Geomagnetic observation system in the Széchenyi István Geophysical Observatory

István Lemperger[1*], Judit Szendrői[1], Csongor Szabó[1], Lukács Kuslits[1], Árpád Kis[1], Sándor M. Szalai[1], Csaba Molnár[1] and Viktor Wesztergom[1]

[1]Institute of Earth Physics and Space Science (ELKH EPSS), Sopron, Hungary

Abstract

Geomagnetic and geoelectric registration has been continuously executed in SZIGO for more than six decades. The Observatory is a member of the global network of the geomagnetic observatories, the so-called INTERMAGNET (www.intermagnet.org). The geomagnetic observation system has recently been renewed in all of its components and the organically related geoelectric measurement system is going to be upgraded and improved, too. Present paper provides a short summary of the new geomagnetic observation system and introduces a few SSC events registered in the SZIGO from the last 12 months via the new observation station.

Keywords: geomagnetic observation, INTERMAGNET.

Introduction - motivation

In the early sixties two antimagnetic houses had been built for the geomagnetic measurements, one for the continuous recordings (called relative house) and the other for the measurement of the geomagnetic absolute values (called absolute house). They were built from limestone, the roof from reed. The continuous recording of the geomagnetic components H, D and Z, and the weekly measurement of the absolute value of these elements were started in July, 1960. The instrumentation was: two variometer sets of the type La Cour (made in Denmark) recording to 30×40 cm photo-paper sheets, two QHM-s (quartz-horizontal-magnetometer), one BMZ (balance-magnetic-zero) (also made in Denmark), a magnetic declinatorium and an Earth inductor (Askania). The magnetic declinatorium originally served in the Observatory Ógyalla, then in Budakeszi and in Tihany, but was later replaced by a magnetic theodolite in Tihany. Nevertheless, it was a very accurate instrument. The conventional magnetic instruments were used until 1989. From 1989

*Corresponding author: István Lemperger (lemperger.istvan@epss.hu)

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till 1991 the measurements of magnetic absolute values were executed utilizing a vector proton magnetometer developed in the Observatory Niemegk. Since 1991 absolute measurements have been preformed by a triaxial fluxgate magnetometer and a proton magnetometer (ELSEC 820). Digital recording of the geomagnetic variation was also started by an ARGOS system (by the British Geological Survey) in 1991. The analogous photographic recording was run parallel during about one year.

Observatory reports of geomagnetic data has been published each year since 1961. As the observatory had in the first times the main aim of the continuous monitoring of the Earth's electromagnetic field of external origin, the chapter Geomagnetism was compiled in coincidence with the chapter Earth Currents. Telluric data is proved to be a very useful supplementation of the geomagnetic registration providing direct information about the local induction effect of the surface geomagnetic variation.

The activity indices reported were determined according to a linear scale, which increased by 7 nT broad steps. Only monthly and yearly averages of the absolute values of the elements were provided. The observatory has belonged to the INTERMAGNET cooperation since 1993. In the first years data were transmitted via METEOSAT satellite and later it has been improved to be transferred by regular email service to geomagnetic information nodes and made also available to the international research community on CD ROM and downloadable from the INTERMAGNET home page.

The co-ordinates of the observatory:

3-character IAGA code: NCK,
Geographic co-ordinates:
$\Phi = 47°38'$ (N),
$\lambda = 16°43'$ (E),
Altitude = 153.70 m (magnetic house),
McIllwain L = 1.9.

The low sampling rate of the geomagnetic variation (one data per minute) was proved to be insufficient to draw conclusion on the source ionospheric current systems and the ultimate magnetospheric phenomena. Thus demand for further improvement of the system has arisen.

Description and commissioning of the new measurement system

To develop and build an accurate and long run reliable, sufficient measurement system the components of the chain had to be selected in a prudent and thorough manner.

The first element of the chain is **the host building** itself which has originally been built utilizing only non-magnetic parts. The so-called relative house's roof has been renovated 2 years ago. The core of the system is a 3-axis **fluxgate magnetometer model FGE** by DTU Space which has a proven track-record at many observatories worldwide. It is easy to set up and operate and has demonstrated baseline stability over decades. The FGE has analog outputs enabling the user to adapt the instrument to their own data logging systems. Main features of the system are as follows:

- 3 linear core fluxgate sensors mounted on a marble cube for good mechanical stability.
- Bias and feedback coils on quartz tube for high temperature stability.
- Highly stable digitally controlled compensation of main field. Very good long-term stability.
- Magnetically very clean electronics which may be placed rather close to the sensor head.
- Temperature sensors in the FGE-sensor head and the electronics.

The next step in the process is the analogue/digital conversion. This task is performed by a **SYMRES USB8CH** 24 bit real-time continuous data acquisition system with an individual A/D per channel architecture. Suitable for sampling from DC to 10 kHz, an on board 4 MB FIFO guards against any data loss even on heavily interrupted and multitasking computers. Sitting outside the PC for improved noise performance, the system communicates its acquired data to the computer via a standard USB port. All analog inputs are fully differential with amplitude ranges of $\pm$ 4 V. The data is processed and stored on a **BeagleBone Black** microcomputer by the platform independent software environment provided by SYMRES. Full featured acquisition programs like DVM and Scope are included with the system software easily controlling acquisition rates and continuously saving acquired data to disk. The pipelined architecture allows simple customization of the provided programs. For developing custom utilities, low level pipeline functions are supplied.

The microcomputers are equipped with industrial quality 16 GB SD cards to secure the reliable data acquisition for long turn. The original flexible pipeline has been supplemented by some extra scripts for automatic quasi real-time data service to an INTERMAGNET GIN and direct real-time data forwarding to a separated high performance **computer/data server** by local network. The last element of the data acquisition system is the server which stores the second sampled geomagnetic data in an SQL database with separated tables for each day and one table for the last 24 hours data. Archived data includes the GPS time stamp, 3 geomagnetic components (X, Y, Z), the sensor temperature (Ts) and the temperature of the electronics (Te) leaving open the possibility of a subsequent temperature correction.

The power of the whole system is supplied from a 12 V 74 Ah battery continuously fed by the central solar power system of the Observatory. Clone system is archived on backup memory card for case of emergency to secure the permanent data acquisition.

Registered events

(Storm) Sudden Commencements (SSC) are defined by an abrupt increase or decrease in the northward component of the geomagnetic field, which marks the beginning of a geomagnetic storm or an increase in activity lasting at least one hour. The sudden commencements and solar flare effects (SFE) are from magnetograms of the worldwide network of magnetic observatories.

The stations, together with their abbreviations, are given in the series IAGA Bulletin No. 32 which contains the yearly compilation of these data. Before January 1966 these reports were published periodically in Journal of Geophysical Research. From then until 1970 they were published quarterly in Solar-Geophysical Data (SGD). Beginning with December 1970, these data are published monthly and, thus, are based on fewer reports and differ slightly from similar data published previously. The decision to publish this less complete report was made in order to make the data available more rapidly. Only events reported by at least five observatories are reported.

The latest SSC reports are provided by Observatorio del Ebro, Roquetes, Spain, on behalf of the IAGA Service on Rapid Magnetic Variations, see Curto et al. (2007).

Seven reported events which can be definitely identified in the SZIGO data from the last 12 months are listed in Table I. and as they appear on the SZIGO registration are demonstrated on Fig. 1-7.

Table I: Reported SSC events based on data of at least five geomagnetic Observatories in the last 12 months.

YYYY	MM	dd	hh	min	Amplitude (nT)					Qualification					Type
2020	10	19	14	41	13.4	9.5	14.7	21.1	22.1	3	2	2	2	3	SSC
2020	10	23	13	20	7.3	7.3	11.4	11	10.8	0	1	1	1	1	SSC
2020	12	10	2	9	20.2	18.5	19.5	25.1	21.8	3	3	3	3	3	SSC
2021	5	12	6	37	27.7	25.5	20.7	46.3	36.4	2	3	2	3	3	SSC
2021	5	26	12	44	13.1	25.1	17.9	20.8	26.9	3	3	3	3	3	SSC
2021	6	2	13	30	8.8	9.8	11.6	13.3	14.8	1	1	2	3	2	SSC
2021	8	27	1	14	12.4	12.8	17.5	12.1	15.7	2	1	1	1	2	SSC

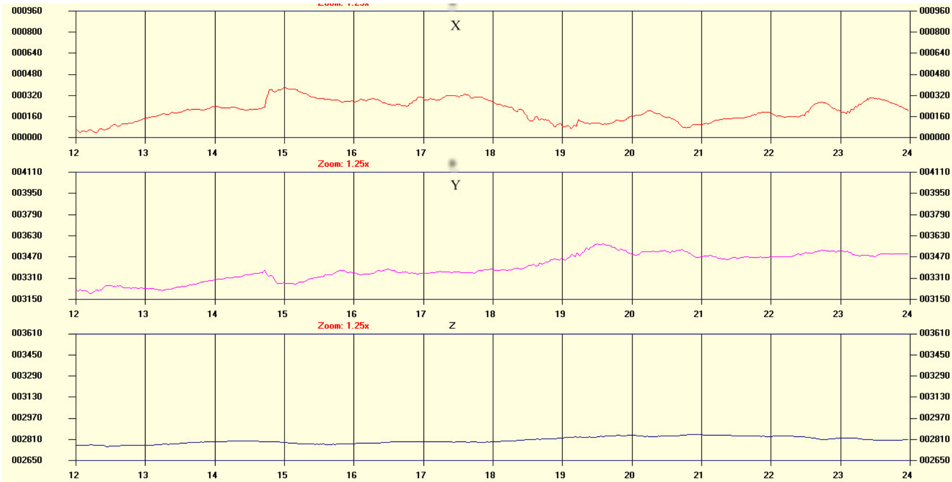

Fig. 1: SSC event identified on SZIGO geomagnetic registration – 19-10-2020 (H, +13.9 nT).

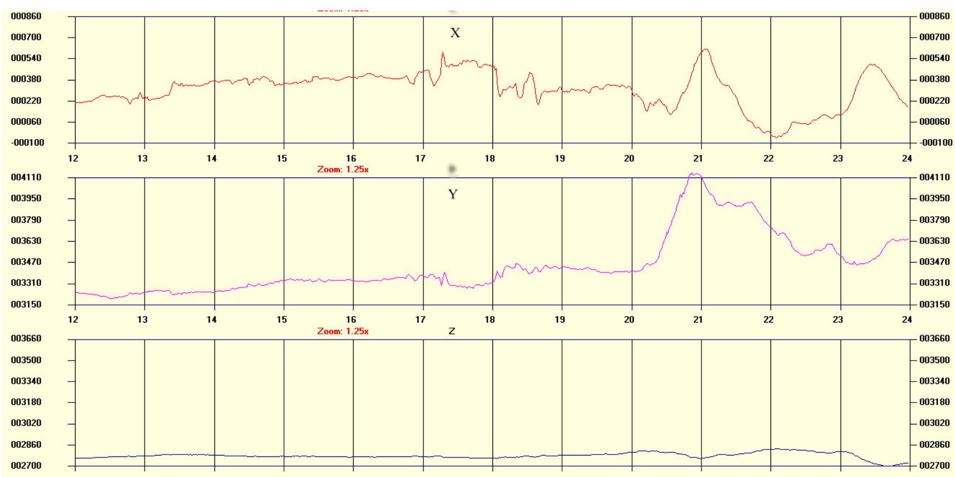

Fig. 2: SSC event identified on SZIGO geomagnetic registration – 23-10-2020 (H, +10.2 nT).

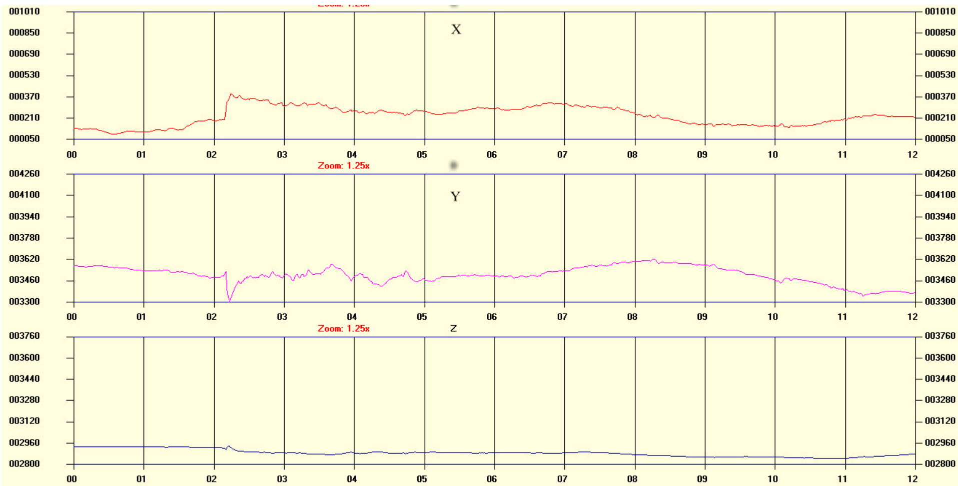

Fig. 3: SSC event identified on SZIGO geomagnetic registration – 10-12-2020 (D, −22.4 nT).

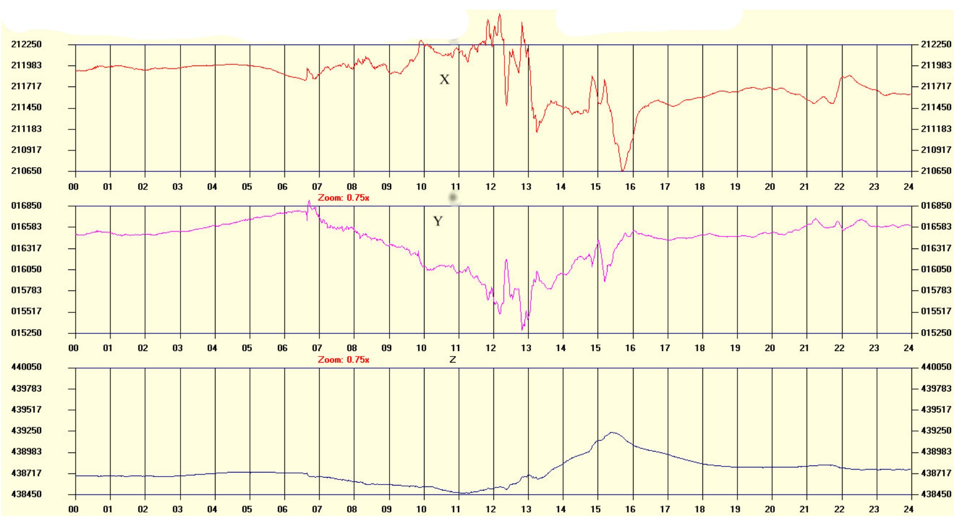

Fig. 4: SSC event identified on SZIGO geomagnetic registration – 12-05-2021 (D, +26.0 nT).

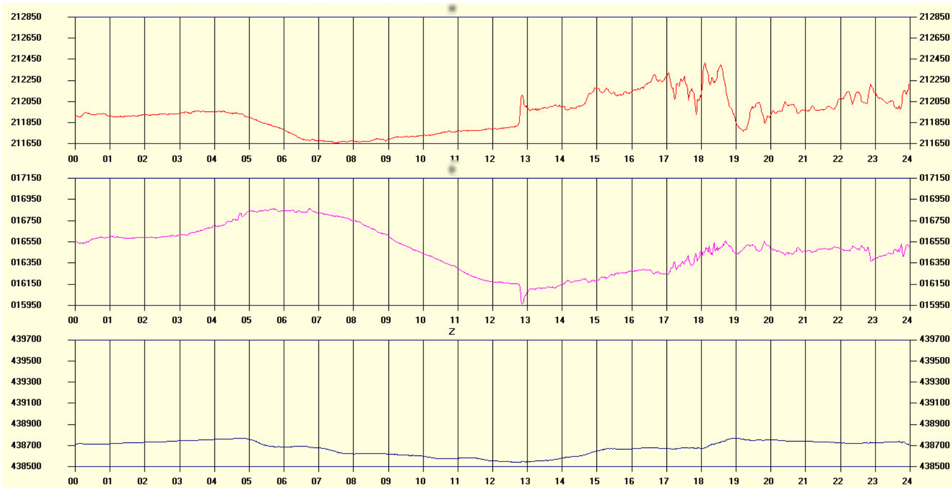

Fig. 5: SSC event identified on SZIGO geomagnetic registration – 26-05-2021 (H, +29.1 nT).

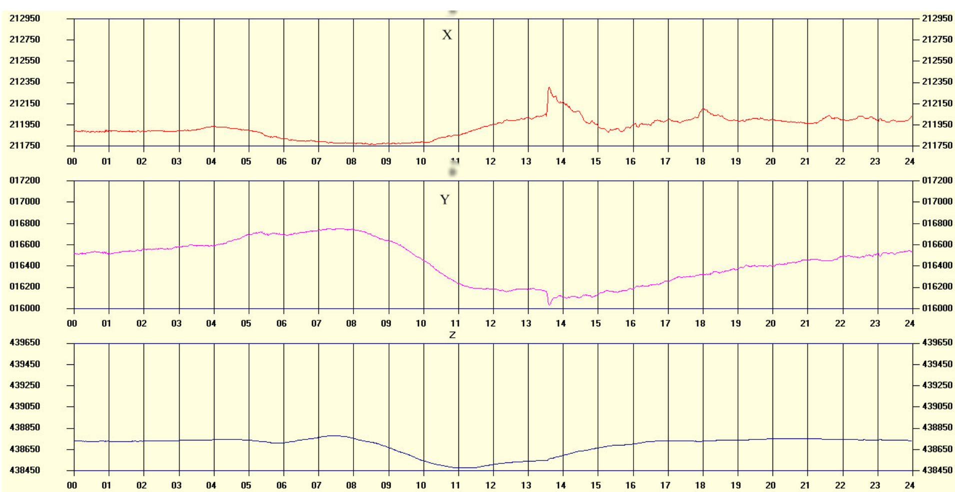

Fig. 6: SSC event identified on SZIGO geomagnetic registration – 02-06-2021 (H, +27.6 nT).

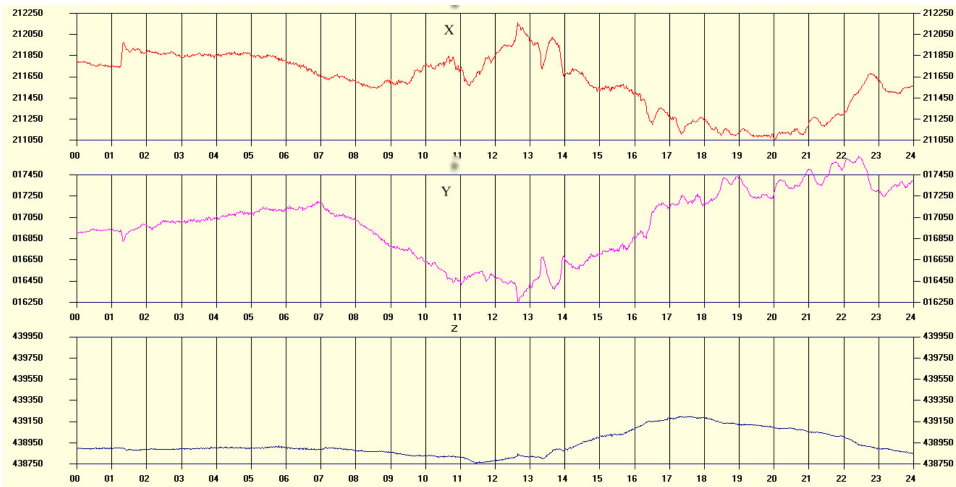

Fig. 7: SSC event identified on SZIGO geomagnetic registration – 27-08-2021 (H, +24.2 nT).

Future prospects

A unique laboratory facility is under construction in the Observatory area in cooperation between Wigner Research Centre for Physics and Institute of Earth Physics and Space Science (Erdős et al., 2019a,b). The main goal of the investment is the implementation of a laboratory environment with an efficient compensation and effective additional shielding of the surface geomagnetic field, eliminating not only the static part, but the external origin dynamic component, too. The quasi real-time second sampled geomagnetic data access is essential for the accurate control of the active compensation system. Furthermore, the geomagnetic and telluric observations will also be accessible within the Space Weather Data Center under construction.

The reconstruction of the permanent geoelectric data acquisition system is also in progress with the intention of increasing the sampling rate, dynamic range and securing data storage, remote access of the telluric registration.

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