SOME ASPECTS OF ALBANIAN SEISMIC ACTIVITY IN 2022

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Abstract: Albania is situated in the Alpine-Mediterranean seismic belt, which includes the zone of contact between the lithospheric plates of Africa and Eurasia. The main cause of Albanian seismicity is the collision of the Adria microplate with the Albanian orogeny. This study presents the results of the analysis of parameters of events and some features of the seismicity that occurred in Albania and its surrounding area during the year 2022. During this year, seismic activity in Albania and its surroundings was characterized by normal seismic activity. In this territory (39.0-43.0N-18.5-21.5E), a total of 3573 earthquakes were recorded, with 7 of them felt by the population of Albania. These earthquakes ranged in magnitude from 0.2 to 5.5 on the Richter scale, with an average depth of 14 km and a maximum depth of 90 km. Of these, 817 had a magnitude ML >2.0 (Richter), 26 had a magnitude ML > 3.5, and 2 had a magnitude ML > 4.3. The earthquake foci were concentrated mostly along five active fault zones: Durresi - Rodon Cape, Lezha - Ulqin, Thirre - Iballe, Vlore – Elbasan - Diber, and Korca - Oher, as well as the Ionian fault zones. The analysis of focal depths indicates that the seismic activity was mainly generated in the upper and middle crust. An increase in seismic activity was registered on the southern border of Albania in Greek territory. The focal mechanism parameters of a moderate earthquake with magnitude ML4.3 that occurred during 2022 can be used to shed light on the seismotectonics of the Thirre (Fushe Arrez) fault zone and the current stress field. This article analyzes the level of seismicity for the year and some of its main features.

Keywords and phrases: Earthquake, seismicity, tectonic fault, crust, local magnitude.

MSC 2010 Classification: 86A15, 86A17, 86A22

1 Introduction

Albania lies within the Alpine-Mediterranean seismic belt, where the African and Eurasian plates collide. As a result, the area is divided into several seismically active belts. The Albanian orogeny is delineated into two distinct areas with different tectonic regimes: the external area characterized by a compressive regime, representing the Outer Albanides, and the internal area exhibiting an extensional regime, representing the Inner Albanides (Aliaj et al., 2010; Ormeni et al., 2013, Mihajlovic et al. 2021).

The principal cause of seismic activity in Albania is the collision between the Adria microplate and the Albanian orogeny. Earthquake foci are predominantly concentrated along active faults and within low-velocity zones (Ormeni et al. 2022, 2023; Marku et al. 2022; Skrame et al. 2023; Como et al. 2024). The thrusting and normal faulting in Albania are likely to be the result of differences in gravitational potential energy between the lowlands of western Albania and the mountains in the east of the country (Aliaj et al., 2010; Ormeni et al., 2013, Bejko et al. 2023; Basholli et al. 2024).

The seismicity is characterized by very frequent microearthquakes, sporadic small and medium-sized earthquakes, and very sporadic large earthquakes. Figure 1 illustrates the epicenters of 3573 earthquakes recorded during 2022.

2 Data and Methods

Seismic activity recorded by the Albanian network, along with data from INGV (Italy), Thessaloniki (Greece), Montenegro, and MEDNET networks, used the Albanian velocity model (Or-

meni 2011) to compile the database for this study (`www.geo.edu.al`; 2022). Within the territory bounded by 39°00'-43°00' N and 18°30'-21°30' E, a total of 3573 earthquakes were recorded, ranging in magnitude from M=1.0 to 5.5 on the Richter scale (Figure1).
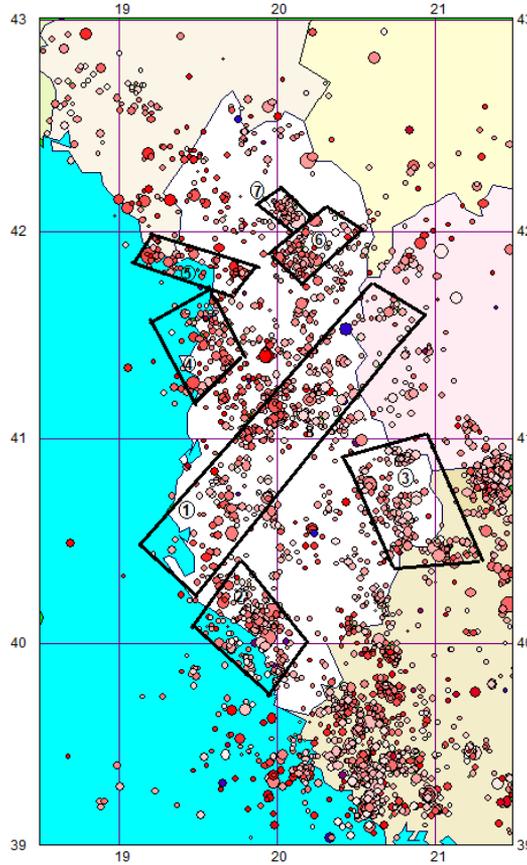
Figure 1: Earthquake map of epicenters occurrence in seismogenic zones in Albania and its surrounding area during 2022

To improve the accuracy of earthquake locations in Albania over the past year, a relocation effort was undertaken, resulting in constrained hypocentral determinations for events within the Albanian territory. The standard procedure involved the use of the HYPO71 program (Haskov and Ottemoller, 2008) from the SEISAN package, along with a local velocity model specific to Albania for earthquake locations. The local magnitude of nearby earthquakes was estimated using the Richter scale (Klein, F.W. 2002).

3   Results and Discussion

3.1   The Main Feature of Seismicity During 2022

During the year 2022, Albania experienced typical levels of seismic activity in certain seismogenic zones. A total of 3573 earthquakes with magnitudes $M \geq 1.0$ were recorded, with an average depth of 14 km and a maximum depth of 90 km. Among these earthquakes, approximately 2912 (92%) occurred at depths between 0 and 25 km, while 8% occurred at depths between 25 and 45 km. Only 34 earthquakes, accounting for 1.1% of the total, occurred at depths exceeding 45 km (fig2). By analyzing the distribution of earthquake depths, it can be concluded that the seismoactive zones in Albania are predominantly located within the upper and middle crust. The depth of these earthquakes is particularly relevant for geodynamic studies, especially in terms of their effects on the Earth's surface and their potential to cause damage to buildings and infrastructure. The minimum magnitude of earthquakes recorded each month was 1.0 on the Richter scale, while the maximum magnitude ranged from 3.1 to 5.5 Richter throughout the year.
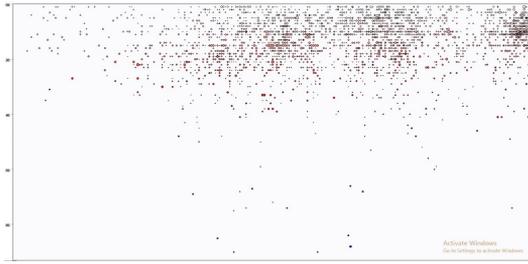
Figure 2: Distribution of the earthquakes foci according to the depth.

In 2022, the earthquake activity in Albania and its surrounding regions was notable, with a total of 817 earthquakes recorded with magnitudes $M_L > 2.0$ Richter. Among these, 88 earthquakes had magnitudes greater than 3.0 Richter, while 9 earthquakes had magnitudes greater than 4.0 Richter, and 1 earthquake exceeded 5.0 Richter. The majority of earthquakes were located within the magnitude range of 1.0 to 2.3 Richter (fig. 3 (a)). Nine earthquakes, with magnitudes ranging from 3.8 to 5.5, were felt by the population of Albania. The earthquake foci during 2022 were primarily concentrated along five seismogenic zones. Overall, seismic activity in 2022 remained within the range of normal levels when compared to seismic activity throughout the century.

subcaption

(a) Distribution of the number of earthquakes according to magnitude

(b) The diagram of earthquake occurrences per month during 2022
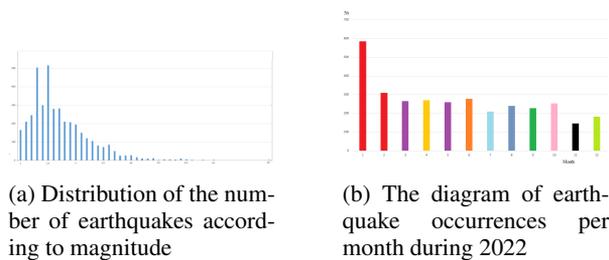
Figure 3: Overview of earthquake distributions and occurrences.

The information about earthquake occurrences in Albania throughout the months of 2022 (fig. 3 (b)) shows that the number of earthquakes recorded per month were: 586 in January, 210 in February, 265-277 per month from March to June, 209 in July, and from November to December, between 145 and 182 earthquakes per month. This data illustrates fluctuations in earthquake activity throughout the year, with peaks in activity observed in January and from March to June, and a decrease in activity during July and towards the end of the year.

3.2   Vlorë - Elbasan - Diber Seismoactive Zone (1)

This fault zone, trending northeastward for approximately 200 km within Albanian territory, comprises fragmented normal faults intersecting with the Krasta tectonic zone and dividing the Mirdita ophiolites zone into two main segments. This seismogenic zone has been the source of 321 earthquakes, ranging in magnitude from 1.0 to 3.6 Richter, with an average depth of 13 km (fig. 1, zone 1). Among these, 24 earthquakes had magnitudes greater than 3.0, with 3 of them exceeding 4.0 Richter, and an average depth of 12 km. Roughly 44% of the earthquakes occurred in the seismically active upper earth crust, while approximately 54% were situated in the middle crust. Only 2% were registered in the lower earth crust and uppermost mantle beneath the VED zone, which has a thickness of 50 km. The moderate earthquake, with a magnitude of 4.3 Richter, was recorded 8 km northwest of the Shupenza village on October 9. The Vlora–Elbasani–Diber fault zone is renowned for its high seismic activity in Albania, operating under an expanding tectonic regime and influenced by low-velocity layers (Ormeni et al., 2017).

3.3   Himare - Borsh - Kardhiq Seismoactive Zone (2)

In the Borsh-Kardhiq seismogenic zone (fig. 1, zone 3), a total of 216 earthquakes were recorded, with magnitudes ranging from 1.0 to 3.9 on the Richter scale, an average depth of 12 km, and a maximum depth of 74 km. Among these, five earthquakes had magnitudes equal to or greater than 3.0. The Ionian zone, which extends northwest-southeast, is characterized by transversal motion with a left compressive and normal component. The left compressive aspect is evident from the displacement of mountain ranges. During the year 2022, there was a slight increase in seismic activity in the Borsh-Kardhiq segment of the Ionian seismogenic zone, as well as in the southern part extending into Greek territory. A moderate earthquake with a moment magnitude (Mw) of 3.9 occurred on August 23 at a depth of 15 km, approximately 4 km southeast of Borshi village. This earthquake was felt at intensity levels IV-V in Borsh and Lukova villages.

3.4   Korca-Oher Seismoactive Zone (3)

This seismogenic zone (fig. 1, zone 4) has produced a total of 206 earthquakes during 2022, ranging in magnitude from 1.0 to 3.8 Richter, with an average depth of 11 km and a maximum depth of 45 km. Among these, four earthquakes had magnitudes greater than 3.0, with an average depth of 9 km. Approximately 46% of the earthquakes occurred in the seismically active upper earth crust, while about 53.5% were situated in the middle earth crust. Only two earthquakes were registered in the lower crust and uppermost mantle beneath the K-O zone, which has a thickness of 45 km. The moderate earthquake, with a moment magnitude (Mw) of 3.8, occurred on March 3 at a depth of 5 km, approximately 7 km northwest of Maliqi town. This earthquake was felt at intensity levels IV-V in Maliqi town.

3.5   Durresi – Rodon cape seismoactive zone(4)

This area constitutes a seismic zone with an approximate NNW-SSE orientation in western Albania (fig. 1, zone 4). It's important to note that Durres-Rodon Cape lies in the front of Albania orogeny, converging with the Adria microplate, due to this the strongest compressional movements are registrated here [Aliaj2010, OzturkOrmeni2021]. A total of 87 earthquakes have been recorded in this area during this year with ranging in magnitude from 1.0 to 3.4 Richter, with an average depth of 16 km and a maximum depth of 50 km. Approximately 23 earthquakes, or 27%, occurred in the seismically active upper part of the earth crust, while about 59 earthquakes, or 69%, occurred in the middle part of the earth crust. Only 4% were registered in the lower part of the earth crust and uppermost mantle beneath this region, which has a thickness of 35 km. These seismic events were distributed along a NNW-SSE belt along the Adriatic coastline.

3.6   Lezhë-Ulqin seismoactive zone (5)

In this transversal zone, a total of 68 earthquakes were recorded, with magnitudes ranging from 1.0 to 3.9 Richter, and an average depth of 20 km, with a maximum depth of 34 km. One of these earthquakes, with a magnitude of 3.9, occurred in the Adriatic Sea (fig. 1, zone 5). Approximately 99% of the seismic activity in this area originated in the seismically active upper and middle earth crust. It's important to note that Lezha-Ulqini is situated near the forefront of Albania orogeny, converging with the Adria microplate, which results in the strongest compressional movements in this area [Ormeni2013]. This tectonic position, coupled with active tectonic faults, has been the source of powerful earthquakes that have impacted Ulqini and its surrounding areas throughout history.

3.7   Kurbnesh – Kukes seismoactive zone (6)

This transversal seismogenic zone, oriented SW-NE, is situated within the inner part of Albania orogeny, characterized by high mountains (fig. 1 zone 6). This fault zone exhibits complex geomorphology and has experienced numerous earthquakes throughout the year 2022. During this period, a total of 92 earthquakes were recorded, with magnitudes ranging from 0.5 to 3.3 Richter, an average depth of 15 km, and a maximum depth of 29 km. Four of these earthquakes

had magnitudes equal to or greater than 3.0 Richter. Approximately 92% of the seismic activity in this area originated in the seismically active upper and middle earth crust, with only 8% occurring in the lower earth crust and uppermost mantle of this zone. The Kurbnesh-Kukes-Prizren tectonic fault extends in a southwest-northeast direction, spanning approximately 90 km and dipping in the northwestern direction. This fault zone is classified as a normal fault type but is also accompanied by strike-slip elements.

3.8 Fusha e Qarrit-Iball seismoactive zone(7)

In the Fusha e Qarrit-Iball seismogenic zone (fig. 1 zone 7), a total of 97 earthquakes were registrated, with magnitudes ranging from 1.0 to 4.3 Richter, with an average depth of 12 km, and a maximum depth of 29 km. Among these, three earthquakes had magnitudes equal to or greater than 3.0 Richter. This zone, with a northwest-southeast extension, is characterized as a transversal zone with reverse compressive faults. Approximately 32% of the earthquakes occurred in the seismically active upper part of the earth crust, while about 67% were situated in the middle part of the earth crust. Only one earthquake was registered in the lower crust beneath the Fusha e Qarrit-Iball zone. The moderate earthquake, with a moment magnitude (Mw) of 4.3, occurred on January 14 at a depth of 5 km, approximately 5 km east of the Fushe-Arrez tectonic zone. This earthquake is associated with an oblique fault such as the Bushal fault, occurring in ophiolites rocks. This fault extends from Qelaj in the west to Fushe-Arres, where it intersects with a fault originating from the south, near Rubiku, and then turns towards Dimal-Fushe - Arres, continuing northeastward to Qafa e Malit, Shire, Kalimash, Kukes, Gjegjan, and beneath the Koritnik Mountain. The earthquake was felt at intensity levels V-VI in Fushe - Arres town and at intensity level V in Puka town.

3.9 Seismicity near the Albania border

The strongest earthquake occurred on January 9 with a magnitude of M 5.5 and a depth of 4 km, near the town of Florina in Greece, approximately 38 km from the southeastern border of Albania. The intensity of the earthquake was measured at degree VII-VIII EMS-98. It was felt at a V degree in towns such as Pogradec, Bilisht, and Korca, and at an IV degree in towns like Gramsh, Çorovoda, and Erseka. This mainshock was followed by a series of 389 aftershocks throughout the year 2022. These aftershocks ranged in magnitude from M 1.0 to M 5.5, with 20 of them registering M$\geq$3.0 and 2 with M>4.0. Most of the aftershocks, about 377, occurred in the seismically active upper and middle earth crust, while only 12 were located in the upper mantle beneath the Florina area. These aftershocks were distributed along a NE-SW belt on the Greece orogeny, as depicted in Figure 1. Additionally, significant microseismic activity was observed along the southern border of Albania with Greek territory, with 821 earthquakes recorded with magnitudes less than 3.0 Richter, along with 20 small earthquakes ranging from 3.0 to 4.1 Richter.

4   Conclusion

The seismic activity in Albania and its surrounding territories, as analyzed in this paper, primarily originates from six zones characterized by diverse neotectonic features and earth crust structures. These active zones include Vlora-Elbasani-Diber, Kurbneshi-Kukes, Korca-Oher, Durres-Rodon Cape, Lezha-Ulqin, and Borsh-Kardhiq, along with the Thirre zone, where the strongest earthquake of Ms4.8 occurred on October 17. The focal mechanism of this earthquake suggests normal fault with a left strike-slip component, in alignment with the geological structures of the area. Additionally, seismic activity is intensified in the transversal tectonic fault of Fier – Elbasani – Diber - Tetova, particularly in the Elbasani geothermal area. A slight increase in seismic activity was also observed along the Ionian seismogenic zone, specifically in the Borsh-Kardhiq segment. The Korca-Oher region forms a predominantly NS-trending active seismotectonic zone in southeastern Albania, extending into southeastern North Macedonia. Based on these analyses, the seismicity in Albania orogeny and its surrounding regions during 2022 was relatively low, compared to seismic activity observed throughout the century.

5 Acknowledgements

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