RESEARCH ARTICLE

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Some Features of Seismicity in Bulqiza-Macukull Fault Zone During This Century

Rrapo Ormeni and Xhorda Kanani

ABSTRACT

During two decades of this century, the Albanian and its surrounding seismicity is dominated by high values. One active fault zone, determined on the foci and energy of earthquakes is Bulqiza-Macukull zone. On August 11, 2018 a moderate M_s5.2 earthquake sequence burst in the Bulqiza-Macukull tectonic fault zone. The main shock was located 8 km northwest of Bulqiza town and was felt over a larger area of northern, central and southern Albania. The Bulqiza-Macukull tectonic segment is exposed on the ground at a length of about 35 km, according to the SE-NW direction. The database of this study, composed of 305 seismic events with M_L>1.0 is characterized by tectonic earthquakes activity in this fault zone. The focal mechanisms solution of the moderate earthquake indicate stress regime in this zone. The analysis of main aspects of seismicity during this century provides us correct interpretations of seismotectonics, geodynamic phenomena of the Earth's crust. The Bulqiza-Macukull transversal fault zone presents a threat to the nearby urban and hydropower areas.

Keywords: earthquakes, fault zones, seismicity, seismotectonics.

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Rrapo Ormeni*
Department of Seismology, Institute of Geosciences, Polytechnic University of Tirana, Albania.
(e-mail: rrapo55@yahoo.com)
Xhorda Kanani
Department of Physical Engineering, Faculty of Mathematical Engineering and Physical Engineering, Polytechnic University of Tirana, Albania.
(email: xhorda_kanani@yahoo.com)

****Corresponding Author***

I. Introduction

The Albanides represent the assemblage of the geological structures in the territory of Albania. They are situated in the Alpine-Mediterranean seismic belt and accommodate part of the deformation due to the collision of the Adriatic microplate with the Eurasian plate.

The Albanian territory is a natural seismological laboratory. From the tectonic point of view, the Albanian orogen consists in two domains: the external compressional domain, constituting the outer Albanides, and the internal extensional domain, constituting the inner Albanides. There are longitudinal and transversal active fault zones with all types of faults: reverse faults, normal faults, strike-slip faults and oblique faults. The Albanian orogen and its surroundings are interrupted by longitudinal faults in NW-SE direction and transversal faults in different directions (Fig. 1).

Seismicity in Albania is characterized by microearthquakes, small earthquakes, moderate earthquakes, and strong earthquakes. The four well-known types of tectonic earthquakes occurred in Albania during two decades: earthquakes with mainshock followed by aftershocks, earthquakes with foreshocks and aftershocks, swarms and compound earthquakes.

The neotectonic faults in eastern Albania are normal faults with oblique components that have NE–SW trends (Sulstarova 1986; Muço 2007; Kiratzi 2011; Ormeni *et al*. 2013). The August 11, 2017 M_s=5.2 earthquake sequence, studied here, occurred near the Bulqiza town in the northeastern part of the Albanian orogen.

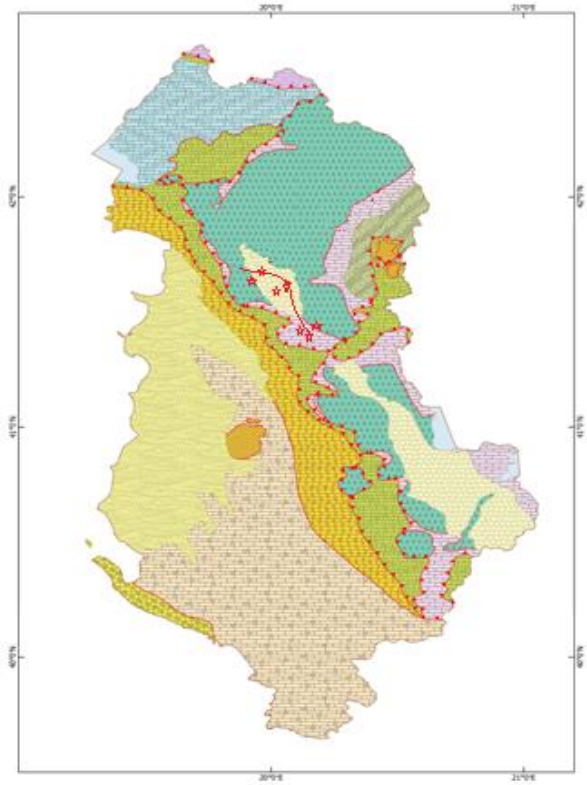

Fig 1. Schematic tectonic map of Albania and epicenters of moderate tectonic earthquakes M_L>5.0 and significant inducted seismic events during 2001-2021 in Albania and its surroundings.

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II. Data and Methods

Seismic phases recorded by the Albanian network, integrated with data of INGV (Italy), Thessaloniki (Greece), Montenegro and MEDNET networks are used to prepare the monthly seismological bulletin of Albania. The seismological stations are as follow: Albanian Seismological Network ASN (Bci, Sda, Puk, Kks, Laci, Bpa, Vlo, Tpe, Kbn, Lsk, Srn), Aristotle University of Thessaloniki – AUTH (Fna, Nest, Igt, Mev, The, Lkd2), National Institute of Geology and Volcanology INGV (Sgrt, Mrvn, Noci, Sgrt), Montenegro Seismological Montenegro PDG (Bry, Nky, Bey, Pvy, Pdg, Hcy, Bum, Ulc), Seismological Network of North Macedonia SKO (Sko, Uhr), Seismological Network of Kosovo KSN and MEDNET (Tir).

The catalog used is compiled from monthly seismological bulletin of Department of Seismology, Institute of Geosciences, Polytechnic University of Tirana (Ormeni 2020). The database of this study, composed of 305 seismic events with M_L>1.0, is characterized by tectonic earthquakes (Fig. 2).

The standard procedure uses the program Hypo invers (Klein, 2000) of the Atlas package, and the velocity model (Muco *et al*., 2001; Ormeni, 2011) for earthquake locations. Some formula for the determination of the magnitude according to the time duration and the amplitude of the seismic signal are also used.

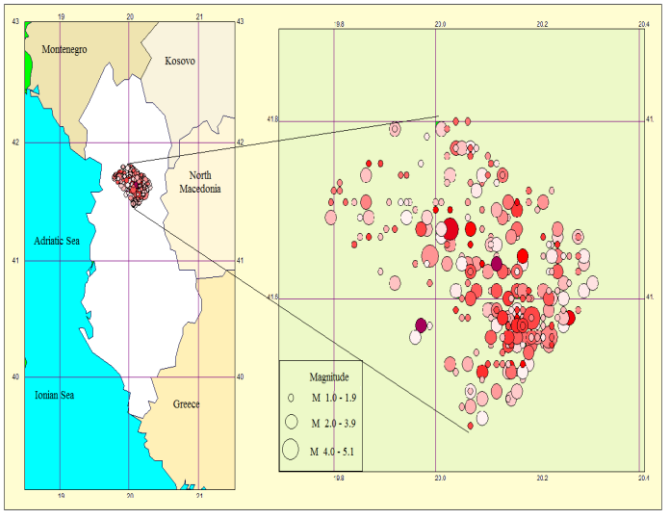

Fig. 2. Epicenters map of M>1.0 earthquakes in Bulqiza-Macukull during 2001-2021.

III. Tectonic Setting of the Bulqiza-Macukull Zone

During the two last decades, the Bulqiza-Macukull region, north of Albania, has been struck by hundred earthquakes and some moderate earthquakes M_w≥4.0 and one of M_w=5.4.

The tectonic segment Fushë - Bulqizë – Selishtë – Qafë - Murrë – Vinjoll – Derjan of Bulqiza-Macukull fault zone is active nowdays. This tectonics initially has a trajectory southeast-northwest from Fushë-Bulqizë to Selishtë, that coincides with the periphery of the ultrabasic massif of Bulqiza (Fig. 3). In the area of Selishtë, between Derjan and Macukull, the tectonics arches and takes an almost east-west direction. This tectonics is outlined approximately according to the contact of the ophiolitic massif of Bulqiza and the ophiolitic massif of Lura. We think this represents an old tectonics, reactivated from time to time. The focal mechanism solution of August 12, 2018 moderate earthquake Mw5.4 in Fushë-Bulqizë–Selishtë segment shows that the event was caused by a triggered normal fault with strike-slip component and a NW-SE direction of extension.

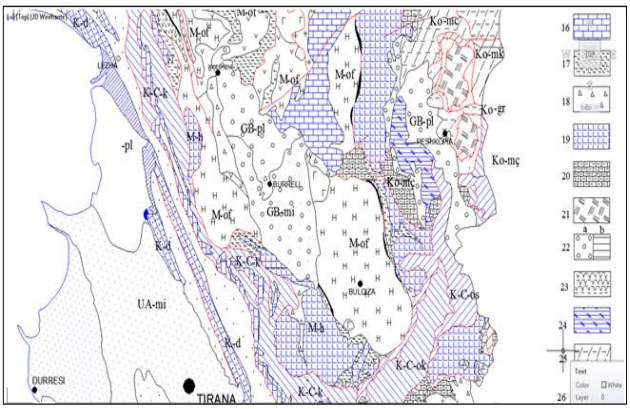

Fig. 3. Schematic tectonic map of Bulqiza-Macukull region.

IV. Results and Discussion

A. *Some Main Features of Seismicity*

Bulqiza-Macukull is a transversal fault zone, characterized by a moderate level of seismicity, as highlighted also by the recent earthquake of August 11, 2018 (M_L5.1), with an epicenter 8 km north of Bulqiza and with effects in the Bulqiza and Burreli area.

On this fault zone, during the two last decades, an increase of seismic activity has been recorded on two faults as follows: on the segment Fushë-Bulqizë-Selishtë, and on Vinjoll–Derjan fault.

About 305 seismic events have been located, with magnitude ranging from 1.0 to 5.1, average depth 13 km and seismotectonic coefficient b 0.85. The total number of earthquakes is 305, with magnitude M > 1.0 of the Richter scale. The cumulative number of earthquakes during over two decades tends to increase (Fig. 4). Statistics from 2001 to 2021 show that every year, inside the B-M territory, two earthquakes of a magnitude M≥ 3.0 Richter occur, and that every two years occurs one M>4.0 earthquake.

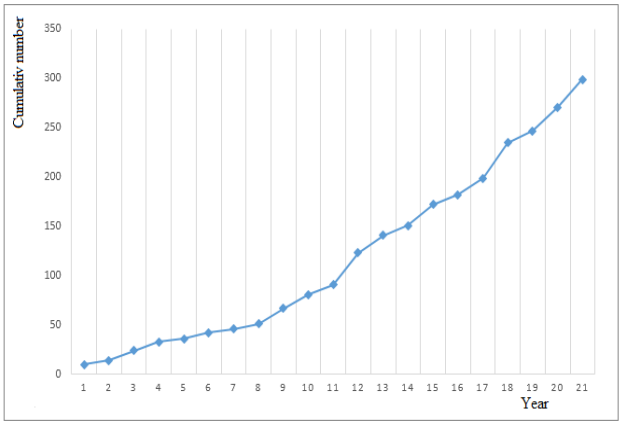

Fig. 4. Annual cumulative number of earthquakes for Bulqiza-Macukull zone.

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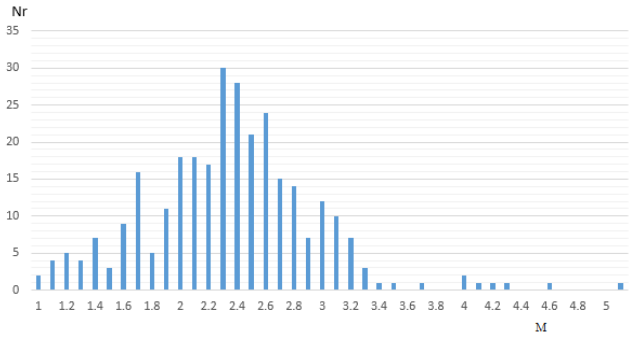

Fig. 5. Distribution of the number of earthquakes according to the magnitude.

The minimum magnitude of earthquakes located each year ranges from 1.0 to 1.7 (Richter) while the maximum magnitude ranges from 3.2 to 5.1 (Richter) (Fig. 5). The cumulative number of earthquakes during this century, indicates that the highest seismic rate has been recorded during 2011-2012 and 2018.

The increasing of cumulative number in 2008 explained the aftershock of August 11, 2018, Bulqiza earthquake Mw5.4, 8 km northwest of Bulqiza town (Fig. 6).

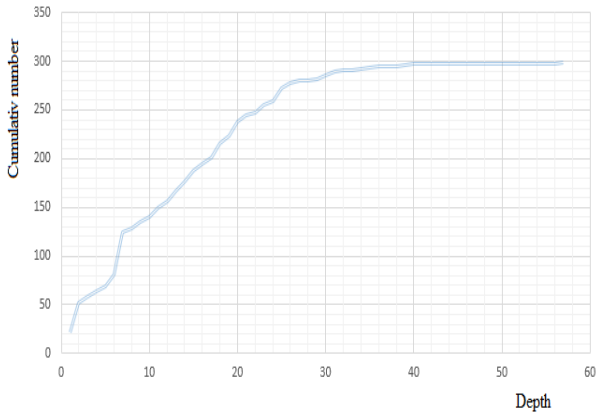

Fig. 6. Distribution of the cumulative number of earthquakes according to the depth.

Fig. 5 shows the number of located earthquakes grouped by magnitude. The maximum number of earthquakes is for magnitudes ranging from 1.6 to 3.1 Richter, while the catalog starts from magnitude 1.0. About 280 of them or 92% are distributed in depth between 0 and 25 km, and 25 earthquakes or 8% are distributed in depth over 25 km and the maximum concentration is in depth between 1 and 20 km (Fig. 6).

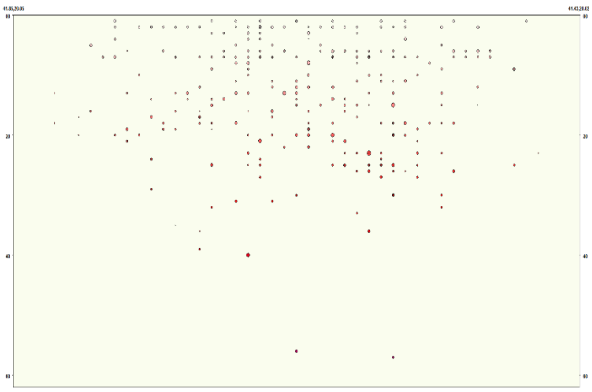

Fig. 7. Profile of distribution of the foci of earthquakes according to the depth.

Fig. 6 shows high increase of cumulative number of depths up to 25 km, which after 40 km is almost constant. Only 2 of them are distributed over 45 km in the uppermost mantel (fig. 7). By generalizing the data from the depths of earthquakes, statements show that the seismoactive layer in Albania is located in the upper and middle crust.

In conclusion of this study, the depths of earthquakes in the Albanian territory are concentrated mainly in the Earth's crust and a few in the uppermost mantle. During this century BM zone is characterized from dynamical processes that happen mainly in the upper and middle crust and seldom in the uppermost part of the mantle.

The depth generated by earthquakes represents an interest for seismotectonic studies, especially related to geodynamics of the Earth's crust. About 7 earthquakes were felt by population of this area.

B. Focal Mechanisms of M_w>5.4 Earthquakes

We present the focal mechanism solutions from EMSC data for the moderate earthquakes (Mw5.4) that have occurred in this active fault zone during this century. The rupture processes of these moderate events, focused on the slip distribution along the fault planes, were studied (Fig. 8).

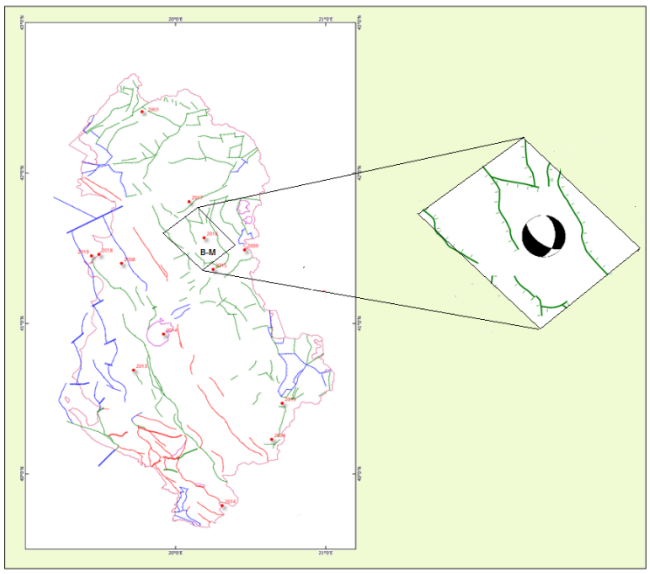

Fig. 8. Detailed seismotectonic map of Albania (Aliaj, 2001), with epicentres of earthquake M>5.0 and the Bulqiza-Macukul fault zone with beachball of the focal mechanism of August 11, 2018 mainshock.

The focal mechanism solution of the August 11, 2018 mainshock has an active plane striking (strike) 332° NE, an inclination of the hanging wall (dip) of 67° and a hanging wall displacement (rake) of -168° (downward motion), in direction NE and dipping to the NW is in good accordance with the geomorphological observations. Based on the focal mechanisms, we find that the August 11, 2018 earthquake, which occurred at a shallow depth (23 km), was caused by normal faulting with dextral strike-slip elements in a NE-SW extensional stress direction. These focal mechanisms (Fig. 8) show the predominance of normal fault motion with a strike-slip component, and this normal fault motion is compatible with the present -day NE-SW extension.

The focal mechanisms solution indicates that the extensional regime was the main cause of the seismic activity along this fault zone.

V. CONCLUSIONS

On the Bulqiza-Macukull fault zone during this century have been located 305 earthquakes of a magnitude greater than 1.0 Richter. The focal mechanism of the August 11, 2018 (M_w =5.4) earthquake shows that this earthquake was caused by horizontal extension, and consequently, it occurred on a normal fault controlling the transverse uplifting of the Bulqiza-Macukull zone.

The analysis of the focal mechanisms indicates the predominance of normal faulting with a strike-slip component, to the NW-SE extension in northeastern Albania. The Bulqiza-Macukull fault zone exhibits increased seismic activity and has generated moderate earthquakes over the last years and it is expected to continue to be active in the future.

This study of seismicity, focal mechanisms of the last moderate earthquakes, distribution of aftershocks emphasizes many geologic and seismotectonic characteristics of the areas that constitute a threat for the nearby urban areas of north-eastern Albania. The analyses of 2001-2020 seismicity show that was mainly generated in the upper and middle crust and less in the uppermost mantel, under the tectonic conditions described previously. From the analysis of concentration of earthquakes foci, results that earthquakes of larger magnitudes have greater depth than those of a smaller magnitude.

The analysis of seismic activity features during this century enables us to correctly interpret the seismotectonics, geodynamic phenomena of the Earth's crust.

CONFLICT OF INTEREST

Authors declare that they do not have any conflict of interest.

REFERENCES

[1] Aliaj Sh, Koçiu S, Muço B, Sulstarova E. *Seismicity, seismotectonic and seismic hazard assessment in Albania*. Published by the Albanian Academy of Sciences, 2010.
[2] Haskov J & Ottemoller L. *Seisan: The erthquake analysis software*. University of Bergen, Norway, 2008.
[3] Kiratzi A. The 6 September 2009 Mw=5.4 Earthquake in Eastern Albania – FYROM border: Focal Mechanisms, Slip Model, Shake Map. *Turkish Journal of Earth Sciences*, 2011;20:475–488.
[4] Klein F.W. *Hypocenter location program Hypoinvers*, USGS, 2002.
[5] Muço B. Focal mechanism solutions and stress field distribution in Albania. *Albanian Journal of Natural & Technical Sciences*, 2007;1:129-138.
[6] Ormeni Rr. P- & S-Wave Velocity Model of the crust and uppermost mantle of the Albania region. ELSEVIER, *Journal of Tectonophysics*, 2007;497:114_12
[7] Ormeni Rr, Kociaj S, Fundo A, Daja Sh, Doda V. Moderate earthquakes in Albania during 2009 and their associated seismogenic zones, *Italian Journal of Geosciences*, 2013;132(2).
[8] Ormeni Rr., Dushi E., Gjuzi O, Muci D, Minarolli A., Dushi I., Kasa E., Hajrullai S. *Monthly seismological bulletin of Albania".* www.geo.edu.al; 2001-2020. Institute of Geosciences, Energy, Water and Environment, 2019.
[9] *Monthly seismological bulletin and earthquakes catalogues of Albania*. www.geo.edu.al, Archive of IGEWE.
[10] Sulstarova E. *The focal mechanism of earthquakes and the field of present tectonic stresses in Albania.* D. Sc. Thesis, Seismological Centre, Tirana, Albania, 230 pp (in Albanian), 1986.