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THE ELECTROMAGNETIC PRECURSORY PHENOMENA ASSOCIATED WITH THE EARTQUAKES OCCURED IN THE VRANCEA SEISMOGENIC ZONE

CONTENTS

ABSTRACT

A continuous monitoring of electromagnetic (EM) parameters connected with seismic activity has been carried out since 2000 year at the National Geophysical Observatory Surlari (NGOS), which is located at about 140 km far away of the epicentral area of the seismic-active Vrancea zone. This paper presents the results of a research project which has been granted by the Romanian Academy and it was motivated by the successful experimental data obtained one year before. The main purpose of this work was to elaborate a methodology able to bring to the light a new EM parameter, time invariant for a given geological structure, under non-seismic conditions, such as so called normalized function Bzn = Bz/B (where: Bz is the vertical component of the magnetic induction and B is the horizontal geomagnetic component perpendicular to the strike direction of the geological structure). The temporary anomalous behavior of the parameter Bzn, as a result of the stress changes at the crustal and subcrustal levels, computed for the two months (March and May 2001), was interpreted to be an EM precursor occurred within an interval of some days before a seismic event having a magnitude higher than 3.0. To have a comprehensive view on the applied methodology, this paper is focused on a description of the EM equipment together with the magnetotelluric tensor impedance decomposition technique (used to carry out the type of the geological structure and the strike direction) and the seismicity of the Vrancea zone.

KEY WORDS: Electromagnetic precursory parameter, normalized function Bzn, methodology, seismicity, Vrancea zone

1. INTRODUCTION

Short-term electromagnetic prediction has not been achieved yet despite its importance and many years of research. Recognizing the importance of the recently research works, carried out in countries like China, Italy, Japan, Greece, Russia and USA, published and presented at international symposia, where two kinds of pre-seismic electromagnetic phenomena precursors were reported as: (1) signals possibly emitted from earthquake sources (geomagnetic/geoelectric changes in wide frequency bands); (2) anomalous transmission of electromagnetic waves due possibly to disturbed ionosphere (transmission anomaly of man-made VLF waves and scattering of radio waves VHF), this paper will discuss specifically about a new methodology able to carried out an electromagnetic precursory parameter, time invariant for a given geological structure under non-seismic conditions and which becomes unstable within interval of some days before occurring an seismic event. In this respect, in the paper the following topics will be analyzed: theoretical base of the normalized function Bzn; the establishment of the optimum placement for observation point and evaluation of its geoelectric pattern; monitoring geomagnetic field in order to accomplish the daily variation of the normalized function Bzn, simultaneously with seismic events, with the aim to establish possible connection between them.

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2. THEORETICAL BASE OF THE NORMALIZED FUNCTION BZN

Is well known that at Earth surface the geomagnetic component Bz is entirely secondary field and its existence is an immediate indicator of lateral inhomogeneity (WARD *et alii*, 1970). Bz is produced essentially by B (precisely for two dimensional cases) and consequently a normalized Bz function defined as:

$$Bzn = Bz/B \qquad (1)$$

should be time invariant for a given 2D structure (Stanica, 2001).

In addition to the magnetotelluric tensor impedance, vertical resistivity S_z may be computed:

$$s_z = 0.2\ T\ |E_{II} / B_z|^2 \qquad (2)$$

where: T is the period (in seconds) and E_{II} is electric field parallel to the geological strike direction.

Also, is possible to write the relation:

$$s_{II} = 0.2\ T\ |E_{II} / B|^2 \qquad (3)$$

where: S_{II} is resistivity parallel to the strike.

Thus, in terms of resistivity the normalized function Bzn may be estimated as:

$$|Bzn| = (s_{II} / s_z)^{1/2} \qquad (4)$$

As we have seen in relation (1), the normalized function Bzn could be used as a precursory parameter of seismic event measuring both the vertical component Bz (obtained directly from continuous monitoring of the geomagnetic field) and horizontal geomagnetic component B, which has to be correctly evaluated by using the magnetotelluric tensor impedance decomposition technique (BAHR, 1988, 1990), necessary for to evaluate the geoelectric pattern below the observation station, too.

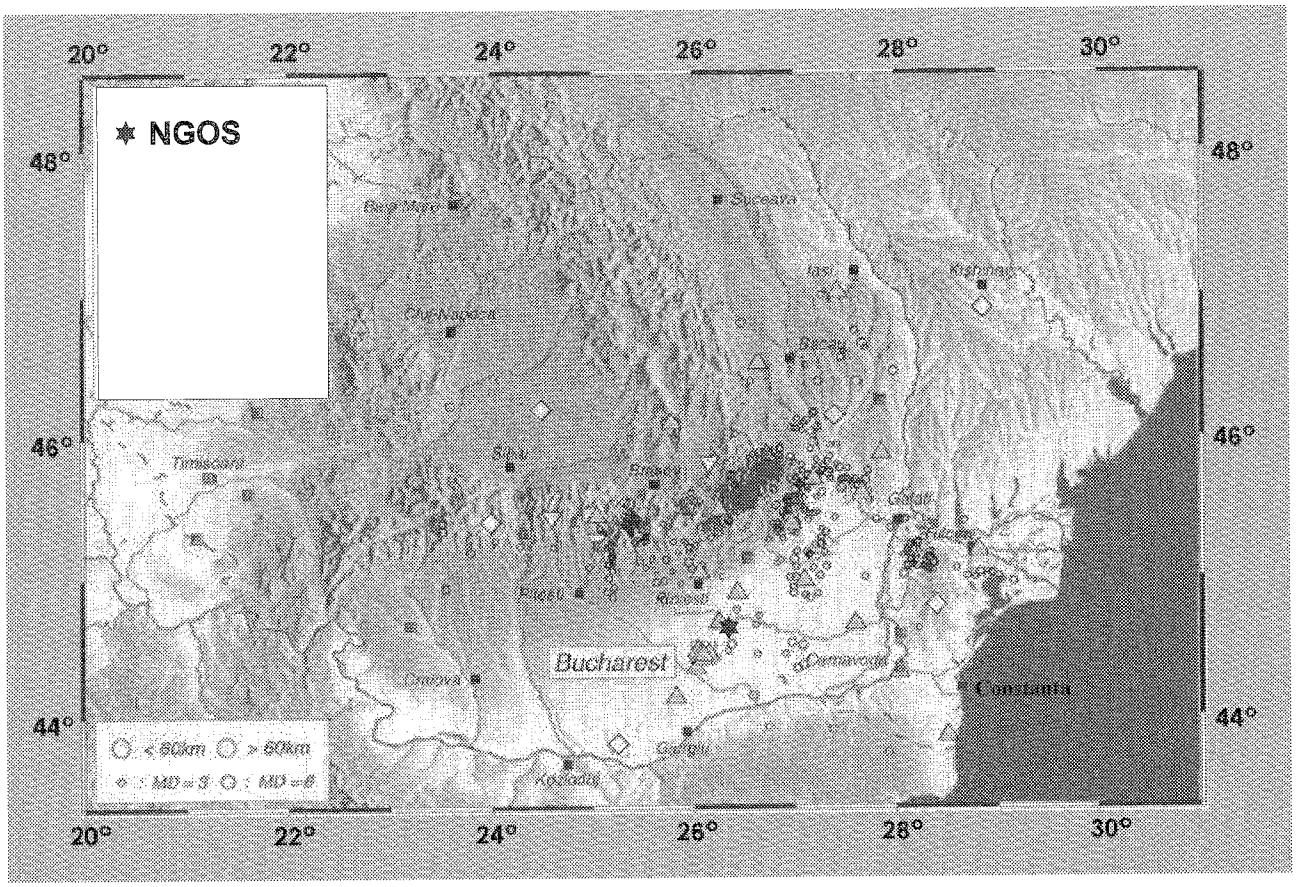

Fig. 1 - Location of the NGOS.

3. THE GEOELECTRIC PATTERN OF THE MEASURING POINT NATIONAL GEOPHYSICAL OBSERVATORY SURLARI (NGOS)

With the aim of identifying the best placement for continuous monitoring of the geomagnetic field and to reveal the short-term precursory parameter of the seismic events, we made magnetotelluric (MT) measurements at NGOS (Fig.1) by using the GMS 06 system installed on mobile laboratory of geodynamic (STANICA & ZUGRAVESCU, 2002). In order to evaluate the geoelectric pattern below the measuring point, the MT data processing have been made with the help of MAPROS software packages (Metronix, Germany) and, consequently, the following basic tasks have been performed:

Real time-display of the electromagnetic data and all important parameters (Fig. 2);

Evaluation of skew coefficients (here being less then 0.2 what means that the geological structure is of 2D type) and strike direction (which for subcrustal levels is about east-west, thus correct values of B are given by the horizontal geomagnetic component orientated towards north - Fig. 2);

The NGOS is placed along an alignment delimited towards north-east by the epicentral Vrancea zone (at about 130 km) and to south-west by Bucharest city (at about 40km). The criteria for selection of this point are presented above and the following aspects must be included, too:

It is far enough to the epicentral Vrancea zone (about 140 km), so that the parameter Bzn is not/less affected by the earthquakes of magnitude less then 3.0;

The existence of logistic base able to supply optimal monitoring of geomagnetic data and electronic connection with Bucharest able to make data transfer in real time;

4. CONTINUOUS MONITORING OF GEOMAGNETIC DATA AND RESULTS

The continuous monitoring of geomagnetic data was accomplished using the recording system MAG03 DAM (Bartington – England), with 6channel, 24 bit resolution for the collection of date from three axis magnetic field sensor MAG03 MC/MSL, data transmitted to the laptop via an optically isolated RS232 serial link (Fig.3). The parameters of the data acquisition card are under software control and additional program collects data at each 5seconds and stores one-minute average values to disk.

Daily average distribution of the parameter Bzn in correlation with Vrancea's deep seismic events occurred simultaneously within the time interval 1-19 March, 2001, is presented in figure 4. The analysis of the Bzn parameter distribution permitted us to identify following aspects:

The normal values of the Bzn parameter in non seismic conditions are of about 1.8615 (± 0.001);

Anomalous behavior within the range 1.860-1.863

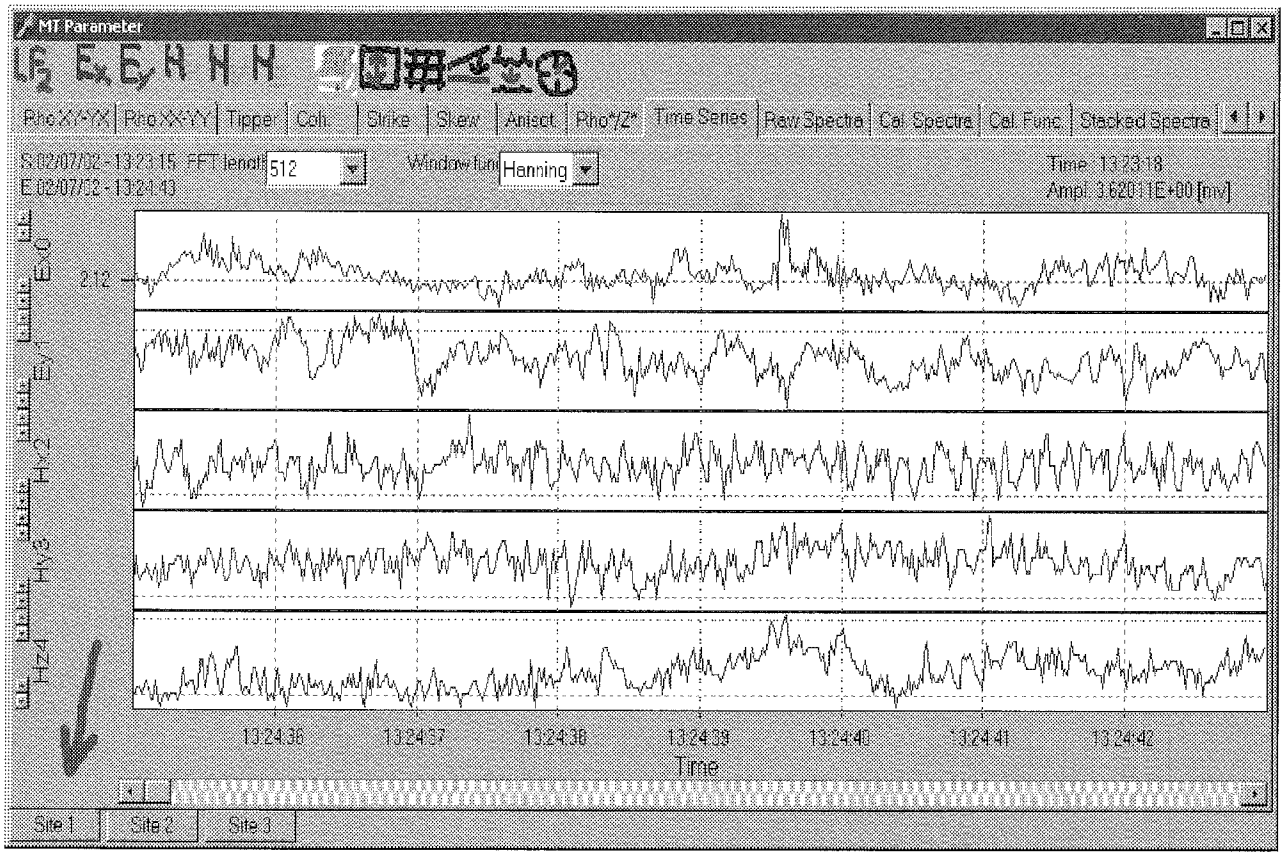

Fig. 2 - Real time-display of the electromagnetic data and the main parameters (including skew coefficients and strike direction).

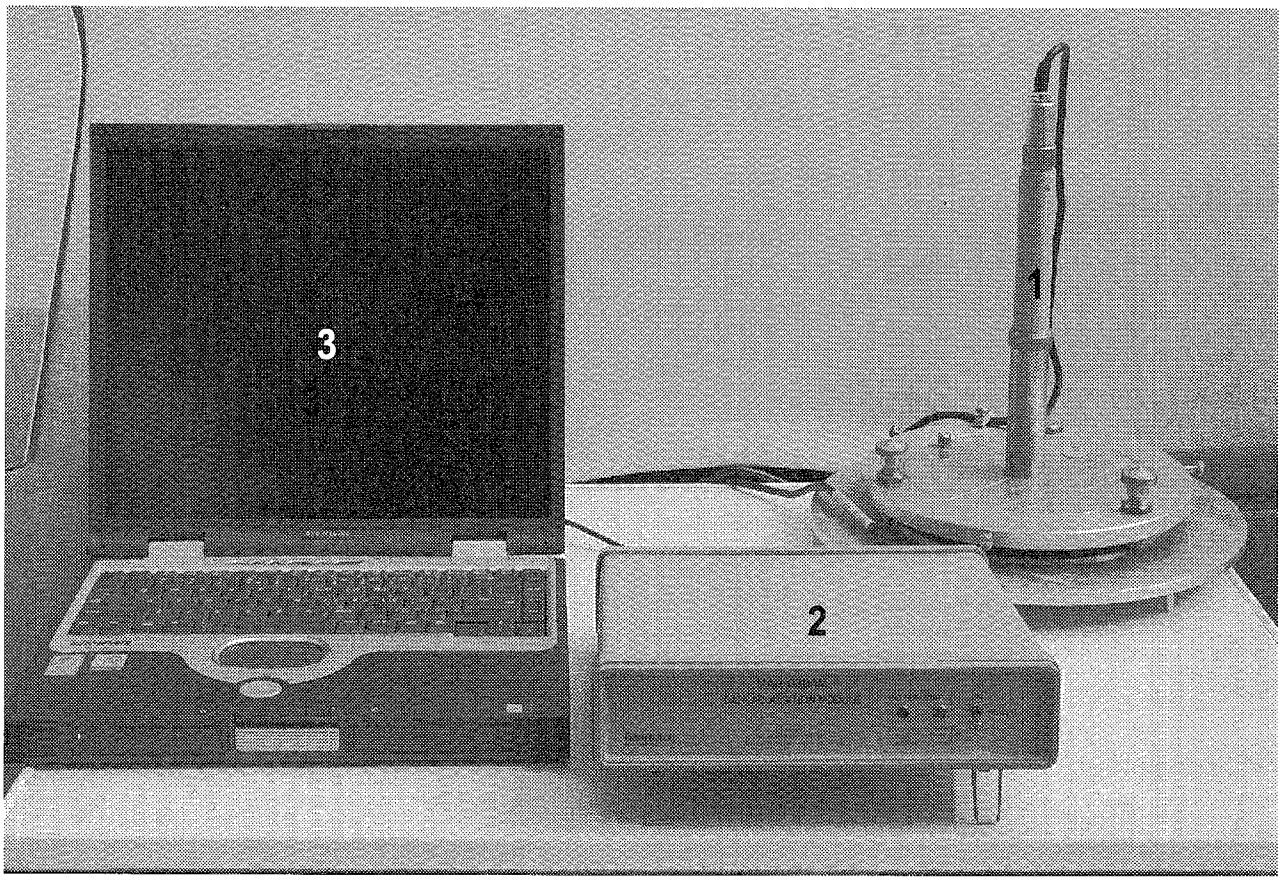

Fig. 3 - The geomagnetic recording system MAG03 DAM. 1 - three axis magnetic sensor; 2 - data acquisition module; 3 -laptop computer.

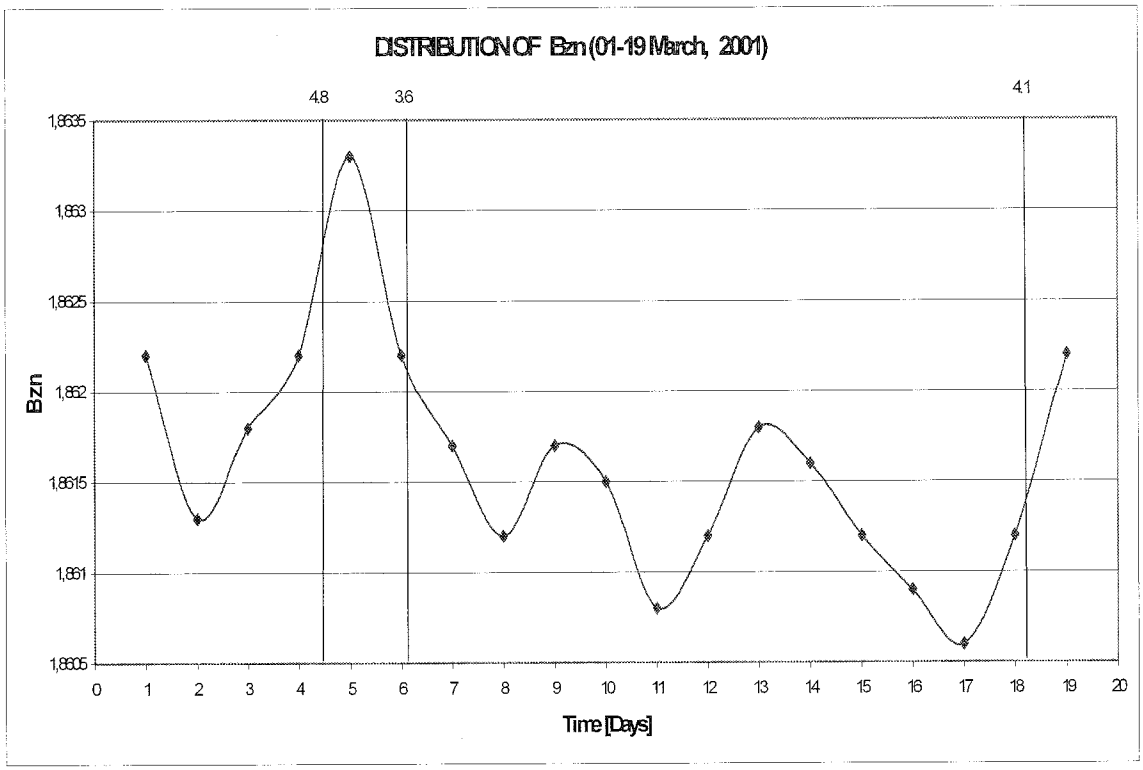

Fig. 4 - Daily average distribution of the parameter Bzn in correlation with Vrancea's deep seismic events occurred simultaneously between 1 and 9 March, 2001.

which may be associated with seismic events of magnitude higher then 3.0.

5. CONCLUSIONS

The new methodology regarding short-term precursory parameter applied firstly at the NGOS gives us the possibility to point out the followings:

With some days before occurring an earthquakes with M>3.0 the normalized function Bzn has a significant increase in respect of its standard deviation, as a result of the lithospheric conductivity changes produced by the dehydration of the rocks, associated with rupturing processes and fluid migration through faulting system inside the Vrancea slab and its surrounding areas;

At this stage of researches, is not possible to make any predictable correlation between the magnitude of seismic event and the magnitude/shape of Bzn function, so that in near future all the efforts should be done in this direction;

The study of EM phenomena/parameters associated with EQ is clearly an urgent scientific need if we are to truly understand the physics of lithospheric failure and make use of all relevant data in mitigation program for natural disasters such as earthquakes.

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REFERENCES

BAHR K. (1988) - *Interpretation of the magnetotelluric impedance tensor: regional induction and local telluric distortion*. Journal of Geophysics, **62**, 119-127

BAHR K. (1990) - *Geological noise in magnetotelluric data: a classification of distortion type*. Physics of the Earth and Planetary Interiors, **66**(1990), 24-38.

STANICA D. (2001) - *Precursory phenomena of the Earthquakes produced in the seismic active Vrancea zone reflected by specific changes of the electromagnetic parameters*. IAGA-IASPEI, 19-31 August, Hanoi, Vietnam, 2001, Abstracts Volume, p.21-22

STANICA D. & ZUGRAVESCU D. (2002) - *Mobile geophysical laboratory for complex studies in geodynamic active zones*. International Workshop and COST Action-625: Active Fault; Analysis, processes and monitoring, Universita di Camerino, Italy, May 3-6, 2002, Abstract Volume, 132-133.

WORD R.D., SMITH H.W., BOSTICK JR. F.X., (1970) - *An investigation of the magnetotelluric tensor impedance method*. The University of Texas at Austin, Texas, USA, pp.242