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Bucharest

GEODYNAMIC TORSION PROCESS OF THE SEISMOGENIC RELIC SLAB AND THE INTERMEDIATE DEPTH SEISMICITY OF THE VRANCEA ZONE

Dumitru STANICA and Maria STANICA

OUTLINE:

- SEISMIC ACTIVE VRANCEA ZONE; GEOTECTONIC OVERVIEW:

- CRUSTAL MAP (Sandulescu and Visarion, 2000);
- DEEP GEODYNAMIC MODELS:

1. Wenzel et al., 1998: CRC (Germany)+ RGVE (Romania) groups;
2. Linzer, PANCARDI, 2000;
3. Sperner et al., 2005;
4. Martin et al., 2006
5. Zadeh, 2005

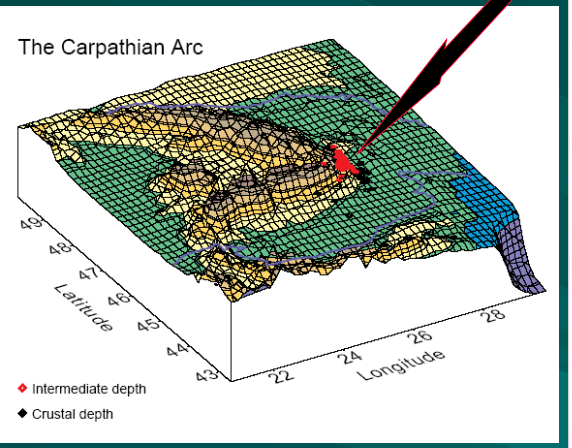
- THE ELECTRICAL CONDUCTIVITY ANOMALY-TRANSEUROPEAN SUTURE ZONE AND ACTIVE FAULTS (ELECTROMAGNETIC DATA):

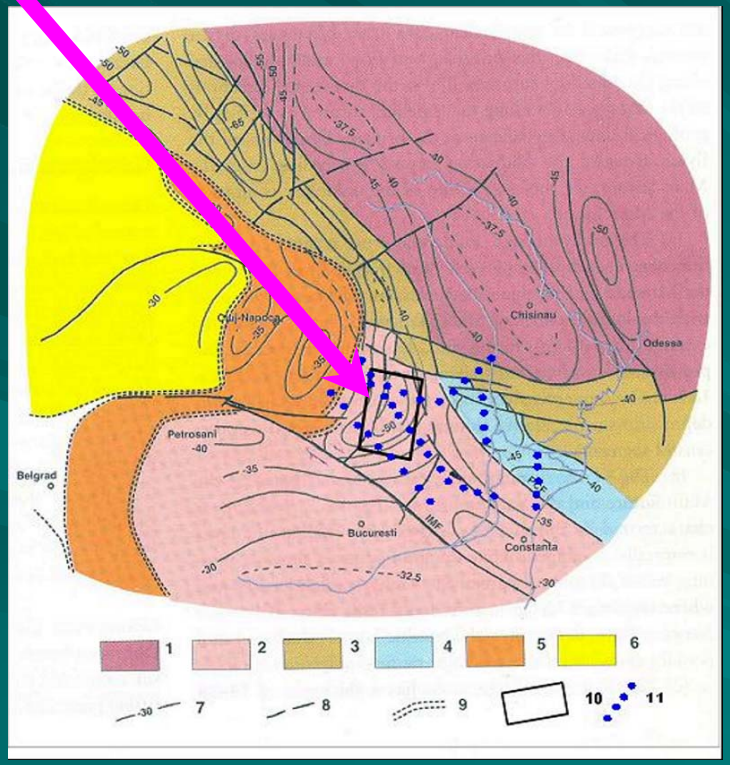
1. CEMES (Central Europe Mantle geoElectrical Structures) NATO-Project (2001-2003) :
   - 1D and 2D lithospheric resistivity models;
   - 3D images with mantle conductance distribution
2. Lithospheric peculiarities on the Romanian territory:
   - 1D, 2D models (including resistivity/phase response functions)
   - 3D tomographic images;
3. Carpathian electrical conductivity anomaly
4. TransEuropean Suture Zone (TESZ)
5. Geodynamic model Vrancea zone

GEOTECTONIC OVERVIEW

CRUSTAL MAP (Sandulescu and Visarion, 2000)

Vrancea zone



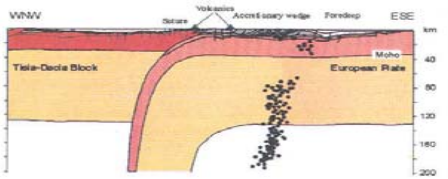


1. Precambrian East European Platform crust;
2. Precambrian Moesian Platform crust;
3. Paleozoic Scythian Platform crust;
4. Cimmerian-North Dobrogea crust;
5. "Transylvanian" type crust;
6. "Pannonian" type crust;
7. Depth to Moho;
8. Main deep faults (mostly transcrustal);
9. Position of the suture zones at the Moho level ;
10. Seismic active Vrancea zone
11. Magnetotelluric profiles

Deep Geodynamic Models-Vrancea zone

Model 1

Subduction beneath the suture



Pro:

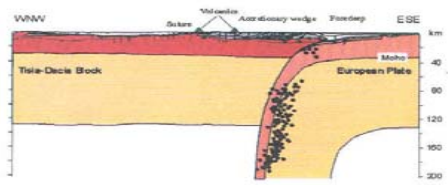
- 'Normal' configuration, i.e. subduction at the place, where it should be according to the surface suture
- Accretionary wedge and foredeep at the right place

Contra:

- Earthquakes at the wrong place
- Calc-alkaline volcanics at the wrong place
- No explanation for alkaline volcanics
- High-veolcity body (tomography) further to the SE

Model 2

Subduction beneath the foredeep



Pro:

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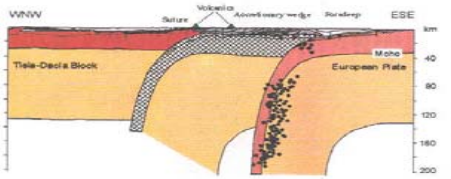
Contra:

- Accretionary wedge at the wrong place
- No suture known beneath the foredeep
- Surface structures do not fit with the location of the subduction zone
- no explanation for alkaline volcanics

Model 3

Two subduction zones



Pro:

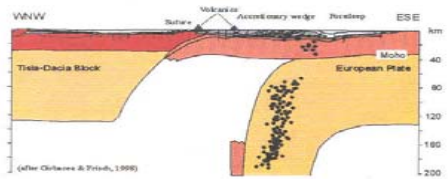
- Earthquakes at the correct place
- Calc-alkaline volcanics at the correct place
- Surface structures and accretionary wedge for the western subduction zone are at the correct place
- High-velocity body correlates with eastern slab

Contra:

- No suture known beneath the foredeep
- No accretionary wedge for the eastern subduction zone
- Doubled amount of shortening necessary
- Western slab not visible in tomography data
- no explanation for alkaline volcanics

Model 4

Subduction beneath the suture followed by delamination



Pro:

- Earthquakes at the correct place
- Calc-alkaline volcanics at the correct place
- Logical explanation for the alkaline volcanics
- Surface structures and accretionary at the correct place
- High-velocity body at the correct place

Contra:

- Reason for delamination? - Why not a complete break-off?
- No explanation for earthquakes in (ductile) lower crust

Wenzel et al., 1998 CRC (Germany)+ RGVE (Romania) groups

Four geodynamic models for the Vrancea subduction process under discussion

DEEP GEODYNAMIC MODELS

Wenzel et al., 1998: CRC (Germany)+ RGVE (Romania) groups

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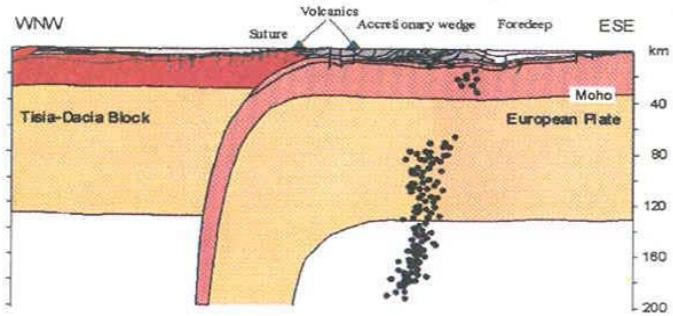
Subduction beneath the suture



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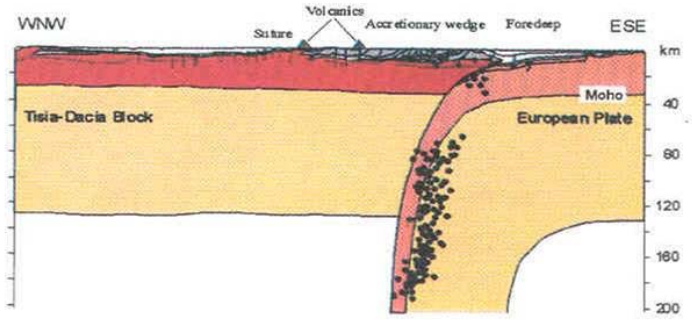

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Wenzel et al., 1998: CRC (Germany)+ RGVE (Romania) groups

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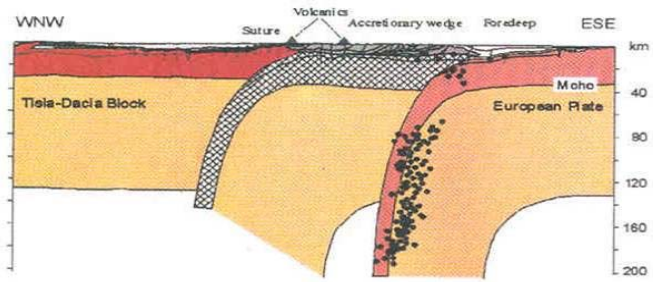
Two subduction zones



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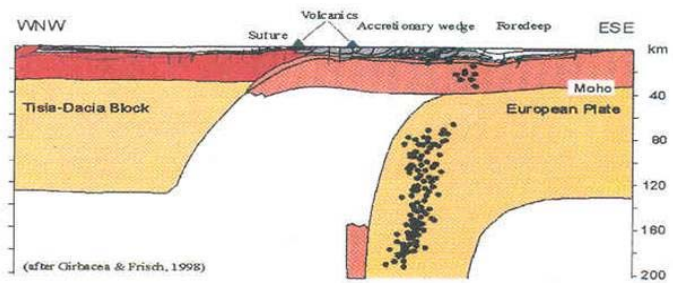
Model 4

Subduction beneath the suture followed by delamination



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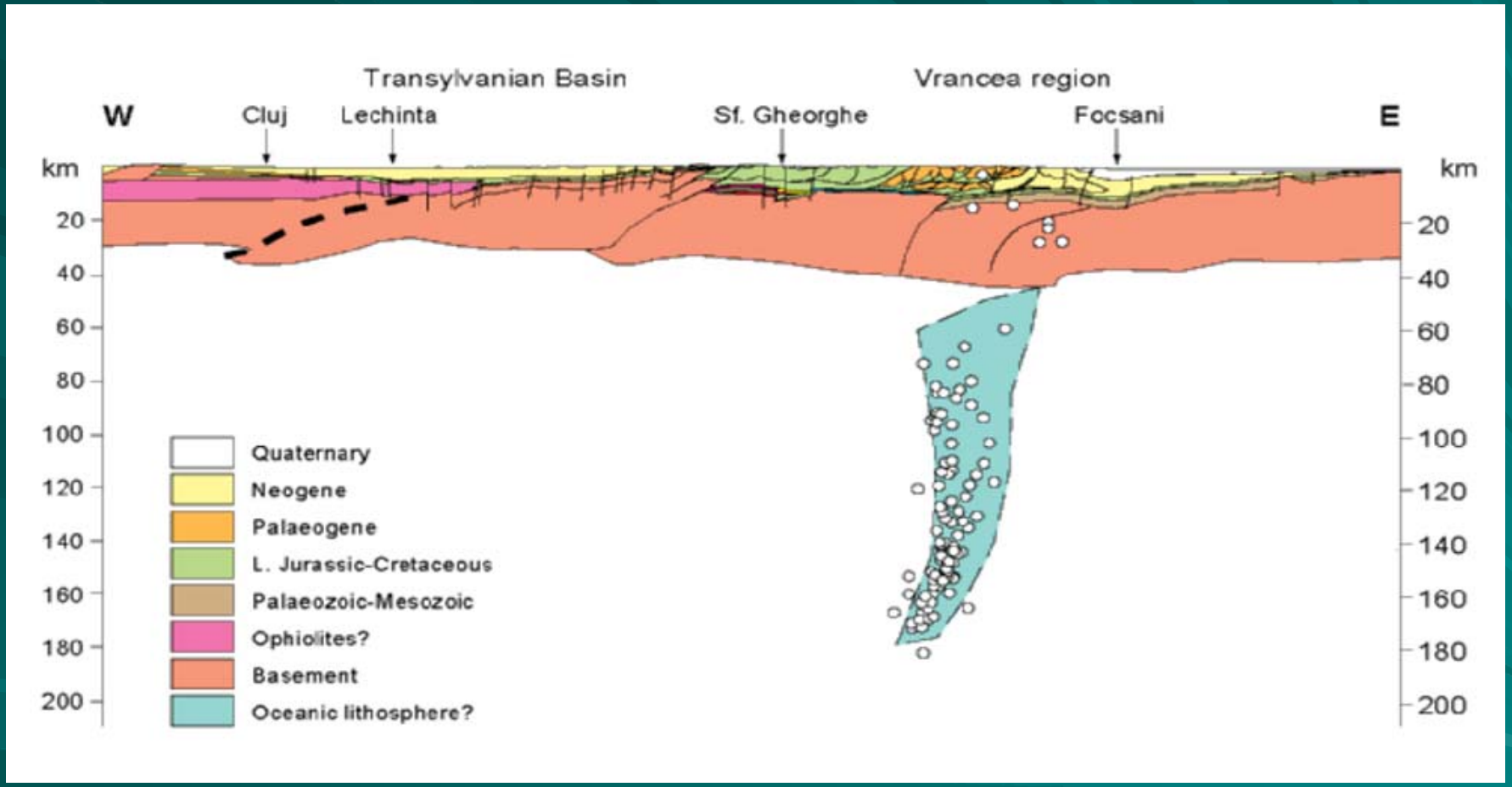
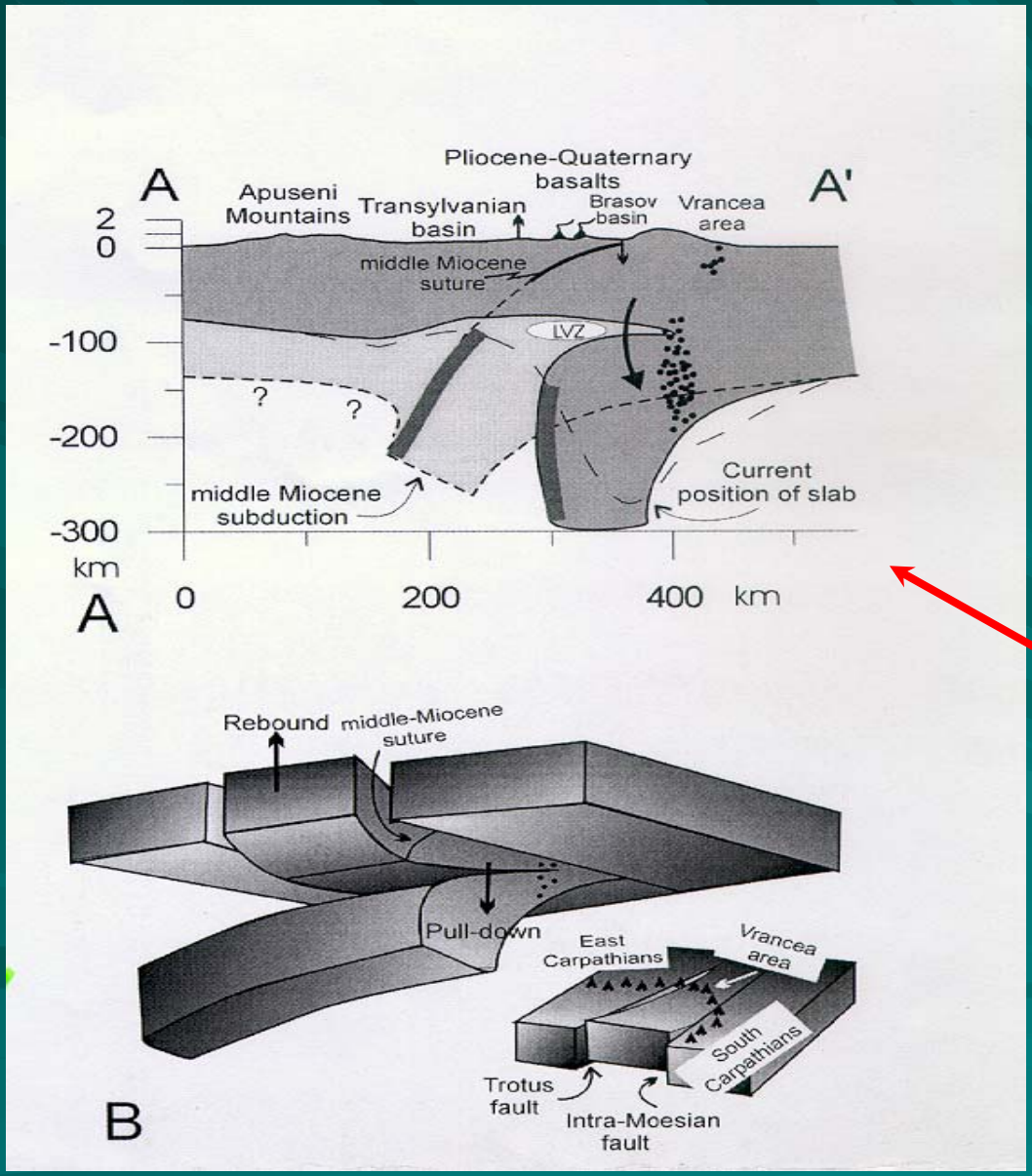
DEEP GEODYNAMIC MODELS



HYPOTHETICAL LITHOSPHERIC CROSS - SECTION SHOWING THE CONCENTRATION OF EARTHQUAKES IN THE VRANCEA AREA AND THEIR RELATIONSHIP TO A SINKING SLAB IN THE UPPER MANTLE

(Linzer, PANCARDI, 2000)

DEEP GEODYNAMIC MODELS



Gvirtzman, 2003

DEEP GEODYNAMIC MODELS

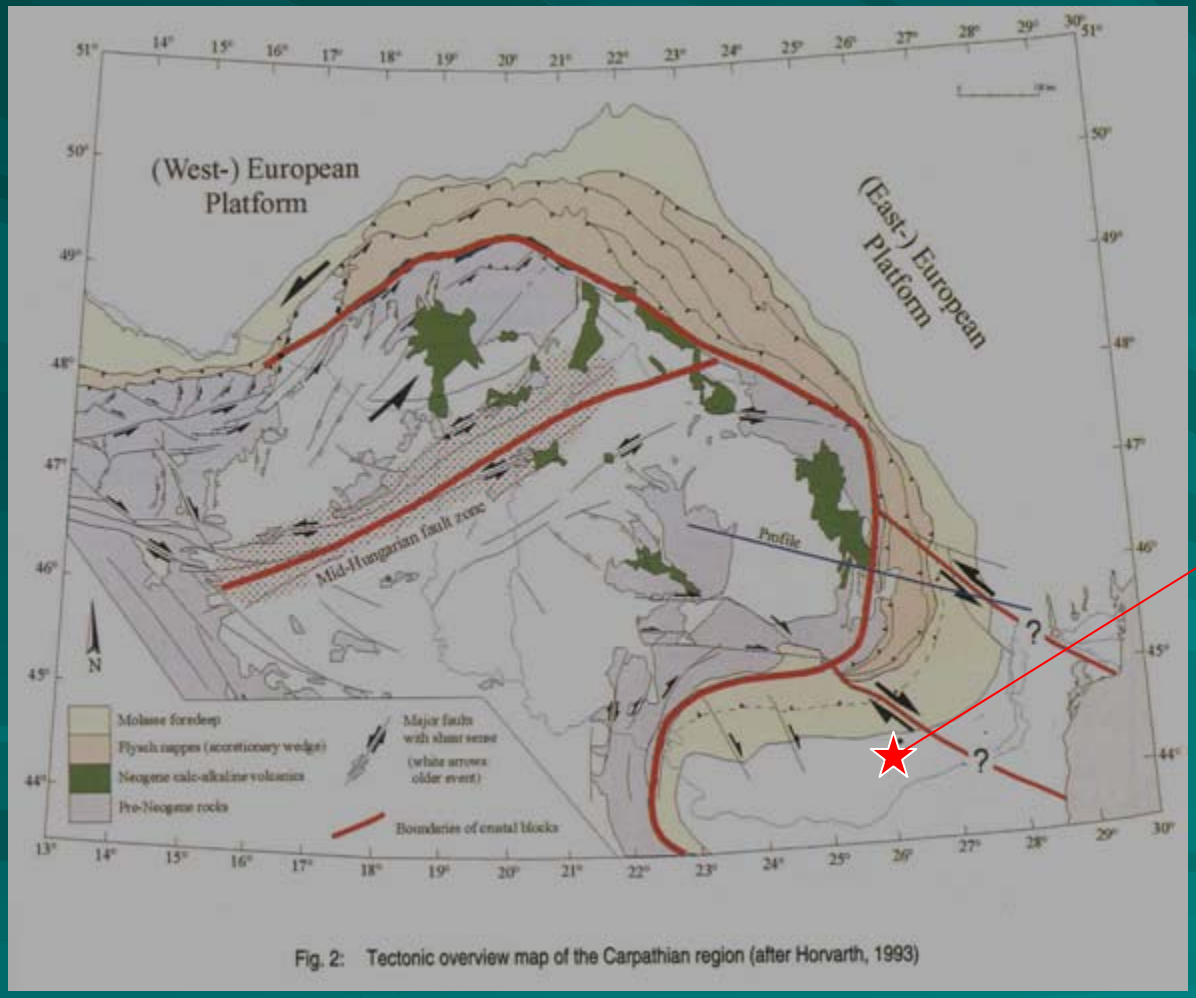
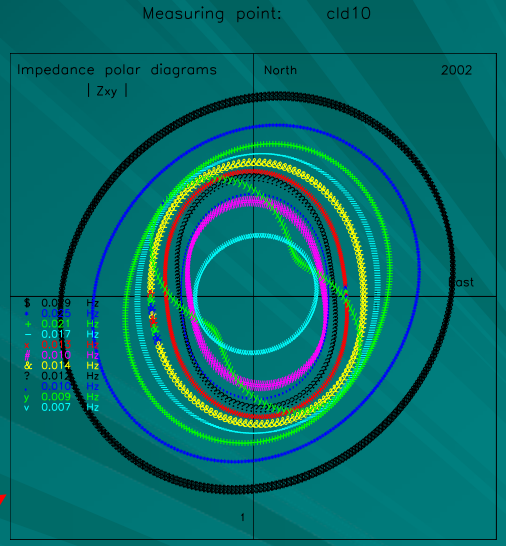
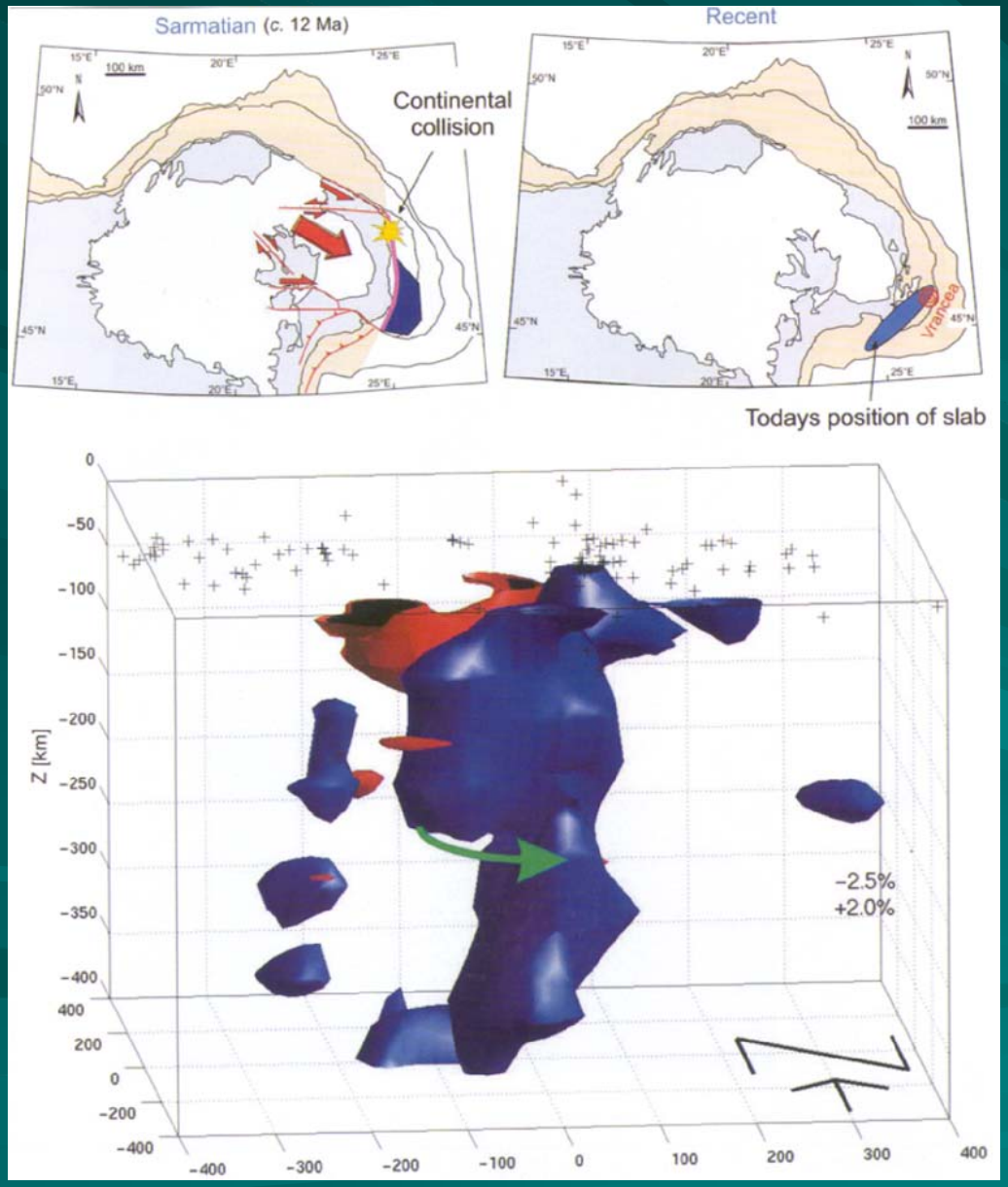


Fig. 2: Tectonic overview map of the Carpathian region (after Horvarth, 1993)



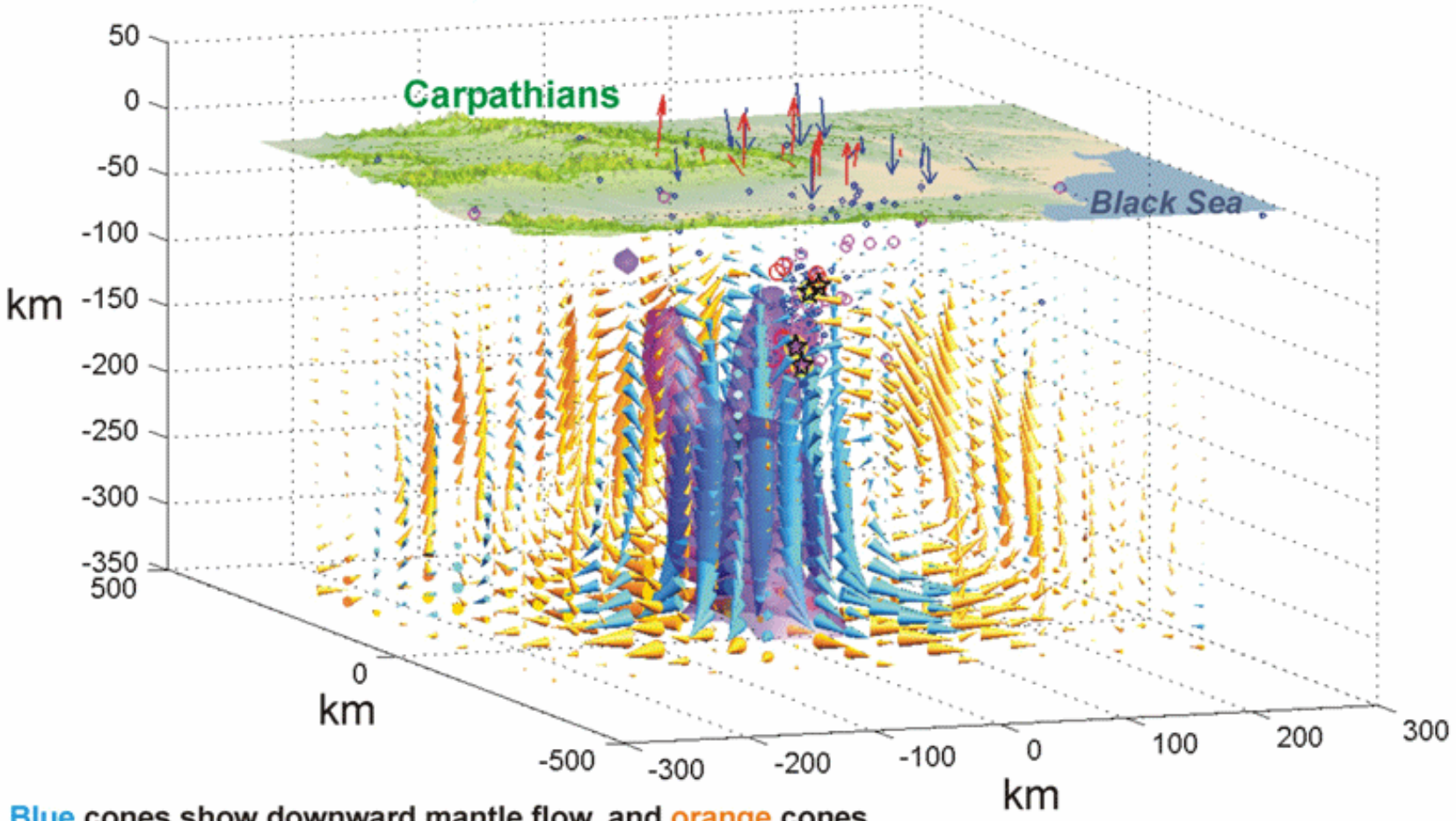
DEEP GEODYNAMIC MODELS



Top:
Geodynamic evolution of plate subduction in SE Romania since the late Miocene (12 Mil.years ago)
(Sperner et al., 2005)

Bottom :
Tomographic image of the subducted slab as high velocity body viewed from SSW
(Martin et al., 2006)

Mantle flow induced by the slab descending beneath the SE-Carpathians



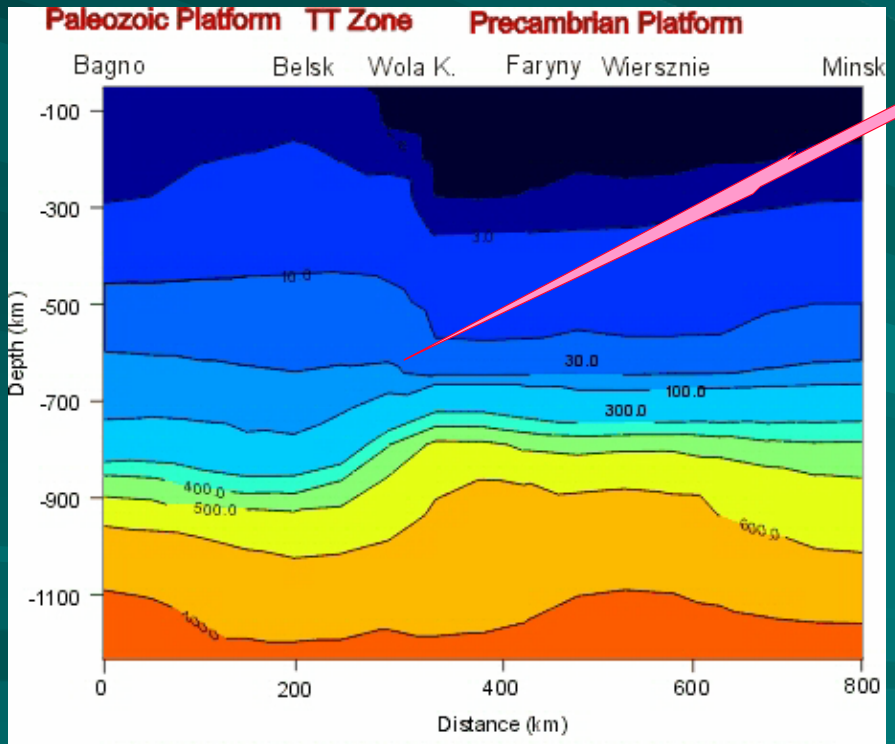
Blue cones show downward mantle flow, and **orange** cones illustrate upward mantle flow. **Red** and **blue** arrows on the top are GPS data on vertical movements. Circles and stars are earthquake hypocentres.

Alik Ismail Zadeh, 2005

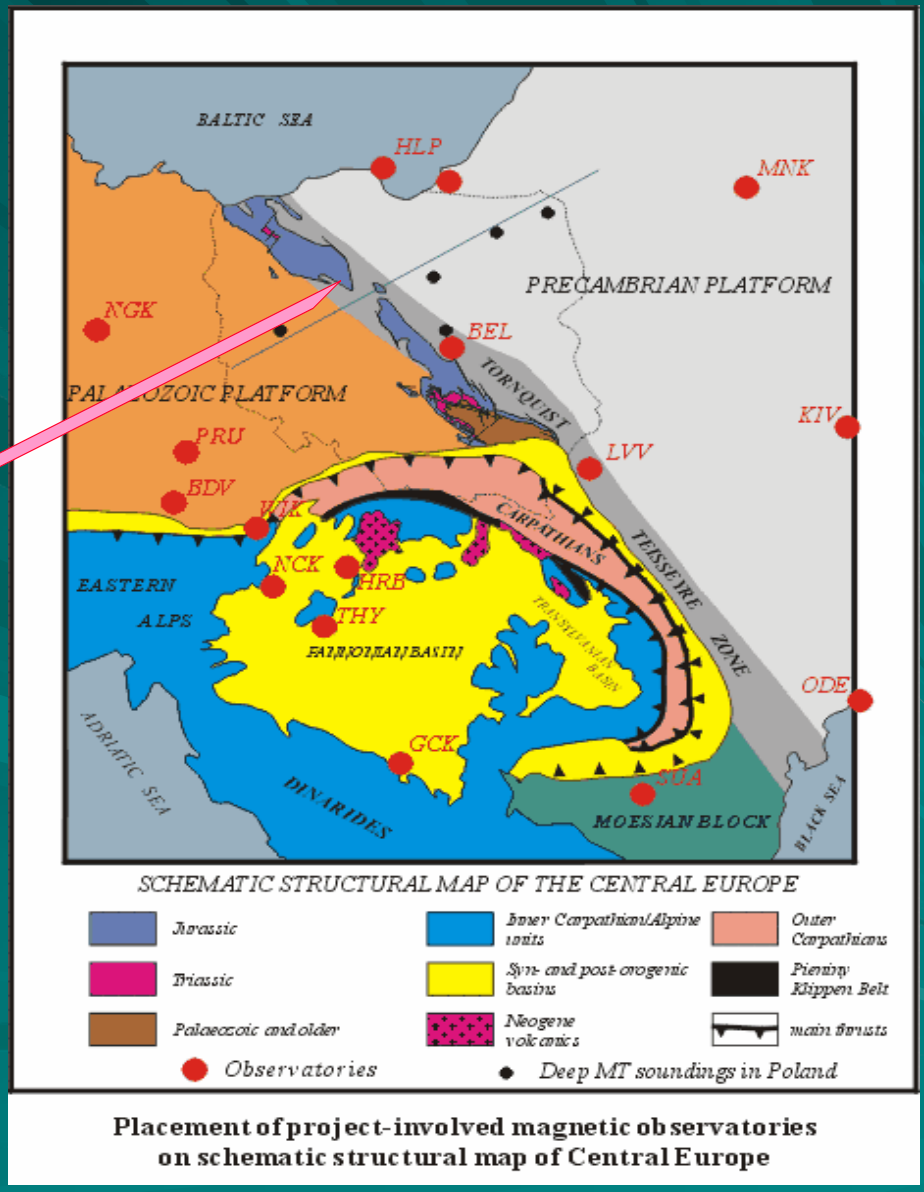
TESZ - Electromagnetic data

- CEMES (Central Europe Mantle geoElectrical Structure) NATO-Project

B. Deep Electromagnetic Soundings of the Mantle around the TESZ

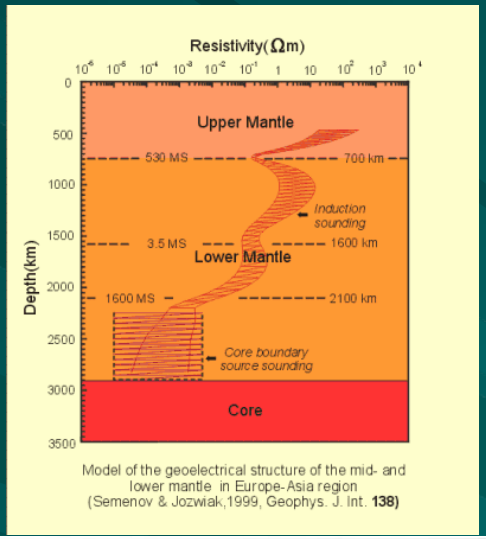


Distribution of conductance (kS) along "Polonaise" profile (Semenov & Jozwiak, 2001)



Placement of project-involved magnetic observatories on schematic structural map of Central Europe

TESZ - Electromagnetic data



Model of the geoelectrical structure of the mid- and lower mantle in Europe-Asia region (Semenov & Jozwiak,1999, Geophys. J. Int. **138)**

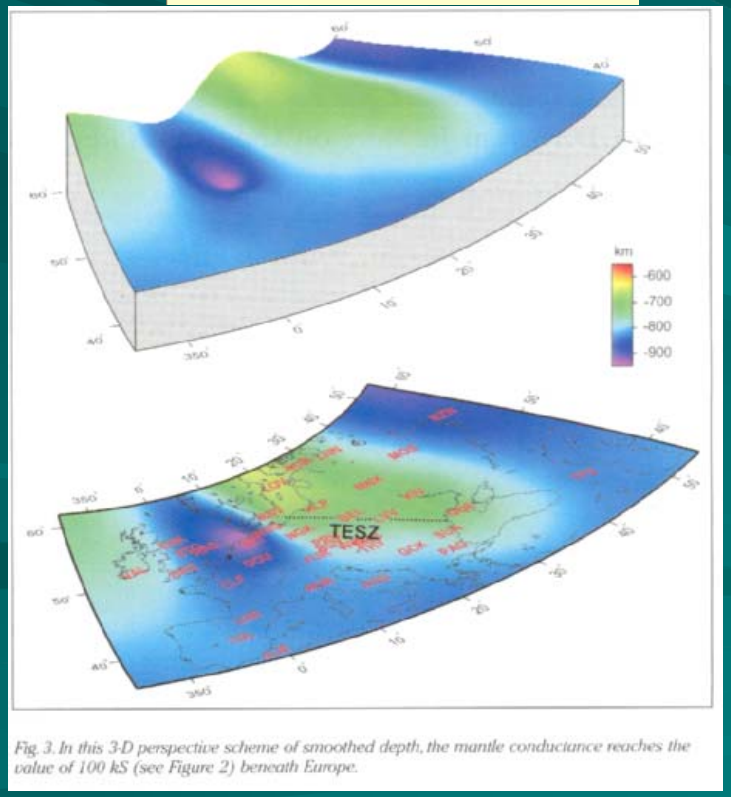
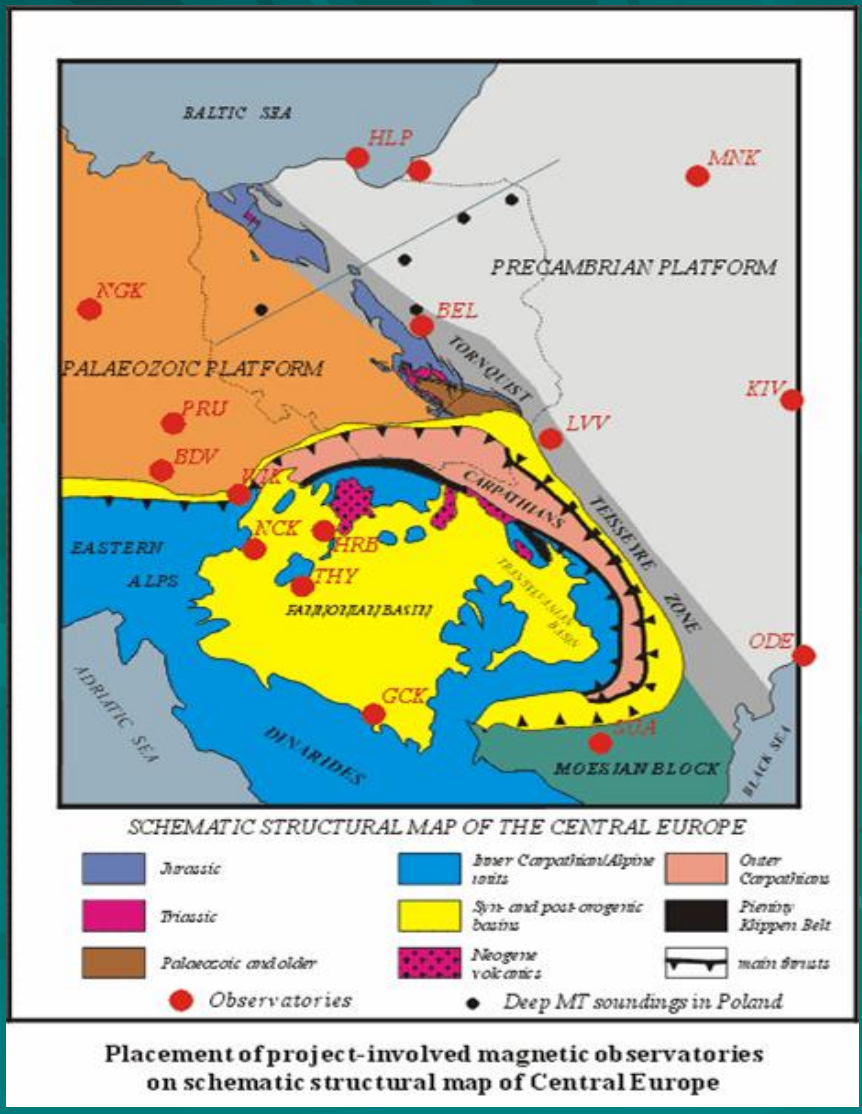
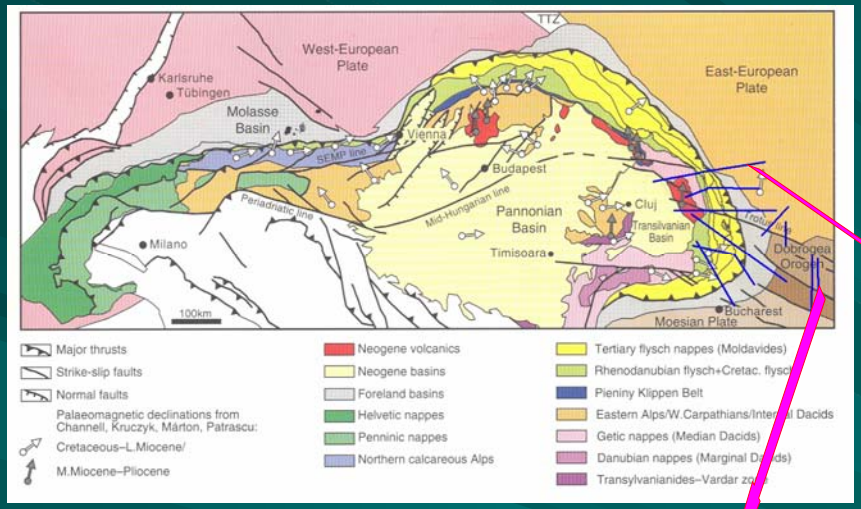


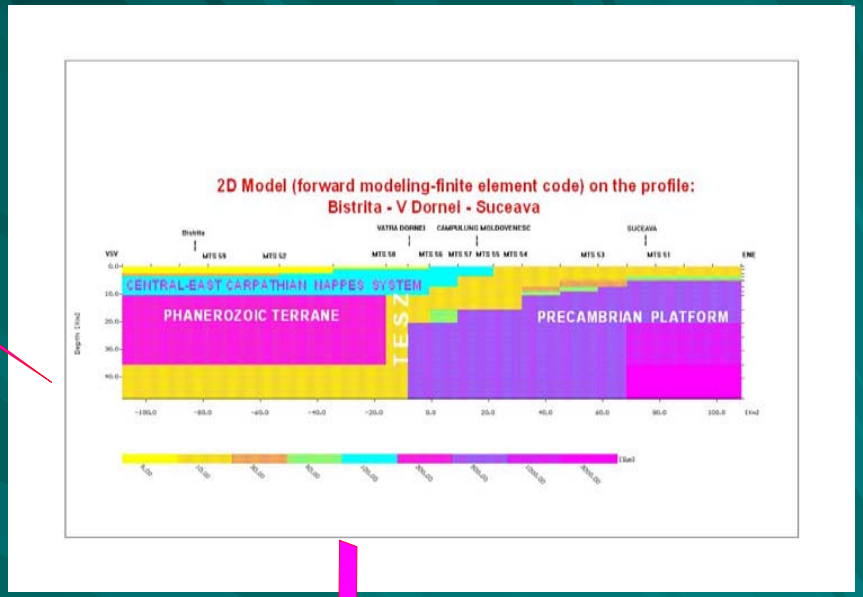
Fig. 3. In this 3-D perspective scheme of smoothed depth, the mantle conductance reaches the value of 100 kS (see Figure 2) beneath Europe.



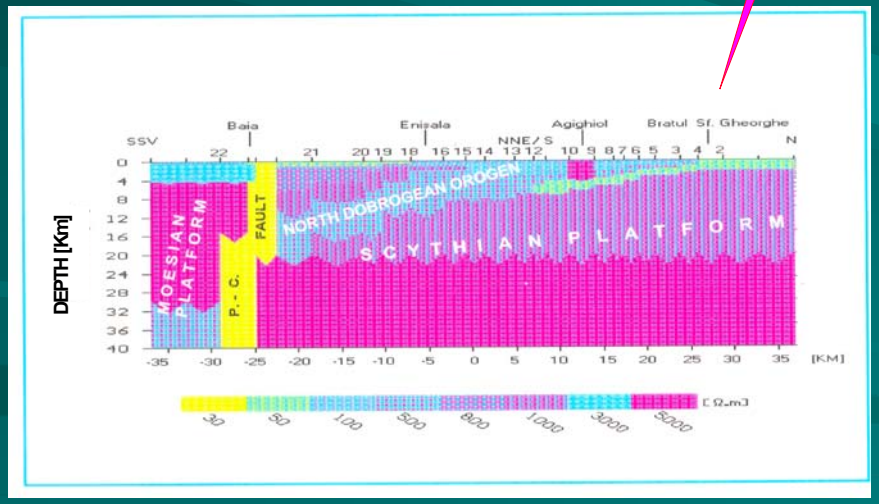
Placement of project-involved magnetic observatories on schematic structural map of Central Europe

TESZ - LITHOSPHERIC PECULIARITIES ON THE ROMANIAN TERRITORY : 2D MT models and response functions

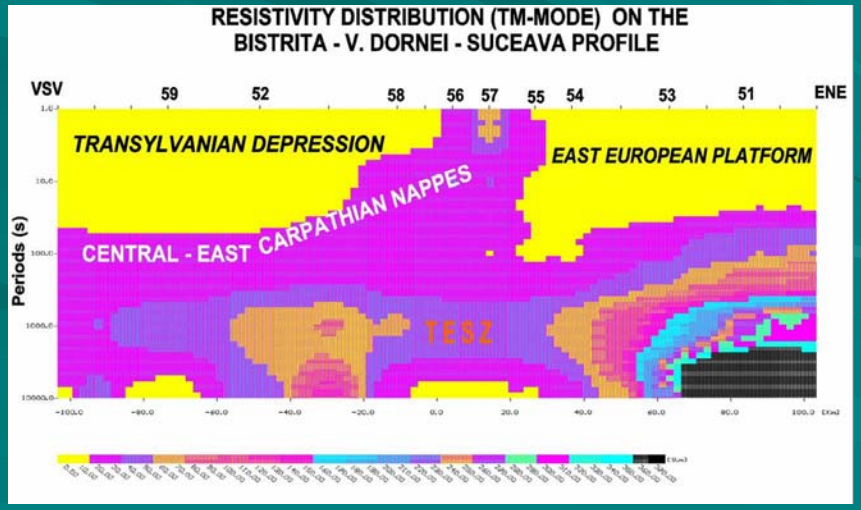




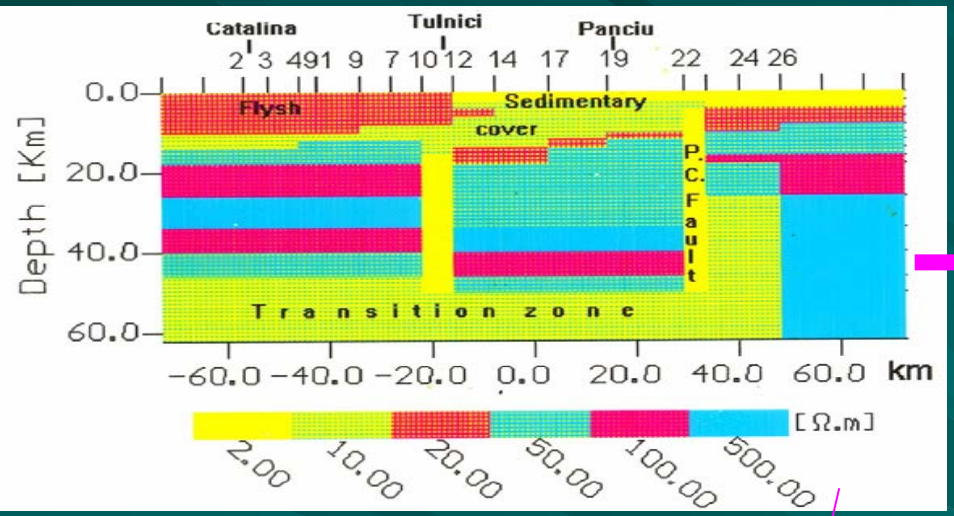
Resistivity response of the 2D model

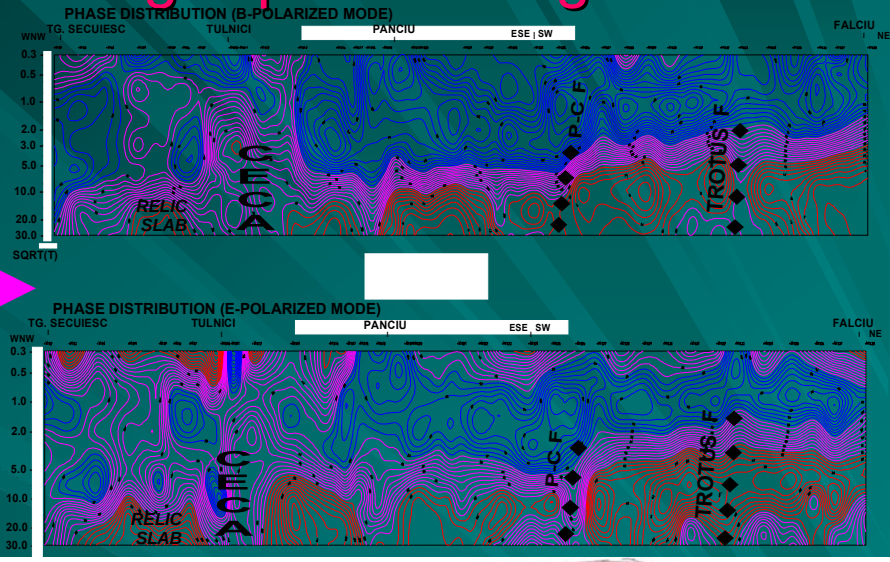


2D-tomographic image (ρ) along the blue line (Dobrogean Orogen) perpendicular to the Peceneaga-Camena (P-C) active fault

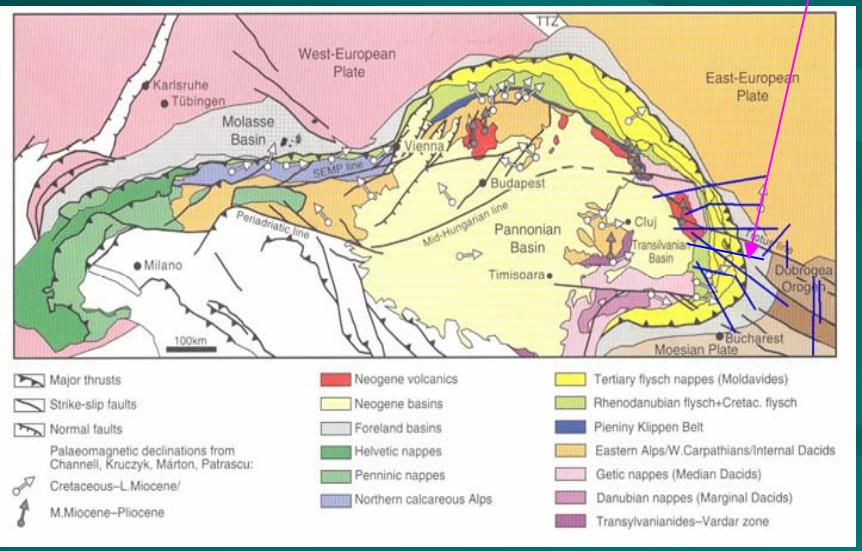


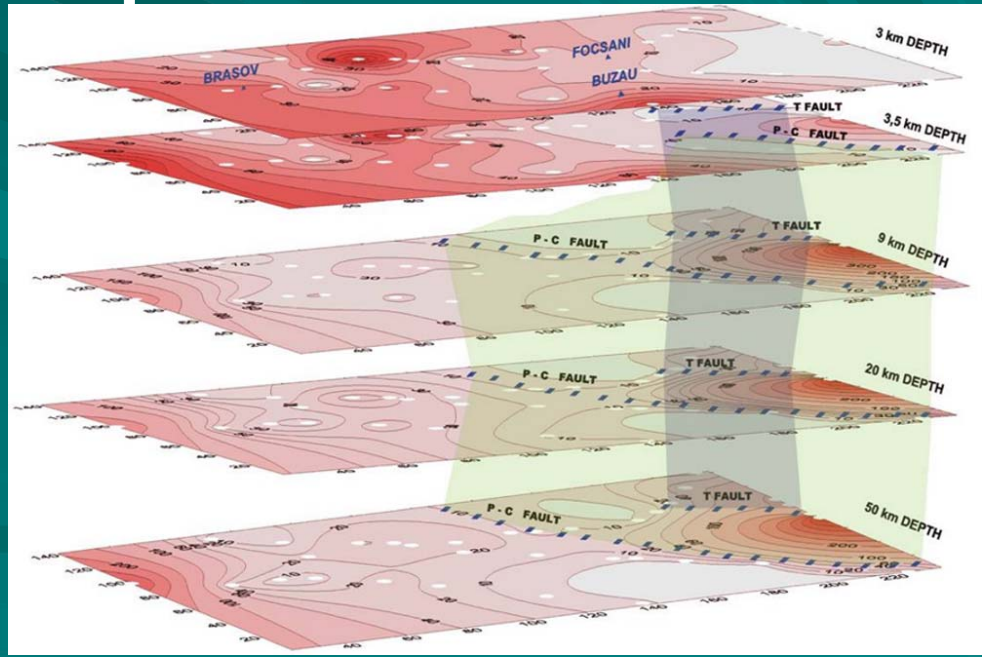
2D MT models and 3D tomographic images





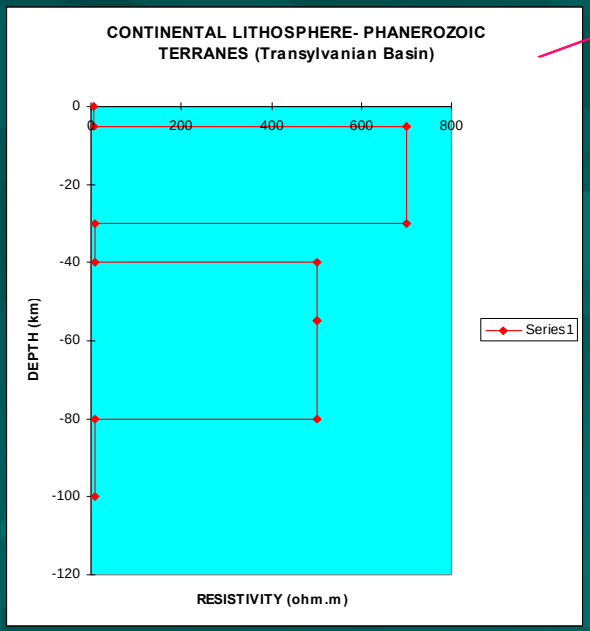
2D MODEL VRANCEA ZONE
Profile: Catalina - Tulnici - Panciu
(Forward modeling-finite element code)

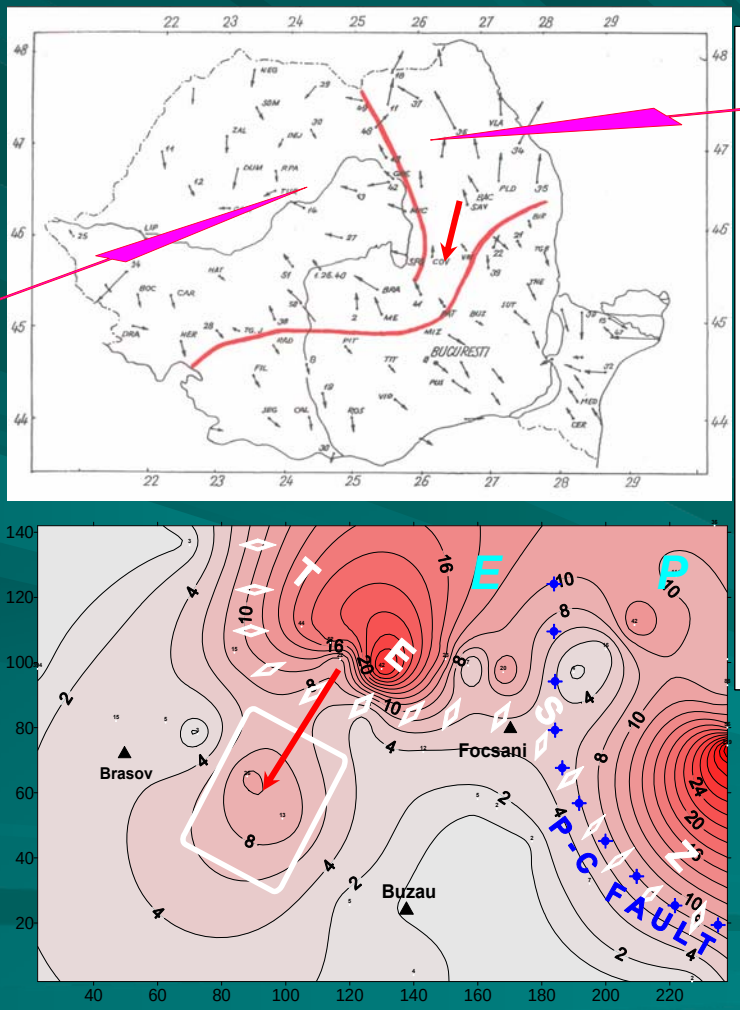


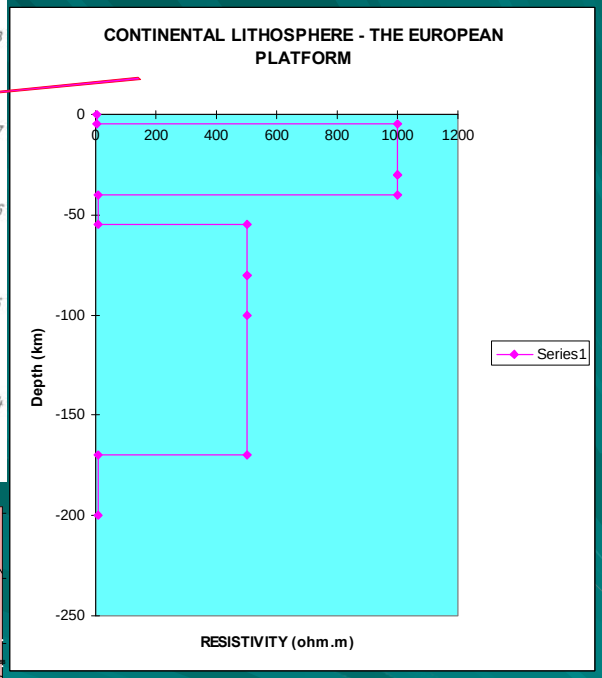


3D magnetotelluric tomographic image in the Vrancea zone on the 3-50km depth interval; green plane is the Peceneaga-Camena fault; blue plane is the Trotus fault.

Carpathian Electrical Conductivity Anomaly (CECA)



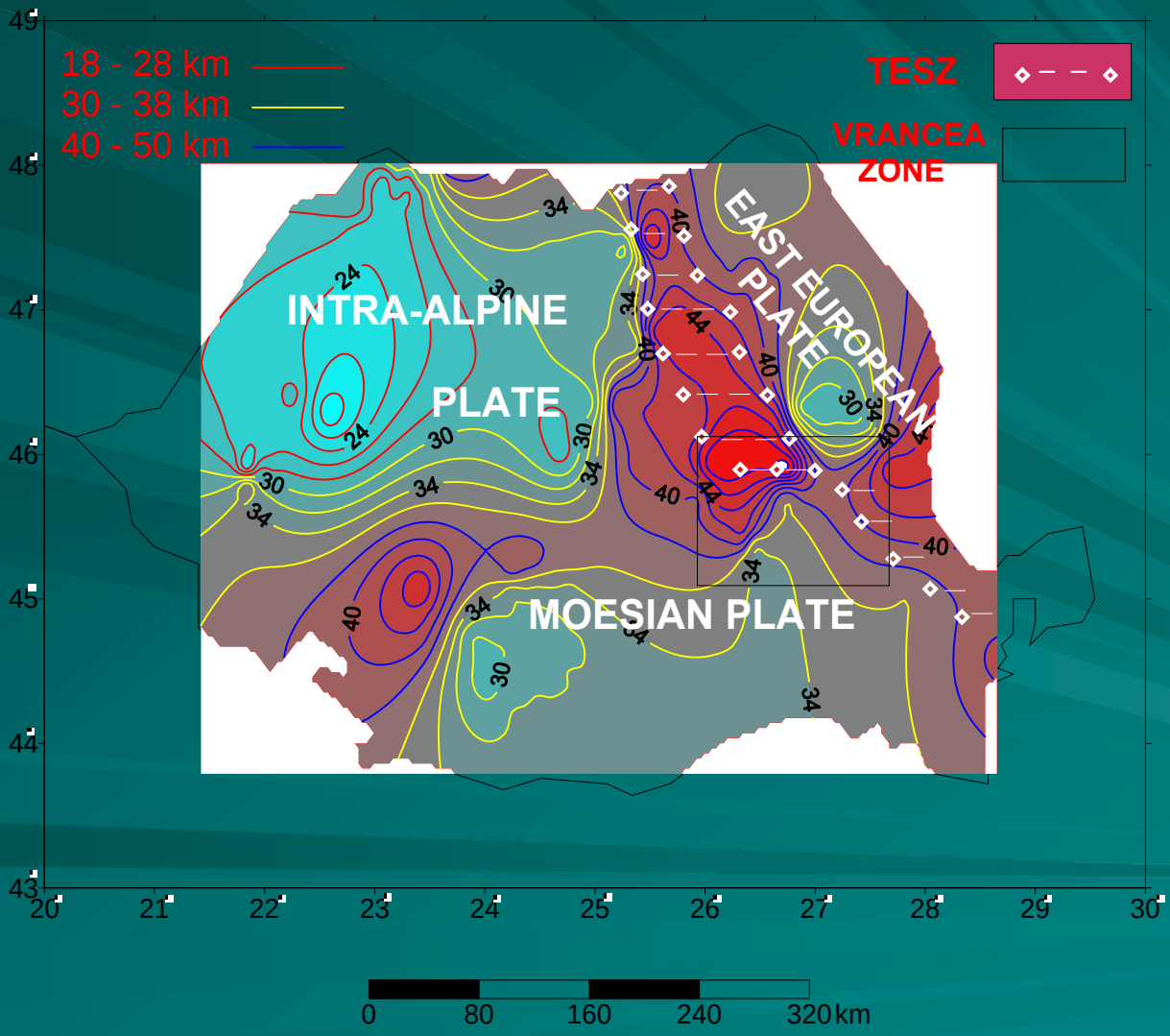




Resistivity distribution at 100km depth

TESZ - LITHOSPHERIC PECULIARITIES ON THE ROMANIAN TERRITORY : MT Data

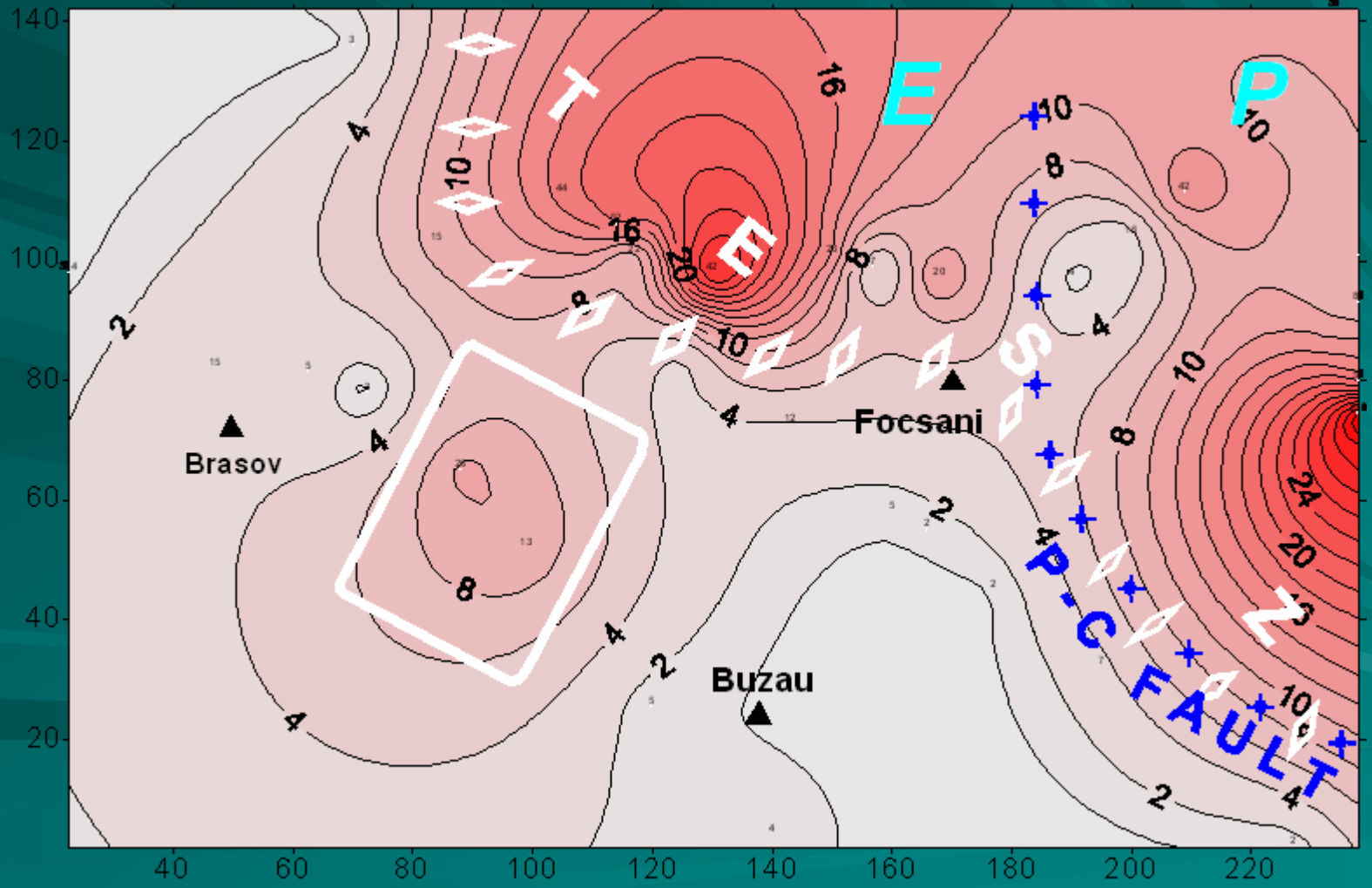
BRITTLE-DUCTILE TRANSITION ZONE IN THE LOWER CRUST



Stanica, Stanica - 1999, 2001

Magnetotelluric tomography (resistivity) at 100 km depth

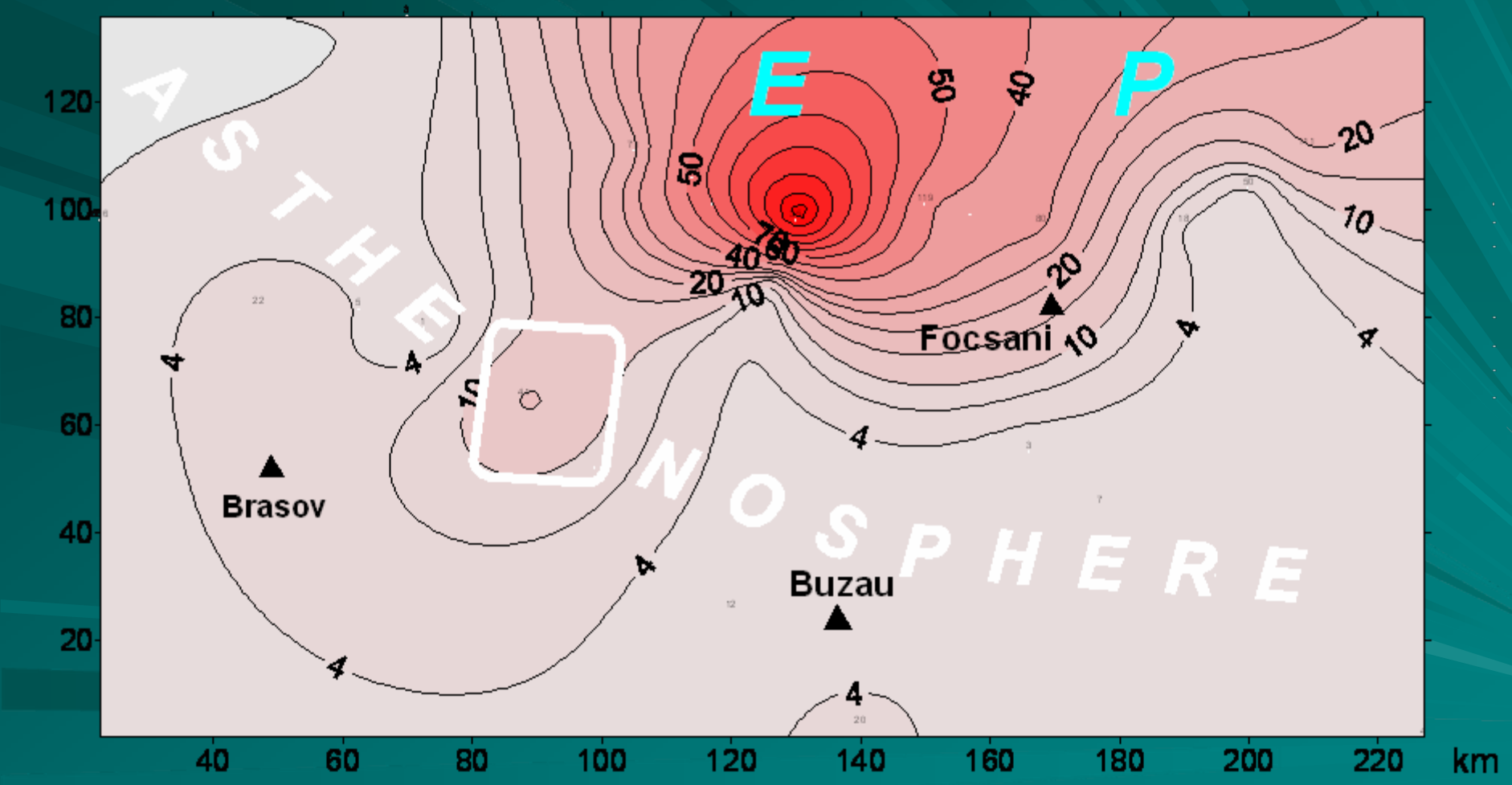
EP - European Platform;
white diamonds - Trans-European Suture Zone;
blue cross-wises - Pecenaga-Camena fault;
white rectangle - horizontal cross-section through the relic slab.



Magnetotelluric tomography (resistivity) at 150 km depth.

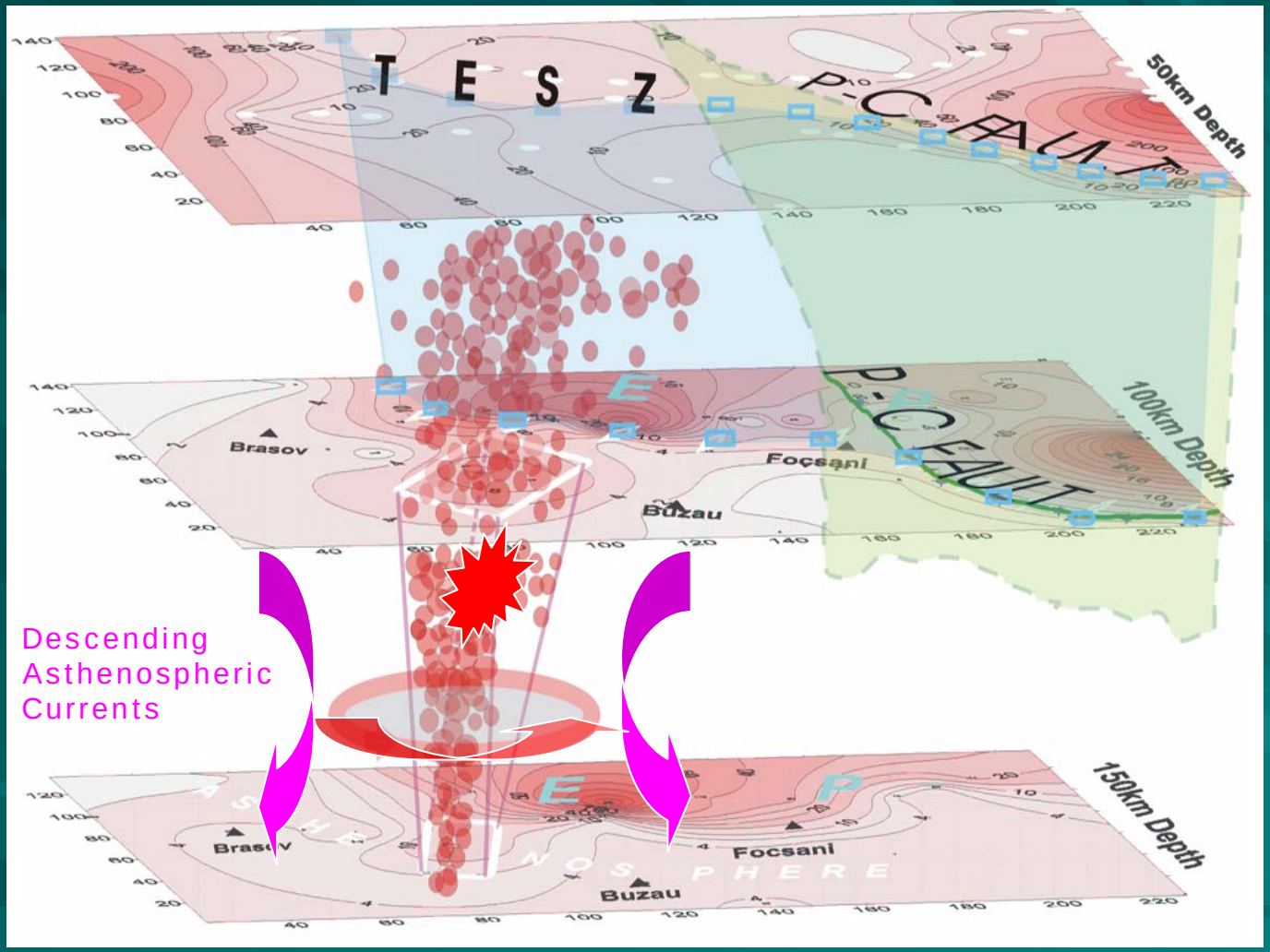
EP - European Platform;

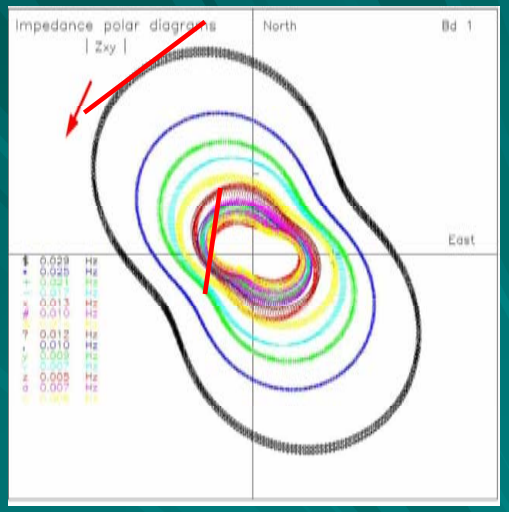
White rectangle - horizontal cross-section through the relic slab.

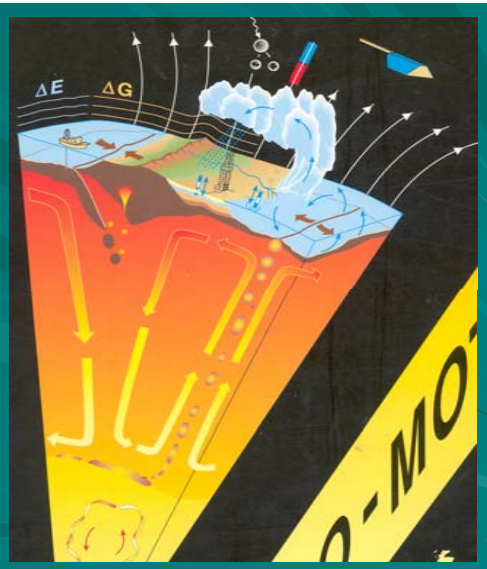


Deep Geodynamic Model (50-150km) - Vrancea zone

MT- TOMOGRAFIES - torsion process of the relic slab



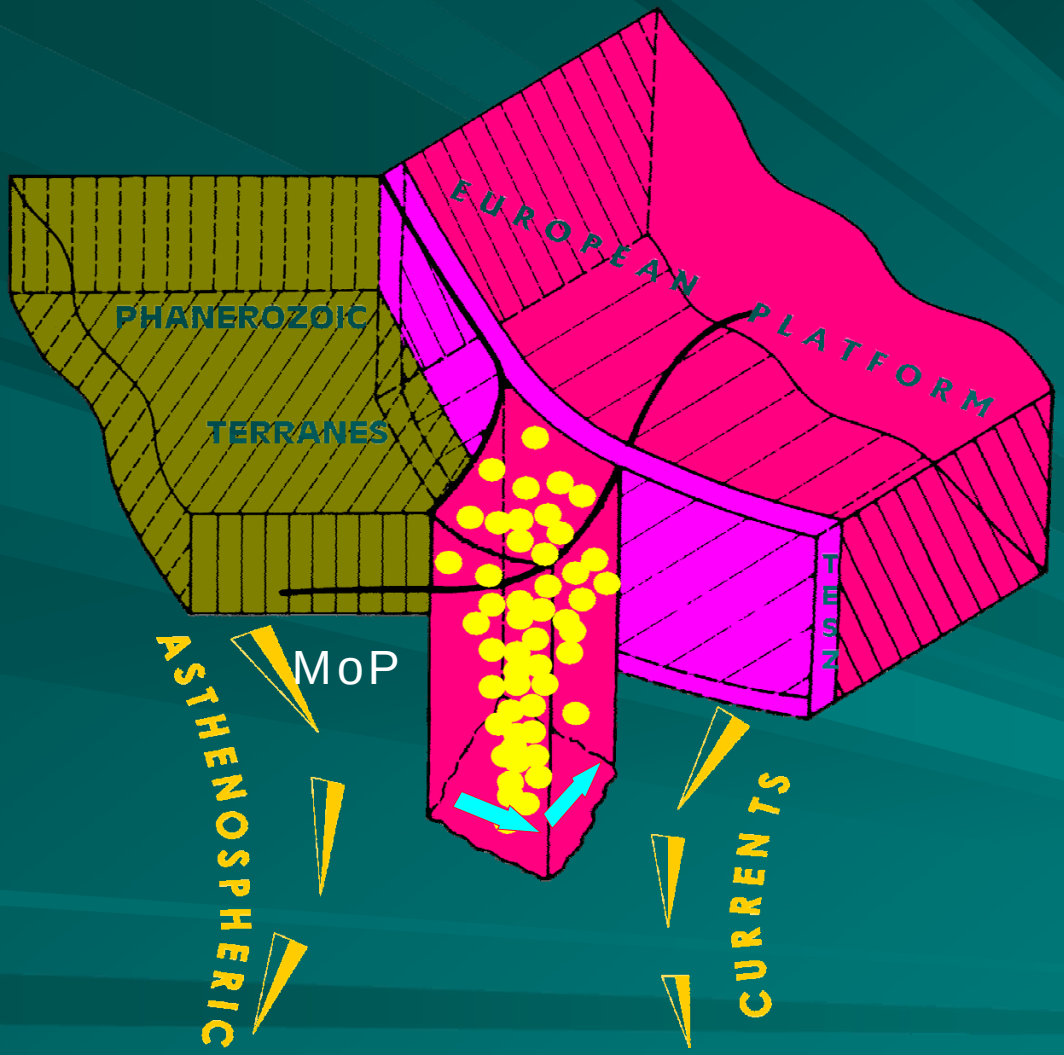




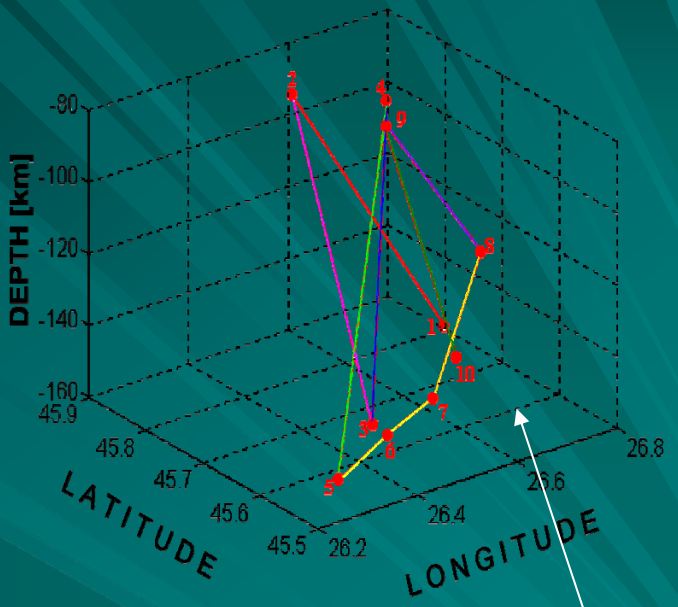
Stanica et al., 2004

GEO-MOTION GROUP

Geodynamic model- Vrancea zone



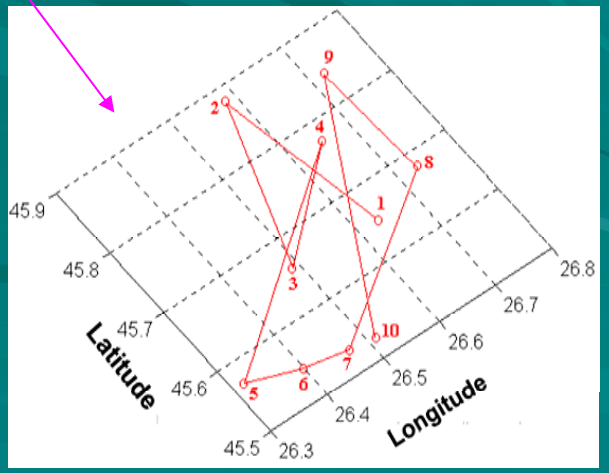
Geodynamic model elaborated beneath the crustal level. The thick black lines represent CECA; yellow circles are intermediate depth earthquakes(Stanica et al., 2004)



INTERMEDIATE DEPTH EQ

hypocenters

epicenters



SUMMARY:

- The inferred torsion that may result from the effects due to descending asthenospheric currents, on one hand, and to the irregular shape of the relic slab on the other, is capable, in our opinion, of generating a torque that may increase shear stress and drive faulting and re-shear within the rigid slab.

- If this is the case, then the triggering of the intermediate-depth earthquakes, in the Vrancea zone, may be interpreted as the rock response to active torsional processes sustained by a counterclockwise rotation of the slab which is induced by the complex interplay among the threefold structure of the lithosphere, in this sector of the Eastern Carpathians, and the surrounding asthenosphere.

Acknowledgments:

This study is supported by the Ministry of Education and Research, National Program "PN2", Contract No.31-018/2007-2010

THANK YOU !