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SOME BASIC ASPECTS OF SEISMIC ACTIVITY DURING 2015 YEAR

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ABSTRACT

Albania is situated in Alpine-Mediterranean seismic belt comprising the zone of contact between lithosphere plates of Africa and Eurasia. Here African and Eurasian plates collide, giving origin to some seismically active belts. In particular Albania is at the junction between the Adriatic microplate and Eurasian plate as it is known, Albania is a country of high seismic activity (Aliaj et al 2001). It is characterized by intense micro-seismic activity and small and medium-size earthquakes and only seldom by large event. Seismic phases recorded by the Albanian network, integrated with data of Thessalonicy (Greece), Montenegro and INGV (Italy) networks, are used to prepare the database for this year. We present here the results of the analysis in parameters of events and some features of seismicity that have occurred in the Albania and surrounding area during 2015. The earthquake foci are concentrated mostly along the some active faults: 1). In the Vlora-Lushnje-Elbasan-Dibra transversal fault zone. From the Seismotectonic point of view, the Vlora-Lushnje-Elbasan-Dibra transversal fault zone belongs to a complex faulting environment, and according to the actual map of neotectonic zonation of Albania is located in the boundary between the two main tectonic zones characterized by compression and extensional. In the vicinity of Fieri was registered a small series of earthquakes that have the same level of magnitude and supposed to be an inducted seismicity. 2). In the Kurbnesh-Skavica seismogenic zone. It lies in the area of inner Albanides, along a depressional zone of faults extending nearly meridional and relatively narrow. 3). In The Ionian seismogenic zone. It occurs in the tension stresses directed nearly east-west is characterized by new differentiating movements of high gradients and by many and frequent earthquake epicenters. 4) In the Gjiri-Lazlit-Lezha seismogenic zone. It lies in the area of depresional zone occurs in the tension stresses. Increased seismic activity was registered nearby of southern Albania on the Greece territory.

Keywords: Earthquakes, Seismicity, Epicenter, Fault, Focal Mechanism

I INTRODUCTION

Albania is situated in Alpine-Mediterranean seismic belt comprising the zone of contact between lithosphere plates of Africa and Eurasia. The main geological structures found within the Albanian territory are called the Albanides, which are part of the Dinaric-Albanid-Hellenic arc of the Alpine orogeny. They are located between Helenides in the south and Dinarides in the north, which together form the Dinaric branch of the Mediterranean Alpine Belt. In the west, they are limited by the Apulia-Gargano foreland. The Albanides consist of magmatic

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and sedimentary rocks of Ordovician to Quaternary age according to the most recent studies (Aliaj et al, 2001). The Albanian orogen and its surroundings are divided into two active tectonic domains: an external compressional domain, constituting the Adriatic collision zone (Outer Albanides), and an internal extensional domain (Inner Albanides). The main cause of Albanian seismicity is the collision of Adria microplate with the Albanian orogeny. Albania is characterized by intense micro seismic activity and small and medium-size earthquakes and only seldom by large event. The earthquake foci are concentrated mostly along the active faults (Aliaj et al, 2001., Ormeni et al, 2010). The typology of the earthquakes in Albania comprises all four primary and well-known types of earthquakes: earthquakes with main-shock followed by aftershocks, earthquakes with foreshocks and aftershocks, swarms and compound earthquakes (Ormeni et al, 2012). We present here the results of the analysis in parameters of events and some features of Seismicity that have occurred in the Albania and surrounding area during 2015. The strongest earthquake occurred on November in the vicinity of Ballenja village northeastern of Albania, the seismic activity reached an intensity of VI-VII degrees on EMS-98 scale.

II DATA AND METHODS

On Albania and its surrounding territory, between 39°00'-43°00' N and 18°30'-21°30'E, 489 earthquakes was located with M_L=2.0 -5.0 (Richter) (Ormeni et al, 2015). In the territory inside the Albanian boundary was located 367 earthquakes. Figure 1 shows the Seismicity located for the period of time 2015. Statistics show the same level of seismic activity during 2015 compared with seismic activity 2014. Seismic phases recorded by the Albanian network, integrated with data of INGV (Italy) Montenegro, Thessaloniki (Greece) networks, are used to prepare the database for this study (fig. 1). The standard procedure uses the program Hypoinvers (Fred.W.Klein, 2002) of the Atlas packet, and velocity model Vel-Albanid (Ormeni, 2011) for earthquake locations. Some formula for determination of the magnitude according to the time duration of the seismic signal is also used. For felt earthquakes of M_L > 3.5, questionnaires are distributed in the affected areas, in order to estimate the macro seismic intensity.

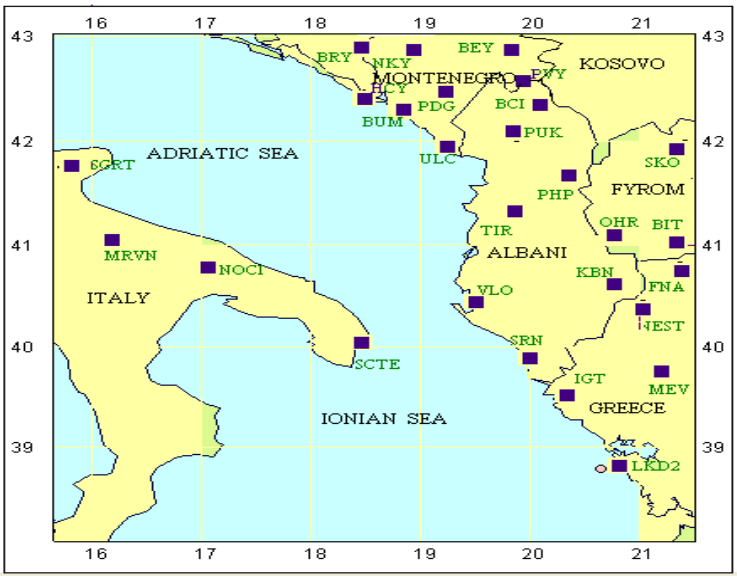

Fig 1. The map of 27 stations used for localization of the earthquakes occurred during 2015

III RESULTS AND DISCUSSION

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3.1. Some Feature of Seismicity

Moderate seismic activity was recorded at transversal fault zones. The most of local earthquakes about 93% are distributed in depth between 0 and 20 km, with average depth 8 km and maximum depth 46 km (Fig 2). Depths maximum concentration is between 1 and 8 km. The upper and middle crust is the most seismoactive layers in Albania lithosphere (Ormeni et al, 2014). The analyses of 2015 seismicity shows that the seismicity was mainly generated in the upper and middle crust.

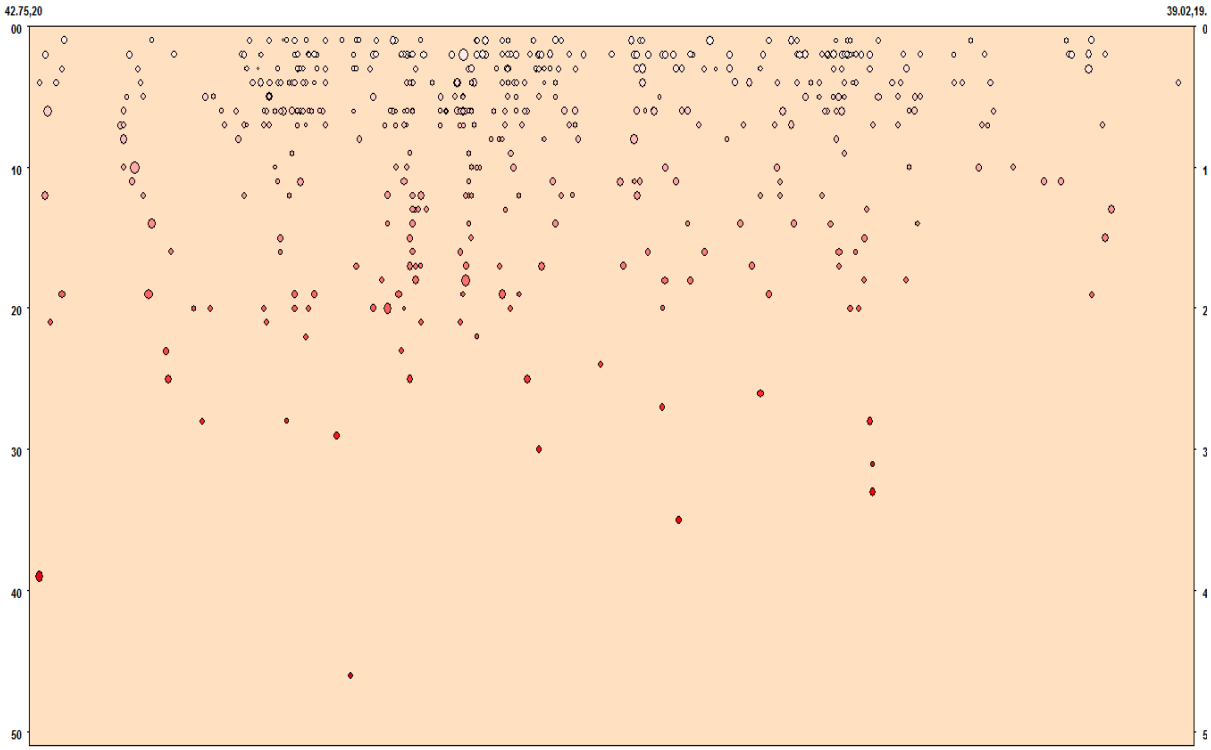

Fig 2. Distribution of focus of earthquakes according the depth

During the day time (06-18h) 236 of total number of earthquakes occurred and 253 at the night (18-06h). The average number of earthquakes located each month in Albania during 2015 is 41. From January to July there were 44 to 68 located earthquakes. In August to October the number of located earthquakes largely decreases (32), in November the number of located earthquakes increase over than 85 earthquakes (Fig 3). The earthquake foci during 2015 year are concentrated mostly along the active faults. The epicentral distribution of earthquakes shows that: Vlora-Lushnja-Elbasani-Dibra (1) , Gjiri i Lazelit –Lezha (2), Kurbnesh-Skavic (3) and Ionian (4) seismogenic zone are more active (Fig 5).

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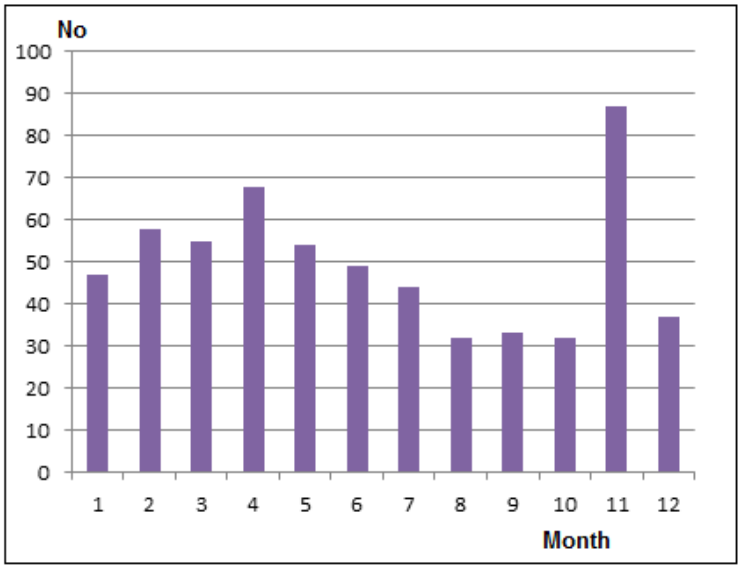

Fig 3. Distribution of number of earthquakes according the months of 2015 year

Cumulative number of $M_d \geq 2.0$ earthquakes in the catalogue shows roughly linear increase with time, which could be interpreted as that the catalogue homogeneous for the $M_d \geq 2.0$ earthquakes (Fig-4).

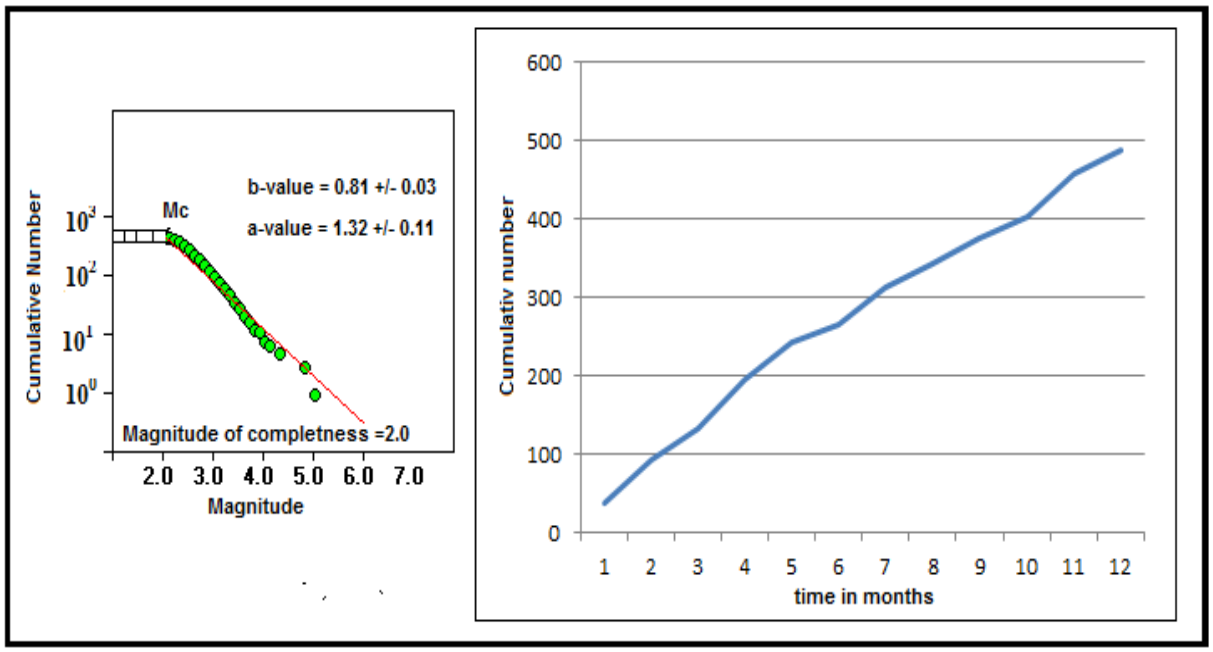

Fig 4. Cumulative numbers of the earthquakes in the seismicity data covering the time period 2015 (this centuary) are plotted against magnitude (left) and time (right).

The relationship between the size of an earthquake and its frequency of occurrence named as FMD (Gutenberg and Richter, 1944) and defined as:

$$Log_{10}N = a - bM$$

where N cumulative number of earthquakes with a magnitude exceeding a given magnitude *M*, and *a* and *b* are constants. These constants in average for Albanian earth crust are respectively: *a=1.32* is positively related to

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level of seismic activity in Albania, *b=0.81* has been shown to be inversely related to the shear stress in the crust (Wiemer and Wyss, 1997), is positively correlated with the increasing heterogeneity in the crust (Mogi, 1962). It has been shown that anomalously low *b* value along a fault zone corresponds to asperities that govern earthquake occurrence behaviour (Wiemer and Wyss, 1997). To calculate *b* value, we have used the maximum likelihood method (Aki, 1965) (Fig-4).

3.2 The Vlora-Lushnja-Elbasani-Dibra seismogenic zone (1)

On this transversal zone were located 146 earthquakes with M_L = 2.0 - 5.0, with average depth 8 km and maximum depth 30 km, and seismotectonic coefficient b=0.84. About 25 earthquakes have M_L>3.0 and two of them with M_L>4.5 and two of them with M_L=5.0 and M_L=4.8 ocurred in Bulqiza region at November 01 with respectively time 06h27m and 06h30m. Intensity Io = VI-VII degree (EMS-98), felt VI-VII degree at Ballenje village and its surrounding, VI degree at Bulqiza town, V-VI at Peshkopi, Burreli, Tirana towns , V at Elbasani, Librazhdi, Kruja towns , IV-V at Durres, Shengjin, Gramsh, Pogradec, towns, IV at Shkoder, Kukes, Fieri towns. The most of earthquakes on the fault Vlora-Lushnje/Elbasani-Dibra during 2015 have occurred mainly in the Elbasani-Dibra segment (Fig 6. zone 1). This segment comprising fragmentary NE-striking normal faults (Rr. Ormeni and E. Dushi). These earthquakes expresses the increased recently seismic activity especialy in the Elbasani-Dibra segment of this transversal faulting zone. The focal mechanisms of the moderate earthquake occurred on the 01 of November at 06:26 (UTC), magnitude (M_L5.0) indicate oblique faulting with a strike-slip component is the same with the other earthquake with magnitude (M_L4.8). This region forms a roughly NE−SW-trending active seismotectonic zone in eastern Albania that continues in the western FYROM (Ormeni et al., 2013). The focal mechanisms solutions of earthquake with magnitude (ML5.0): Strike=158°, Dip=56° and Rake (Slip) = -163° that was triggered from oblique faulting with a strike-slip component (fig. 5). The fault plane, has a dip 56° and is associated with the activation of the Elbasani-Dibra deep fault zone. These earthquakes have occurred in a four-minutes period from each-other. Occasionally, two or more events, often of similar size occur on nearby but different rupture surfaces close together in time, but with a delay such that their rupture times do not overlap.We call this clases of earthquakes compound earthquakes of Ballenja (Bulqiza district). They are of considerable interest because they imply rupture processes other then those predicted by elastic fracture mechanics. Perhaps the most common type of compound earthquake is when the rupture surfaces of two events are contiguous. These compound earthquakes cannot be explained with linear elastic fracture mechanics because the time delays between the individual events are to long to result from elastic processes (Ormeni et al., 2012).. Because an earthquake dynamically loads the surrounding region, compound earthquakes can result from viscoelastic relaxation in the immediate postseismic period, resulting in a redistribution of loads.

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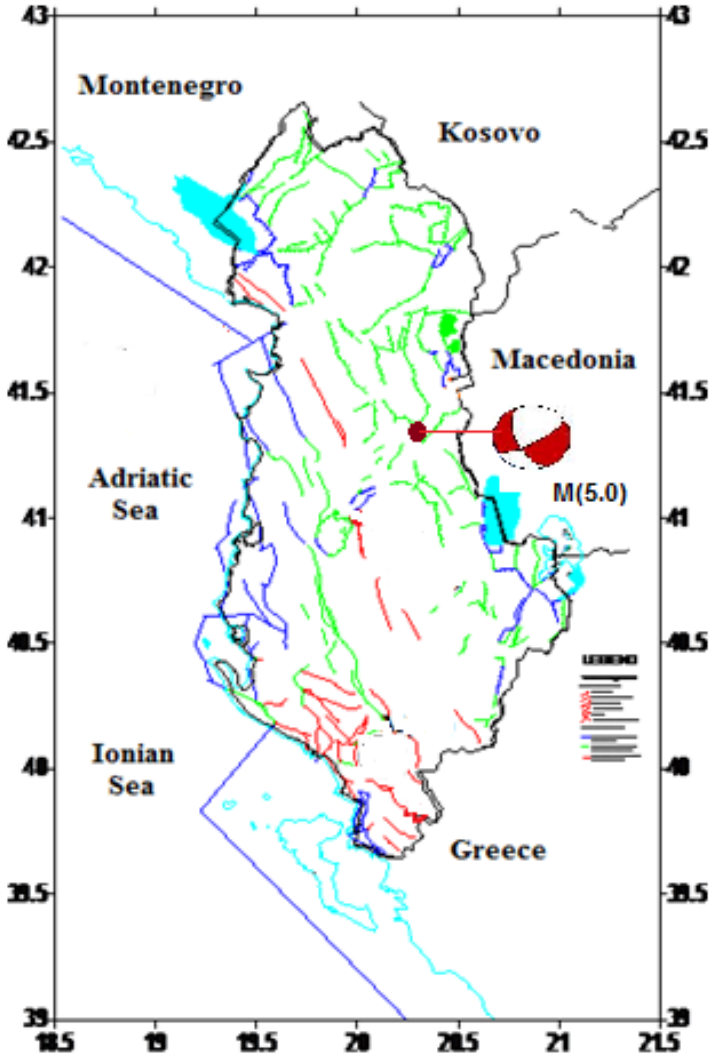

Fig 5. Seizmotectonic map of Albania (Aliaj et al., 2001)and focal mechanism of earthquake with M_L=4.8 (modified from Ormeni 2015)

This region forms a roughly NE−SW-trending active seismotectonic zone in eastern Albania that continues in the western FYROM (Ormeni et al, 2013). From the Seismotectonic point of view, the area belongs to a complex faulting environment, and according to the actual map of nontectonic zonation of Albania it is located in the boundary between the two main tectonic zones characterized by compressional and extensional movements. To this fault zone are related many geological phenomena comprises all four well-known types of earthquakes being seismoactive and now (Ormeni et al, 2012). Seismic hazard for series of compound earthquakes in this case is very high and direct connection with the geology of the location. Results of 2015 seismicity presented in this paper are intended to enable community officials and the general public to better understand the Vlora-Lushnja-Elbasani-Dibra zone earthquakes threat and to encourage a more comprehensive discussion of the its next great event

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3.3 The Gjiri Lazelit-Lezha seismogenic zone (2)

The Gjiri Lazlit-Lezha area, outer side of folded Alpine orogen with high mountains, hilly chains, extensive areas that are entirely under the power dynamics of rivers, abandoned riverbeds, lagoons and numerous wetlands, Shkodra Lake and in contact to the Adriatic Sea. On this zone were located 23 earthquakes with M_L=2.0 -3.5, with average depth 8 km and maximum depth 46 km, and seismotectonic coefficient b = 0.70. From them 5 earthquakes are with M_L>3.0 and one earthquake is with M_L=3.5 (Richter) occurred on the 2th of May at 02:39 local time that has been felt by the population of Northwestern Albania. This region forms a roughly NW−SE-trending active seismotectonic zone in western Albania. It is necessary to underline that Gjiri Lazlit-Lezha is located in face of the orogeny front, in convergence with Adria micro plate, and for this reason compressional movements here are strongest ones (Fig 6 zone 2) .

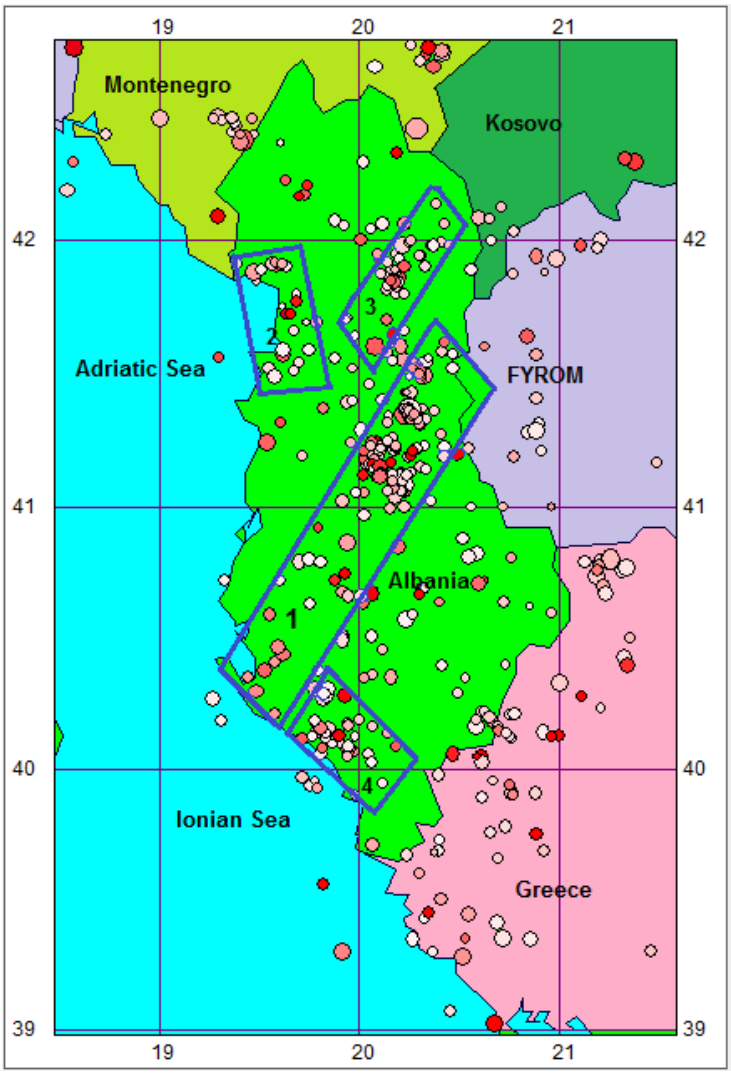

Fig 6. Epicentral map of earthquakes occurrence during 2015, for the Albanian territory and surrounding area

3.4. The Ionian seismogenic zone (3)

On this fault zone were located 41 earthquakes with M_L>2.1 with average depth 6 km and maximum depth 20 km, and 9 of them with M_L>3.0 and seismotectonic coefficient b = 0.71. On the surfaces of these uplifts, too, there are faults and flexures, expressed also with contrasts in relief; it appears very active in this year throughout its length. The Ionian fault zone with west-southeast extension is a transtensive with left compress and normal component. The left compress evidenced by displacement of the mountain streams (Fig 6. Zone 3).

3.5. The Kurbnesh-Skavica seismogenic zone (4)

This transversal seismogenic zone with direction SW-NE is in the inner side of folded Alpine orogeny with high mountains (Fig 5. Zone 4). During this year were located 59 earthquakes with M_L>20 where 4 of them with M_L>3.0 and one with M_L>4.0. and seismotectonic coefficient b = 1.01. The earthquake that occurred on the first of February at 00:20 (UTC), epicenter coordinates 41.60°N; 20.08°E, the focal depth 20 km has magnitude (M_L = 4.1) has been felt by the population of middle Albania. By generalizing the data from the depths of earthquakes have a range of about 1-20 km show that the seismactive layer in this zone is in upper to middle crust This fault zone characterized by a complex geomorphology and in addition, has been hit by numerous earthquakes during 2015.

3.6. Increased seismic activity was registered in northern part of Greece near Albanian territory. The max magnitude is 3.5 in east of the Korca town.

IV CONCLUSIONS

The most seismic activity inside the Albanian territory, analyzed in this paper have been generated along the some active faults: Vlora-Lushnja-Elbasani-Dibra, .Gjiri i Lazelit –Lezha, Kurbnesh-Skavic and Ionian seismogenic zones. Increased seismic activity was registered abroad of Albania on the Greece territory. Based on analysis of the moderate earthquake of Ballenja and in previous strong earthquakes, the Vlora-Elbasani-Dibra-Tetova transverse fault zone plays an important role in the seismotectonics of Albania, as well as the FYROM. The seismicity of 2015 year emphasizes many geologic and seismotectonic characteristics of the Vlora-Elbasani-Dibra-Tetova transverse fault zone constituting a threat for nearby urban areas of Albania and the FYROM. The local earthquakes are distributed in depth between 0 and 20 Km. The analyses of 2015 seismicity shows that the seismicity was mainly generated in the upper and middle crust, under the tectonic conditions described previously.

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