4.7.2. VRANCEA INTERMEDIATE DEPTH SEISMICITY WITHIN THE GEODYNAMIC FRAMEWORK OF THE SE CARPATHIANS FORELAND

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4.7.2.1. Introduction

Intermediate earthquakes within the Vrancea region (Romania) occur within full continental environment, in a very confined epicenter area, but with a large vertical extension in depth. Only two other seismic nests with similar peculiarities are known worldwide: Bucaramanga (Colombia) and Hindu Kush (Afghanistan).

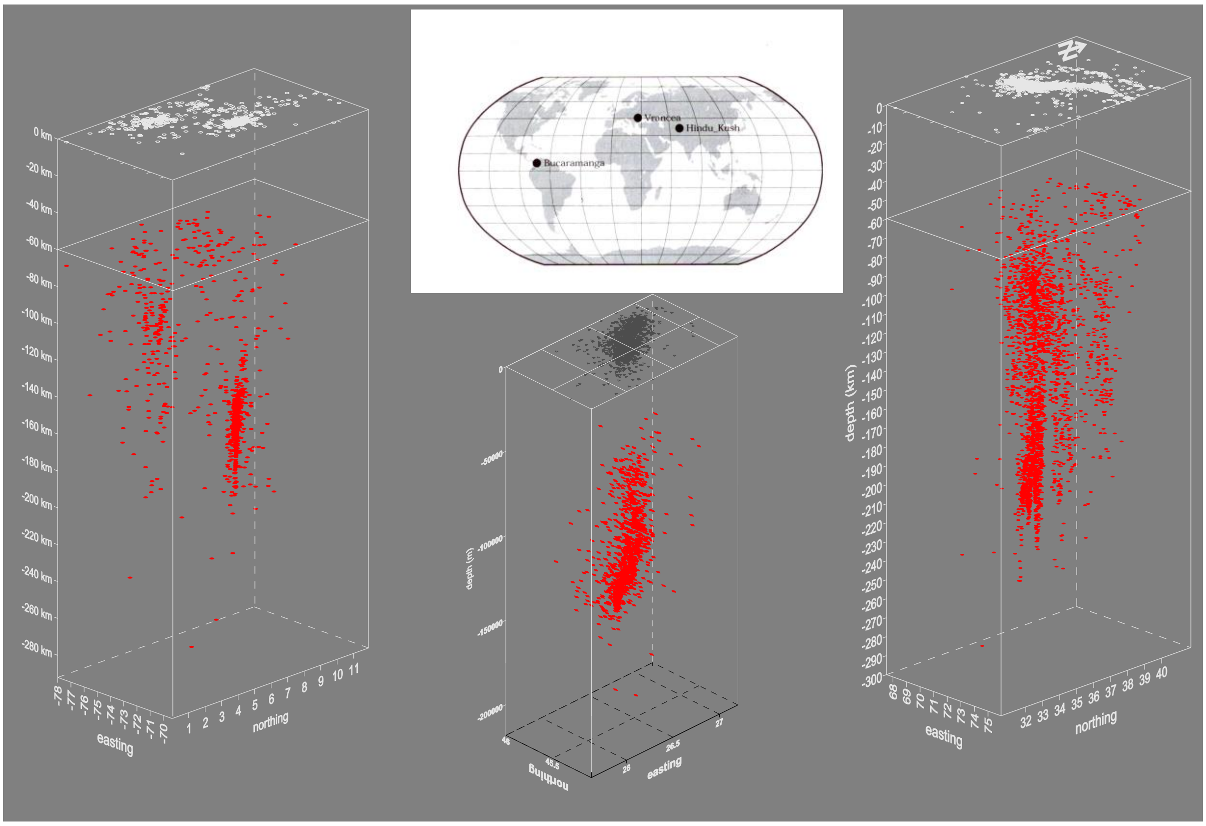

Fig. 4.7.2.1. Comparative view of the intermediate depth seismic nests in the world. From the left to the right: Bucaramanga (Columbia), Vrancea (Romania) and Hindu Kush (Afghanistan). Key map shows locations

Comparisons between geometry and dynamics of seismicity in the three regions (Besutiu, Cadicheanu, 2003) revealed both similarities and discrepancies. Attempts based on subduction hypothesis were made to explain peculiarities of the Vrancea seismicity. However, it should be mentioned that there are some strong evidence against

such hypothesis starting with the unusual geometry of the seismic zone, and total absence of the subduction related volcanism. Consequently, alternate solutions, such as mantle/crust delamination, or the unstable triple junction, were proposed.

4.7.2.2. Geotectonic setting

In the Vrancea area three tectonic plates join each other (e..g. Constantinescu et al, 1976; Besutiu, 2001): East European Plate (EEP), Intra-Alpine sub-plate (IaP) and Moesian sub-plate (MoP). MTS data (Stănică et al, 1986) showed distinct lithosphere thickness for each of them: 80-90 km within IaP, 120-150 km for MoP, and more than 150 km for EEP. Just in the Vrancea zone, the magnetotelluric soundings data pointed out the asthenosphere at about 250 km in depth. Various geophysical data (magnetics, heat-flow, gravity, geomagnetic induction vector, magnetotelluric soundings, seismicity, etc.), were used to reveal the path and nature of the contacts between the tectonic plates, usually hidden by thick sedimentary covers: Peceneaga-Camena dextral strike-slip fault (between MoP and EEP), Trans-Getica dextral strike-slip fault (between MoP and IaP), and Tornquist-Teisseyre compression zone (between IaP and EEP). Two seismic belts are located along the strike-slip plate boundaries, while TTZ compression contact does not seem to generate seismicity.

4.7.2.3. Geodynamic framework

Past to recent geodynamics in the studied area were examined based on geological and geophysical evidence. Among various geodynamic events, the Black Sea opening played a major role in the seismotectonic setting of the SE Carpathians foreland (Besutiu, Zugravescu, 2004). Following the crust extension generated by the West Black Sea basin

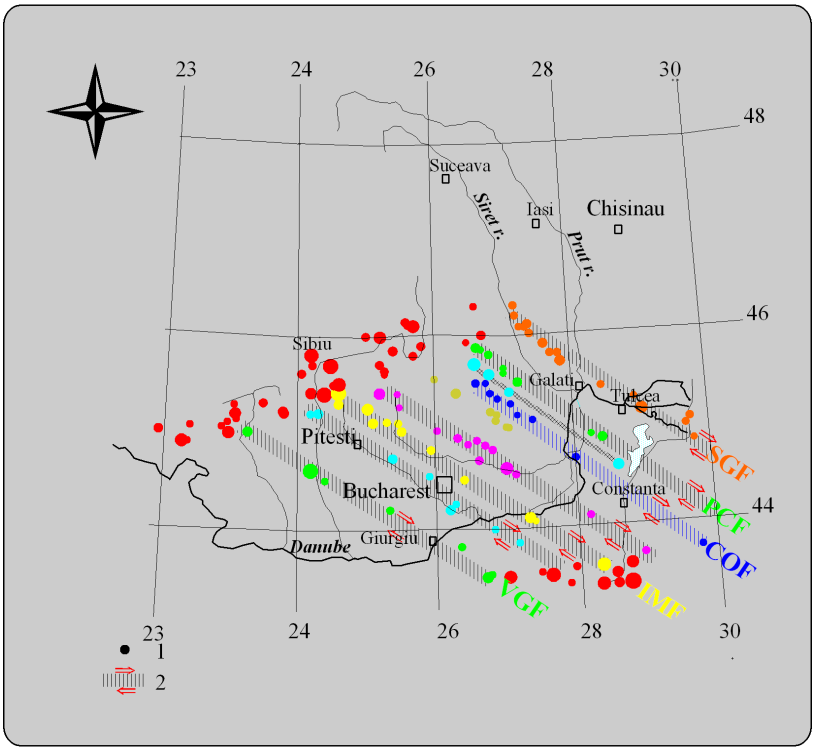

Fig. 4.7.2.2. Epicenters of the last millennium recorded earth-quakes lined up along the major crustal faults within SE Carpathians foreland by using polynomial regre-ssion analysis (according to Besutiu, 2001a)
1, epicenter; 2, fault

opening, some major faults were reactivated or created in the NW inland, splitting the SE Carpathians into several crustal slivers. After the Black Sea basin ended its evolution, the active geodynamic factor in the SE Carpathians seems to be tectonic forces generated by active rifting in the SW Arabian plate. The Arabian Plate “push” is transmitted to the SE Carpathians foreland through the micro-plates located between the major Eurasian and African plates. Regional stress tensor in the area, as inferred from borehole breakouts and/or earthquake focal mechanisms, shows a NW strike along the Peceneaga-Camena fault (the NE boundary of MoP), which turns towards WSW along the northern boundary of MoP (Trans-Getica fault) suggesting a small scale tectonic escape along TGF, to which active seismicity within South Carpathians should be associated. By using the polynomial regression analysis within SE Carpathians foreland it has been showed that epicenters of the crustal events are lined up along the track of several major faults: Sfântu Gheorghe (SGF), Peceneaga-Camena (PCF), Ostrov-Sinoe (OSF), Intramoesian (IMF), Varna-Giurgiu (VGF), etc). It is likely that under the action of tectonic forces generated by the active rifting in Red Sea and Aden Bay, crust compartments are pushed toward NW, but usually stay together by friction. However, when tectonic forces exceed the friction, the above mentioned slivers slip relatively each to another, and generate crust seismicity along their wedges.

On the other hand, the West Black Sea basin opening provided the necessary speed excess to MoP to generate the unstable transform-transform-compression triple-junction within Vrancea zone, pushing down the lithosphere fragment squeezed between the plates.

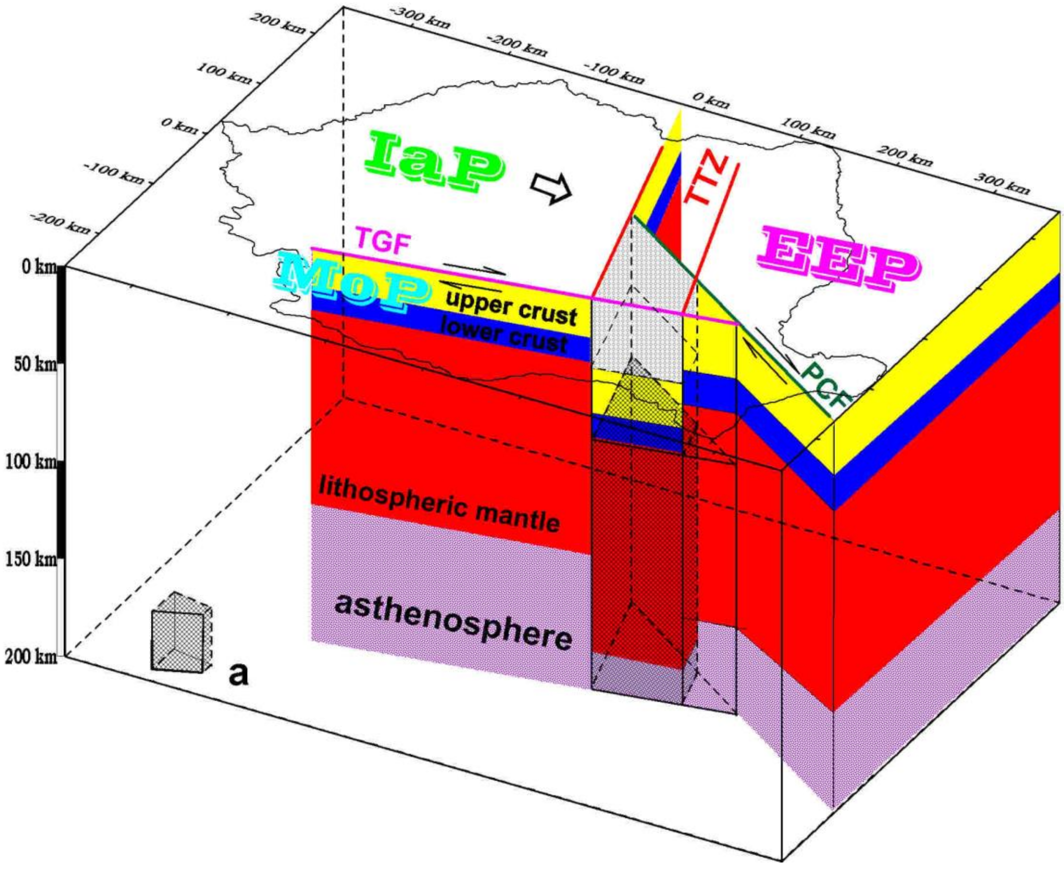

Fig. 4.7.2.3. Basic scheme for the unstable transform-transform-compression triple junction within Vrancea zone (according to Besutiu, 2001b)
a) lithosphere collapsed sector. For additional explanation see the text

Consequently, the upper colder lithosphere compartment penetrated the hotter upper mantle and provoked various temperature-accommodation phenomena to which intermediate earthquake may be associated: convective currents, thermal stress, phase transform processes, dehydration, etc. Within such circumstances, any acceleration into the MoP speed, due to intensification of the rifting in the Red Sea or Aden Bay, would be able to generate both seismicity along MoP faults (by breaking down the friction between crustal slivers), and/or intermediate earthquakes within Vrancea zone (by accenting the sinking of the lithosphere fragment which would increase the thermo-baric disequilibrium).

4.7.2.4. Seismicity migration

Statistics on the location of the Vrancea intermediate earthquake foci between 1940-2000 outlined two major features in agreement with basic triple-junctions mobility:

- an overall SW migration of seismic activity with a slight deepening, interrupted by the catastrophic event of March 4, 1977, when the trend reversed;
- a vertical clustering of hypocenters, indicating the presence of three lithosphere compartments, separated by decoupling zones, with distinct increasing dynamics towards the depth under the action of mantle currents.

In fact, a distinct dynamics of the lithosphere compartments separated by the high active seismic zones at 90 km, 130 km and 150 km was revealed that suggest a depth related different mobility of the Vrancea unstable triple junction.

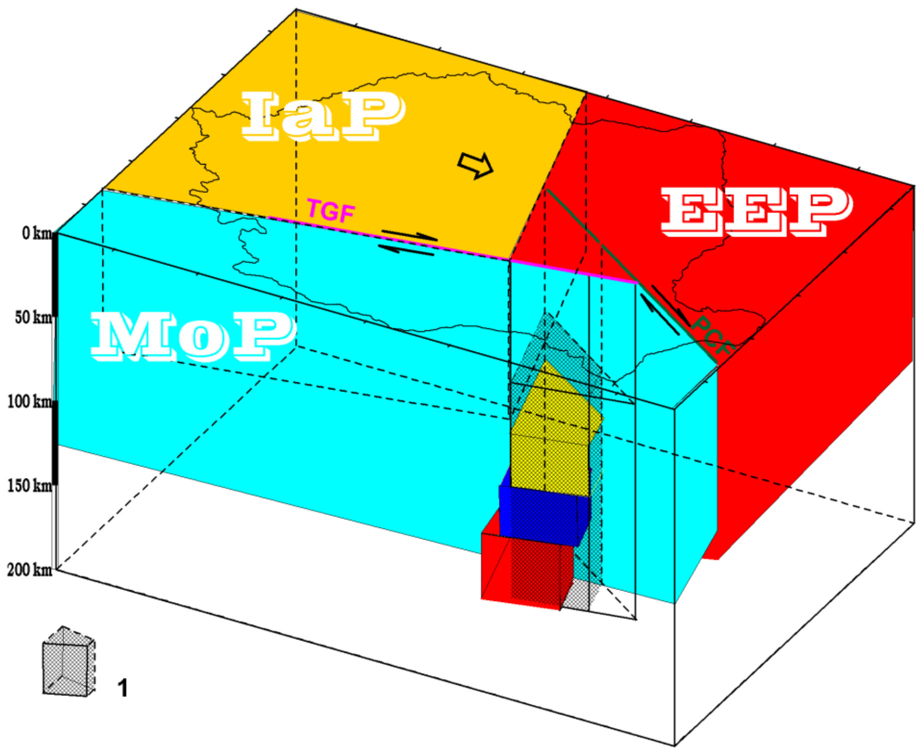

Fig. 4.7.2.4. Cartoon showing different dynamics with the depth of the lithosphere compartments within Vrancea unstable triple-junction as inferred from statistics on the earthquake occurrence
1) collapsed lithosphere. For additional explanations see the text

It should be mentioned that a new trend reversal in seismicity dynamics has been recorded after the large earthquake on 1990, similar to situation preceding the disastrous March 4, 1977 earthquake, which could be interpreted as a precursory of an extreme event in Vrancea during the next years. However, a clear conclusion on this direction could be possible only by adding more information to the actual model.

4.7.2.5. References

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