI started with this coil to develop its first digital MT system (DEF1). Of course, all our experiments have been done in our observatory.

Our greatest instrument development was to design a five channel audiomagnetotelluric (AMT) instrument for synoptic registration and tensorial measurements with field data processing in a co-operation with the Geophysical Department of the Oulu University (Finland). This instrument contains the full magnetotelluric data processing software completed by that one for the determination of the complex induction vector (MV) for 12 frequencies from 4.3 Hz to 2300 Hz (Fig. 8). The on-line measurements of all MT and MV data in the 80's was a great success. A lot of investigation in the Eastern Alps and in the Southern Bohemian Massif have been carried out by using this instrument (Ádám et al. 1988, Arič et al. 1997).

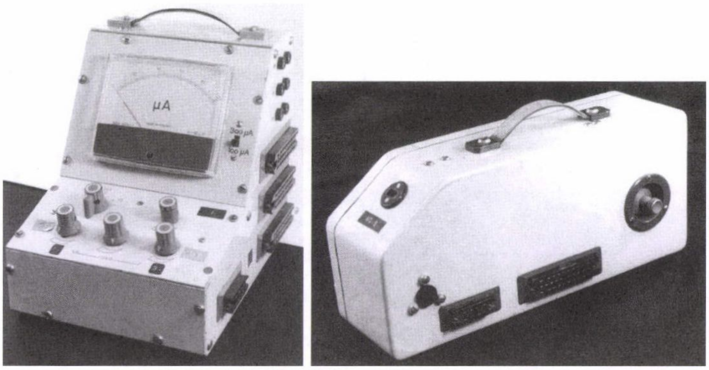

Fig. 7. Photo of the MTV-2 variometer (Ádám and Major 1967)

6. The Observatory as "magnetotelluric etalon" in Hungary

Our magnetotelluric measurements started at the very beginning of the sixties (last century) both in the field (Ádám and Bencze 1961) and in the observatory. The MT results obtained in the observatory initiated a lot of new ideas concerning the anisotropy of the distribution of the (MT) electric resistivity, the deep structure of the Earth in the Pannonian Basin, etc. (Ádám 1963). Methods have been elaborated for the determination of the magnetotelluric anisotropy for a large period domain (Ádám 1964). Later in papers (e.g. in the *Nature*, Stegena et al. 1971) it has been emphasized that the magnetotelluric anisotropy could be a useful tool in the study of the plate tectonics. On the MT sounding curves of the observatory it has been at first detected that the conductive asthenosphere — corresponding

Fig. 8. On-line audiomagnetotellurics instrument (Ádám et al. 1988)

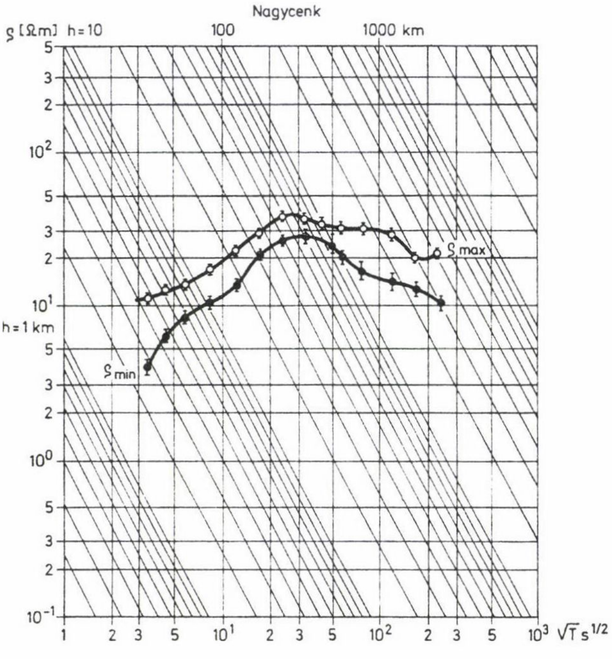

Fig. 9. MT sounding curves measured in the observatory (Ádám et al. 1981)

to the Gutenberg's low velocity layer in the upper mantle — has a very shallow position — 60 km depth — in the hot Pannonian Basin (Ádám 1963). Later this statement stimulated me to find relation between the depth of the asthenosphere and the regional heat flow in general (Ádám 1978). A resistivity decrease corresponding to the mineral phase transition at the depth 410 km also appeared in the magnetotelluric sounding curves of the observatory (Ádám and Verő 1967, Ádám et al. 1981). (See here one of the most complete MT sounding curves in Fig. 9.)

The observatory during the 80's became an etalon for testing of different magnetotelluric instruments partly developed in the country (e.g. ELGI) or imported (e.g. OKGT). One of the most precise sounding has been done by the OKGT's Phoenix MT instruments in 3 nearby sites of the observatory using the "remote reference stations" (Report of Z. Nagy, 1986).

By this measurements the geoelectric structure of the subsoil of the observatory also become better known.

7. Summary

Of course, the mentioned different experiments which were carried out in our observatory during decades are "only" additional works to the primary task of an observatory i.e.: to record the geomagnetic/ionospheric etc. variations for long time study of the physics of Earth and its environment (magnetosphere, ionosphere, Sun-Earth relation, space weather, etc.). Thus changes in the geoelectromagnetic transfer functions have been detected during the solar eclipse August 11, 1999 (Ádám et al. 2005).

Our observatory has been prepared for its primary tasks since the very beginning of its activity (August 1957) by application and completion of its instrument pool. The mentioned "additional" works and their results partly helped to make acquaintance with the geophysical (geological) background of the observatory, partly helped to develop instrument in physically known circumstances which later served the observatory in his activity.

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