ACTIVE TECTONIC PROCESSES ON THE TERRITORY OF ROMANIA

***Ion Stelea*[1]**

Abstract. The maximum gravimetric anomalies, correlated with isostatic data, with the morphology of the Moho discontinuity and with depth seismic data highlight the presence of four lithospheric microplates on the territory of Romania, one inside the Carpathian Orogen (the Interalpine Microplate) and three outside (the Eastern European Plate, the Moesian Microplate and the Black Sea Microplate). Their slip directions are convergent on the Carpathian orogen. The regions affected by continuous uplift and continuous vertical descent movements during the Quaternary are outlined on the neotectonic map of Romania. The consequences of these tectonic movements are also assessed.

Key words: horizontal movements, vertical movements, consequences

INTRODUCTION

Tectonics is the discipline of geology that deals with Earth dynamics, and neotectonics is the branch of tectonics that deals with recent tectonic processes. How recent differs from region to region, depending on the age of the last orogeny in the region we are referring to. Therefore, recent tectonic processes are post-orogenic tectonic processes, i.e. post-Cretaceous in the Carpathians, post-Miocene in the Subcarpathians, and Quaternary in the Subcarpathians of the Vrancea Bend. The equivalent of the term post-orogenic tectonic processes is that of active tectonic processes, which is used regardless of the age of the region we are referring to. It is also the reason why we also use it in the present paper.

THE REGIONAL CONTEXT

Horizontal movements. The maximum gravimetric anomalies, correlated with isostatic data, with the morphology of the Moho discontinuity and with depth seismic data highlight the presence of four lithospheric microplates on the territory of Romania (Airinei, 1977), one inside the Carpathian Orogen (the Interalpine Microplate) and three outside (the Eastern European Plate, the Moesian Microplate and the Black Sea Microplate). Their slip directions are convergent on the orogenic chain, the Interalpine Microplate in the W-SW direction, the East European plate in the roughly E-W direction, the Black Sea Microplate in the NW direction and the Moesian Microplate in the WNW direction (Fig. 1a). The Black Sea Microplate moves faster than the Moesian Microplate and the East European Plate, a fact attested by the high seismicity of the contact with the orogen in the Vrancea Bend which is a subduction contact.

This geodynamic model will be completed and partially modified by Săndulescu (1984; 1994) based on detailed geological data on the territory of Romania and

[1] Dr. CS I, Geological Institute of Romania, e-mail: ionstelea@yahoo.com

newer geophysical data on the deep structure of the Moesian Platform (Visarion et al., 1988) and its tectonic relationships with the orogen in the Făgăraș Mountains area (Visarion and Săndulescu, 1991).

In the model made by Săndulescu (1984; 1994), the East-European Platform is an immobile counterfort, which induces the crustal block inside the Carpathian Arch a rotational movement, from an initial displacement in the eastern direction to one in the southeast direction, towards the internal part of the Vrancea Bend. The Interalpine Microplate represents the Pre-Apulian Block, and the Black Sea Microplate is actually the eastern (Dobrogea) sector of the Moesian Platform, separated from the western (Wallachian) sector by the Intramoesian Fault.

Vertical movements. The regions affected by continuous uplift and continuous vertical descent movements during the Quaternary are outlined on the neotectonic map of Romania (Bandrabur et al., 1971; Fig. 1 b). Uplift movements with very high intensity are registered in the flysch zone of the Eastern Carpathians. The inner Foredeep in this area is affected by high-intensity uplift movements. The metamorphic basement of the Eastern Carpathians and of the central and eastern South Carpathians is affected by uplift movements of medium intensity. Uplift movements with reduced intensity take place in the Northern Dobrogea, in the Getic Subcarpathians and in the orogenic area in the west and north-west of the country, respectively the Almaj, Semenic, Poiana Ruscă, Apuseni, Gutâi and Țibleș mountains.

Descent movements with high intensity affect the external Foredeep in the bend area of the Eastern Carpathians, between Buzăului Valley and Trotușului Valley. The external Foredeep between the towns Titu, Brăila and Adjud, and the Pannonian Depression in the Arad-Cenad and Zarand-Salonta areas are affected by medium-intensity descent movements. The rest area of the Pannonian Depression, the Moesian Platform near the Vrancea Bend, the intramountain depressions from the upper basins of Olt and Mureș rivers and the Scythian Platform in the Danube Delta area are affected by low-intensity descent movements.

Negative movements in the Lower Quaternary and positive movements in the Upper Quaternary were recorded in the south and west of the Moesian Platform, along the Foredeep from Târgoviște to the Danube, in the Târgu-Jiu Depression, in the Scythian Platform and the adjacent Foredeep, as well as in the intermontane depressions from the Olt River basin. Reverse movements, positive in the Lower Quaternary and negative in the Upper Quaternary, were recorded in the southeast of the Transylvanian Depression, between the Olt River and the Făgăraș and the Perșani mountains. The Transylvanian Depression, the central and southern Dobrogea, and the central-northern area of the Moldavian Plateau, together with the neighboring Foredeep, are regions of relative stability during the Quaternary. The internal Foredeep in the south-eastern half of the Vrancea Bend is affected by intense fold deformations, while the external Foredeep in the north-eastern half of the bend is affected by reduced fold deformations. These are the newest deformations in the Romanian Carpathians area (Săndulescu, 1994).

LOCALIZED TECTONIC PROCESSES. CONSEQUENCES

Intramoesian Fault. In the opinion of the authors Visarion and Săndulescu (1991), the Intramoesian Fault does not appear at the Făgăraş Mountains because it is buried under the Getic Sheet at a depth of 10 km. However, recent tectonic data show that the fault currently crosses the metamorphic basement of the Făgăraș Mountains, with dextral slip and asymmetrical structure, being accompanied by secondary faults only in its western compartment (Stelea, 2017). The current path of the fault in the Făgăraș Mountains is marked by an alignment of cataclasites over 100 m thick (Fig. 2 a, b). On the ramifications in the western compartment, numerous landslides occur in the sedimentary formations of the Titești Basin.

The tectonic movements along the fault during the Cretaceous and Miocene contributed to the achievement of the alpine structures in the eastern of the South Carpathians. In the area of the Moesian Platform, both compartments of the fault move towards the orogen, but at different speeds, higher for the eastern compartment that subducts under the Vrancea Bend. The western compartment collides obliquely with the orogen without generating the thrusted structures that the eastern compartment generates in the Vrancea Bend (Săndulescu, 1994).

The Intramoesian Fault has an important seismic activity, the depth of the foci covering the entire thickness of the middle and the upper crust. In his monograph on the earthquakes in Romania, Atanasiu (1961) mentions eight earthquakes that fall along the Intramoesian Fault in the Făgăraş Mountains area (the so-called Făgăraș earthquakes) and in the Moesian Platform area: May 19, 1872, Câmpulung Muscel (degree V); October 13, 1894, Câmpulung Muscel (degree III); November 25, 1897, Urziceni (depth 2 km); October 26, 1898, Urziceni (depth 2 km); January 26, 1916, Făgăraș Mountains (depth 10-15 km, degree V at Titești, Cumpăna, Arefu, Mușetești and Nucșoara); January 5, 1940, Câmpulung Muscel (degree VI, depth 7-8 km); November 21, 1943, Câmpulung Muscel (depth 2 km); April 12, 1969, Câmpulung Muscel (depth 8 km). From this short list of it turns out that the Câmpulung Muscel area is a seismic epicenter for the earthquakes along the Intramoesian Fault.

The fault creates stability problems for the slopes of the Argeş Valley in the area of the Vidraru Accumulation Lake, especially on the right slope, where extensive slope stabilization works were necessary. Other serious problems appeared on the fault tract in southern Transylvania, west of Sibiu, seriously affecting the works on the A1 Highway, in the sector of the Aciliu locality in 2015, 2016, as well as 2017, the year when the expertise of the Geological Institute was requested. In September 2017 it was a disaster on the highway in this sector. The embankment dug in the Bucium Hill, consisting of clays, clayey sands and marls, had taken it downhill destroying all the drainage works (water collection channels, pipes) and the textile net for soil protection. Wide ravines, 2-3 m deep, furrowed the hill from top to bottom and successive landslides crossed the hill horizontally.

At the western head of the Aciliu Viaduct, the concrete slabs from the abutments were cracked and dislocated (Fig. 2 c, d).

Vrancea Bent. It is the most famous seismic zone in Romania, where the largest earthquakes occur, many with deep foci, located in the asthenosphere, on the subduction plane of the eastern sector of the Moesian Platform. The list of earthquakes in this epicentral area is very long and it is not appropriate to give a complete list here, we mention only a few after Lungu et. al (2013): October 26, 1802 (magnitude 7.9; largest earthquake of all time, popularly known as the great Good Friday earthquake); November 10, 1940 (magnitude 7.7, depth 150 km); March 4, 1977 (magnitude 7.5, depth 109 km; greatest damage verified); August 30, 1986 (magnitude 7.1, depth 133 km).

The Danubian Bend. The pressure exerted by the western compartment of the Moesian Platform in the Danubian Bend of the Carpatho-Balkan Orogen led to the appearance of two types of extensional fractures: dextral strike-slip extension and perpendicular extension. The largest are the faults with dextral slip, such as the Cerna-Jiu fault, which also extends south of the Danube, the Balta-Baia de Aramă tectonic alignment and the Turnu Severin-Târgu Jiu Fault, which is also a seismic line (Atanasiu, 1961) and continues south of the Danube through the Timocului Fault (Visarion et al., 1988). Fractures with perpendicular extension appear across the bend, such as the Obârșia Cloșani Fault, Isverna Fault, Iron Gates Gorge and numerous other faults on the territory of Yugoslavia (Marović et al., 1997). The cited author believes that the Danube course through the Iron Gates was tectonically controlled by a fault system (unspecified), associated with vertical uplift and descent movements on various sectors of the gorge. In our opinion, the main role in the formation of the Iron Gates Gorge and the Danube capture by the hydrographic basin of the Black Sea was played by the transverse faults with perpendicular extension.

CONCLUSIONS

The vertical movements are practically imperceptible to humans, but the horizontally movements of the crustal blocks are accompanied by intermittent discharges of the telluric energy that can cause significant material damage and loss of human life. Of course, these tectonic movements cannot be controlled but these must be taken into account in the construction of civil and industrial buildings and roads. The damage suffered by the A1 Highway on the Aciliu sector in the years 2015-2017 is a typical case of ignoring an important active fault such as the Intramoesian Fault.

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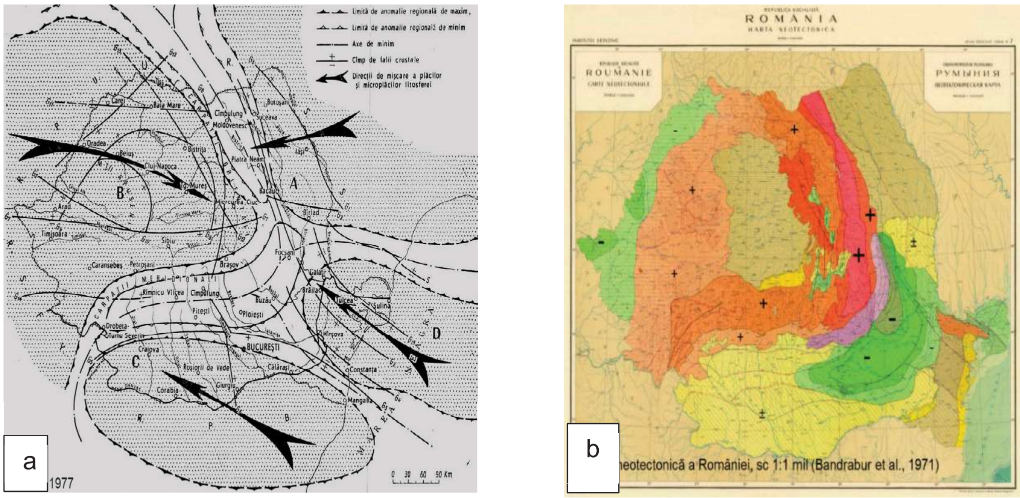

Figure 1. a) The horizontal movements of the lithospheric plates on the territory of Romania (Airinei, 1977). b) The neotectonic map of Romania, scale of 1:1 000 000 (Bandrabur et al., 1971) with the regions affected by vertical movements of uplift (+), downlift (-) and with changes of direction (±) during the Quaternary (Bandrabur et al., 1971). Further explanations in text.

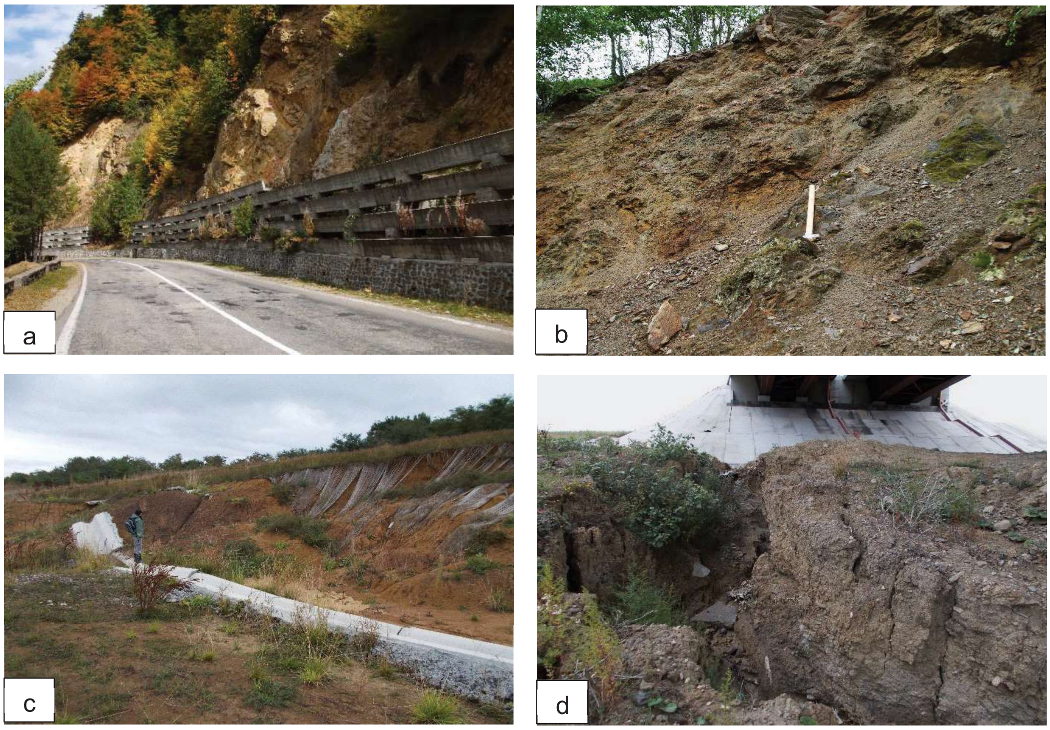

Figure 2. a) The Intramoesian Fault on the right bank of Lake Vidraru with cataclased augen gneisses and slope support works. b) The Intramoesian Fault in the northwestern Făgăraș Mountains, Moașa Sebeșului Valley, with cataclased micaschists. c) The cutting slope from Dealul Bucium with the destroyed drainage works and the broken protective nets. d) Deep ravine at the western head of the Aciliu Viaduct. Further explanations in text.