RESULTS - STAGE 2009

To monitor certain "physical operators" characteristic to the landslide triggered by seismic events of Vrancea zone, and to apply some correlation methodologies of the two geodynamic processes, in this study we realized **a theoretical multiparametric approach (skew, strike, electrical anisotropy, parallel resistivity and perpendicular resistivity to the structure) of the electromagnetic and geoelectric fields anomalies in order to emphasize the interconnection between structure, evolution and geodynamic instability level.**

A. Determination of the significant electromagnetic parameters:

- **Impedance tensor,** that characterizes the liniar interdependence

between electric and magnetic fields components simultaneously recorded, by means of relation:

$$\begin{pmatrix} E_x \\ E_y \end{pmatrix} = \begin{pmatrix} Z_{xx} & Z_{xy} \\ Z_{yx} & Z_{yy} \end{pmatrix} \begin{pmatrix} H_x \\ H_y \end{pmatrix}$$

- **Parallel resistivity ($\rho\|$) and perpendicular resistivity ($\rho\perp$):**

$$\rho_{\|} = 0.2/f * | Z_{\|} |^2$$

where $Z\| = E\|/H\perp$, and f is frequency (Hz)

$$\rho_{\perp} = 0.2/f * | Z_{\perp} |^2$$

where $Z\perp = E\perp/H\|$;

- **Skew parameter (characterizing the structural dimensionality) :**

$$\kappa = |S1|/|D2| ,$$

where $S1 = Zxx + Zyy$ şi $D2 = Zxy - Zyx$

Skew parameter (κ) must be < 0.3 so that we can interpret the structure as being as 2D type**.**

- **Strike parameter (direction of structure):**

To determine the direction of regional and/or 2D local structure the following relation is used:

$$tg(4\alpha) = 2\,Re(S2.|D1|)/(|D1|2 - |S2|2)$$

where : $S2 = Zxy + Zyx$; $D1 = Zxx - Zyy$

- **Electromagnetic anisotropy parameter (EA):**

$$EA = |Zyx| / |Zxy|,$$

or, depending of resistivity,

$$EA = |\rho_{\perp} / \rho_{\parallel}|$$

- **Geomagnetic parameter Bzn:**

In case of 2D structure, the vertical magnetic component Bz is mainly produced by the magnetic component perpendicular to the direction of structure (B⊥), and, as a sequence, a normalized function Bz , defined by relation:

$$Bzn = Bz/B\perp ,$$

must be invariable in time for a 2D structure (Word et al., 1970), under circumstances of "seismic calm", and it becomes variable under geodynamic conditions (Stanica et al 2006, 2007, 2009).

In resistivity terms, the normalized function Bzn is

$$|Bzn| = (\rho\| / \rho z)1/2$$

and, implicitly, the normalized resistivity becomes

$$\rho n = \rho\| / \rho z .$$

The last relations emphasize that Bzn may be associated with variation of electrical conductivity produced as a sequence of the ruptural and deshidratation processes of the rocks, accompanied by fluids migration along the faults system existing at crustal and subcrustal level.

B. Interconexiune multiparametrică pentru evaluarea hazardului natural

To assess the natural hazard level of a major landslide triggered by a seismic event in Vrancea zone, on base of indices and indicators, it is necessary to establish the most relevant variables (parameters), in accordance with local and regional conditions specific to areas susceptible at such kind of events.

In this context, it must be mentioned that the multiparametric approach of a structure susceptible of a landslide is useful both for elaboration of geodynamic models and to identify those indicators which may contribute to the evolution predictability of respective hazard phenomenon (Table 1 and Table 2).

TABLE 1 – High frequency electromagnetic data and DC resistivity data, used as variables, indices and indicators for the natural hazard assessment due to landslides

Variables:	Indices	Indicators
1.High frequency electromagnetic data : • resistivitate perpendiculară - $\rho^{\perp}$; • resistivitate paralelă - $\rho^{\parallel}$; • skew; • strike; • anizotropie 2.Geoelectric data – DC resistivity • apparent resistivity; • electric anisotropy	• Multiparametric time series (electromagnetic and geoelectric); • Multiparametric space-temporal distributions spațio-temporale, multiparametrice (electromagnetic and geoelectric); • Frequency of the earthquakes and tectonics of associated processes (active faults, cracking zones, etc.) deduced from electromagnetic, geoelectric and geomagnetic data	• Identification of anomalies in the space-temporal distribution of electromagnetic and geoelectric indicators; •Quantitative evaluation and hierarchy of indices involved in the hazard evaluation;

TABLE 2. Electromagnetic data used as variables, indices and indicators for the natural hazard assessment due to seismic activity

Variables:	Indices	Indicators
1.Low frequency electromagnetic data: • perpendicular resistivity - $\rho^{\perp}$; • parallel resistivity - $\rho^{\parallel}$; • skew; • strike 2. Geomagnetic data • Bzn parameter	1. Temporal distribution: • Bzn parameter associated to intermediary depth seismic activity 2 Multiparametric electromagnetic space-temporal distributions: • characteristics of structural dimensionality	1. Identification of the anomalies in space-temporal distribution of electromagnetic and geomagnetic indices; 2. Quantitative evaluation and hierarchy of indices involved in the hazard evaluation;

DATA DISEMINATIONS

Participation at national and international conferences, and publications

a) Publication in review ISI rated:

D. Stanica and D. A. Stanica, 2009: Constraints on correlation between the anomalous behaviour of electromagnetic normalized functions (ENF) and the intermediate depth seismic events occurred in Vrancea zone (Romania), TAO Journals, Taiwan, accepted for publishing: T090202

b) Publications in reviews international rated (BDI):

Dumitru Stanica and Dragos Armand Stanica: "Carpathian electrical conductivity anomaly (CECA) acting as high sensitive path to emphasize the EM precursory parameters associated to seismic events", Presentation and Extended Abstract in "Collection of the 9-th China International Geo-Electromagnetic Workshop", CIGEW2009, Guilin-China, 4-8.

Dragos Armand Stanica, Maria Stănică and Constantin Diacopolos: "Electromagnetic Responses in the Seismic Induced Landslides Area", Presentation and Extended Abstract in "Collection of the 9-th China International Geo-Electromagnetic Workshop", CIGEW2009, Guilin-China, 8-11.

c) Communications presented at national and international conferences

Stanica, D. A. Stanica, M. Popescu, N. Vladimirescu: Surveying the seismic hazard by using ground based analysis of Earth's electromagnetic field, EGU, Geophysical Research Abstracts, Volume 11, April, Vienna, Austria, 2009, ISSN: 1029-7006.

D.A. Stanica, M. Stanica and C. Diacopolos: Electromagnetic studies on geodynamics related to the landslides associated to the seismic events, EGU, Geophysical Research Abstracts, Volume 11, April, Vienna, Austria, 2009, ISSN: 1029-7006.

M. Stanica and D. Stanica: Vrancea zone geodynamics and the explanation of the earthquakes mechanism, Abstracts Volume at JPGU Meeting, May 2009, Chiba, Japan.

D. Stanica and M. Stanica: Electromagnetic methodology on seismic hazard assessment, Abstracts Volume at JPGU Meeting, May 2009, Chiba, Japan

Dragos Armand Stanica: Near-Real Time Analysis of the Electromagnetic Precursors for Seismic activity, AOGS, Program and Abstracts, IWG07, p343, Singapore, 2009, ISBN 978-981-08-2846-2.

Dumitru STANICA and Maria STANICA : Earthquake-induced landslides geohazard assessment (South Sub-Carpathians) by using electromagnetic data, Abstract Volume IAGA meeting, August 23-30, 2009, Sopron, Hungary.

Stanica D, Stanica D.A., 2009, Carpathian electrical conductivity anomaly (CECA) acting as high sensitive path to emphasize the EM precursory parameters associated to seismic events. In: Papers Collection of the 9th International Geo-electromagnetic Workshop (CIGEW), China, 4-7.

Stanica D.A., Stanica Maria, Diacopolos C, 2009: Electromagnetic responses in the seismic induced landslides areas. In: Papers Collection of the 9th International Geo-electromagnetic Workshop (CIGEW), China, 8-10.

Dumitru Stanica and Dragos Armand Stanica, 2009, Electromagnetic responses related to intermediate-depth earthquakes within Vrancea zone, Conference Abstracts, International Experts Meeting on Carpathian Geodynamic Network, 19-21 November 2009, Bucharest, 15.