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SHORT-TERM EM PRECURSORY PARAMETERS RELATED TO THE INTERMEDIATE DEPTH EARTHQUAKES

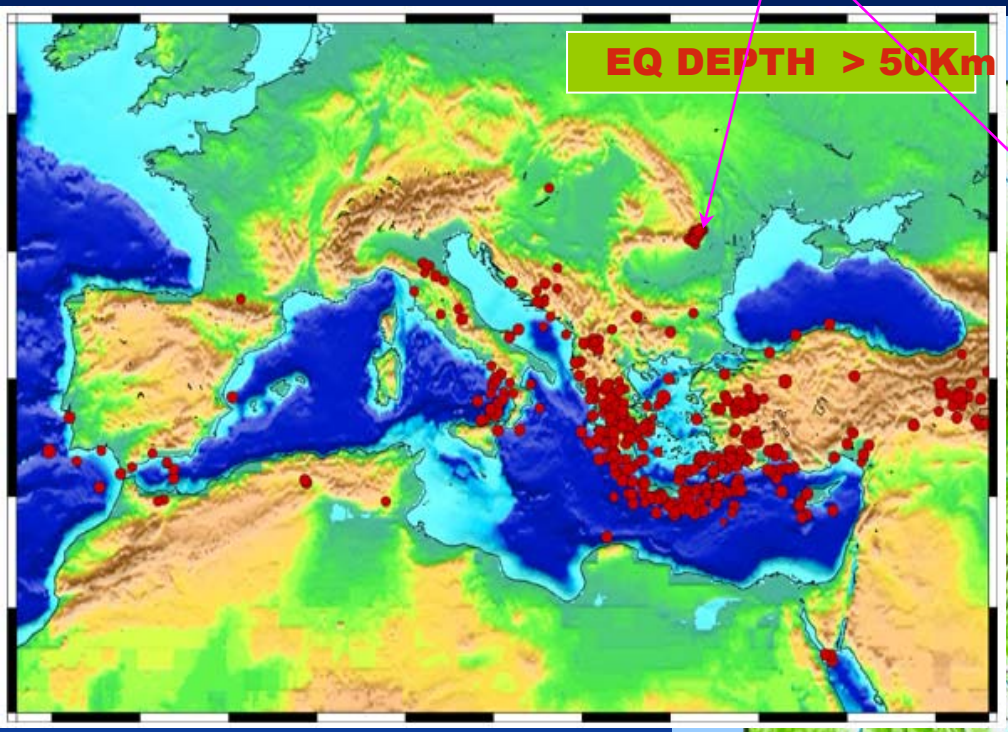
D. Stanica, D.A. Stanica, N. Vladimirescu, M.Popescu

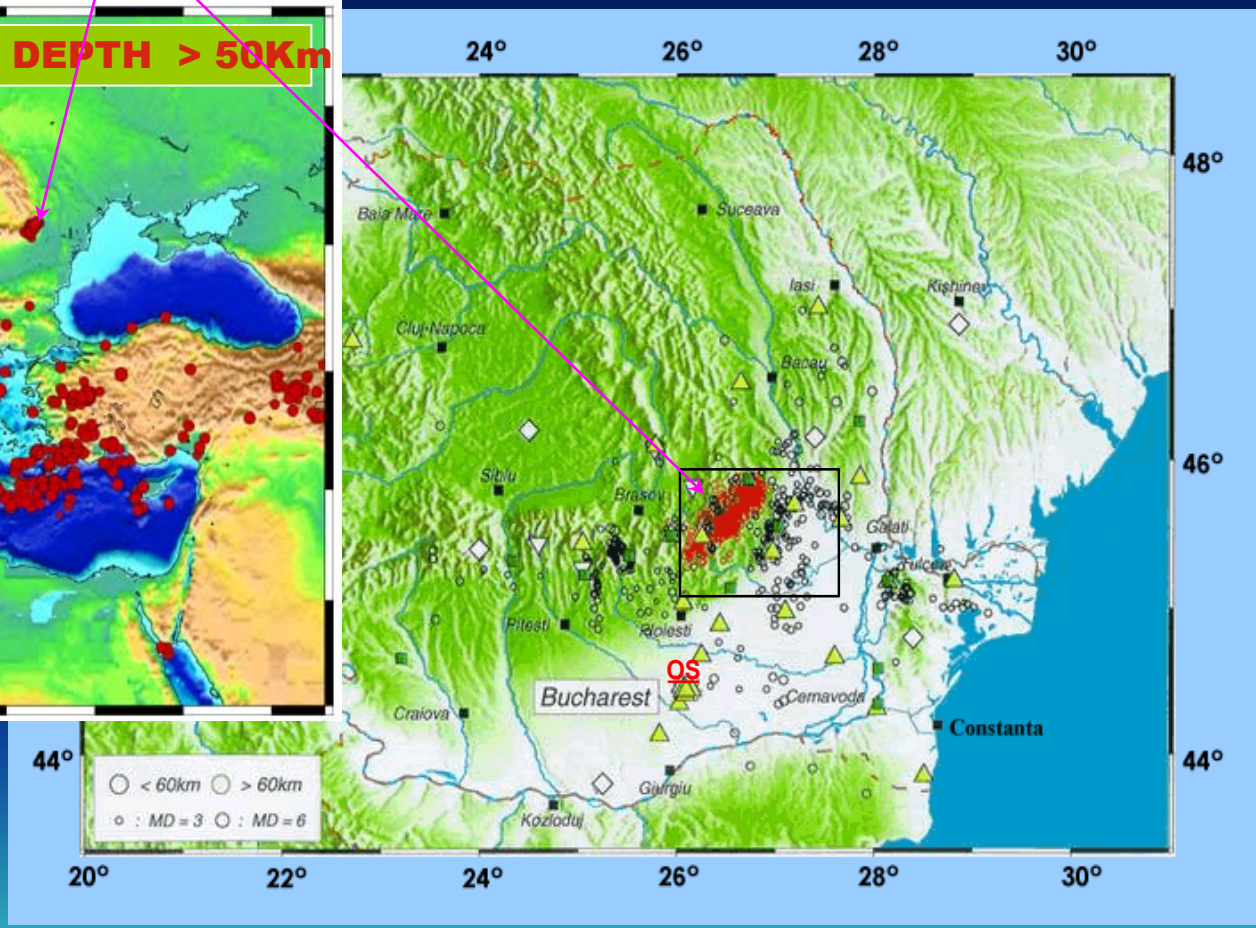
OUTLINE :

- Seismic active Vrancea zone – intermediate depth EQ;
- Ground-base monitoring technique used to emphasize the electromagnetic marks related to the intermediate depth earthquakes:

1. Electromagnetic (EM) phenomena/parameters related to earthquakes
2. EM studies for pattern recognition in order to select the optimum site of observation;
3. Continuous monitoring to get the geomagnetic field;
4. Results :
   - daily mean distribution of the Bzn parameter used as possible precursory marks of the EQ

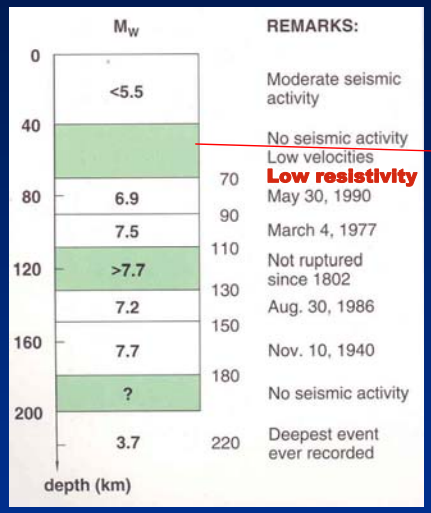
Vrancea zone – intermediate depth EQ

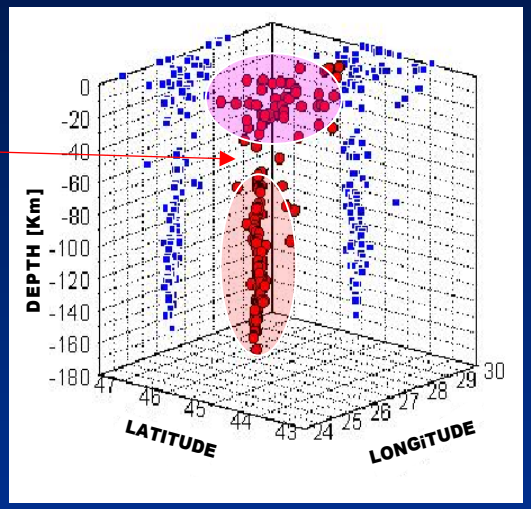




Vrancea zone

Intermediate depth EQ





BUCHAREST – March 04, 1977 (about 1500 people died)

Strong intermediate-depth EQs (since 1600)

No.	Date (month/day/year)	Magnitude
1	9/01/1637	6.6
2.	9/09/1679	6.8
3.	8/18/1681	6.7
4.	6/12/1701	6.9
5.	10/11/1711	6.7
6.	6/11/1738	7.0
7.	4/06/1790	6.9
8.	10/26/1802	7.4
9.	11/17/1821	6.7
10.	11/26/1829	6.9
11.	1/23/1838	6.9
12.	10/06/1908	6.8
13.	11/01/1929	6.6
14.	3/29/1934	6.9
15.	11/10/1940	7.4
16.	3/04/1977	7.5
17.	8/30/1986	7.2
18.	5/30/1990	6.9
19.	10/27/2004	6.0

Electromagnetic (EM) phenomena/parameters related to earthquakes

- **Signals possibly emitted from earthquakes sources:**
  - geomagnetic/ geoelectric changes in ULF – ELF – VLF – LF – HF bands;

- **Anomalous transmission of electromagnetic waves due possibly to disturbed ionosphere:**
  - transmission anomaly of man-made waves (VLF) and scattering of MF radio waves (VHF);

- **Anomalous behaviour of the EM parameters:**
  - the electric conductivity changes in seismic active zones and their neighborhood.

Theoretical information regarding the normalized function Bzn

Surface vertical magnetic component (Bz) is an entirely secondary field and its existence is an immediate indicator of the lateral inhomogeneity. For 2D structure the Bz is produced essentially by $B_{\perp}$ and consequently:

$$Bzn(f) = Bz(f) / B_{\perp}(f) \quad , \qquad (1)$$

should be time invariant for a given 2D structure in non seismic conditions.

We may compute:

$$\rho_z(f)=0.2/f \; . \left| E_{\parallel}(f)/B_z(f) \right|^2, \qquad (2)$$

where f is frequency (Hz) and $E_{\parallel}$ is electric field parallel to the strike

Also:

$$\rho_{\parallel}(f) = 0,2/f \; . \left| E_{\parallel}(f)/B_{\perp}(f) \right|^2 , \qquad (3)$$

thus, in terms of resistivity:

$$\left| B_{zn}(f) \right| = [\rho_{\parallel}(f)/ \rho_z(f)]^{1/2} \longrightarrow \rho_n = \rho_{\parallel}(f)/ \rho_z(f) \qquad (4)$$

(Bzn could be linked to variation of the electric conductivity at the different depth levels into the Earth)

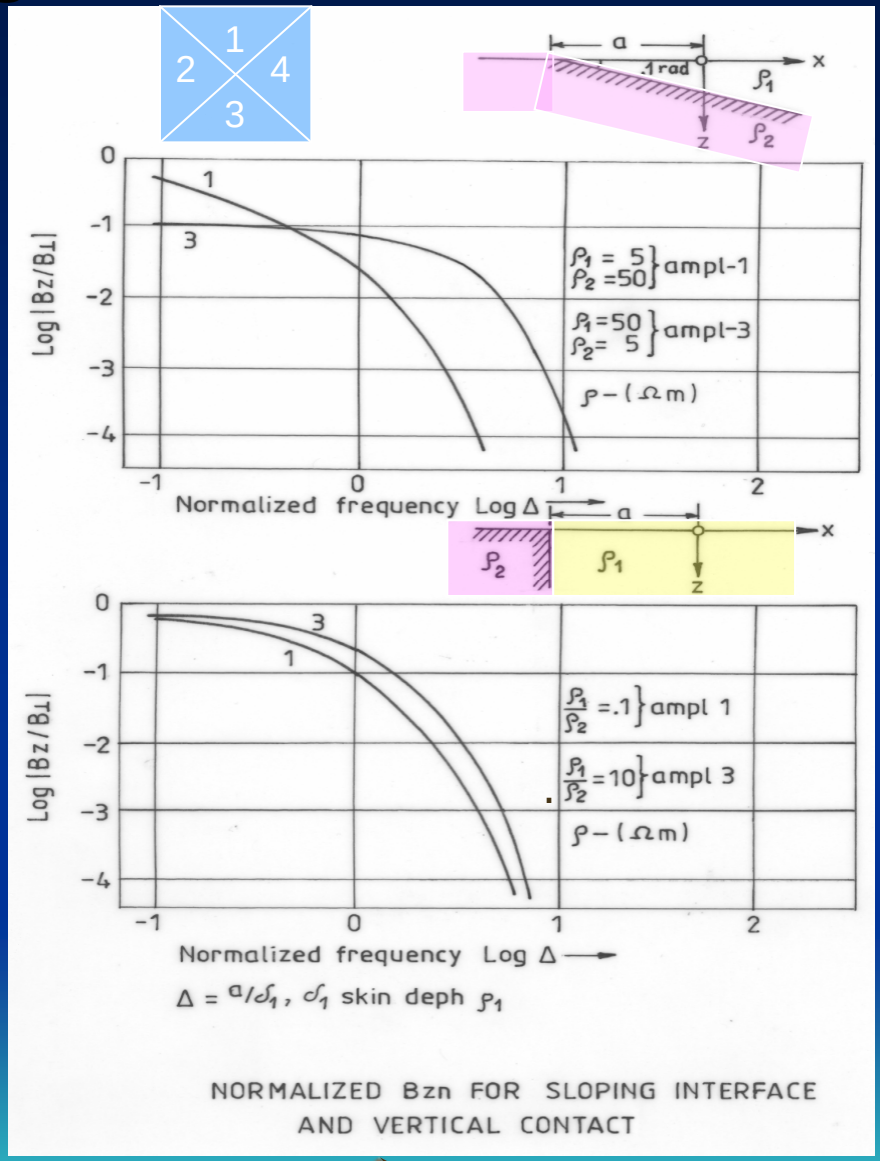
2D modeling by using the finite element code

Approximate field solutions were computed for two simple 2D geometries:

1. The sloping interface solution was obtained by summing all plane waves propagation at real angle, ignoring effects of apex ;

2. The vertical contact solution was computed for two resistivities.

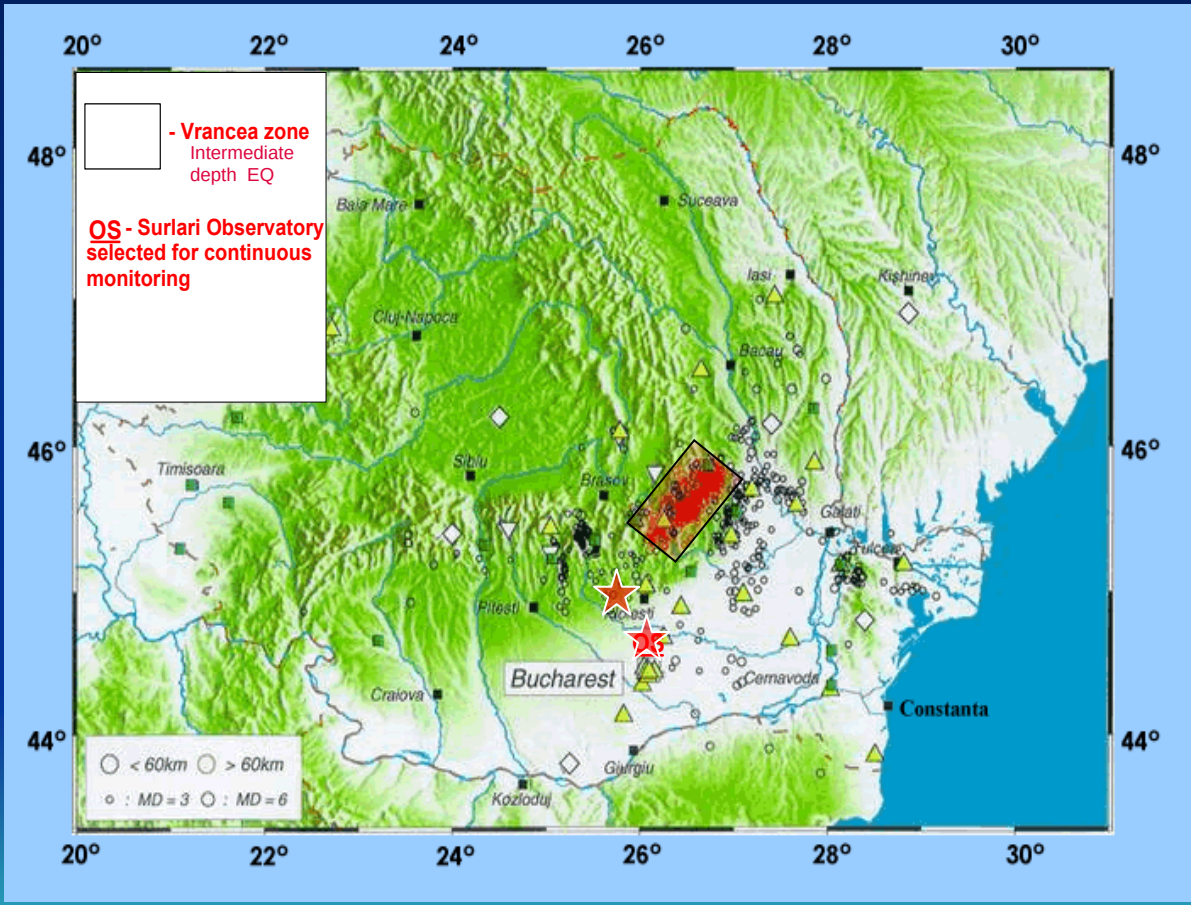
The similarity in the properties of Bzn for the both models is of interest in our study



NORMALIZED Bzn FOR SLOPING INTERFACE AND VERTICAL CONTACT

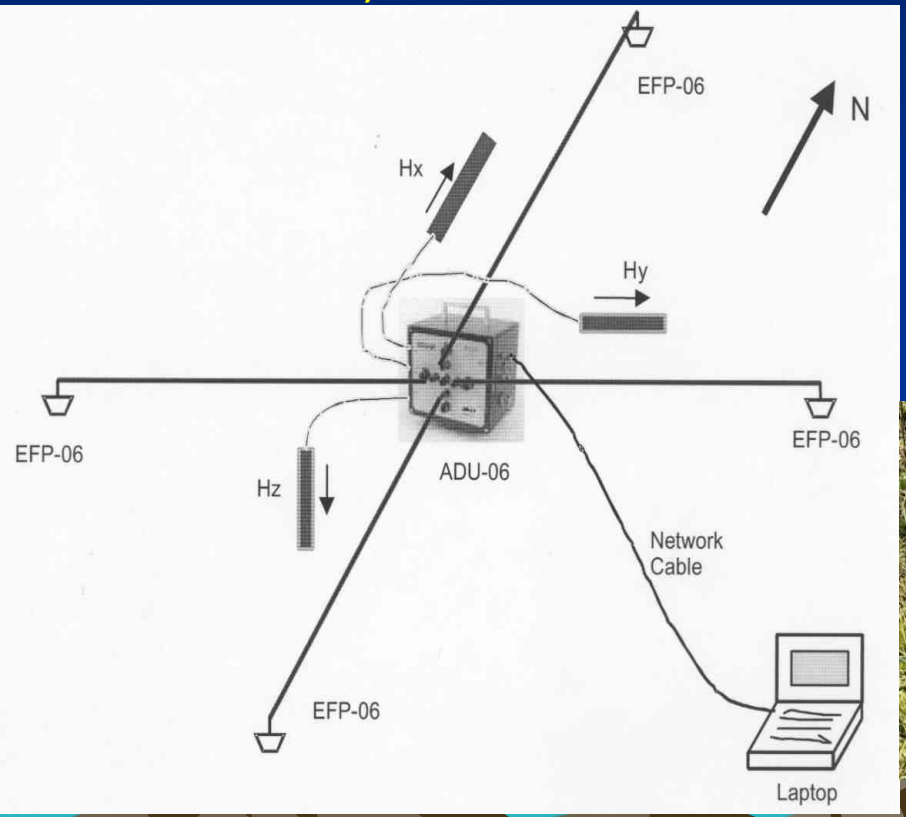
EM studies for pattern recognition in order to select the optimum site of observation

- Type of the geoelectrical structure (skew) ;
- Strike orientation in order to determine $B_{\perp}$;
- Distribution of the Bzn parameter in non seismic conditions.

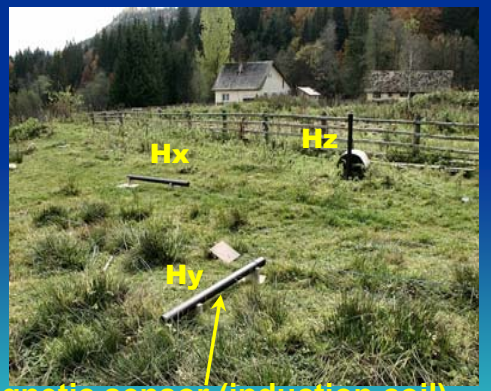


Geophysical equipment used for establishing the geoelectric pattern of the measuring points

- Electromagnetic system GMS-06 used for discrete measurements (ADU 06 with 5 channels, 24 bits; EFP-06 are E-field sensors; Hx, Hy, Hz are induction coil magnetometers; laptop-for real time MT data estimation).

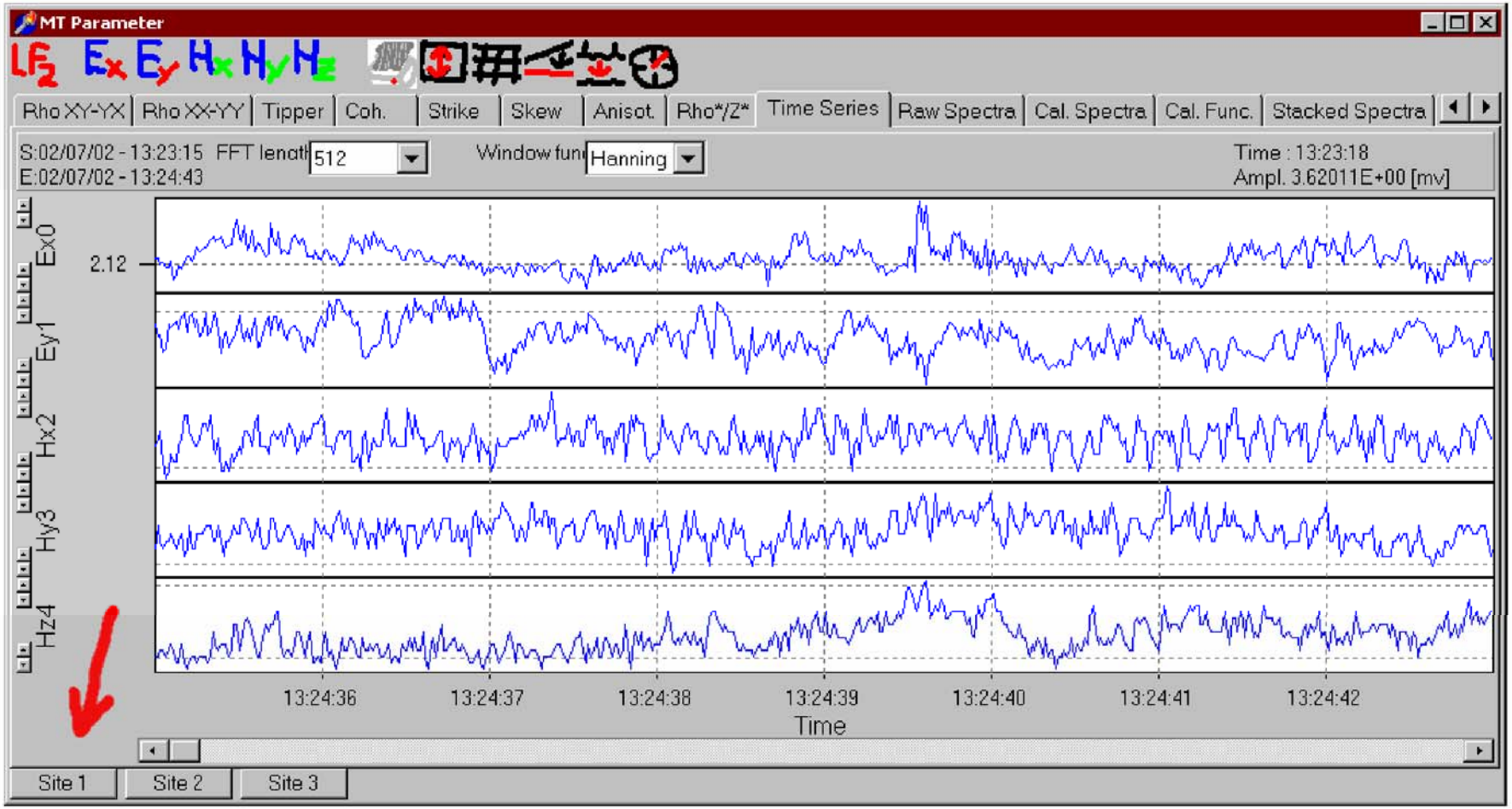


- ADU 06 with 5 channels, 24 bits



2 frequency ranges:
- HF = 0.5kHz - 24 kHz;
- LF = 10^{-4} Hz - 1kHz

EM monitoring and pattern recognition
"MAPROS" – PACKAGES PROGRAM
Real time EM series and MT parameters

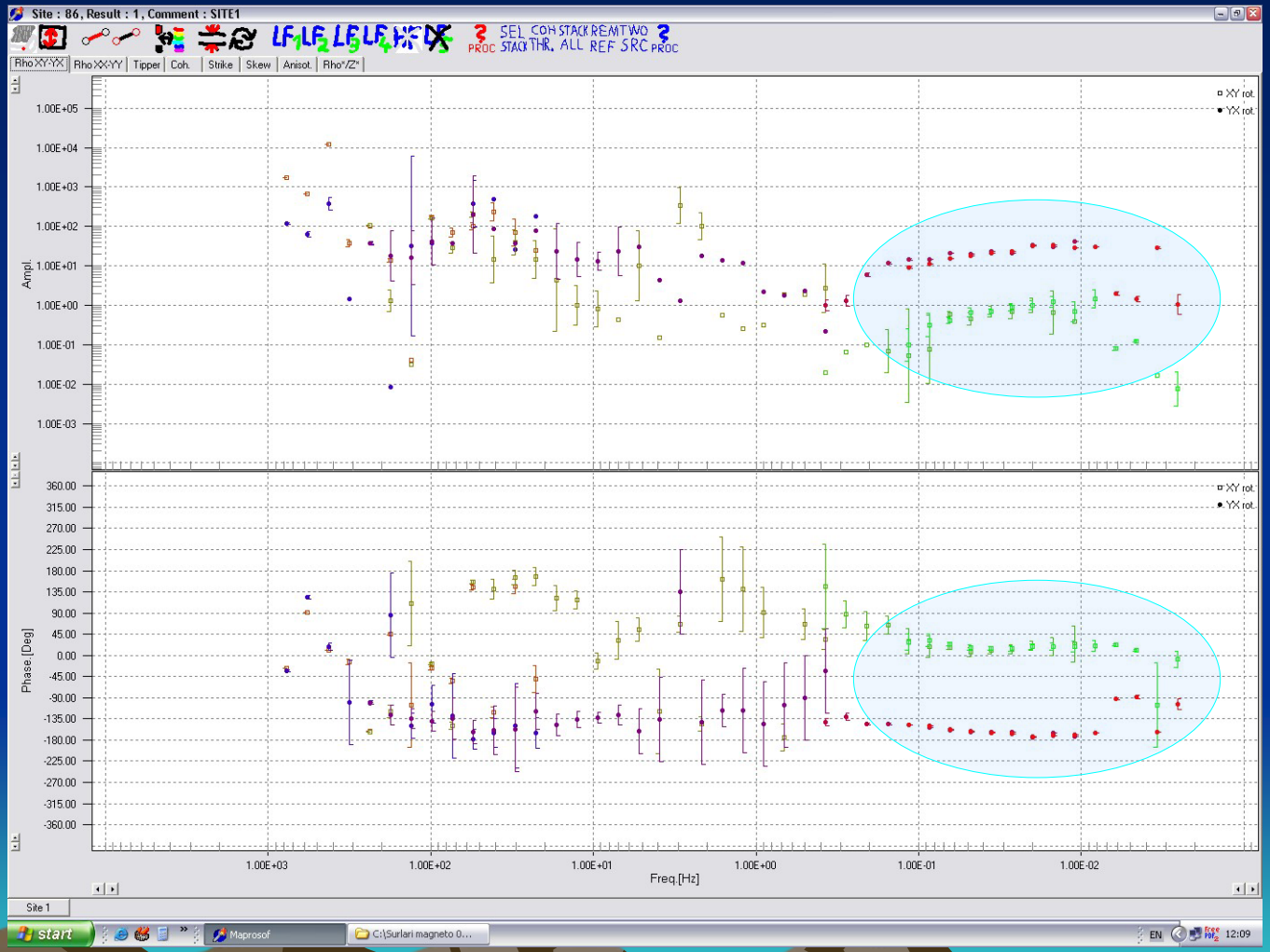


“MAPROS” - PACKAGES PROGRAM

Resistivity and phase

“MAPROS” - PACKAGES PROGRAM

Real time display of the resistivity ($\rho_{\parallel}$, $\rho_{\perp}$) and phase ($\varphi_{\parallel}$, $\varphi_{\perp}$)

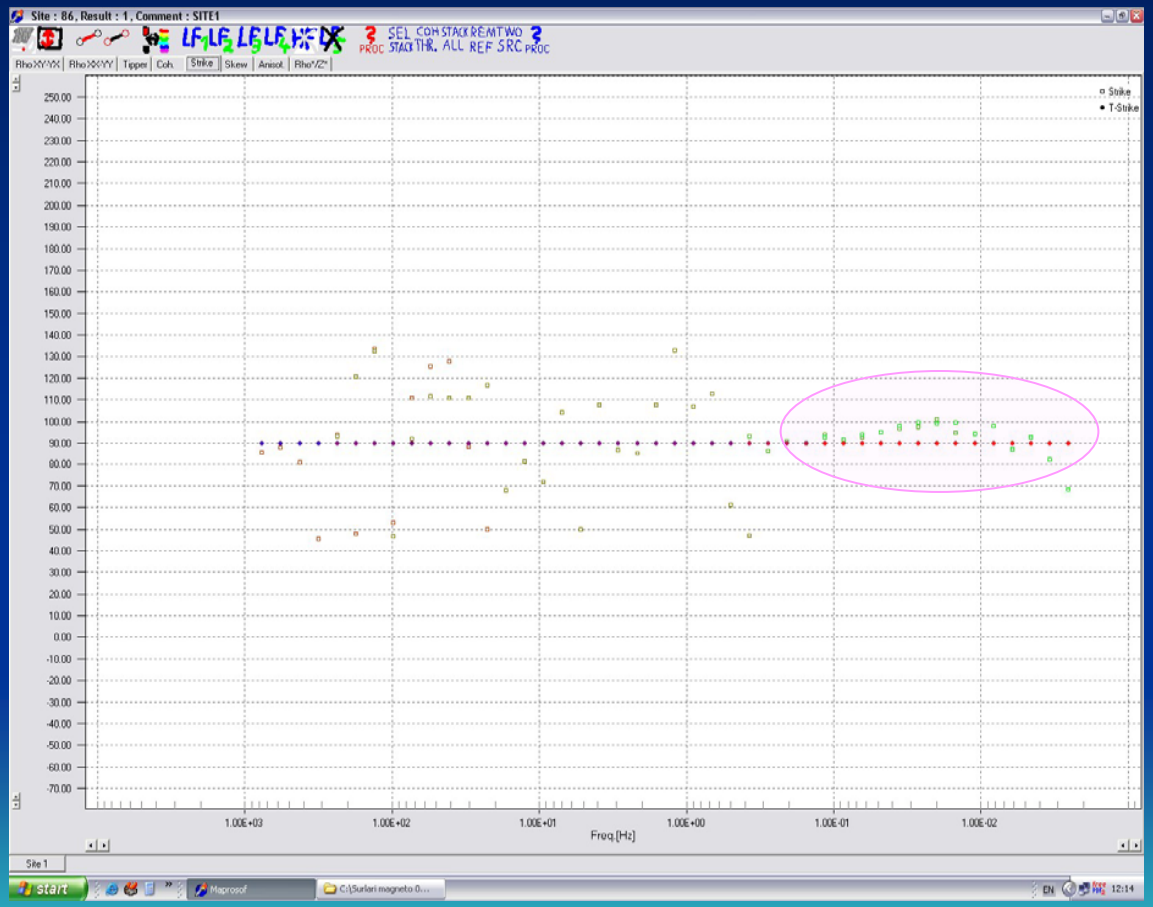


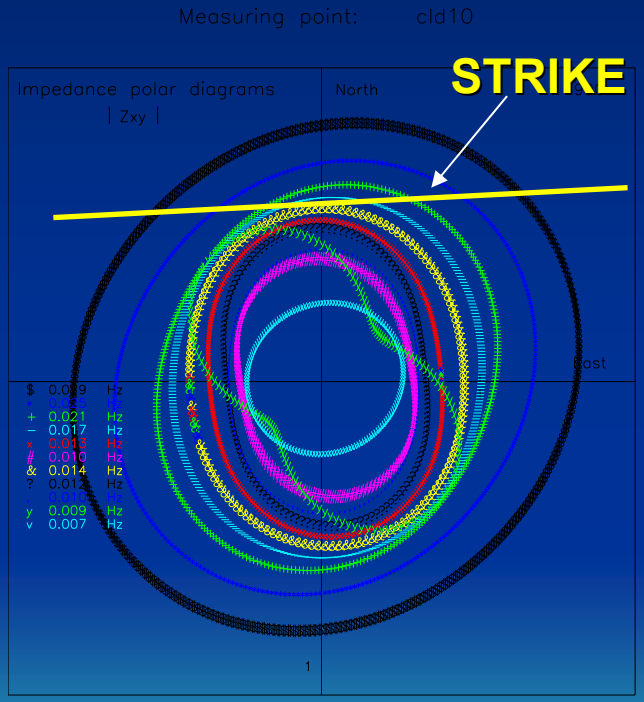
“MAPROS” - PACKAGES PROGRAM

SKEW

“MAPROS” - PACKAGES PROGRAM

STRIKE





Data acquisition module for continuous monitoring of the Geomagnetic field

Geomagnetic System Configuration

MAG-03DAM

acquisition module

6 channel, 24 bit resolution, sampling rate programmable, internal and external battery of 12 V , data storage on laptop HD;

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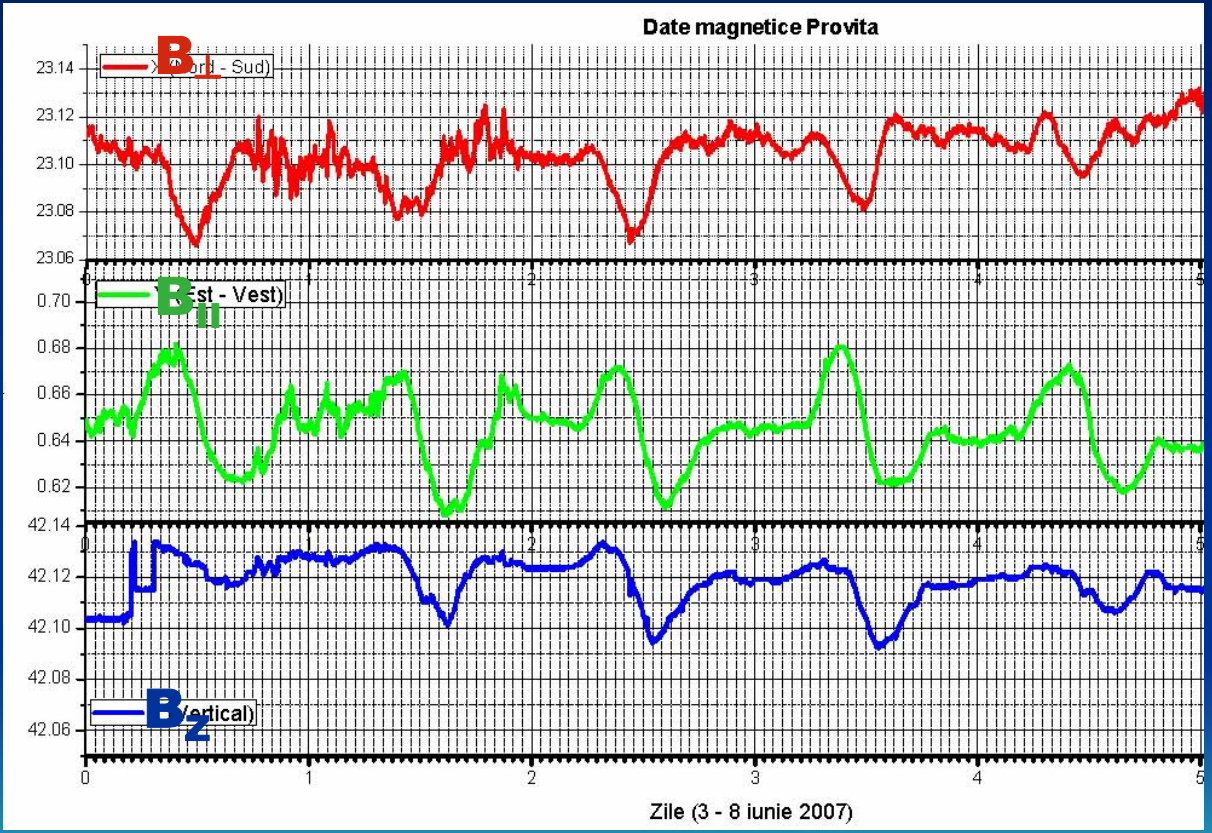
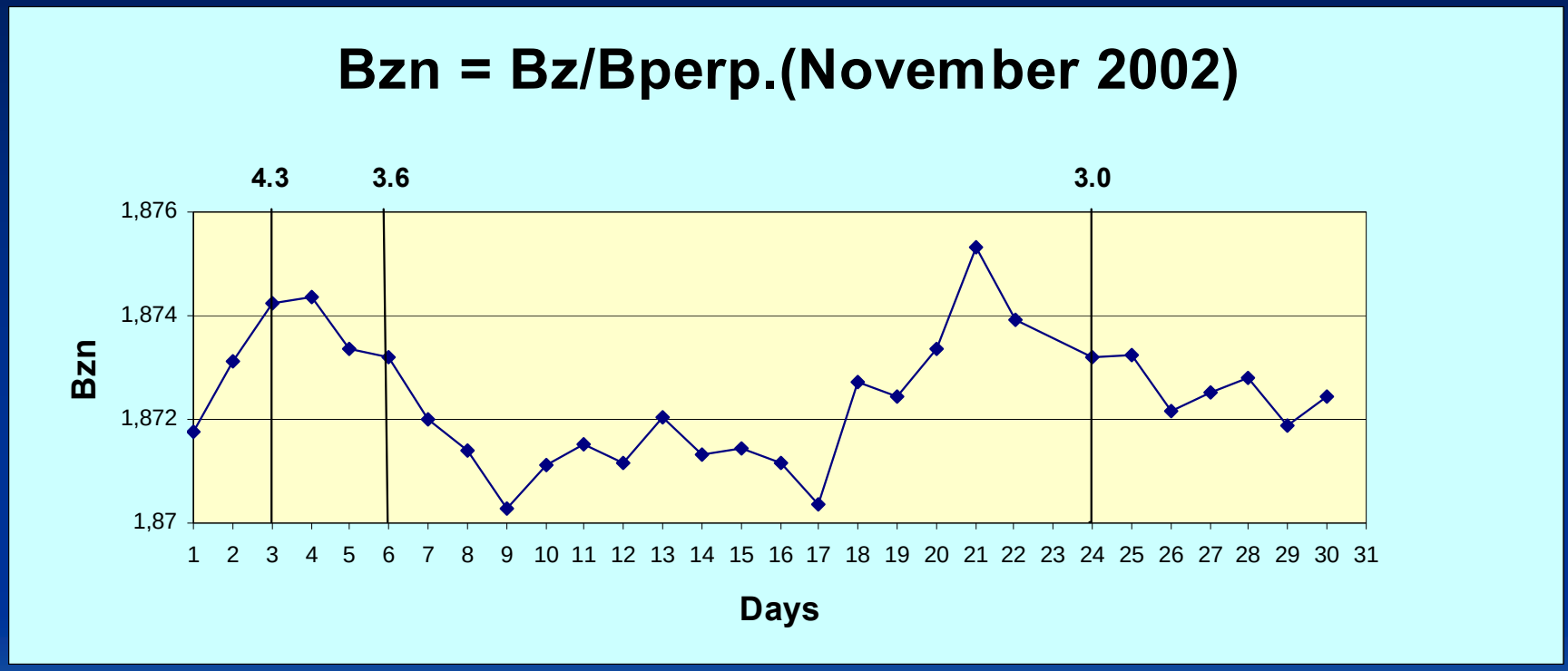
Time variation of the geomagnetic components $B_{\perp}$, B_{II} and Bz



Bzn disturbances linked to the seismic events



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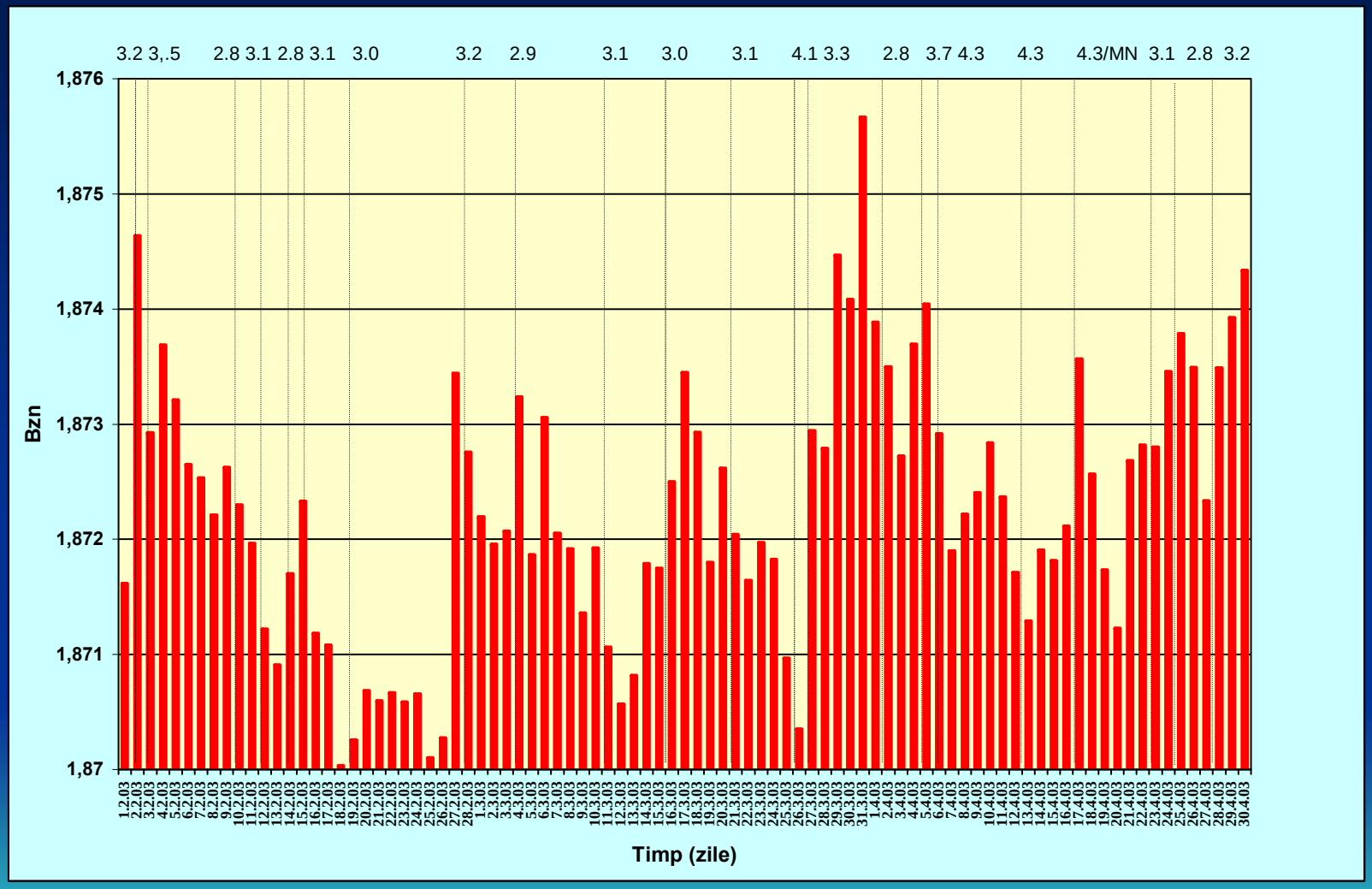
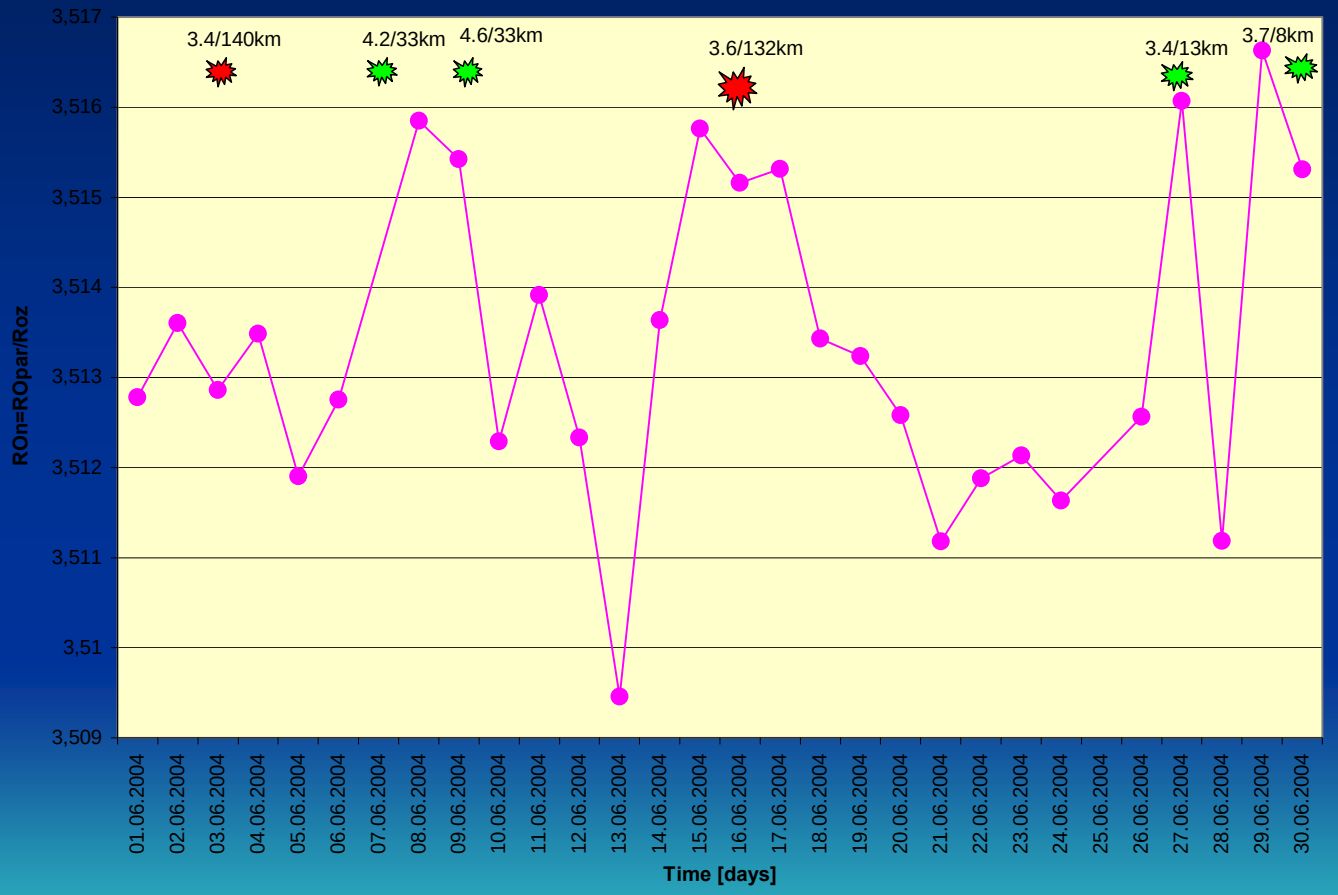


Mean daily values of normalized resistivity (ρ_n) reprezented simultaneously with seismic events.



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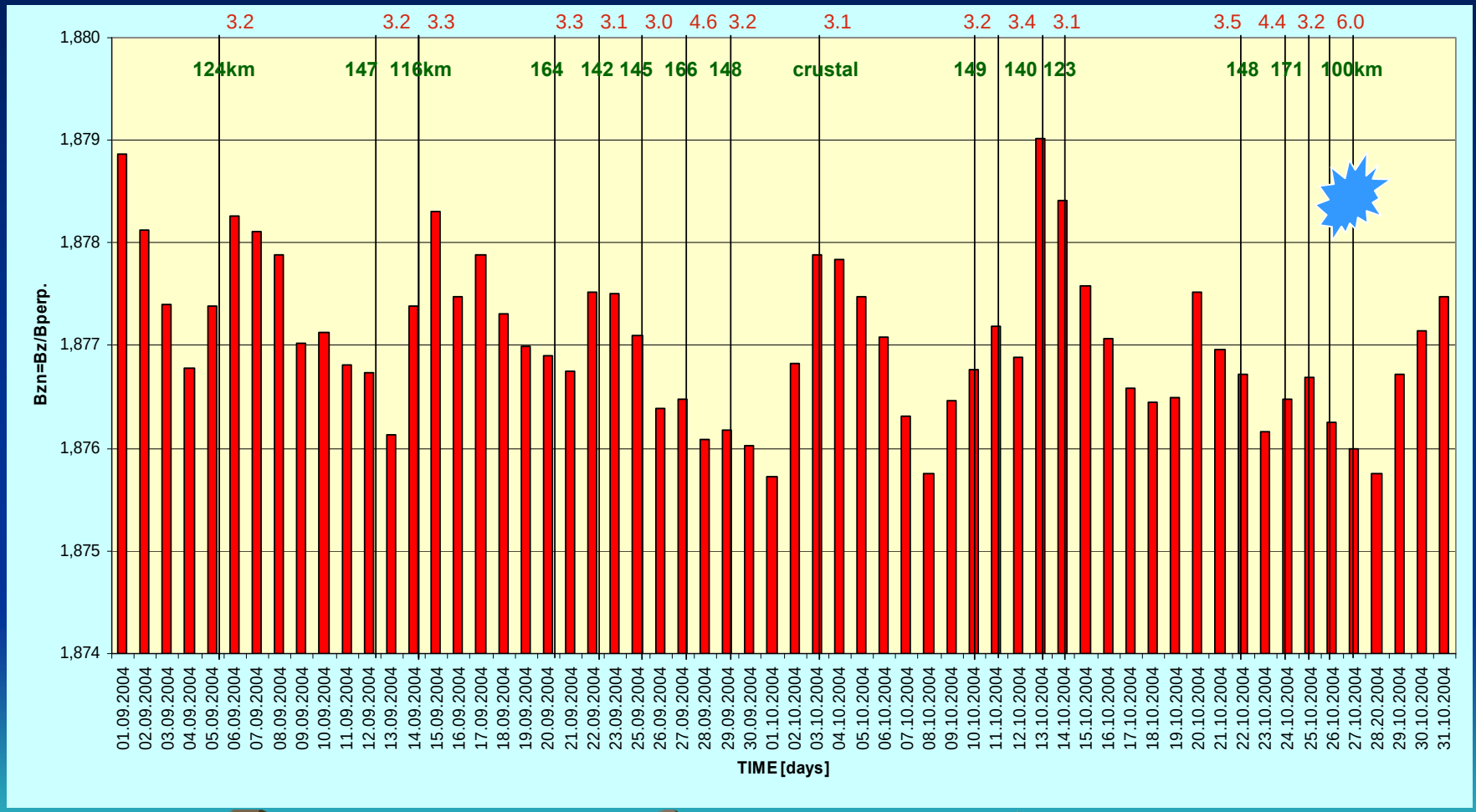

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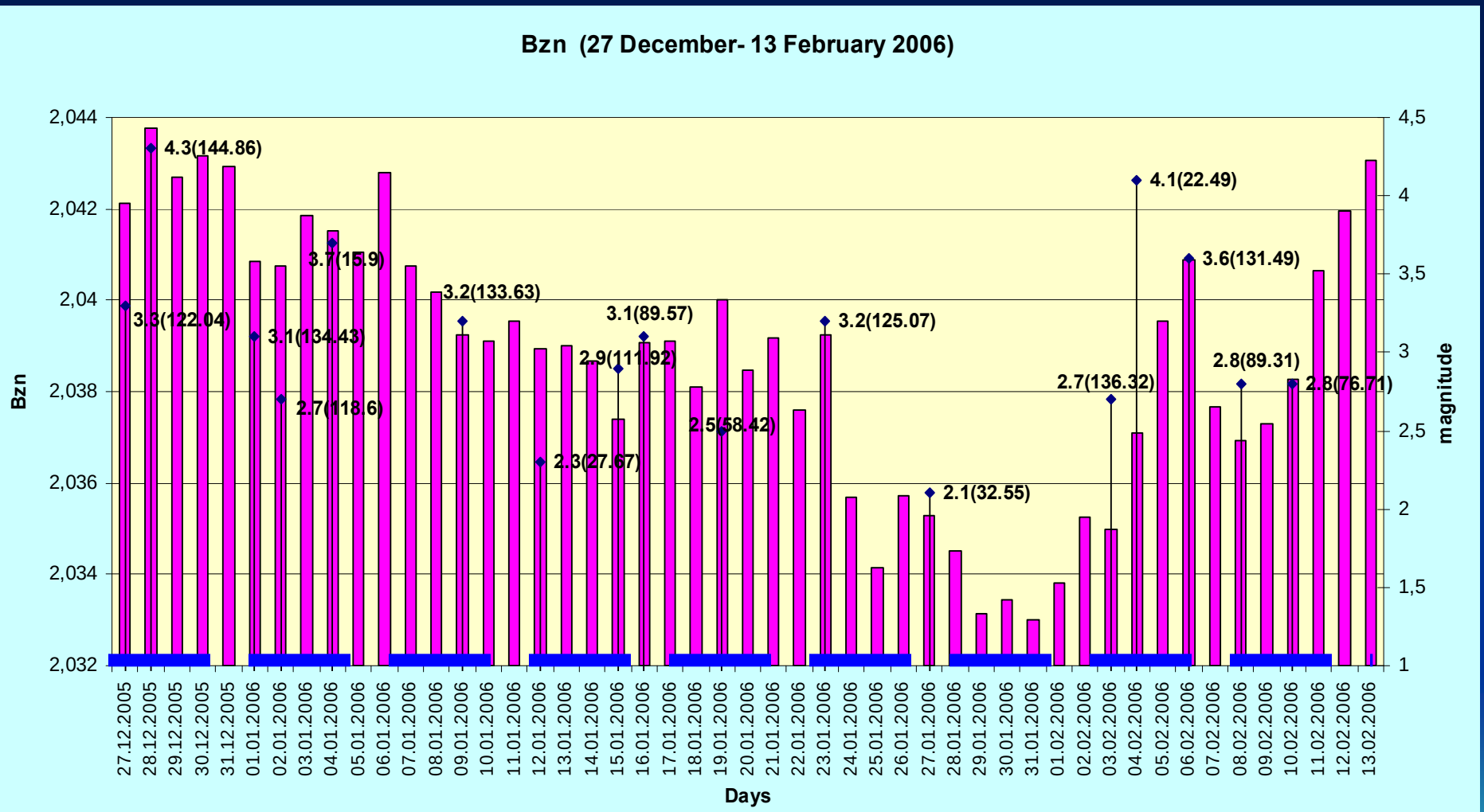
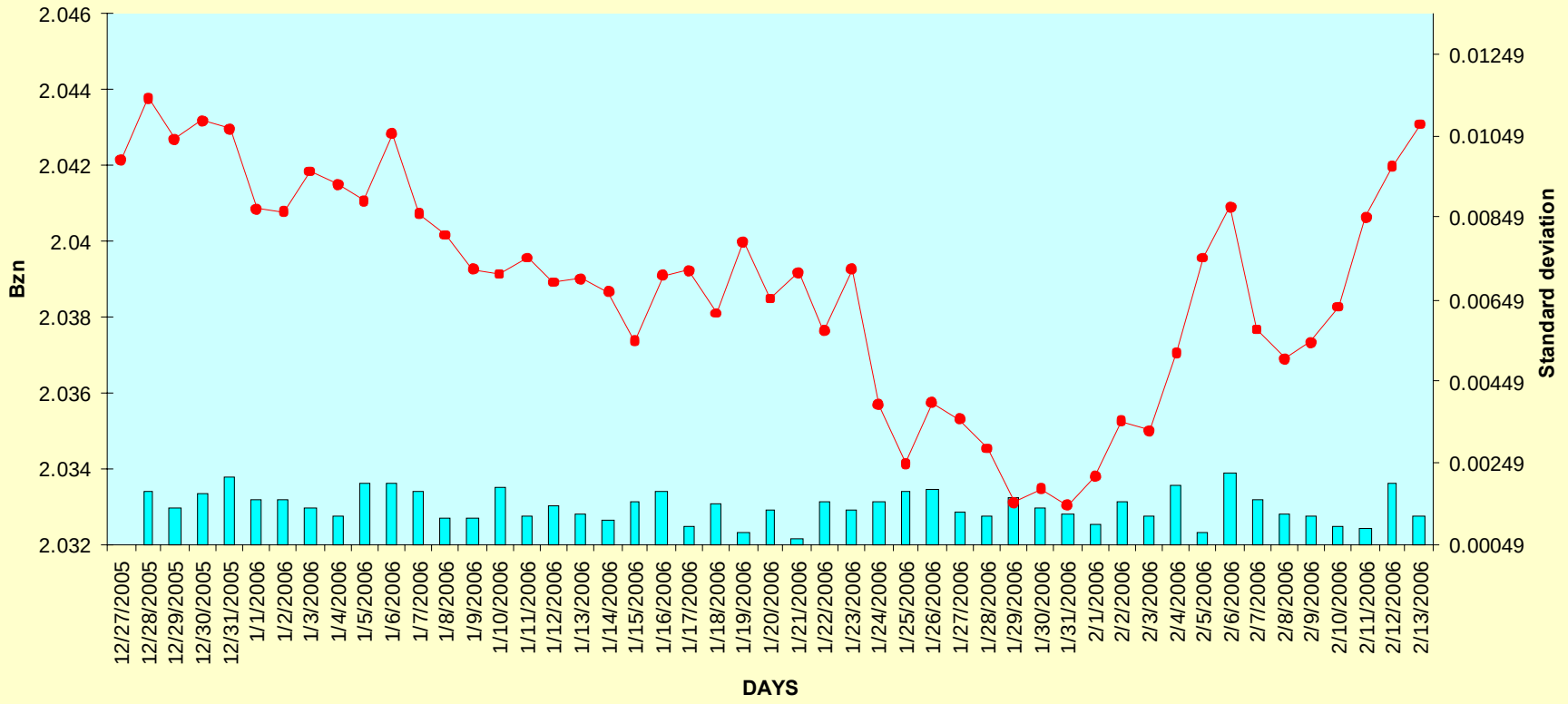


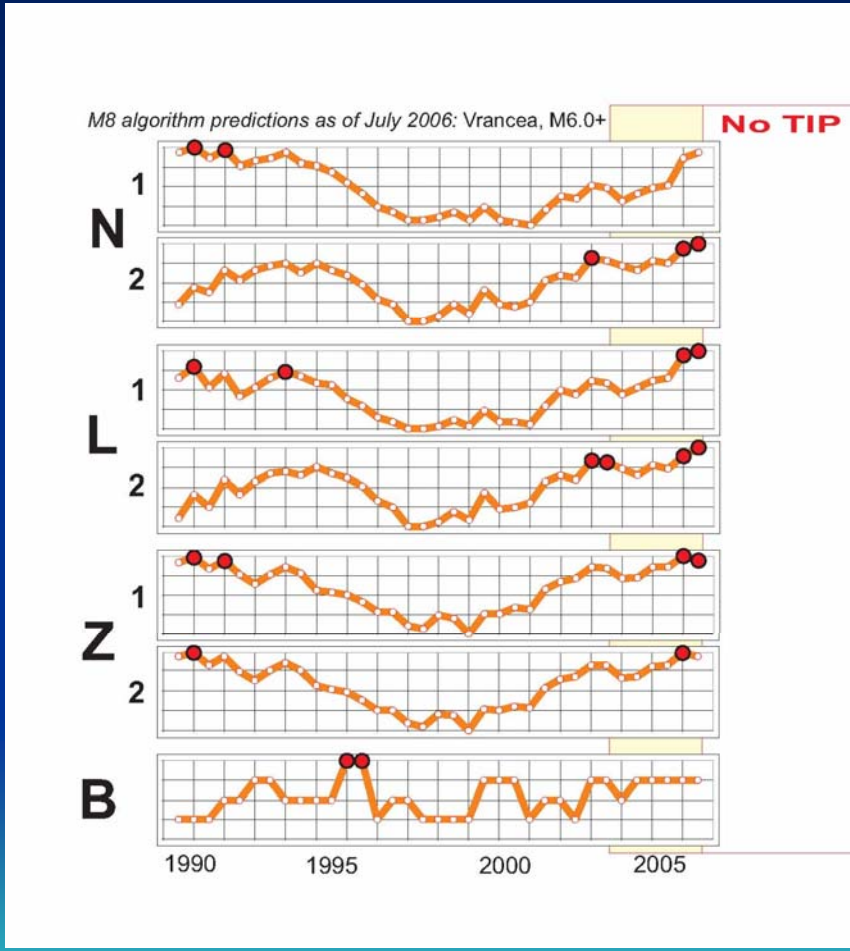
Bzn distribution and standard deviation

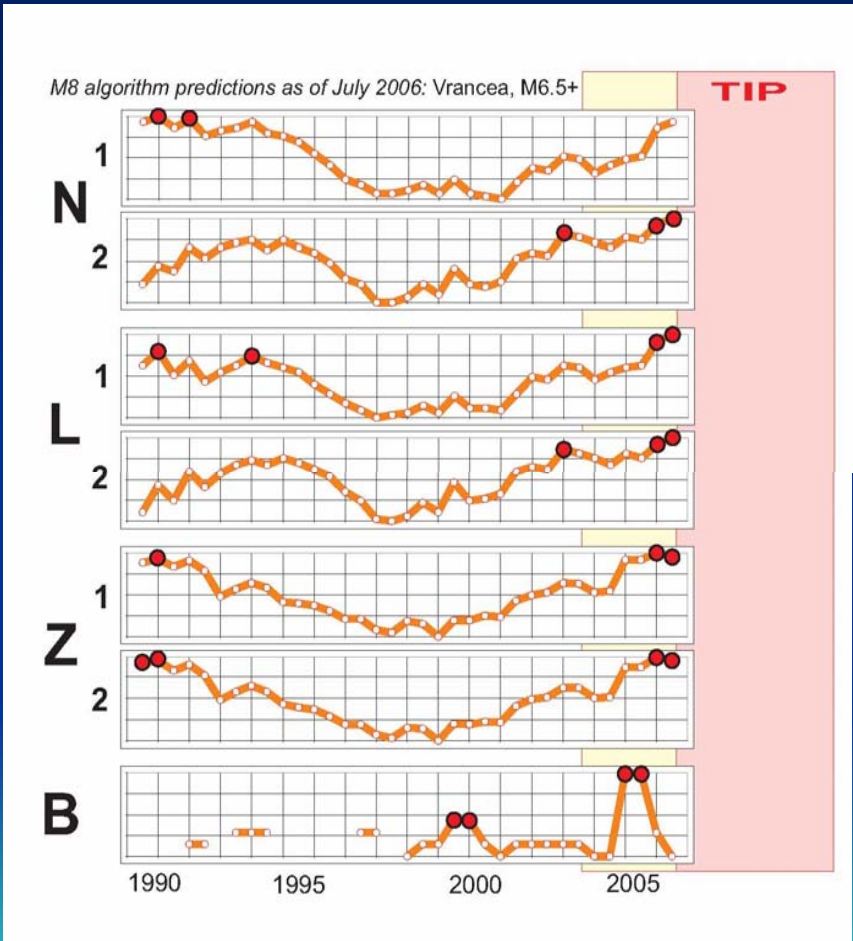


M8 ALGORITHM PREDICTION

(INTERMEDIATE-TERM MIDDLE RANGE)

(KOSSOBOKOV ET AL, 2007)





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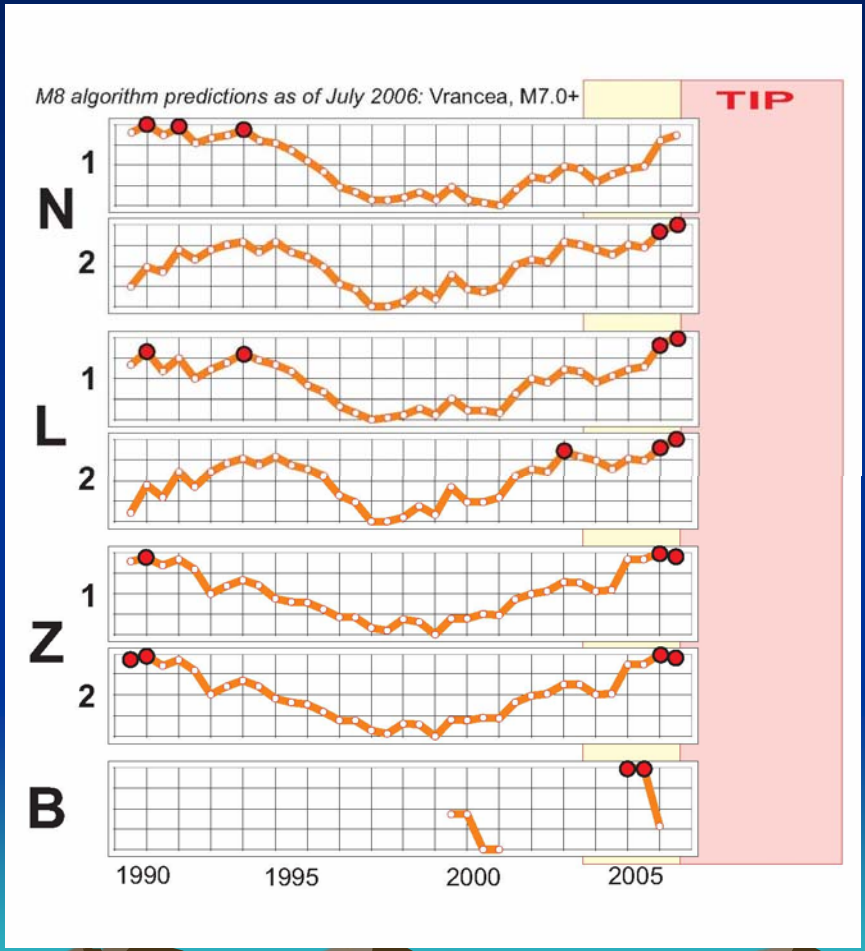
(KOSSOBOKOV ET AL, 2007)



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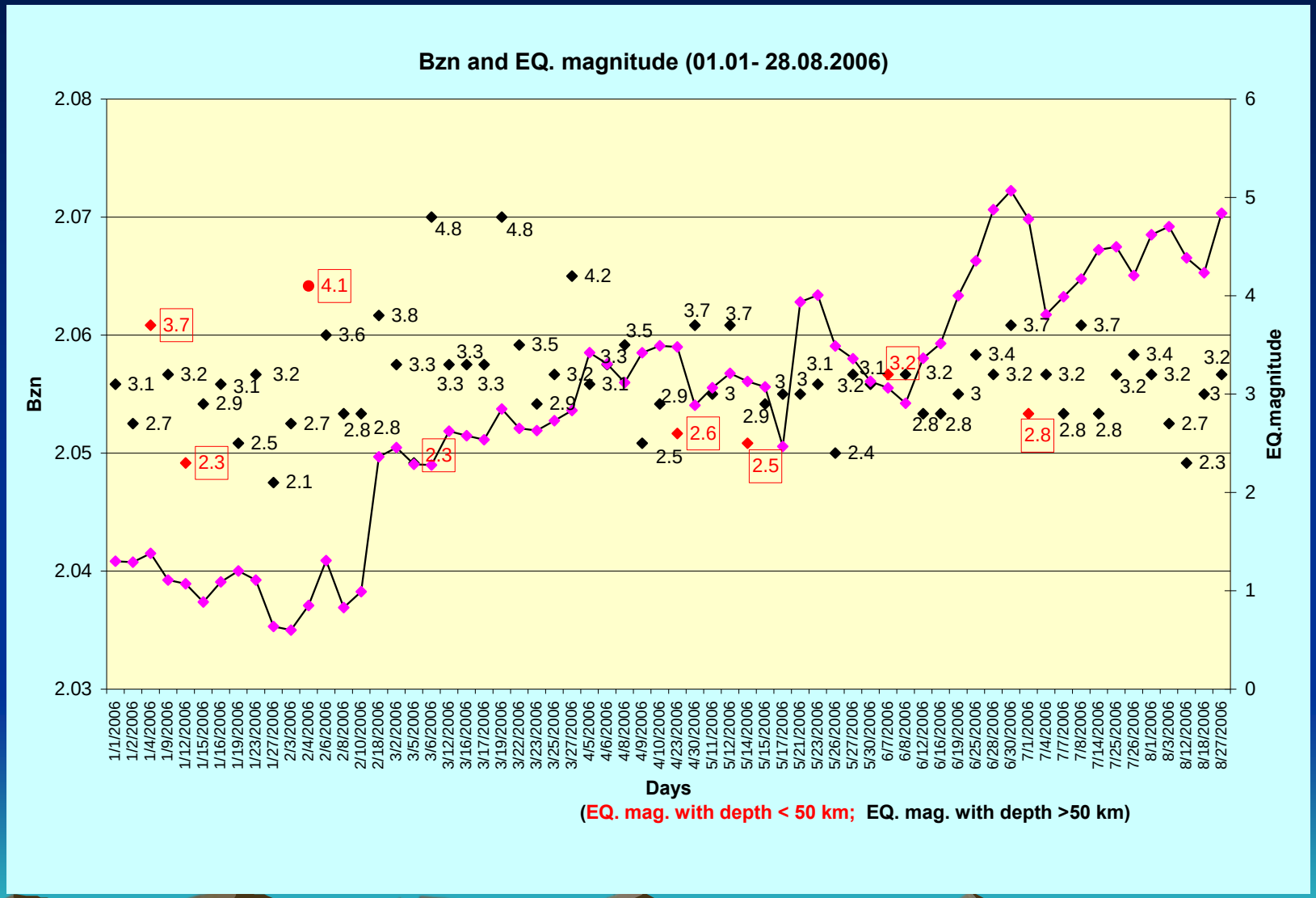

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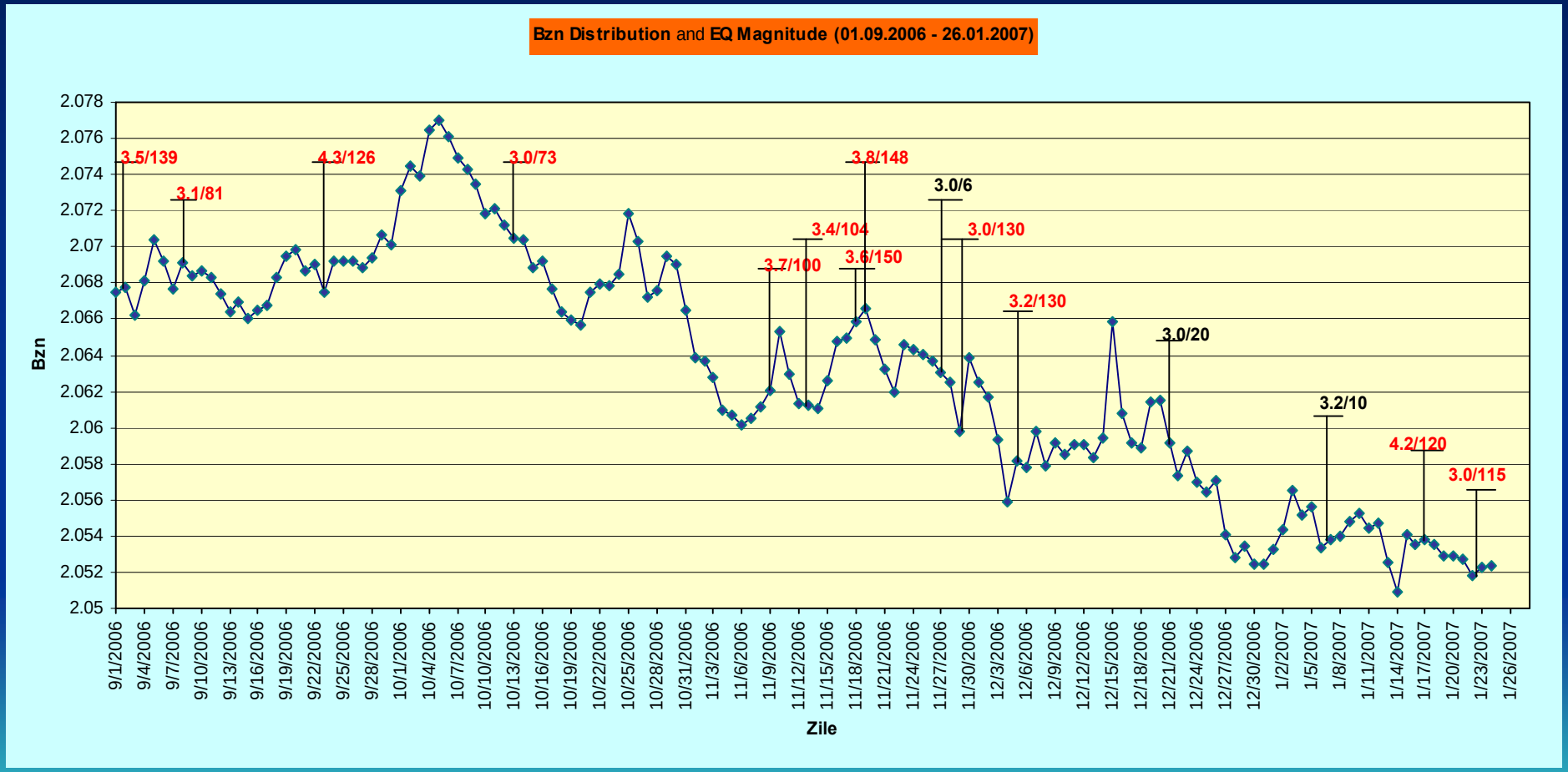
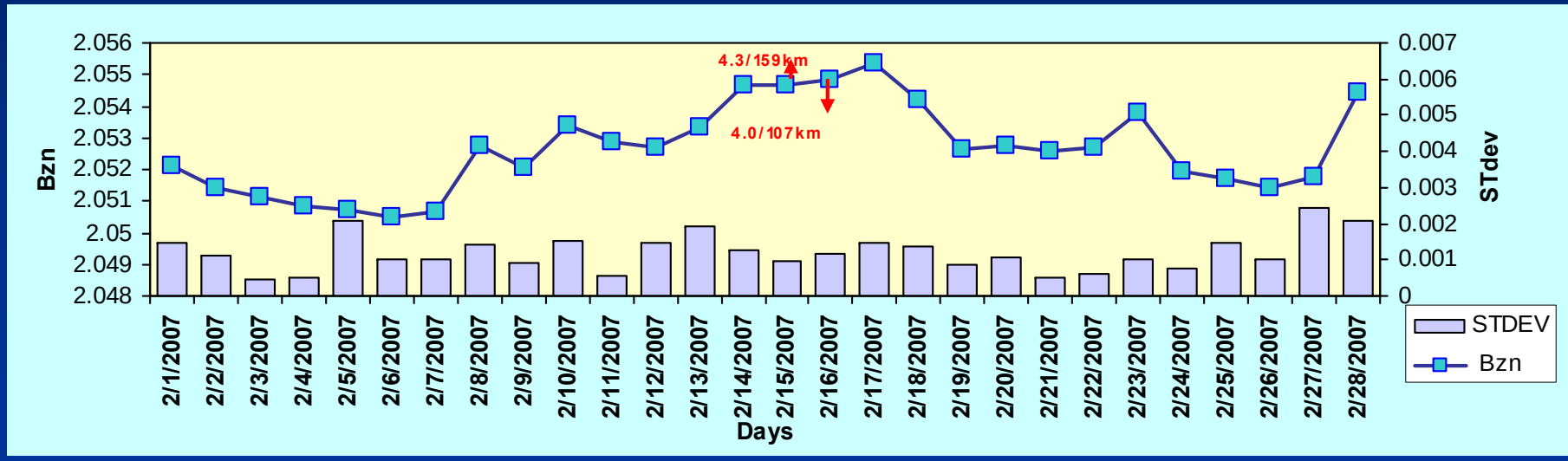


Bzn disturbances linked to the seismic events



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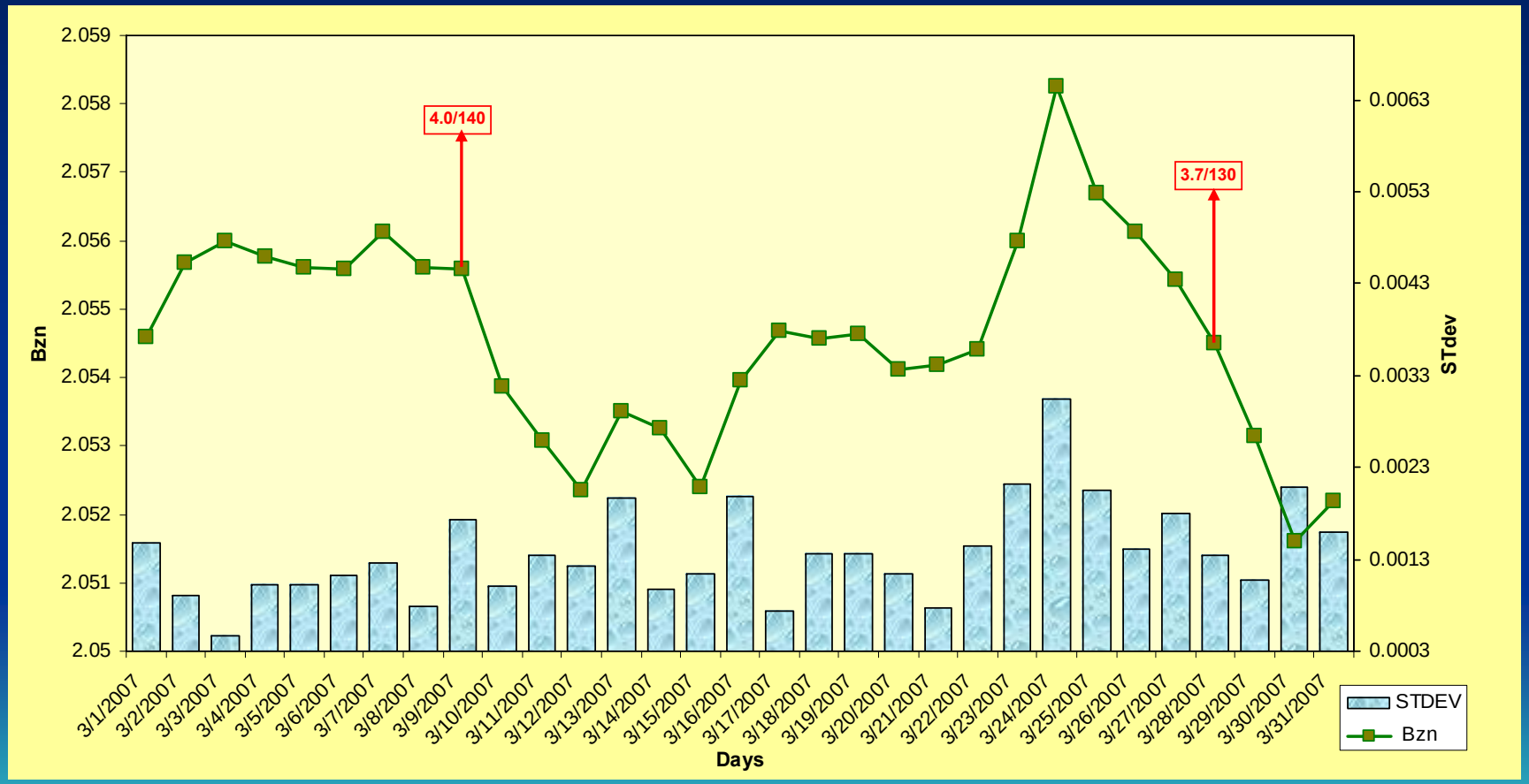

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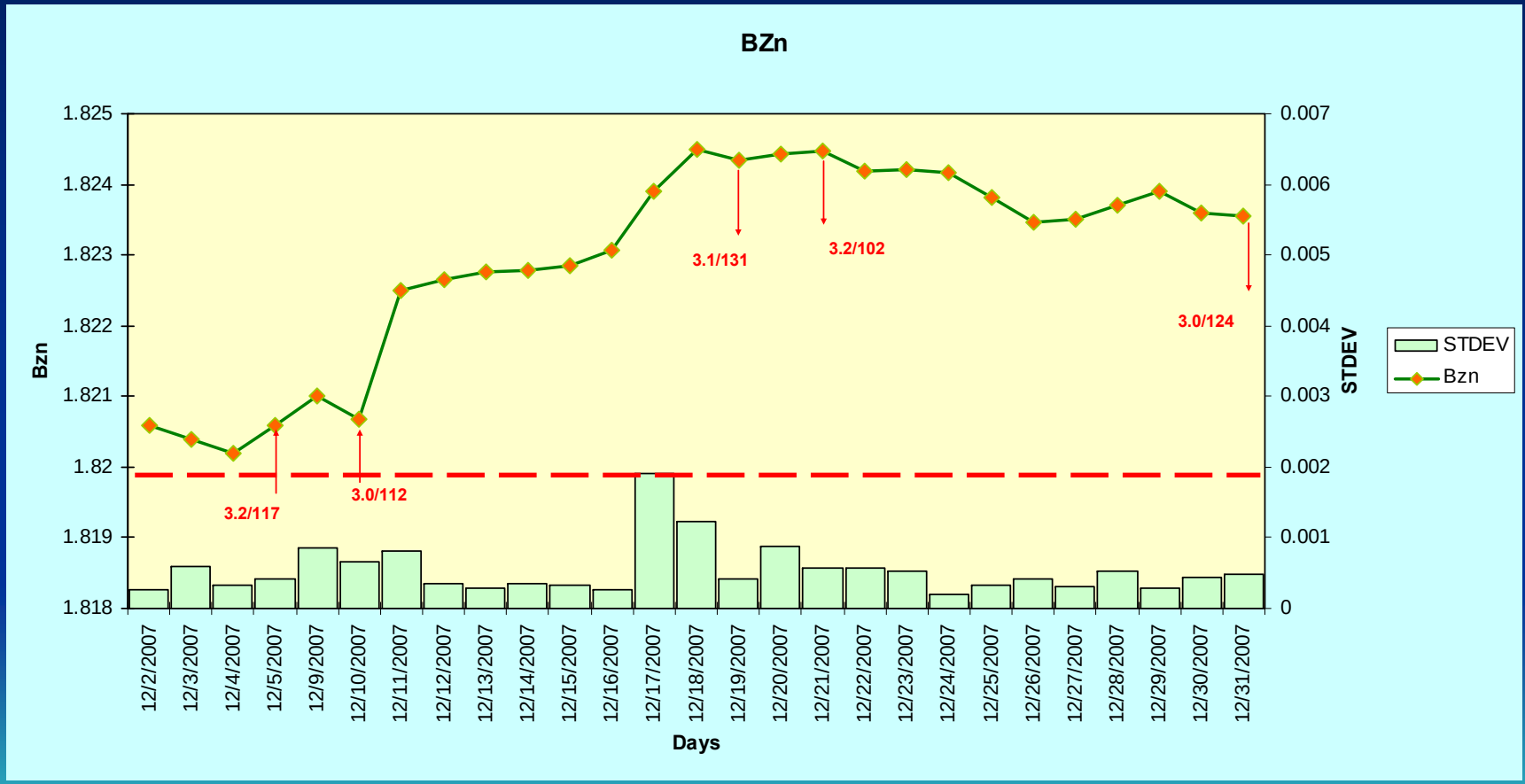

CONCLUSIONS:

- **Some days before an EQ occurred, the daily mean variation of the normalized function Bzn has an anomalous behaviour marked by significant increase versus its normal distribution identified in non seismic conditions, as a result of the lithospheric conductivity changes produced by the dehydration of the rocks, associated with rupturing processes and fluid migration through faulting systems developed inside the Vrancea seismogenic volume and its surrounding areas;**

- **Even if at present it is not possible yet to make any predictable correlation between the magnitude of seismic event and the amplitude/shape of the Bzn parameter, for lack of sufficient data concerning seismic events (M>4), there is a chance to make a step forward on this way;**

Acknowledgments:

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THANK YOU !