The strong Earthquake of 26 November 2019 (Mw 6.4) and its associate active tectonic of Durres region in Albania

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INTRODUCTION

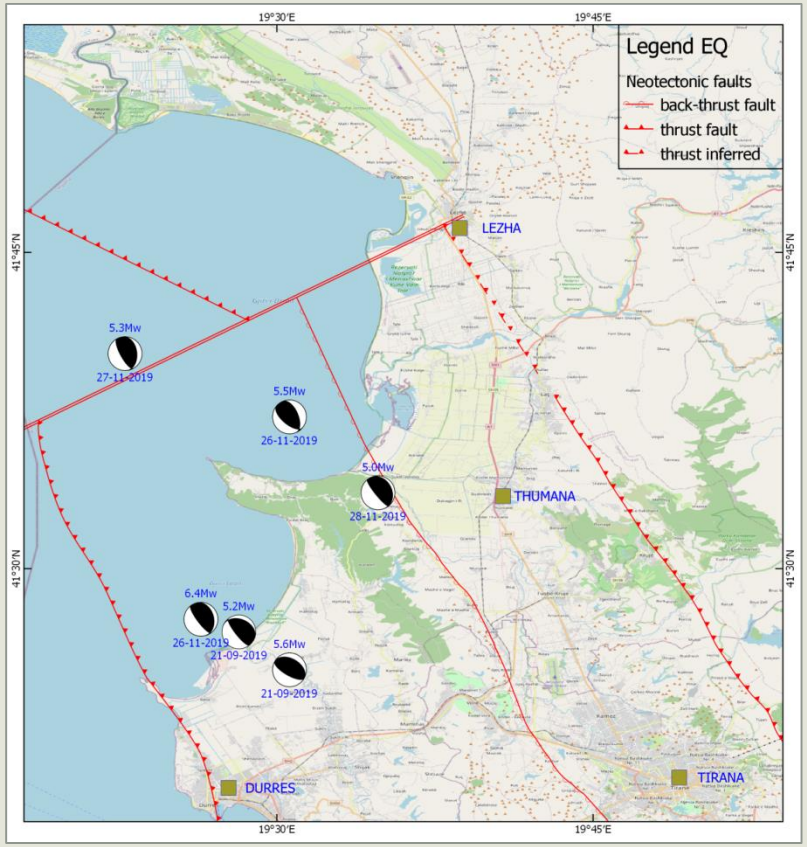
- The African Plate moves to the northward, towards the European continent by 4-10 mm annually and thus, has resulted in regular earthquakes alongside the Eurasia-Africa plate boundary, mainly in Turkey, Greece, Albania, and Southern Italy.
- The Adriatic collision zone is the most active seismic region in Albania and makes up the Ionian-Adriatic coastal earthquake belt at the eastern margin of Adria microplate.

- The western Albanian region has been historically subject to strong earthquakes (Io>VIII EMS-98), as gathered from the numerous data.
- Currently, the seismicity of the Durres' region in Western Albania is characterized by high-energy earthquakes.
- The Durres area, in front of the collision of Adria microplate and Eurasian plate, is one of the most earthquake prone regions in the Albania.
- The devastating human and economic losses caused by the earthquakes of the 21st of September and the 26th of November 2019 need to be analyzed in many aspects.

GEOLOGICAL AND NEOTECTONIC SETTING

- This zone lies in the western part of Albania and is characterized by a compressed regime.
- It is necessary to underline that this faulty zone is located near the Albanian Orogeny front, in convergence with the Adria microplate, and due to this, the compressed movements here are the strongest (Fig 1).

Fig 1.Seismotectonic map of Durres-Lezha area with beach balls of focal mechanisms of main shocks and aftershocks of Mw>5.0 of the Durres earthquakes which occurred on 21th September and 26th November 2019.



DATA

- The earthquakes of 21st September and 26th November 2019 and their aftershocks were recorded by permanent broadband seismological stations that are part of the Albanian Seismological Network, as well as by the neighbouring seismic networks, namely, INGV, AUTH, MSO and MEDNET.
- The epicentres of the main-shocks and subsequent after-shocks are shown in Figure 2.

Figure 2. Epicenters of mainshocks and aftershocks of the September 21st earthquake (right) and November 26th earthquake (left) that occurred in 2019 in the Durres area.

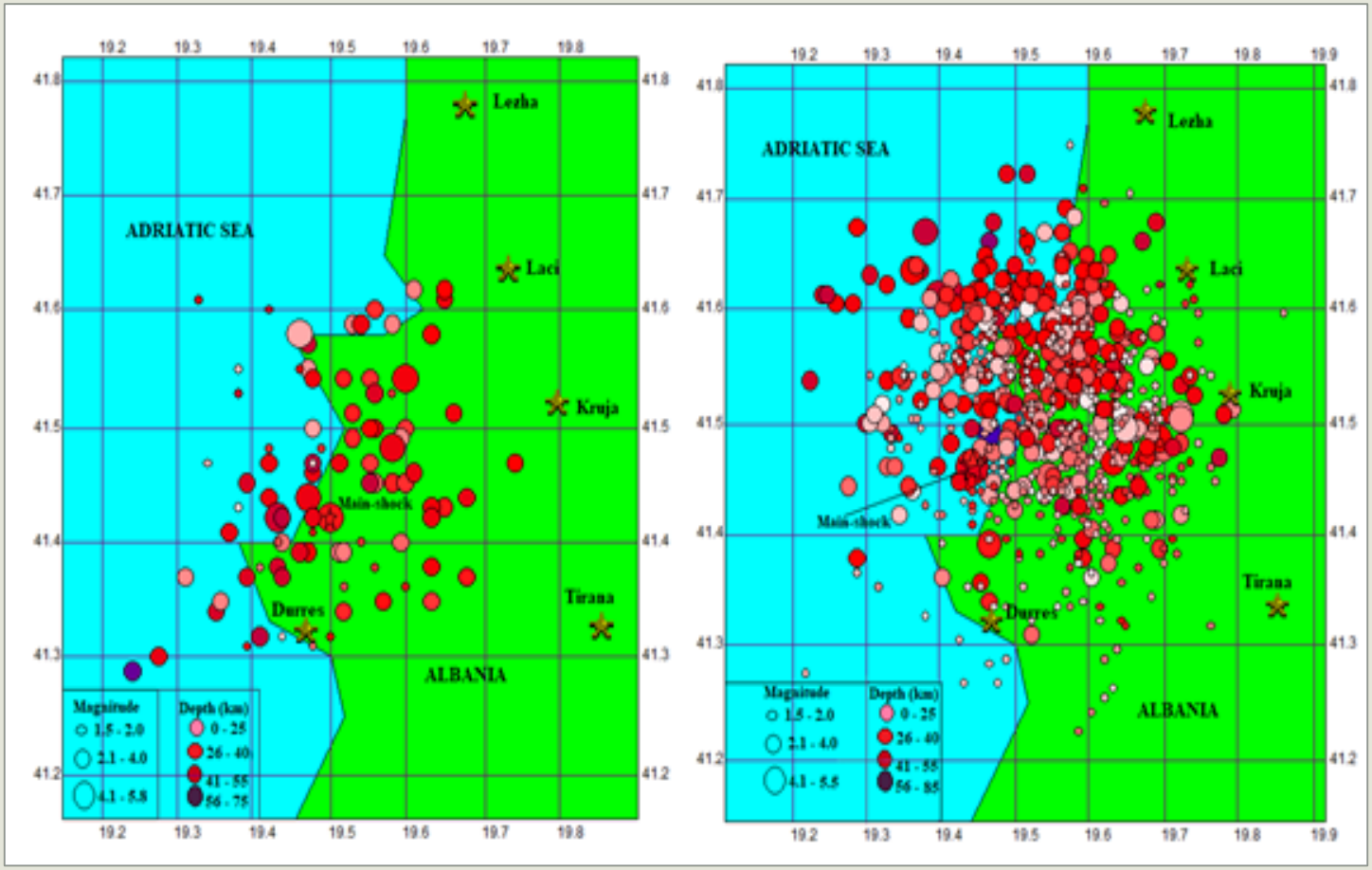


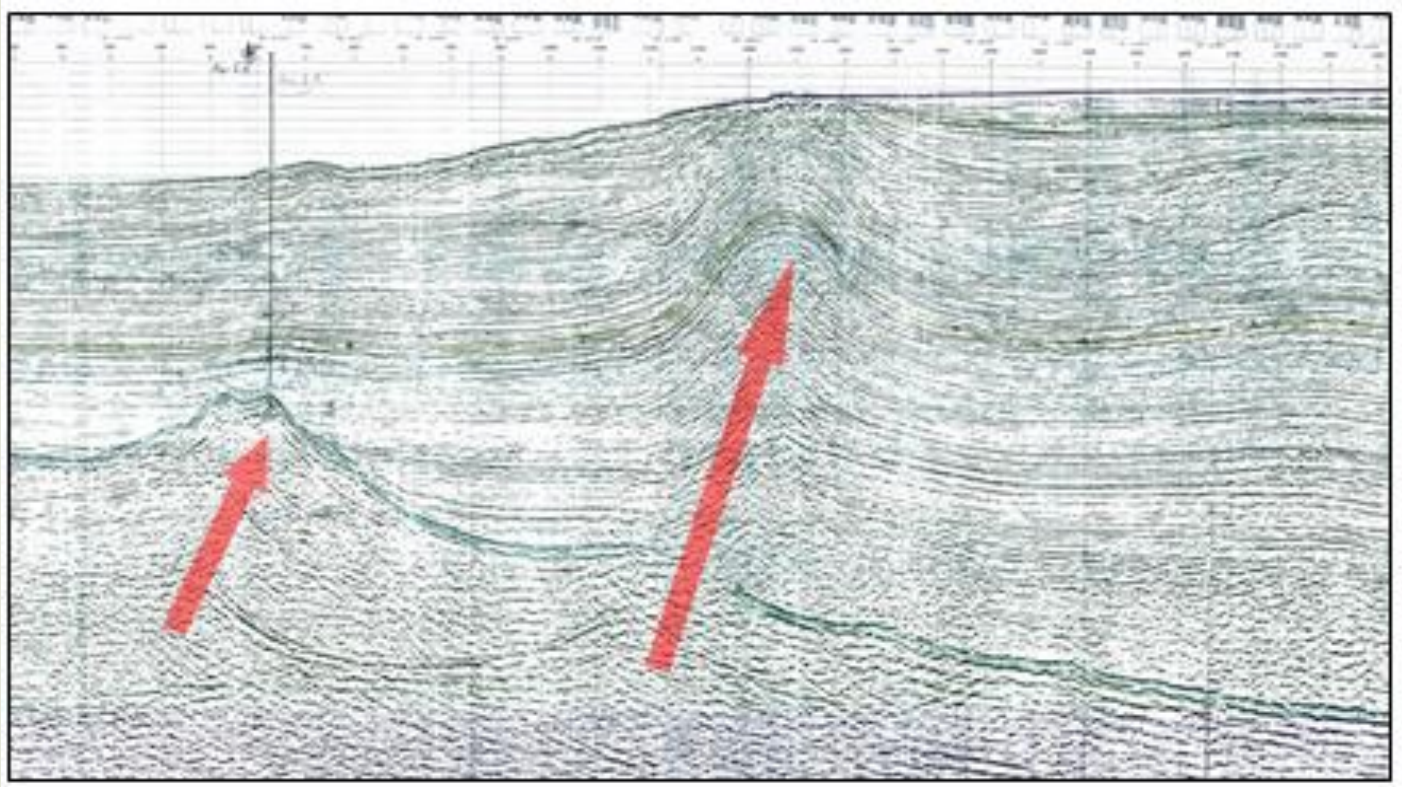
Table 1. The focal mechanism parameters of the of the September 21st earthquake and November 26th earthquake and some aftershocks.

No	Date M-D-Y	Time (UTC) h:m:s	Lat	Long	Depth (km)	Mw	Nodal plane 1 and plane 2			Type of Mechanism
							Strike	Dip	Rake	
1	21-09-2019	14:04:23	41.42	19.51	29	5.6	120	60	90	
2	21-09-2019	14:15:52	41.44	19.47	38	5.2	293	22	63	
3	26-11-2019	02:54:11	41.46	19.44	38	6.4	143	70	82	
4	26-11-2019	06:08:31	41.62	19.51	34	5.5	130	50	72	
5	27-11-2019	14:45:05	41.67	19.38	48	5.3	151	65	80	
6	28-11-2019	10:52:42	41.56	19.58	25	5.0	141	75	87	

THE DURRES EARTHQUAKE 26.11.2019 - GEODYNAMIC MODELING

- The Durres-Lezhe region is characterized by an intense geodynamic activity, expressed through the present seismic activity that is occasionally accompanied by strong and very strong earthquakes.
- The tectonic zone has a longitudinal extension of SE-NW direction and a dip angle toward the NE direction.
- The marker's horizon in the seismic profile shows the rapid sinking of the Adriatic platform microplate towards the East.

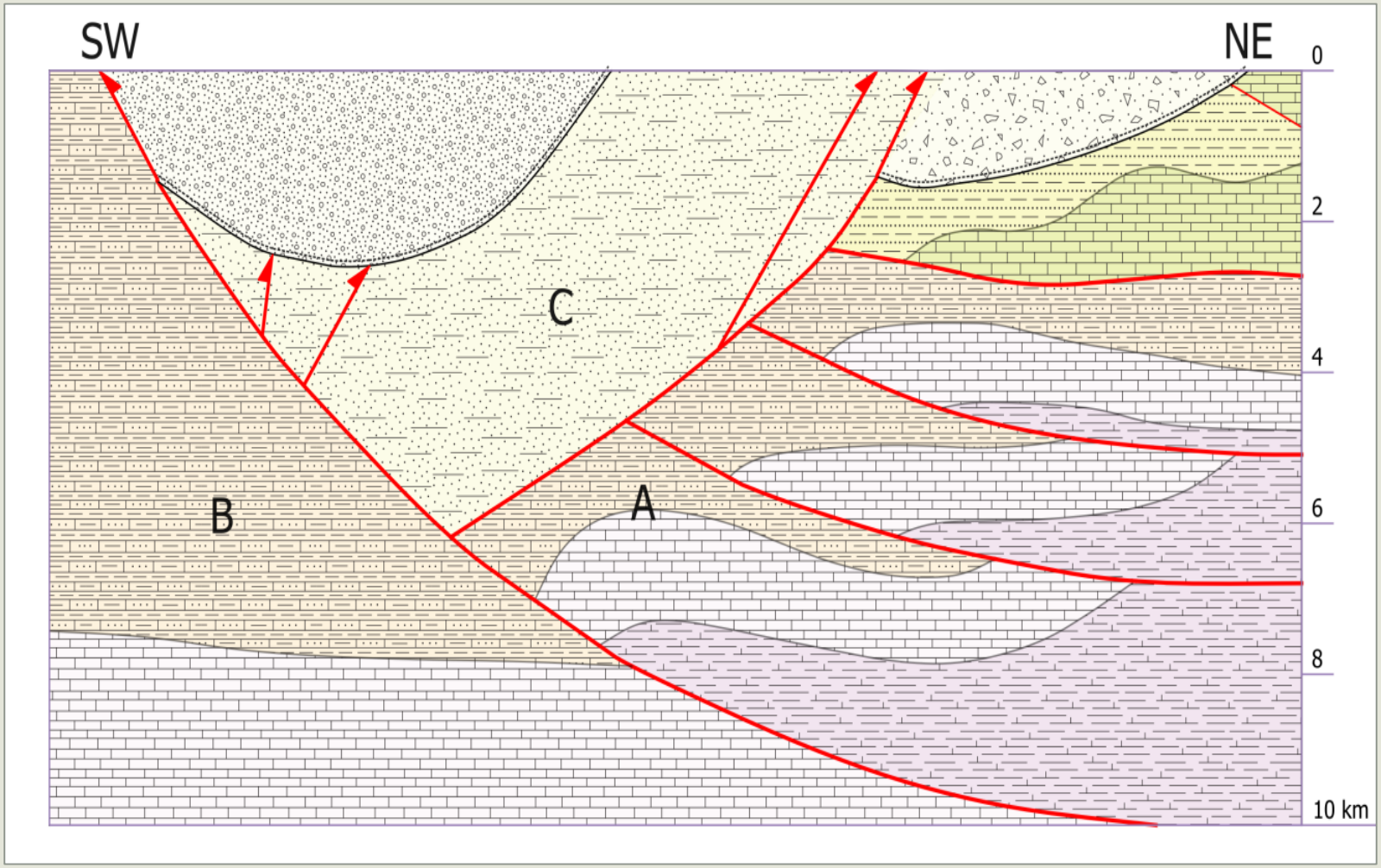
Figure 3. The diapiric structure of the rise of the Adriatic microplate (indicated by the red arrows) through the penetration into the ceiling of the microplate of the Triassic evaporates.



- The evaporitic formation, which serves as the foundation for the geological structure of the External Albanides, is tectonically located below the carbonatic formation.
- This formation is observed throughout the tectonic area of the region and forms the most elevated parts of the landscape, as well as the nuclei of anticline structures.
- The basin of the South Adriatic region has at its core the formation of Triassic evaporites, which form diapiric structures in different places expressed through structural domes shown in the figure 3.

- Furthermore, based on the data of seismic profiles of construction in the depths of the ground, we can interpret the geodynamic model presented in the figure 4.
- In the geodynamic concept, the entire thickness of the rock formations operates in the composition of three large solid masses A, B and C (fig. 4).
- The activation of these geodynamic structures is accompanied by an accumulation of tectonic stresses which serve as sources for seismic events.
- The eastern mass (A) undergoes continuous ascent and displacement towards the West, the western mass (B) which undergoes ascent and descent of the horst-graben type, and the triangular mass (C) that undergoes a transition with alternating tectonic movements, sometimes towards the West, others towards the East.

Figure 4. The tectonical style, structural model and relations between the Adriatic platform and the orogenic zone, in the segment Durres - Fushe-Kruja, built according to the seismic profile with direction SW-NE.



DISCUSSION

- The source parameters of the series which occurred in Durres zone in 2019 can be used to shed light on the seismotectonics and the current stress field of the Durres areas in western Albania.
- The rupture processes of the six strongest events in the series of Durres earthquake 2019 were studied, focusing on the slip distribution along the fault planes.
- The focal mechanisms of the 26th November aftershocks time 06:08:31 (Mw5.5), 27th November aftershocks time 14:45:05 (Mw5.3), and 28th November aftershocks time 10:52:42 (Mw5.3) indicate backthrust faulting.
- The focal mechanism of the 21st September Mw 5.6 time 14:04:23 and its aftershock, that occurred 11 minutes after the mainshock, and the focal mechanism of the 26th November Mw 6.4 time 02:54:11 indicate thrust faulting.
- These earthquakes might have been affected by the activation of a NW-trending reverse fault of Durres-Bishtpalla-Adriatic Sea fault line.
- The focal mechanism of the 26th November aftershocks time 06:08:31 (Mw5.5), 27th November aftershocks (Mw5.3) time 14:45:05, and 28th November aftershocks (Mw5.3) time 10:52:42 indicate back thrust faulting.

- These November earthquake aftershocks might have been affected by the activation of a NW-trending backthrust fault of Vora-Ishem-Adriatic Sea fault line.
- These focal mechanisms of the mainshocks and the strongest aftershocks indicate that the seismic activity was caused due to regional compression (Table 1, Fig. 1).
- These tremors are related to two almost parallel tectonic lines with longitudinal extension SE-NW, but which are of different types, respectively thrust and back-thrust type
- These two tectonic lines of longitudinal extension of SE-NW direction are activated in the same time.
- In addition to the study of instrumental seismic data, field investigations and analysis of macro-seismic data were performed, allowing a full and comprehensive study of the triggering mechanism of 26 November 2009 earthquake.
- In this area, outflows of pressure water have been observed which were associated with sand and clays.
- The phenomenon of liquefaction in these areas has been associated with soil cracks of several cms wide and several tens of meters long.

CONCLUSIONS

- The 26th November 2019 Durres earthquake (Mw 6.4) ruptured along a NW-dipping plane with a strike sub-parallel to the coastline and predominately thrust motion.
- The analysis of the focal mechanisms indicates the predominance of thrust faulting in western Albania is compatible with the present-day NE-SW compression, in response to the convergence between the Adriatic microplate and the Albanian orogeny.
- The geodinamic modeling of the Durres-Lezhe region enables an easier and more accurate interpretation of the seismic events that have occurred in this region, especially the 2019 earthquakes.
- The Durres earthquakes series occurred on different faults with similar orientations that reflect the activation of some fault lines in the Adriatic fault zone and demonstrate a heterogeneous stress state.
- The focal depth analysis reveals that this seismicity was mainly generated in the deep lower crust under tectonic conditions which were described earlier.
- This is according to the geodynamic model presented above, based on the actual geological data of the surface and seismic profiles of the depth, which concluded that the depth of the development of seismic events is expected to be over then 20 km.

- The aftershock locations in the first hours indicate that first group occurred on subsidiary faults and were limited to the primary fault plane, while the second group of aftershocks have migrated in N-E of main shock.
- Aftershocks of the first hours distributed along two parallel fault lines in NW direction in accordance with epicentres of stronger aftershocks with magnitudes M_L>4.5 Richter.
- The field investigation in the epicentre zone revealed several coseismal fractures, the phenomenon of liquefaction, and elevation of the terrain in the epicentre area and its surroundings.
- The 21st September and 26th November 2019 earthquake sequences, as well as the 1926 seismic event that took place in the Durres region, exhibit a rough NW−SE-trending structure which is an active seismotectonic zone in western Albania.
- This study of the Durres earthquakes series emphasizes many geological and seismotectonic characteristics of the areas that constitute a threat for the nearby urban areas of Durres area.

- **Reference**

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