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ACTIVE FAULTS SYSTEMS RELATED TO EARTHQUAKES IN THE CARPATHO-BALKAN AREA

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Introduction

The Carpatho-Balkan is one of the most active seismic area of Europe. The seismicity of the area is related to the active tectonics in the Carpatho – Balkan zone. In term of seismicity in order to create a regional model for the earthquake occurrence and effects on people and environment, a research of the active faults in this area was launched. The main objective of this research is to find a relation in time and space between earthquakes and active faults from in this region.

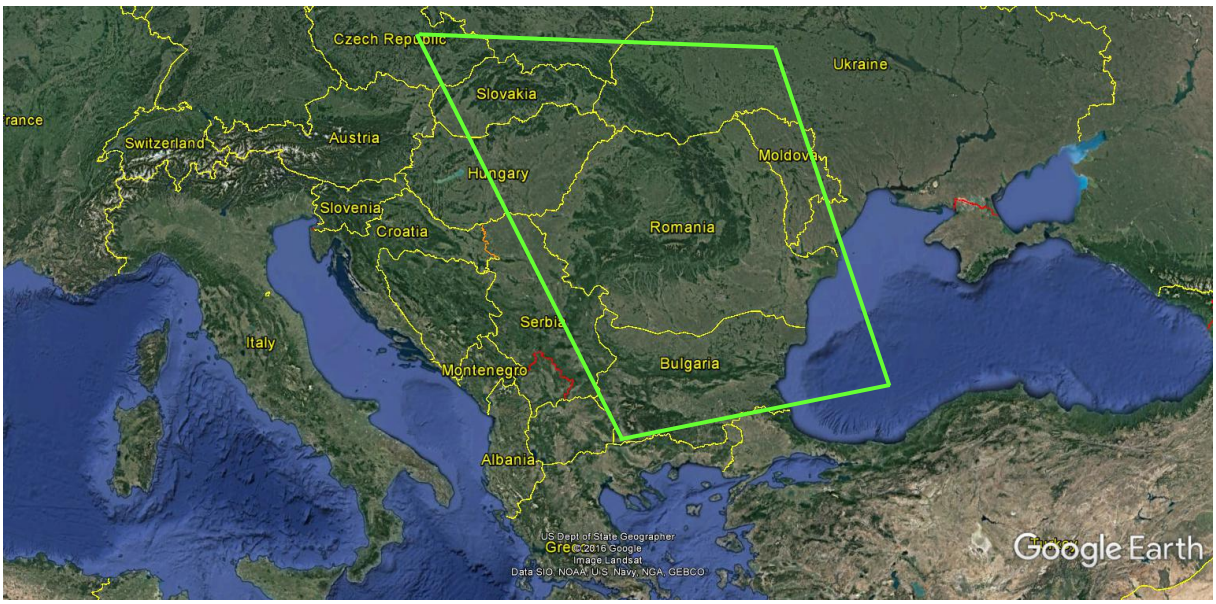

Figure 1. Geographical location of Carpatho-Balkan area
(Modified from Google Earth)

Tectonics and active fault systems in Carpatho-Balkan area

The Carpathians is a geological young European mountain chain formed in the eastward continuation of the Alps. From Slovakia, they developed in a wide shaped arc to near Orsova, Romania, at the Danube River valley (Britannica, 2016). The Balkans lay in the eastern part of the Balkan Peninsula and they run from the Timok River valley near the border between Bulgaria and Serbia, eastward through central Bulgaria to the Black Sea.
The Carpathian-Balkan orogeny resulted from the convergence between Africa and Europe during the past 100 Ma (von Quadt et al., 2005).
From the neotectonic point of view the Western Carpathians are part of the Alcapa (Alpine-Carpathian-Pannonian) block. In this area are five main earthquake zones: the Pezinok-Pernek zone, related with the active Vienna Basin Transfer Fault (Hinch, 2005) responsible of Vienna Basin formation, the Dobra Voda zone, the most intensive and shallow earthquakes around

the Dobra Voda Fault, the Komaro zone related to Raba-Hurbanovo-Darno Fault, the Zilina zone of earthquakes related to ongoing collision and strike-slip movement in the Pieniny Klippen Belt and Central Slovakia zone, related to the Central Slovak Fault (Marko, 2004).
The true geological limits of the Carpathians are, in the west, the Vienna Basin, in the south, the structural depression of the Timok River in Serbia. In the north, northwest, northeast and south, the Carpathians are surrounded by the Sub-Carpathian structural depression. The arc formed by the Carpathians holds the Pannonian Basin and the low mountain and hilly zone of Transdanubia (Kondracki, 1989).

In Romania, the most significant seismicity is located in Vrancea area, where 2-3 intermediate depth strong earthquakes (Mw > 7.0) occur in a century. Tectonics of Romania includes Alpine orogenic structures, pre-alpine platforms and foredeep area: East-European Platform with its western margin-Moldavian Platform, Scythian Platform, Moesian Platform, Carpathian Orogen and North Dobrogean Orogen, Transylvania Basin and Pannonian Basin (Sandulescu, 1984).

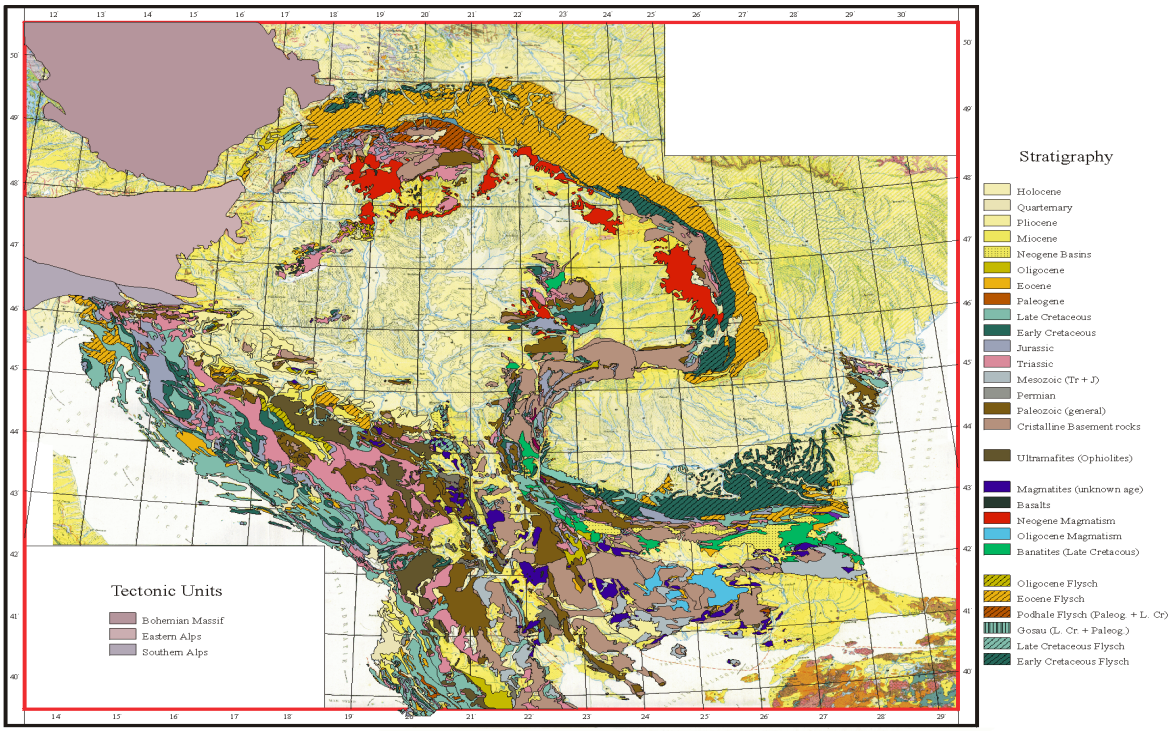

Figure 2. Geological map of Carpatho-Balkan area
(Beck-Mannagetta & Medwenitsch, 1978)

The platforms are of different ages, structure and lithology and the contact between them are long, deep crustal faults, often seismogenic. Barlad Depression is known by a moderate seismicity zone ($M_w \leq 5.6$) and an important role seems to have the Trotus Fault, oriented W-E, and its satellites. Predobrogean Depression and North Dobrogean Orogen have a moderate seismicity and they are separated by the Sf. Gheorghe Fault, oriented NW-SE. Vrancea area was affected during time by very strong earthquakes. The earthquake from 1802 was estimated to be the strongest in the Carpatho-Balkan area, with an estimated magnitude of Mw 7.9 (ROMPLUS, 2016). One of the strongest recorded earthquakes in Europe is the event with Mw7.8 from 1940, Panciu, Vrancea (http://earthquaketrack.com/). The area Focsani-Rm. Sarat is affected by the Capidava-Ovidiu Fault, oriented NW-SE, Zarnesti-Focsani Fault and Valea

Salciei Fault. In the Braila-Galati-Marasesti area, most of the events are related with the Peceneaga-Camena Fault and its satellites.

The Intramoesian Fault is crossing the basement of Moesian Platform, from the shore of Black Sea to Carpathian Orogen (Săndulescu, 1984). The crustal fault systems in the Moesian eastern compartment trend NW–SE, while the western compartment displays faults trending NW–SE, N–S, W–E and NE–SW (Ioane et al. 2015). Recent interpretations of reflection seismic data attested that the NW–SE fault system affects also the Tertiary sediments, while the ENE–WSW system is active until present as transtensional strike-slip (Rabagia et al. 2000, in Ioane et al., 2015).

In the Crisana, Maramures, Satu Mare areas, some moderate magnitude earthquake were observed. Several epicenters areas are known along the crustal fractures: Sighetul Marmatiei on Mara fault, Baia Mare on Dragos-Voda fault and its satellites, Halmeu on Halmeu fault and its satellites, Jibou on Benesat-Ciucea fault (Polonic, 1986).

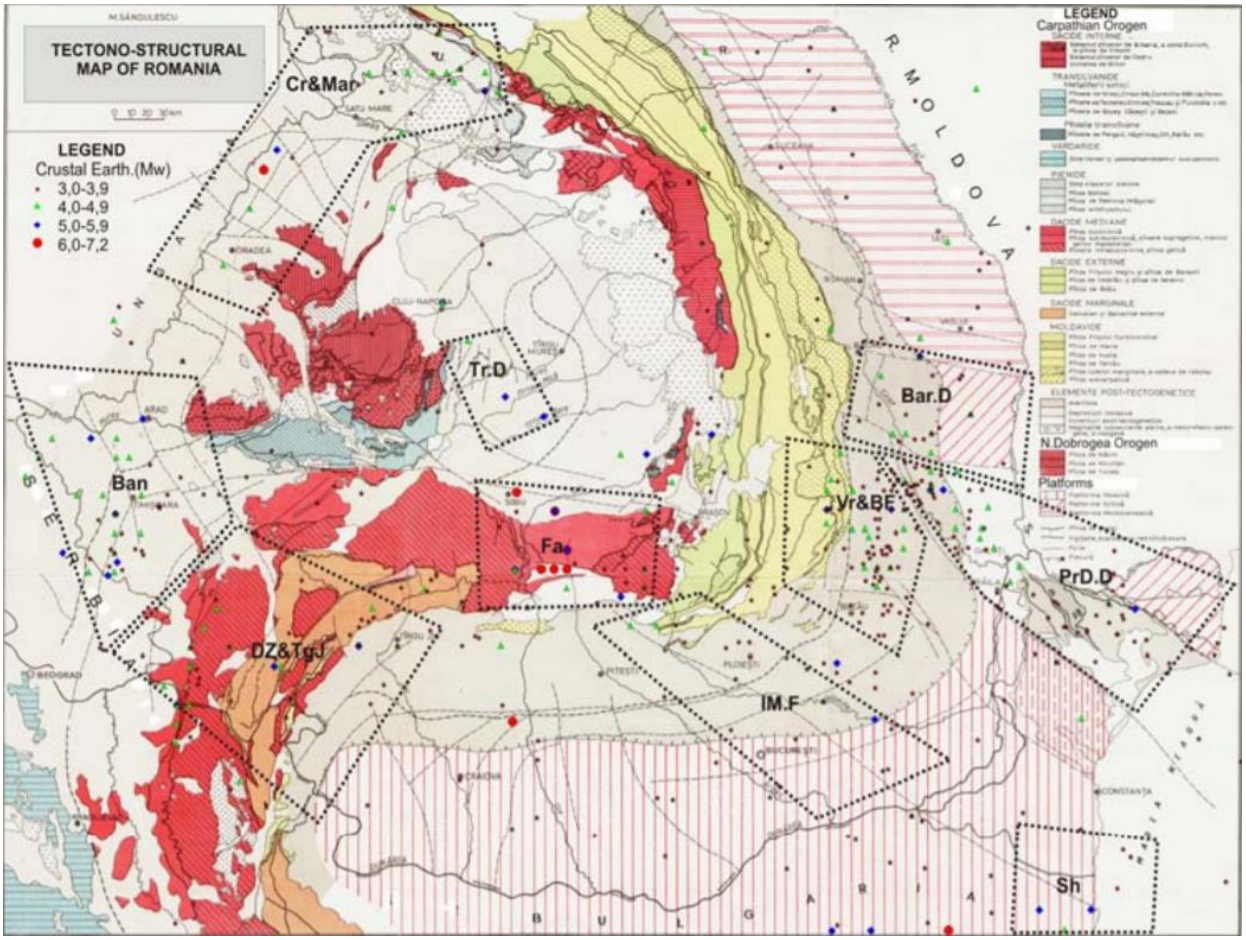

Figure 3. Map of tectonic units in Romania (Săndulescu, 1984), with crustal seismicity zones. Bar.D = Bârlad depression, Vr&BF = Vrancea crustal zone and Focşani basin, PrD.D = Predobrogean depression and North Dobrogean promontory, IM.F = Intramoesian Fault, Sh = Shabla zone, Fa = Făgăraş-Câmpulung-Sinaia zone, DZ&TgJ = Danubian zone and West Oltenia, Ban = Banat zone, Cr&Mar = Crişana and Maramureş zone, Tr.D = Transylvanian depression
(*Bala et al., 2013)*

The Bulgarian territory, like the whole of the Balkan Peninsula, is situated within the range of the Alpine belt. Geologically, the Struma fault zone is the most interesting and at the same time

the most dangerous fault zone on the territory of Bulgaria (Vrablyanski, 1993). The most powerful earthquake in Bulgaria (7.8 M_w, 1904, Struma Valley) has been recorded in this fault zone (Meyer et al, 2002). Other important faults zones in Bulgaria are Krupnik-Kresna seismic zone, (Dobrev, 2011), Maritsa Fault zone, East Vardar Fault Zone, Gorna Oryahovitsa Fault zone (Kotzev, 2006), Shabla/Cape Kaliacra zone where recordings show an active seismicity, generating the strongest earthquakes within the Moesian Platform. The strongest earthquake in this area was of 7.2 Mw, 14 km depth (Stanciu & Ioane, 2016)

Conclusions

The Carpatho-Balkan area is one of the most active tectonic and seismic zones of Europe. In this area the strongest earthquakes of Balkan Peninsula occurred: 1904, 7.8 M_w Bulgaria, Struma Valley; 1940, 7.8 M_w, Panciu, Vrancea and 1977, 7.7 M_w, Nereju, Vrancea (ROMPLUS, 2016). The Vrancea area is defined by significant high seismicity (7.0 M_w) with 2-3 events per year.

This area is affected by important active faults systems, to significant earthquake zones: Western Carpathian, with five major zones; Romania with the most significant zone, Vrancea area; Bulgaria with six important zones.

The published data have been studied for the Carpatho-Balkan area in order to present an overview of the regional active tectonic and the seismic potential of the area and to find the relations in time and space between the occurred earthquakes during historical and geological time.

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