RESULTS - stage 2010

Electromagnetic impedance tensor decomposition

A correct interpretation of the electromagnetic data (EM) implies to know the dimensionality and direction of the investigated structure, and also an adequate method to eliminate local effects in order to carry out a representative structure for seismic-activeVrancea zone.

Monitoring the electromagnetic field in the domain of low frequences (DC-0,1Hz) was accomplished to emphasize the particularities of structural dimensionality and multiparametric space-temporal distribution associated to the intermediary depth seismic activity in Vrancea zone, by obtaining the skew (used to find out 1D, 2D or 3D structure) and strike (used to find out the direction of geoelectric structure) parameters.

Space-temporal distributions of the electromagnetic parameters associated to seismic activity in Vrancea zone

After installing the continuous monitoring system at Geodynamic Observatory Provita de Sus (GOPS), it is presented the mode of obtaining geomagnetic time series ($B_\perp$, By şi B_z) in real time, which are to be used for assessing the Bzn parameter with relation:

$$Bzn\ (f) = B_z(f)/B_\perp(f) \qquad (1\text{-}1)$$

where: $B_\perp$ şi B_z are the two components – perpendicular and paralell- of the geomagnetic field;

f = frequency in Hz

It was also demonstrated that between Bzn and resistivity there is the following interdependence relation (Stanica and Stanica, 2010):

$$\left| Bzn\ (f) \right| = [\rho_{||}(f)/\rho_z(f)]^{1/2} = \rho n\ (f)^{1/2}, \qquad (1\text{-}2)$$

where: $\rho_{||}$ şi ρ_z are the paralel and vertical components of resistivity.

This relation defines the connection between the Bzn parameter and resistivity changes (electric conductivity) produced before a seismic event as a sequence of dehidratation of the rocks associated with rupture and migration processes of the fluides through the system of faults developed inside and in vecinity of seismic focus.

The used monitoring methodology assured the time series corresponding to the geomagnetic components $B_\perp$, By şi Bz, with a sampling rate $\Delta t = 5$ sec., being mediated and stored at every 60 sec. on a computer as a * .txt file. These file were daily transfered to Bucharest by means of Transmission System of Electromagnetic Data (STDE) – wireless type, to be processed for obtaining the Bzn parameter having a precursory character to the seismic activity in Vrancea zone.

Some results with a conclusive character reffering to the seismic hazard assessment in Vrancea, for 2009 year, are presented in Fig.2-1, according to which, for the analized interval, an earthquake (EQ) of $M \geq 4$ is possible to occur when $Bzn \geq 1.846$, while a $Bzn \geq 1.851$ may be, the most probably, a precursory value for an earthquake of $M \geq 5$.

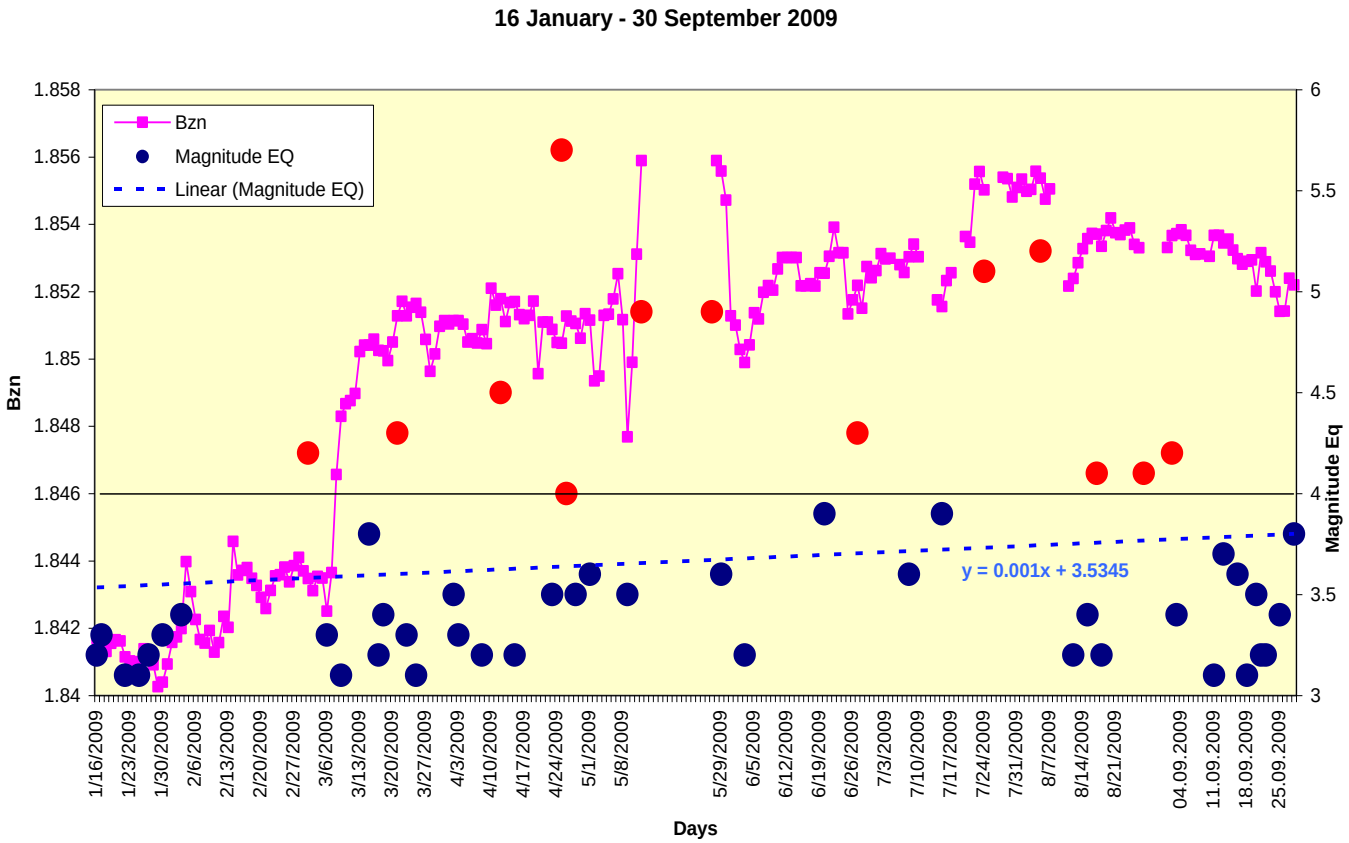

Fig. 2-1.Distributions of the Bzn parameter and seismic activity magnitude in Vrancea zone; blue points represent EQ of M< 4, and red points represent EQ of M ≥4

Space-temporal distribution of the electromagnetic and electric parameters associated to the geodynamic activity of landslides

To assess the hazard generated by landslides, unlike seismic hazard, it was used an HF electromagnetic methodology (5H-20kH) able to emphasize all the parameters giving information from the depth interval 0-50m, so that we can determine not only structural dimensionality characteristics, but, eventually, also the dynamics of rocks volume affected by slip process. Therefore, the landslide Provita de Sus was selected as a 'test zone' that, owing to the relative short distance from Vrancea zone and presence of an active lithospheric fault, brings toghether necessary conditions to associate this with seismic events.

The processing of time series carried out by a continuos monitoring and records in discrete points on this landslide was realized by applying a specialized programs set based on robust spectral analysis and impedance tensor decomposition. This soft permitted to determine all the electromagnetic parameters (paralel resistivy-$\rho_{\parallel}$, perpendicular resistivity-$\rho_{\perp}$, skew, strike and AE) in real time.

Spatial distribution of the apparent resistivity, containing slip interface and a micro-fracture, was put into evidence by means of a tomographic image obtained with vertical electric soundings (SEV) on a profile placed along slip plane (Fig.2-2).

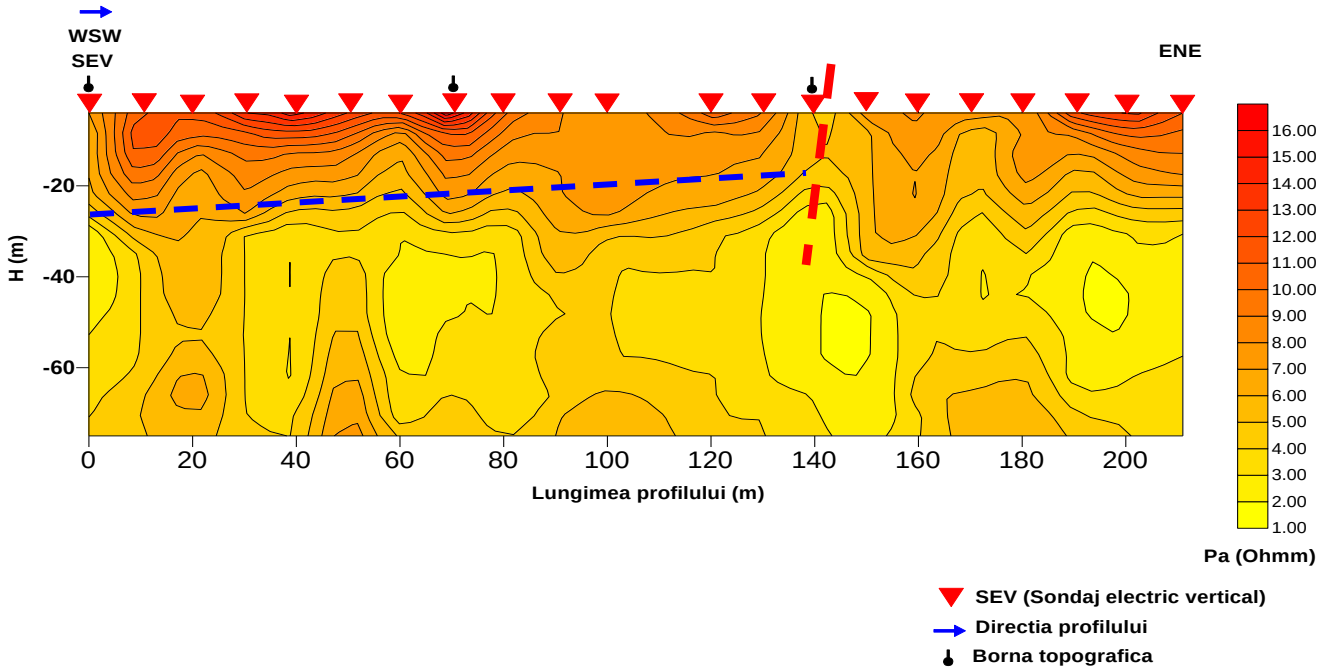

Fig. 2-2. 2D tomographic image of the apparent resistivity distribution and slip surface (marked by blue dashed line); the dashed red line represents a micro-fracture

The assessment of the hazard level for Provita de Sus landslide

To study the evolution in time of the Provita de Sus landslide, associated to seismic activity in Vrancea zone, we considered necessary to take as reference the hazard level determined immediately after the EQ with M=5.0, triggered on 25 April , 2009.

Theoretical approach developed in the frame of this project, reffering to the hazard level assessment of the Provita de Sus landslide, is based on macrozonation methodology elaborated by Mora and Vahrson (1994), which we adapted taking into account information carried out by electromagnetic monitoring. Under these circumstances, the hazard level of this landslide ($H_{landslide}$) is defined by a sum of susceptibility and trigger action factors:

$$\mathbf{H_{landslide} = (Sr * Sl * Sh) * (Ts)}, \qquad (2\text{-}3)$$

To determine the relative hazard level of the Provita de Sus landslide, we applied the equation (2-3) to the conditions specific of zone, taking into account that the triggering factor was the EQ with M=5.0 (April, 2009), in the following way:

$$\mathbf{H_{landslide} = (3 * 4 * 4) * (1) = 48},$$

where:

- **Sr = 3** (**slope angle** of the slip = $\mathbf{18^0}$ and, according to the Mora and Vahrson's classification the susceptibility is **„medium"**;
- **Sl = 4** (from lithological point of view the cover affected by slip is represented by sedimentary rocks of Cenozoic and şi Quaternary age, and, accordingly to the mentioned classification , the susceptibily is „**high"**);

- **Sh = 4** (soil humidity factor is correlated with very low values (**6-8 ohm.m)**of the apparent resistivity observed on the slip surface of the 2D tomographic image (Fig.2-5), then the susceptibility is „**high**";

- **Ts = 1** (pick acceleration on ground (PGA) determined in landslide zone for EQ occured on 25 April, 2009, was ranged between 25-28 cm/s^2 and, according to the classification the seismic trigger action indicator is **1**)

As the $\mathbf{H_{landslide}}$ is **48,** in conformity with Mora and Vahrson's classification (1994), the hazard potential of the Provita de Sus landslide is of **„moderat" type** (class 3 for any $H_{landslide}$ comprised between 33-162)..

Diseminarea informației

To promote the results obtained in the frame of this stage of the project, the involved team published papers in specific reviews (ISI şi BDI) and took part at national and international scientific conferences and workshops.

Papers in speciality review ISI rated

Stanica, D., and Stanica, D.A.: Constraints on correlation between the anomalous behaviour of electromagnetic normalized functions (ENF) and the intermediate depth seismic events occurred in Vrancea zone (Romania), Terr.Atmos.Ocean. Sci., Vol. 21, No. 4, 675-683, **2010**, doi:10.3319/TAO.2009.09.09.01 (T).
D. Stanica, and D. A. Stanica: Anomalous pre-seismic behavior of the electromagnetic normalized functions related to the intermediate depth earthquakes occurred in Vrancea zone, Romania, EGU,NHESS, 2010 (in print).

Papers in speciality review internațional rated

Stanica, D.A, and Stanica, D.: Specific ground-based monitoring system for landslides activity. Rev. Roum.de Geophysique, 54, 2010 (in print).
Popescu, M.: Correlation phase variations of the geomagnetic signal with seismic events. Part I., Rev. Roum.de Geophysique, 54, 2010 (in print).
Dragos Armand Stanica: Analysis of electromagnetic data related to significant earthquakes occurred in February-March period, 2010, in Vrancea zone. Extended abstract in Abstract Volume, EMSEV Workshop, Chapman University, Orange, CA, USA, October 3-6, 2010, 81-84.

Participation at national and international conferences

Dumitru Stanica and Dragos Armand Stanica, Anomalous electromagnetic signals associated with the intermediate depth earthquakes, EGU, Geophysical Research Abstracts, Volume 12, EGU 2010, ISSN: 1029-7006.
Dragos-Armand Stanica, Dumitru Stanica and Constantin Diacopolos, Landslides induced by earthquakes reflected by electric and electromagnetic data, EGU, Geophysical Research Abstracts, Volume 12, EGU General Assembly 2010, ISSN: 1029-7006.
Dumitru Stanica, Dragos Armand Stanica, EM pre-seismic responses related to the intermediate depth earthquakes occurred in the active Vrancea zone, Romania, Abstracts Volume at JPGU Meeting, May 2010, Chiba, Japan.
Dragos Armand Stanica , Dumitru Stanica, EM images used for emphasizing the tectonically-induced electrical conductivity anomaly by the Trans-European Suture Zone in Romania, Abstracts Volume at Japan Geophysical Union Meeting, May 2010, Chiba, Japan.
Dragos Armand Stanica, Analysis of electromagnetic data related to significant earthquakes occurred in February-March period, 2010, in Vrancea zone, **Extended abstract** at Workshop on "Electromagnetic Signals Associated with Earthquakes and Volcanoes" October 3-6, 2010, Chapman University, Orange, CA, USA, 81- 84.
Stanica Dumitru and Stanica Dragos Armand, Investigation of the electromagnetic anomalies induced by intermediate depth earthquakes (M > 4) occurred in Vrancea zone, Abstract Volume, at Workshop on "Electromagnetic Signals Associated with Earthquakes and Volcanoes" October 3-6, 2010, Chapman University, Orange, CA, USA.