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Influence of Soils Conditions on the Macroseismic Effects in the Dukagjin Area Based the Seismic Wave Propagation from Durres Earthquake 26/11/2019

Shemsi Mustafa, Arbresha Mustafa

Abstract: ***Kosovo represents a region with relatively high seismic activity, it has been hit in the past and may be hit in the future by very strong indigenous earthquakes. Geographically, Kosovo is in the contact zone of two large tectonic plates, on one side of Africa that pushes the Euro-Asian and lies at its foundation. For these reasons, the countries in the Mediterranean area belong to countries with high seismic risk, including the surrounding areas. The strongest earthquake recorded and documented in Kosovo is the earthquake of 1921, in the Viti-Ferizaj-Gjilan area with a magnitude of 6.1 on the Richter scale and an intensity of 8.5 on the Mercalli scale. During the recent geological period the region has been embraced from the neotectonic processes which have conditioned the formation of many structural units that are expressed by intensive uplifting and sinking movements. Are used macroseismic data to investigate the influence of local geological structure on earthquake intensities in Dukagjin area of Kosovo. The occurrence of earthquakes is connected with the geological and neotectonics characteristics of the individual regions. The territory of Kosovo is composed of rocks of Precambrian to Quaternary age. In addition soft sediments in the Kosovo basins have a strong influence on seismic ground motion. Macroseismic data are used to investigate Response of Soil class of Dukagjini basin with deposits of Oligocene, Pliocene and Quaternary, where the lake sediments continue during its Pleistocene, (epicenter distance 140 km, Durrës Earthquake 26/11/2019), which had shown, systematic Intensity increase.***

Keywords: ***Seismology, Seismotectonics, Seismic Risk, Earthquake***

I. INTRODUCTION

Strong 6.4-magnitude earthquake with an epicenter 16 kilometers west-southwest of Mamurras, at 03:54 CET (UTC+1) on 26 November 2019 with some (25) seconds and was felt in places as far away till hundreds of km, northeast of the epicenter.

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*Correspondence Author(s)

Shemsi Mustafa, Department of Seismology, Geological Survey of Kosovo, UBT-University of Business and Technology, Prishtina, Kosovo. E-mail: shemsimustafa68@gmail.com, ORCID ID: 0000-0001-6703-9098

Arbresha Mustafa, Faculty of Civil Engineering, University of Pristina, Kosovo. E-mail: arbresha.mustafa1@gmail.com, ORCID ID: 0009-0007-7805-0277

The maximum intensity was VIII-IX (Severe) on the Modified Mercalli intensity scale.

Time histories are of significant importance for seismologists an engineers as they provide basic data for understanding of processes lead to generation of seismic motion. Ground motion at a particular site due to earthquakes is influenced by source, travel path and local soil conditions.

The territory of Kosovo was affected by the earthquake, this area is located in the distance North-East of the epicenter about 140km, based on calculations and analysis of the strength of this earthquake and the geological composition of the area, tectonic structures of Dukagjini had an increase in intensity in this area as a cause of poor soils

The purpose and the estimated study is to evaluate the distribution energy of the Durrës earthquake in the Dukagjini area, the dependence of the attenuation and amplification from a distance, arguing the release of seismic energy of earthquake. From the geological point of view, Kosovo is in a very interesting territory. The territory of Kosovo is characterized by a variety of geological formations. Among these are rocks ranging from old crystalline Proterozoic to Quaternary age comprising sedimentary and magmatic types together with rather less frequent metamorphic rocks.

The main purpose of the paper is to analyze seismic site effects in alluvial basins and to discuss the influence of the knowledge of the local geology (soil) of Intensity increase. Wave amplification is due to a combined effect of impedance ratio between soil layers and surface wave propagation due to the limited extent of the basin.

These results show that the geometry of the basin has a very strong influence on seismic wave amplification in terms of both amplification level and time duration lengthening.

II. WESTERN VARDAR OPHIOLITIC UNITS

The Western Vardar ophiolitic unit comprises ophiolitic units that were abducted onto the Adriatic margin in Late Jurassic to earliest Cretaceous times. This was before this margin became involved in orogeny forming the nappe stack of the easternmost Alps, Western Carpathians, Dinarides and Hellenides (Schmid et al., 2008 and references therein).

They do not represent ophiolitic suture zones but rather represent the structurally upper parts of composite nappes that consist of Adria-derived continental units and previously abducted ophiolites, which formed by out of sequence thrusting (with respect to obduction) during Cretaceous and Cenozoic orogeny. As a result of this, in present-day map view, they form belts or isolated ophiolitic domains in the Dinarides-Hellenides, fig.1. [1] [2].

Thus, in this perspective, the impact of an earthquake can be assessed in terms of expected losses.

Nowadays, the evaluation of the geological effects has been taken into consideration in the framework of risk assessment in order to have a better and correct forecast of the expected damage. In this circumstance, the soil layers amplify or reduce the seismic waves on the crustal surface. Site effects are thus dangerous when the amplification of seismic waves in surface geological layers occurs. In fact, surface motion can be strongly amplified if geological conditions are unfavorable. Generally, specific geological, geomorphologic and geo-structural settings of restricted areas can induce a high level of shaking on the ground surface even in occasions of low intensity/magnitude earthquakes, take in consideration of DAF, Dynamic amplification factor [9][15].

The propagation of energy released by an earthquake through the uppermost crust has a significant impact on the ground motion that is observed at the surface. Due to the heterogeneity of the upper crust, the site amplification effect is highly variable over scales of kilometers or less.

Obtaining real-time information (data) on local seismic events as well as regional and global events with all earthquake parameters including time (date, time for 2019 year), energy released by the earthquake expressed in Magnitude and Intensity worked and examined are shown in fig. 1.

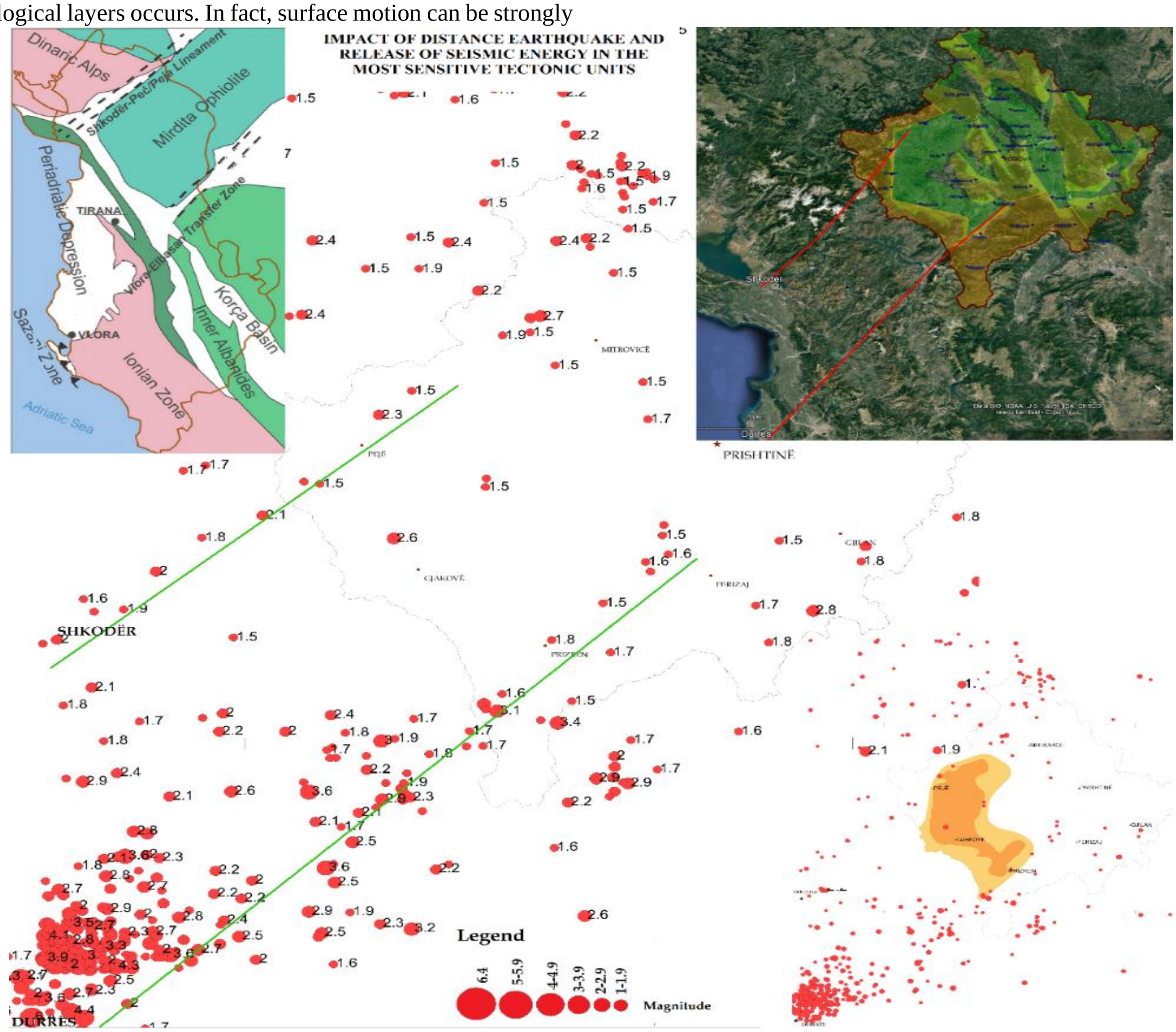

Fig. 1 Seismicity and the Distribution of the Intensity of the Durrës Earthquake, year 2019

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III. NEOTECTONICS STRUCTURE OF KOSOVO

Neotectonics research in territory of Kosovo is closely related with studies of morpho structure units resulting from the neotectonics movements that have taken place during Policient and Quaternary, in the so called neotectonics stage. During neotectonics stage, territory of Kosovo is affected by tectonic processes, which have resulted in formation of new morph-structure units: morph-structure with dominant tendency of uplifting trend and sinking. [3] [10] [11]

A. Structure of Characterized by Trends in Diving

The Dukagjini Basin, which is the largest one, has a peculiar subsided structure, surrounded from north, west and south by uplifted blocks that emerged during the neotectonic evolution. It is a slight deformed asymmetric syncline with low dipping flanks (the north-eastern flank is the largest one).
Dipping of lowland od Dukagjin Zone known as Neogen, which are accumulated in large measure of terigjen molase material, where are also found large reserves of coal, was the area most affected by the Durres earthquake on 26.11.2019, with an increase values of intensity basing on soft soil composition.
Lowland of Dukagjin, which is subdivided into smaller lowlands, such as: the lowlands of Peja – Istog and lowland of Gjakova – Prizren. The Dukagjin lowlands are a units basin of Neogene coal-bearing accumulations and have submerged morphostructure as tectonic forms and take place on the complicated ancient tectonic structure. The area of the Dukagjini Depression is 2000 km2.

- The Peja Lowland. The Peja plain includes the northern part of the Dukagjini Plain and that from Lumbardh of Deçan and Peja in the west to the eastern parts of the Kujavc Stream. In total its length is about 45-50 km and width about 20-25 km. In this western part of the Peja Lowland there is a continuity of Oligocene deposits even during the Quaternary, where lake sediments have continued during the early Pleistocene, but in different climatic conditions. As a result of the immersion of this part of the Peja Lowland, the new forms of the Drini i Bardhë river valleys, Lumbardh of Peja and other watercourses have the form of wide alluvial plains with a tendency to immersion, where the newest sediments are deposited.
- **The Prizren Lowland. The** Prizren Lowland represents the southern part of the Dukagjini Lowland. The surface of this basin is about 450 km2 and is connected to the lower course of the Drini i Bardhe with its tributaries. As a morphostructural dive, there is the same development as the Gjakova Lowland, with the difference that with the help of drilling in the territory of Prizren, the deposits of the Lower Pliocene have not been ascertained. According to the geological data, the Middle and Upper Pliocene deposits, whose thickness is estimated to be around 350m, have been distinguished here. According to the existing data, Pliocene deposits in these terrains have been found with a thickness of up to 700 m, which show that the Neugenic Dukagjini Basin has covered a larger area than the area where Neogene formations are present today. On the whole, the Prizren Lowland represents a morphostructural unit, as part of the Dukagjini Lowland, included by intensive dives, realized in time after other parts of the Dukagjini Lowland.
- Response of geological formations in the lowlands of Peja and Prizren (areas with a tendency to dive) in increasing the values of macroseismic intensity of Durres earthquake the large and well-known Neogene lowlands of Dukagjin zone, in which large masses of molasses terrigenous material have accumulated, where large coal reserves have also been found, which tertiary formations fill the tectonic lowlands of Dukagjini, where Miocene and Pliocene have been found by paleontological research. Neogene formations are represented by Miocene and Pliocene sediments, coal seams and volcanic products. Miocene deposits fill the Dukagjini Basin and are represented by aleurolithic clays, sandy and marl clays, heterogeneous conglomerates, sandstones, stratic clays, clayey-marl limestone's, tuffs and rarely pyroclastic products. Pliocene deposits, which are lake and freshwater, transgressed cover the Miocene formations and fill the Dukagjini basins. These sediments are represented by conglomerates, sandy clays with carbonate concretions, rarely sandy (coal floor), then marl clays, sandy-clayey sediments and rarely with limestone interlayers. Quaternary deposits, these deposits cover the flat plains and river beds of the Drini i Bardhe represented by the sediments of river terraces, alluvial, proluvial, deluvial and moraine products, see fig. 2.

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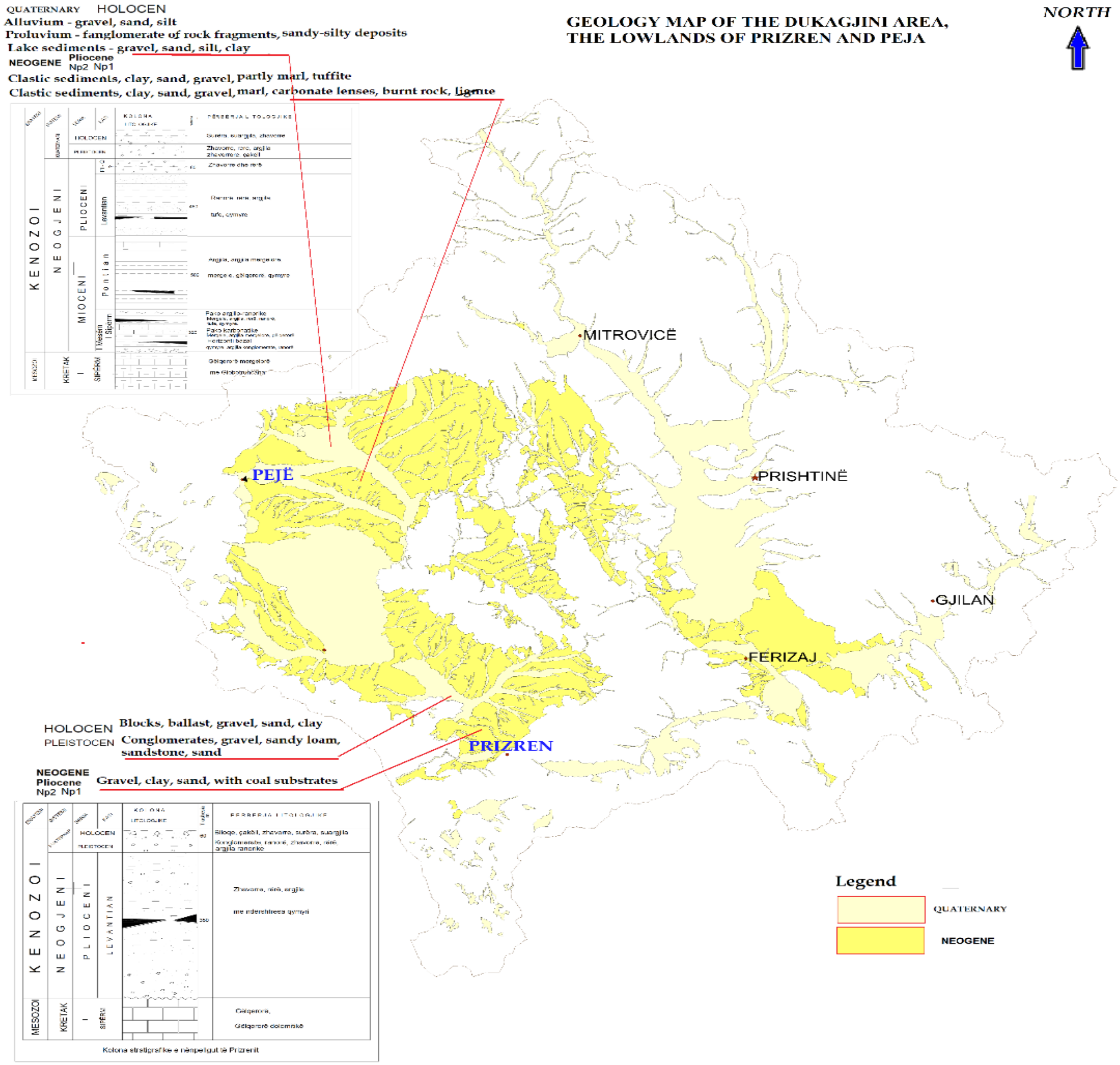

Fig. 2 Map of Geological Formations in the Lowlands of Peja and Prizren

IV. ISOSEISMAL DUKAGJIN ZONE

Estimation of Intensity Increase at an epicenters distance 140 km, from the effects of the upper some meters of rock and soil. Based on the soil conditions in the Dukagjin basin, it can be noticed that we have an increase or decrease of local intensity compared to the so-called middle ground, an area which mainly includes Quaternary deposits, molasses deposits and flysch in which the velocity of transverse seismic waves is relatively small. Have been used some models by some authors, after EMS, Midorikawa and Medvedev, to investigate the impact of local geological structure on earthquake intensity, fig.3.

Medvedev used the seismic rigidity as the results of seismic measurements of longitudinal wave velocities of the corresponding types of soils. The density values of the respective types of soils were taken from engineering-geological surveys data. The obtained values of seismic parameters of different types soils were compared in relation to the values of the highest seismic rigidity. Based on the soil conditions in the Dukagjin basin, it can be noticed that we have an increase of local intensity compared to the so-called middle ground, an area which mainly includes Quaternary deposits, molasses deposits and flysch in which the velocity of transverse seismic waves is relatively small corresponding to granites.

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Then a functional dependence was found, which best satisfied the results of macro-seismic definitions, linking the increment of the intensity with the soil parameters. On the basis of such simple assumptions of Medvedev the expression determining increase of seismic intensity on parameters of soil in the form of the following expression is received: Equation 1 [4]:

$$\Delta I_s = 1.67 * \log \left[\frac{\rho_0 V_0}{\rho_i V_i}\right] \dots\dots\dots\dots\dots\dots\dots\dots (1)$$

ΔI_s - Seismic Intensity increment for soil under condiration with reference to rock

$\rho_0 V_0$ - Velosity of propagation of commpresive seismic wave in the rock and soils

$\rho_i V_i$ - Density of dhe rock and of examined soils

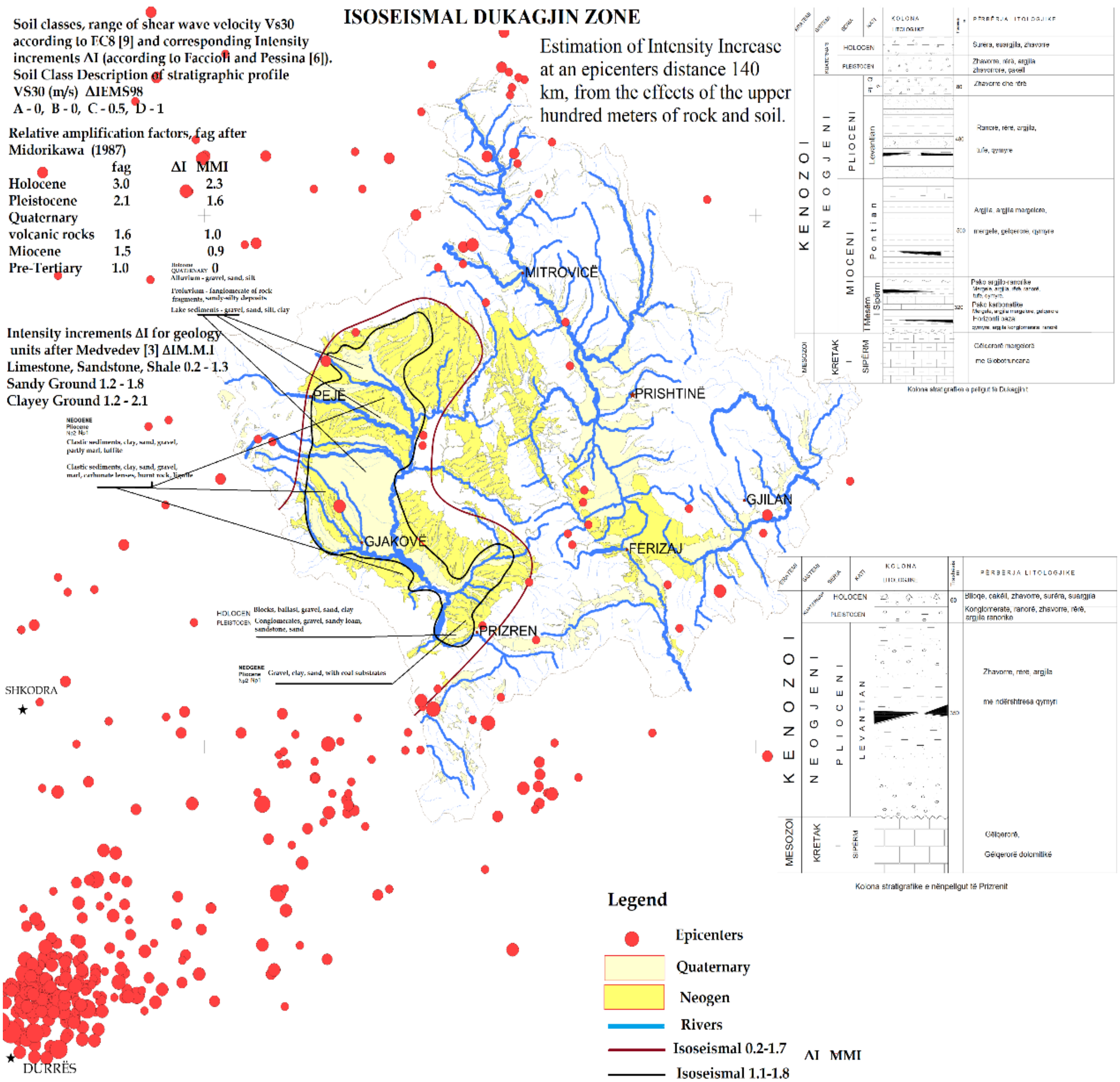

Fig. 3 Map of Distribution of Maximal Intensity for Dukagjin Zone

Results: Processing of data and publications on the seismicity of the area has been done. The special feature of this study was the consideration of data for Durres Earthquake earthquake with intensity 8-8.5, Imm Scale. Based on the results and study macroseismic for Dukagjin zone, seismic values are as follows, tab 1, fig. 4.

Zone 1 Impact of local geological structure in earthquake intensity, Clastic sediments, clay, sand, gravel, marl, party marl, tuffite, carbonate lenses, burnt rock, lignite; ΔI Increase = 0-0.9.

Zone 2 Impact of local geological structure in earthquake intensity, Alluvium gravel, sand, silt fragments, sandy-silty deposits, conglomerates sandy loam, sandstone; ΔI $_{\text{Increase}}$ = 0.2-1.3.

Zone 3 Area with finely dusty sand, mud and mud clay, peat which have the level of groundwater up to near the earth `s surface, endangered by floods on earthquake intensity ΔI $_{\text{Increase}}$ =1.3-2.1.

Seismic attenuation describes the loss of energy in the experience from seismic waves when they propagate. For the Dukagjin Area we got for study Durres Earthquake, which result in different attenuation values, where at a distance of 140 -164 km, results with these values of IMM (Intensity). (Papazchos and Papaioannou), equation 2. [5], [6], [7], [8], [12], [13],[14].

$$I - I_0 = -3.227 \log \sqrt{1 = \frac{\Delta^2}{\Delta^2}} - 0.0033(\sqrt{\Delta^2 + h^2 - h}) \ldots\ldots\ldots\ldots(2)$$

Table 1. Vs and ρ of Geological Formations

Soils	ρ	Vs
Humus soil, peat	**1.1**	**50**
Clayey soil	**1.5**	**120**
Sandy soil	**1.6**	**200**
Hard soil	**2.0**	**250**
Clayey soil	**1.7**	**300**
Sandy soil	**1.9**	**500**
Hard soil	**2.1**	**500**
Clay, sand, gravel, Old-rocks	**2.3**	**> 800**

Zone 3 Area with finely dusty sand, mud and mud clay, peat which have the level of groundwater up to near the earth `s surface, endangered by floods on earthquake intensity ΔI $_{\text{Increase}}$ =1.3-2.1

I_{MM} = Durrës – Prizren - 144 km = 5.2-5.3 +ΔI $_{\text{Increase}}$ = 0.2-1.4 ≈ 5.8-6.3

Zone 1 Impact of local geological structure in earthquake intensity, Clastic sediments, clay, sand, gravel, marl, party marl, tuffite, carbonate lenses, burnt rock, lignite; ΔI Increase = 0-0.9

Zone 2 Impact of local geological structure in earthquake intensity, Alluvium gravel, sand, silt fragments, sandy-silty deposits, conglomerates sandy loam, sandstone; ΔI $_{\text{Increase}}$ = 0.2-1.3

Zone 3 Area with finely dusty sand, mud and mud clay, peat which have the level of groundwater up to near the earth `s surface, endangered by floods on earthquake intensity ΔI $_{\text{Increase}}$ =1.3-2.1

I_(MM)= Durrës – Gjakovë - 145 km = 5.1-5.3 + ΔI Increase = 0.2-1.4 ≈ 5.8-6.3

Zone 1 Impact of local geological structure in earthquake intensity, Clastic sediments, clay, sand, gravel, marl, party marl, tuffite, carbonate lenses, burnt rock, lignite; ΔI Increase = 0-0.9

Zone 2 Impact of local geological structure in earthquake intensity, Alluvium gravel, sand, silt fragments, sandy-silty deposits, conglomerates sandy loam, sandstone; ΔI $_{\text{Increase}}$ = 0.2-1.3

I_{MM} = Durrës – Pejë - 164 km = 4.8-5.1 +ΔI $_{\text{Increase}}$ = 0.2-1.2 ≈5.5-6.0

Zone 1 Impact of local geological structure in earthquake intensity, Clastic sediments, clay, sand, gravel, marl, party marl, tuffite, carbonate lenses, burnt rock, lignite; ΔI Increase = 0-0.9

Zone 2 Impact of local geological structure in earthquake intensity, Alluvium gravel, sand, silt fragments, sandy-silty deposits, conglomerates sandy loam, sandstone; ΔI $_{\text{Increase}}$ = 0.2-1.3

Zone 3 Area with finely dusty sand, mud and mud clay, peat which have the level of groundwater up to near the earth `s surface, endangered by floods on earthquake intensity ΔI $_{\text{Increase}}$ =1.3-2.1

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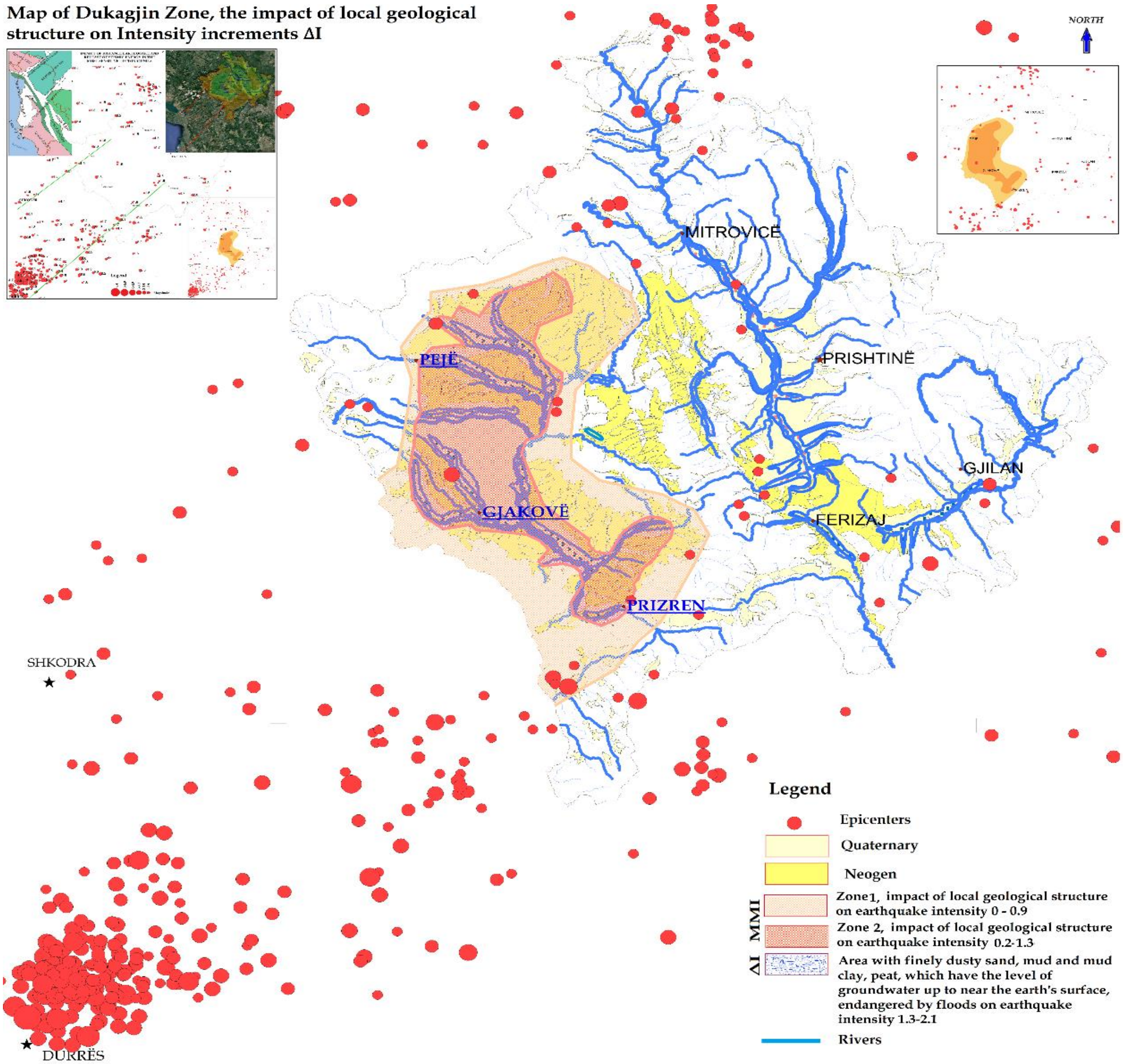

Fig.4 Map of Dukagjin Zone, Isoseiste `s of Diferent Intensity from Impact of Local Geological Structure

V. CONCLUSIONS AND RECOMMENDATIONS

It is a normal practice in many countries that, in certain time intervals, the seismic hazard maps are updated continually, in order to include and reflect the latest achievements in seismology at local, regional and global level. We think that a study program is necessary to be undertaken in near future to include further review of the hypocenter parameters of the Kosovo earthquakes. Another problem would be Microseismic Study of all urban zones for a precision of seismic parameters in detail that helps a lot for the projections of buildings. In conclusion, we think that this study represents an achievement in the philosophy of seismic hazard assessment for Kosovo. These results can be improved in the future if we'll have:

- Further improvement of the seismicity parameters through the updating of the earthquake data base for Kosovo and the surrounding areas
- A regional seismotectonic model that links seismicity with the active tectonic faults, their focal mechanism, etc.
- More accurate models for the prediction of ground motion parameters based on regional strong motion records in Kosovo and the surrounding areas.

Based on all these parameters and seismic values presented and studied, it turns out that the Dukagjin Zone is a seismic zone with differnt geology conditions, so for engineers and architects in their designs important design parameters should be taken into consideration.

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Ethical Approval and Consent to Participate	No, the article does not require ethical approval and consent to participate.
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Authors Contributions	All authors have equal contribution in this article.

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AUTHORS PROFILE

Shemsi Mustafa, Doctor of Technical Sciences, Earthquake Engineering and Engineering Seismology Professor on Fundamentals of Earthquake Engineering, Faculty of Architecture and Spatial Planning Higher Education Institution-UBT, Lagja Kalabria p.n, Prishtinë Leader of the Seismic Network of Kosovo, Sector of Geophysics and Engineering Geology. Field Earthquake Engineering, Engineering Seismology, Sector of Geophysics and Geotechnics, experience 17 Years- till Leads the work on the Seismological Network of the Republic of Kosovo; It monitors seismic activity of the country as well as collects, stores, processes, analyzes and publishes seismological data obtained through this network; Studies on seismic phenomena manifested on land, buildings and other objects, compilation of seismological maps at the national, local, and squares of construction of objects of particular importance; Provides geophysical services for solving geological engineering problems; Makes estimates of geological and geological-engineering hazards; Ministry of Economic Development, St. Nënë Tereza nr. 36, Toskan 10000, Prishtinë, Kosovo

Arbresha Mustafa, a dedicated Master's student in the Faculty of Construction during the 2020/21 academic year, immerses herself in the intricate realm of construction, fervently seeking knowledge. Her professional journey unfolds with precision at Bechtel Enka, where she specializes in the supervision of bridges, roads, and pilots, demonstrating meticulous management of daily reports and measurements through. Currently, Arbresha actively contributes to the design of towering structures at BB Architects, starting in March 2023. Her narrative takes shape as she showcases proficiency across a spectrum of professional programs, including Tower, Armcad, AutoCAD, and Ftool. Moreover, she exhibits an emerging mastery of Etabs and Robot, encapsulating a dynamic blend of academic prowess and practical expertise.