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GEOPHYSICAL INSIGHTS INTO THE STRUCTURE AND GEODYNAMIC EVOLUTION OF THE SE CARPATHIANS AND RELATED FORELAND IN THE CONTEXT OF THE BLACK SEA OPENING

The paper brings into discussion geophysical evidence for jointly explaining the unusual craton seismicity in front of the SE Carpathians and the upper mantle intermediate-depth earthquakes in the Vrancea zone within the frame of the geodynamic environment generated by the W Black Sea opening and further evolution of the lithosphere expelled towards NW by rifting.

Key words: potential fields, seismic tomography, geodynamics, Black Sea opening, faults, earthquakes.

Introductory

A brief examination of the seismicity map of Romania (Fig. 1) reveals at least two unusual peculiarities: (i) the intermediate-depth earthquakes (EQs) in the so-called Vrancea region, located within full intra-continental environment of the bending zone of East Carpathians, and (ii) the unexpected craton seismicity of the Eastern Moesian Platform and SW margin of the East European Platform, occurring between Carpathians and the Black Sea shore. The presence of the crustal events with vertical extension fault-plan mechanism exclusively within the epicentre area of intermediate-depth seismicity (iii) also represents a challenging issue.

The paper aims at presenting a coherent geodynamic model, for jointly explaining both crustal and upper-mantle seismicity in the area, within the geodynamic setting triggered by the W Black Sea opening and currently maintained by the active rifting in SW Arabian Plate.

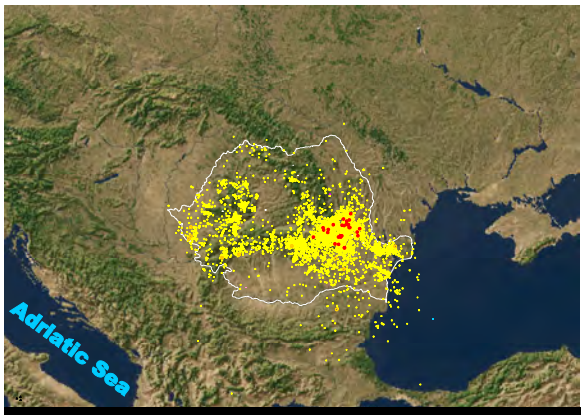

Fig. 1. The seismicity map of Romania.

Earthquake information according to ROMPLUS catalogue. Yellow dots show epicentres of crustal events; red dots mark crust EQs with vertical extension fault plan mechanism

On the Black Sea genesis

Despite many years of research, the Black Sea opening still represents a debated issue. Two main ideas are facing each-other. One of them claims for the opening of the Black Sea basin during a single geodynamic event, namely the extensional environment created behind Pontides by the northward subduction of the Neo-Tethys Ocean floor [Nikishin et al, 2001], while other authors [Banks et al, 1997] advocate for a distinct opening of the W and E Black Sea basins.

In fact, echoes of the both models are expected in several geophysical images. For instance, the assumed N-S expansion of the Black Sea floor should generate magnetic stripes on the sea bottom striking E-W for both E and W Black Sea. Instead, as it has been previously shown [Besutiu, Zugrăvescu, 2004], the residual geomagnetic and gravity anomalies over the W and E Black Sea basins strike almost perpendicular each-other: NE-SW for the western part and NW-SE for the eastern basin (Fig. 2). Furthermore, correlation between gravity and geomagnetic effects in the two basins advocates for a different timing of the two rifts: while gravity high, corresponding to the oceanic (denser) lithosphere, in the central W Black Sea basin associates with a geomagnetic high indicating a normal magnetization epoch (well-corresponding to the Middle to Upper Cretaceous geomagnetic calm), for E Black Sea, the central gravity high associates with a geomagnetic low, suggesting that opening of E Black Sea was not coeval with the western basin, but took place during a geomagnetic reversal, that may be encountered later on only, during Late Cretaceous-Paleogene time, as indicated on the magnetostratigraphic scale. The overthrust of E Pontides over W Pontides, as revealed by off-shore seismics, strongly supports the idea of a later opening of E Black Sea.

Discussion

Within the above-mentioned circumstances, it seems that lithosphere expelled by the W Black Sea opening split the NW inland into several slivers (Fig. 3) by creating/reactivating some major faults trending NW-SE, such as Odessa Fault (OF), Sfantu Gheorghe Fault (SGF), Peceneaga-Camena Fault (PCF), Capidava-Ovidiu Fault (COF), Intra-Moesian Fault (IMF), Varna-Giugiu Fault (VGF) etc. The seismic tomography brings clear evidence on the effects of the W Black Sea opening such as (i) the velocity indent created by the NW expelled lithosphere replacing previous Moesian Plate (MoP) terrane (corresponding to the so called MoP Dobrogean sector), and (ii) fingerprints of the above mentioned NW trending faults at the bottom of the crust and even deeper, suggesting their trans-crustal nature. For instance, PCF may be followed in the pattern of the P waves velocity down to more than 150 km depth, as a lithosphere boundary between MoP and the East European Plate (EEP).

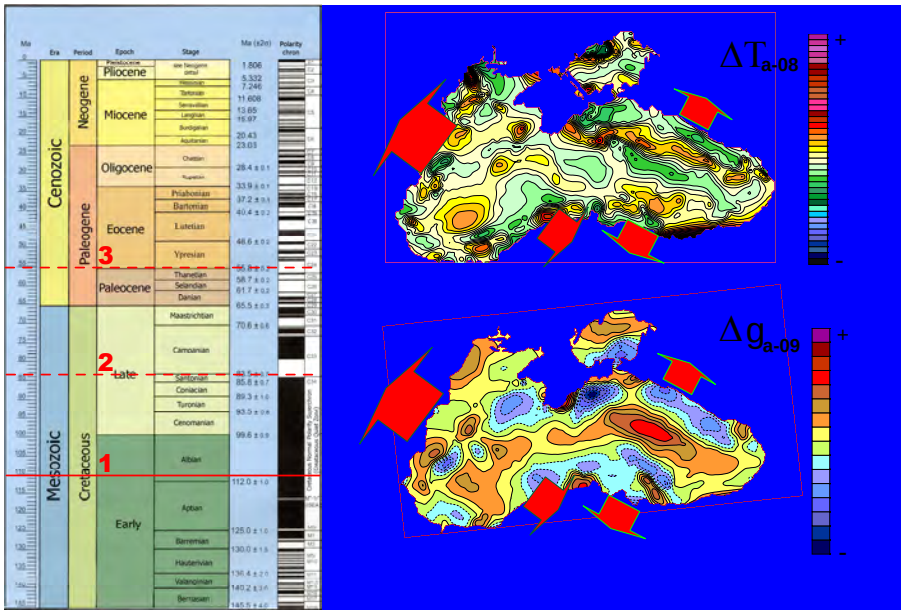

Fig. 2. Residual geomagnetic (ΔT_a) and gravity (Δg_a) anomalies over the Black Sea area (right) along with the magnetostratigraphic scale (left).
An 8th order polynomial trend has been subtracted from the geomagnetic observations, and a 9th order polynomial trend has been removed from the gravity data. Red arrows mark the assumed directions of the basins opening [according to Besutiu, Zugrăvescu, 2004]

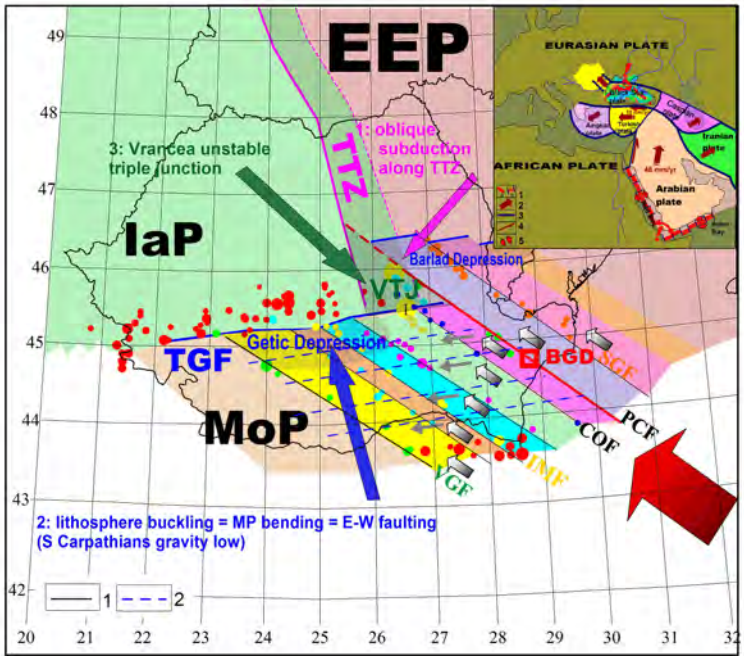

Fig. 3 Cartoon showing geodynamic setting of the SE Carpathians and related foreland following the W Black Sea opening.
Red arrow, the main tectonic push; grey arrows, direction of the stress split along active faults within MoP; EEP, East European Plate; IaP, Intra-Alpine Plate; MoP, Moesian Plate; VTJ, Vrancea triple junction;TTZ, Tornquist-Teisseyre Zone; TGF, Trans-Getica Fault; 1, rift-generated/reactivated faults; 2, secondary faults created by the MoP downward bending; coloured dots, epicentres of crustal EQs clustered along fault zones; BGD, Baspunar geodynamic observatory. **The inset:** regional geodynamic frame. 1, paleo-, and active rifts; 2, tectonic forces; 3, plate boundaries; 4, GPS observed displacement and yearly rate; 5, rift opening

Accommodation of the rift-generated lithosphere took place in front of the vertical edge of the Intra-Alpine Plate [Constantinescu et al, 1976] through a lithosphere buckling with the MoP downward bending that generated a secondary fault system striking WSW-ENE. It seems that after the Black Sea ended its evolution, the geodynamic engine in the area has became the active rifting in the SW Arabian Plate,

whose tectonic push is transmitted towards the Carpathians through the micro-plates located between Eurasian and African mega-plates (Fig.3). Consequently, tectonic compartments located in front of Carpathians are pushed towards NW, but usually move together kept by friction. However, when tectonic forces exceed the friction, they may relatively slip each-other thus generating crustal EQs along the edges in their upper, brittle part. It seems also that, speed excess related to W Black Sea opening created within the bending zone of East Carpathians the necessary environment for an unstable triple-junction [Besutiu, 2001] to which intermediate-depth seismicity may be associated based on thermo-baric accommodation phenomena in the lithosphere sunken into the upper mantle (such as thermal stress and phase-transform processes). Any acceleration of sinking, as a consequence of the evolution of tectonic forces driving the plates, may consequently increase the amount of the seismic energy released. An attempt for monitoring tectonic forces acting in SE Carpathians is currently conducted on the PCF, at the Baspunar geodynamic observatory (BGD), revealing a good correlation between fault slip rate (closely related to tectonic forces) and seismic energy released by EQs in front of SE Carpathians.

Concluding remarks

Lithosphere expelled by the W Black Sea opening split the MoP into vertical slivers by reactivating or creating two major fault systems: striking NW-SE, perpendicular to the rift, and, respectively, WSW-ENE, parallel to the IaP margin. Speed excess provided by the basin opening created the environment for a FFT unstable triple junction within Vrancea area, to which the intermediate-depth seismicity may be associated. After the Black Sea ended its evolution, the geodynamic 'engine' in the area has become the active rifting in the Red Sea and Aden Bay, pushing the Arabian Plate. It seems that tectonic forces are farther transmitted through the micro-plates located between the Eurasian and African Plates and push the above-mentioned tectonic compartments towards the Carpathians, thus being responsible for the both crustal and upper mantle EQs.

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ГЕОФИЗИЧНА ІНТЕРПРЕТАЦІЯ СТРУКТУРИ І ГЕОДИНАМІЧНОЇ ЕВОЛЮЦІЇ ПІВДЕННО-СХІДНИХ КАРПАТ ТА ПРИЛЕГЛОГО ПРОГИНУ В КОНТЕКСТІ РОЗКРИТТЯ ЧОРНОМОРСЬКОГО БАСЕЙНУ

Л. Бешутіу

В роботі обговорюються геофізичні докази, що одночасно пояснюють незвичну сейсмічну активність кратону у зоні, прилеглій до південно-східних Карпат, та землетрусів середньої глибини у верхній мантії у зоні Вранча в рамках геодинамічного середовища, генерованого розкриттям західної частини чорноморського басейну і подальшого переміщення літосфери у північно-західному напрямку за рахунок рифтингу.

Ключові слова: потенціальні поля, сейсмічна томографія, геодинаміка, розкриття Чорного моря, розломи, землетруси.

ГЕОФИЗИЧЕСКАЯ ИНТЕРПРЕТАЦИЯ СТРУКТУРЫ И ГЕОДИНАМИЧЕСКОЙ ЭВОЛЮЦИИ ЮГО-ВОСТОЧНЫХ КАРПАТ И ПРИЛЕГАЮЩЕГО ПРОГИБА В КОНТЕКСТЕ РАСКРЫТИЯ ЧЕРНОМОРСКОГО БАССЕЙНА

Л. Бешутиу

В работе обсуждаются геофизические доказательства, которые одновременно объясняют необычную сейсмическую активность кратона в прилегающей зоне юго-восточных Карпат и землетрясений средней глубины в верхней мантии в зоне Вранча в рамках геодинамической среды, генерируемой раскрытием западной части и черноморского бассейна и дальнейшего перемещения литосферы в северозападном направлении за счет рифтинга.

Ключевые слова: потенциальные поля, сейсмическая томография, геодинамика, раскрытие Черного моря, разломы, землетрясения.

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