



Seismotectonic Settings of Kosova

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Abstract: The geological-tectonic building of Kosova is very complicated. As the result of this building Kosovo is one of the most active countries in East-South Europe. Based on the existing seismic hazard maps of Kosovo for repeating periods of 100, 200, 500, 1000 years, in Kosovo it's possible to occur an earthquake with maximum magnitude 9. Geological build of building location and seismic hazard is necessary to study the resonance effect which can cause in objects by one earthquake. The causer of resonant effect or amplification of amplitudes is the height of objects and topography of location. In generally those amplifications are caused by long-period components of seismic waves, while the short period of amplitude components are reduced.

Keywords: *seismotectonic, seismic risk and hazard, amplification, resonance*

Introduction

Territory of Kosovo by seismic-tectonics aspect presents the most active countries, where the disastrous earthquakes with autochthon character can be expected. Data on the past earthquakes testifies clearly that the occurrence of disastrous earthquakes in some parts of the territory of Kosovo was evident earlier, so among the historic earthquakes we can mention the one of 1456, which occur Prizren with intensity IX, MSK-64, then in 1552, the surroundings of Peja was occurred by an earthquake with the intensity VIII, MSK-64 scale. The strong earthquakes have occurred also later, as it is the one of 1921 with epicentre intensity IX, MSK-64 scale, which hits the region of Ferizaj-Viti-Gjilan, then the earthquake in 1980, which hits the region of Kopaonik with intensity VIII, MSK-64 scale and the last on in 24 April 2002 with epicentre intensity VII¹/₂, MSK-64 scale that it damage hard the Gjilan Municipality. The Territory of Kosovo also is characterised with that it is also subject to strong motion from the earthquakes, which the epicentre was out of the territory of Kosovo, in Macedonia, Albania, Montenegro and Serbia.

These two phenomena, the local autochthon seismicity and seismicity caused by distant earthquakes, prove that Kosovo is ranked in the territory with the high seismic activity. This pretty high activity dictates the enterprise of general required studies, in order that base on analyses and synthesis of gained complex data, to be given a full, real and realisable table for the assessment of seismic hazard of Kosovo.

Neotectonic Structure of Kosova

The aspect of the neotectonic exploration in the territory of Kosovo are closely linked with the studies of morphostructural units created by neotectonic movements, in the most new geological period, during Pliocene and Quaternary, in the so-called neotectonic stage. The study of neotectonic activity of Kosovo is closely linked with the knowledge of the early geological structure, in order to discover the relation between the early tectonic movements and neotectonic movements. During neotectonic stage, the territory of Kosovo is involved by tectonic processes, which have conditioned the formation of new morphostructural units: morphostructures with dominant tendency in uplift and in dip.

We emphasise that the areas with new marked volcanic activity have a special place in Kosovo and many valuable minerals are linked with it.

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Territory with Dominant Tendency in Uplift

Territory with dominant tendency in uplift, in tectonic map shall be delimited with the izolines of neotectonic deformation, which shows the real value of the vertical uplifting during Neogene and Quaternary. During our days, the post-volcanic activities manifest with the phenomenon of thermal water, which proves the existence of emphatic geothermal field.

We have divided in special units the territory of Kosovo with dominant tendency in elevation, denominated with number from 1 to 13 (Figure 1).

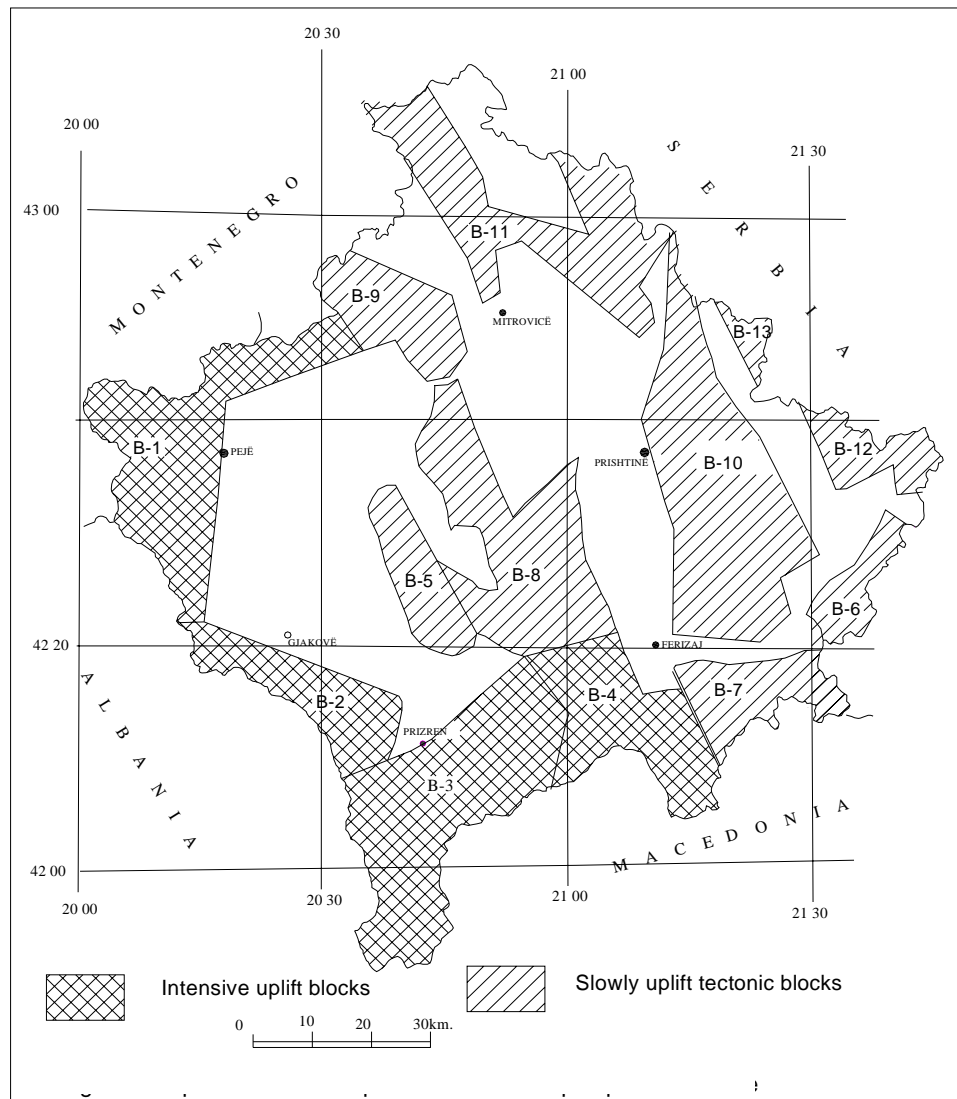


Figure 1. Morphostructural map of Kosova with uplift predominance

Territory with Dominant Tendency in Subsiding

Neotectonic units are clearly empathic in territory of Kosovo, which represent the morphostructural dip. These are the biggest and known of Neogene basins, in which the great mass of terrigene molasses material is accumulated, where also the great lignite reserves are documented (Elezaj and Kodra 2008). These Basins are known (Figure 2):

1. *Dukagjini Basin*, that it is divided in the smallest one, such as: Peja Sub-basin, Gjakova Sub-basin, Prizren Sub-basin and Bellanicë Sub-basin.
2. *Drenas Basin*,
3. *Fushe Kosova Basin*, in which are included also: Besiana (Podujevë) Sub-basin and Morava e Binçës Sub-basin.
4. *Dardana (Kamenica) Basin*

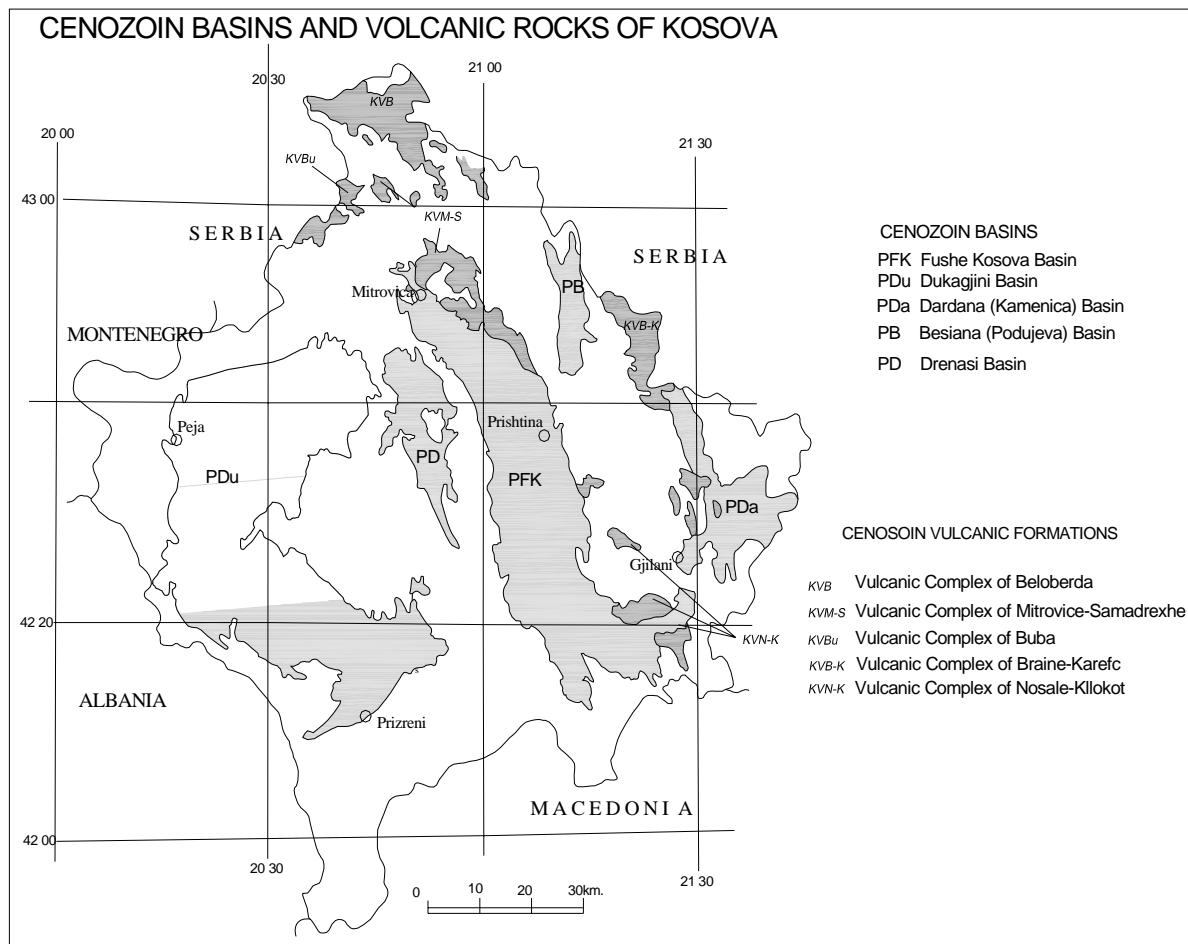


Figure 2. Cenozoin basins and volcanic rocks of Kosova

Seismicity of the Territory of Kosova

From the seismological view, Kosovo present a region with high seismic activity which it is hit backward and can be hit also in future by very strong autochthon earthquakes, which they have shallow focus, that are generated in the earth crust, maximum 15-20 km deep in underground (Elezaj, 2001). Territory of Kosovo has several powerful zones of seismic sources, or seismogenic sources, as follow:

1. Seismogenic zone Prizren-Pejë maximal magnitude of $M=6.6$ Richter scale,
2. Seismogenic zone Ferizaj-Viti-Gjilan with maximal magnitude $M=6.1$ Richter scale,
3. Seismogenic zone Kopaonik with maximal magnitude $M=6.0$ Richter scale, (Elezaj, 2001; Sulstarova et al., 1980; Sulstarova & Aliaj, 2001).

These zones of seismic source in Kosovo have generated the strong earthquakes in the past and can be generated them also in the future. Among the strongest earthquakes which have hit Kosovo are:

1. Earthquake of Prizren, 16 June 1456 with epicentre intensity $I_0=9$ scale MCS and magnitude 6.6 Richter scale;
2. Earthquake of Peje, 11 November 1662 with epicentre intensity $I_0=8$ scale MCS and magnitude 6.0 Richter scale;
3. Earthquake of Ferizaj, 26 February 1755 with epicentre intensity $I_0=9$ scale MSK-64 and magnitude 6.1 Richter scale;
4. Earthquake of Ferizaj-Viti, 10 August 1921 with epicentre intensity $I_0=9$ b scale MCS and magnitude 6.1 Richter scale;
5. Earthquake of Kopaonik, 18 May 1980 with epicentre intensity $I_0=8$ scale MCS and magnitude 6.0 Richter scale (Sulstarova et al, 2000; Orana et al., 1985; Elezaj, 2001; Pekevski, 2001).

During the last century and until now, territory of Kosovo have been affected by 82 earthquakes with intensity 5 scale, from them 34 earthquakes with intensity 6 scale, 12 earthquakes with intensity 7 scale, 10 earthquakes with intensity 8 scale (1 earthquake belongs to period before 1900) and 3 earthquakes with intensity 9 scale (2 earthquakes belong to period before 1900) (Elezaj, 2001).

Region of Ferizaj-Gjilan is affected by two stronger earthquakes, 1755 and 1921. Earthquake of the year 1921, with the same epicentre intensity $I_0=9$ scale with the one of the year 1755, is repeated here after 166 years.

Earthquake of the year 1921 is followed by many strong after shocks 7 and 8 scale MCS, which they have lasted for a year, from August 1921 until September 1922 (Elezaj, 2001).

Seismotectonic Characteristics of Kosovo

During assessment of seismic activity, base on the existing data and the up to now experience from the realised exploration, the seismotectonic characteristics of Kosovo are given than the data offered from seismological statistics. These issues have been discuses for the description of seismicity of Kosovo (Elezaj, 2002):

1. Active faults and their seismotectonic activity,
2. Zones of seismic sources,
3. Geological criterion of seismicity of Kosovo

3.1.1 Active faults and their seismotectonic activity,

Identification of faults and their classification according their demonstration in field is presented in Figure 3, which it evidences the active tectonic faults in details shown with numbers from 01 until 026, that it complicates the new neotectonic structure of Kosovo.

Active faults in neotectonic stage and today stage represent the natural borders between blocks (units) with tendency in elevation and basins with tendency in dip, between horst and graben.

3.1.2 Zones of seismic sources in Kosovo

According the map of seismic sources (Arsovski, 1985 and the modified one Elezaj, 2002), we will see that these zones of seismic sources are distinguished in the territory of Kosovo: Ferizaj-Viti-Gjilan, Skënderaj, Mitrovicë, Pejë-Gjakovë-Prizren-Dragash and Kopaonik. The highest values of expected maximal magnitude are: Ferizaj-Viti-Gjilan (6.5), Skenderaj (5.0), Mitrovicë (5.0), Pejë-Gjakovë-Prizren-Dragash (6.6) and Kopaonik (6.0).

Geological criterion of seismicity

Geological criterion is related with the processes developed during neotectonic stage where the main morphostructures have been formed in the today landscape. These processes are continuity of the early neotectonic period, and because of this they serve as a reliable data on the forecast of country and the power of future earthquakes.

Contrast relations between the new basins with graben form and mountain elevation with horst form, represented by active faults, constitute the prognosed geological criteria for the possible earthquakes that can be happened in the future. The active faults are such like that enclose the Dukagjini Basin from north and west, also the cross system of faults delineated from the Quaternary Basin of Morava e Binçës from Ferizaj in Viti and further towards Gjilan, where it is also generated the earthquake of 24 April 2002.

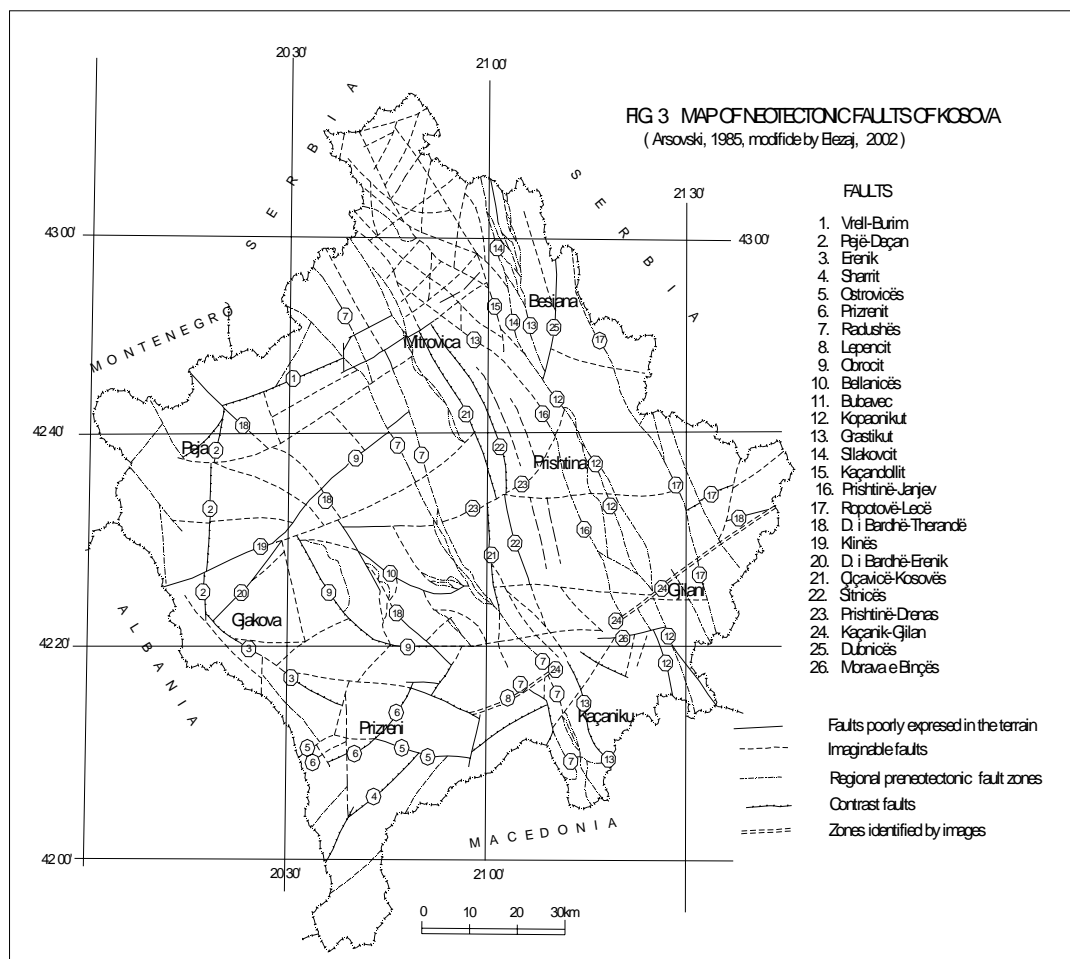


Figure 3. Map of neotectonic faults of Kosova

It must emphasise that the most dangerous territory are related with the tectonic node where the active tectonic fault of systems are intersected with different extension direction. The tectonic nodes are like in Pejë dhe Prizren, where there are generated two powerful historic earthquakes, respectively the earthquakes of the year 1662 and 1456.

Assessment of Seismic Hazard of Kosovo

Based on the maps of seismic hazards presented in fig. 4, according to maximal intensity with repetitious period 500 years and maximal acceleration (Fig. 5) for repetitious period 500 years

(Arsovski, 1985 modified by Elezaj & Kodra, 2008), it can be ascertained that Kosovo can be a land subject to considerable seismic hazards in the specified future foreseen according to Eurocode 8 for calculation of seismic constructions. The data of these maps are taken based on the calculation of resonance effects for territory of Kosovo (Mustafa, Hasi & Elezaj, 2006).

Resonance Effect of Seismic Waves in Objects

The powerful earthquake action is destructive, especially among those cities where the density of building is high. In the other side, the most existing buildings in Kosovo do not fulfil seismic conditions determined by the new technical data on the designing according to EUROCODE 8.

The basic aim of direct designing and execution of construction according to seismic conditions is the protection of people life, which it means that the building also before the most powerful earthquakes which are expected in the future, shall not be destroyed, but their damage can not be avoid. The special importance has the seismic security of buildings where there are emplaced the tools and devices important for the function of life.

Because of this, the seismic assessment of buildings is necessary, but also to the existing ones, in order to avoid the destructive effects of earthquakes such as in people also in the material goods. Hereupon, we will review below the bringing of constructions of buildings during the possible action of earthquake through resonance effect based on the probability of occurrence of earthquake in territory of Kosovo, for time period of repeat, 500 years (Arsovski, 1985 modified by Elezaj & Kodra 2008) (Figure 4). Relation between the maximal intensities and land acceleration is shown in Table 1 (Mustafa, Hasi & Elezaj, 2006).

Table 1.Relation between intensity and acceleration

SCALE (MSK-64)	ACCELERATION (m/s ²)
I	< 0.0025
II	(0.0025-0.005)
III	(0.005-0.010)
IV	(0.010-0.025)
V	(0.025-0.050)
VI	(0.050-0.10)
VII	(0.10-0.25)
VIII	(0.25-0.50)
IX	(0.50-1.00)

As it is seen in the table nr. 1, values of seismic coefficient for intensity VIII scale (MSK-64) are from 0.25 to 0.50, while for intensity IX scale (MSK-64) are from 0.50 to 1.00. The exact value of seismic coefficient depends on the three main factors: earthquake epicentre, topography of area and geological construction of land. Consequences are present in table 2 (Mustafa, Hasi & Elezaj, 2006).

Table 2. Critical belt of periods

T (s)	amax. (m/s ²)	A (m)	Resonance effect	Intensity (MSK-64)	Settlement
0.81	0.49 g	0.081	8(kate)	VIII	Prishtina, Prizreni, Peja,
1.6	0.25 g	0.16	16(kate)	VIII	Gjakova, Drenasi, Deçani, Mitrovica, Vushtrria, Skenderaj

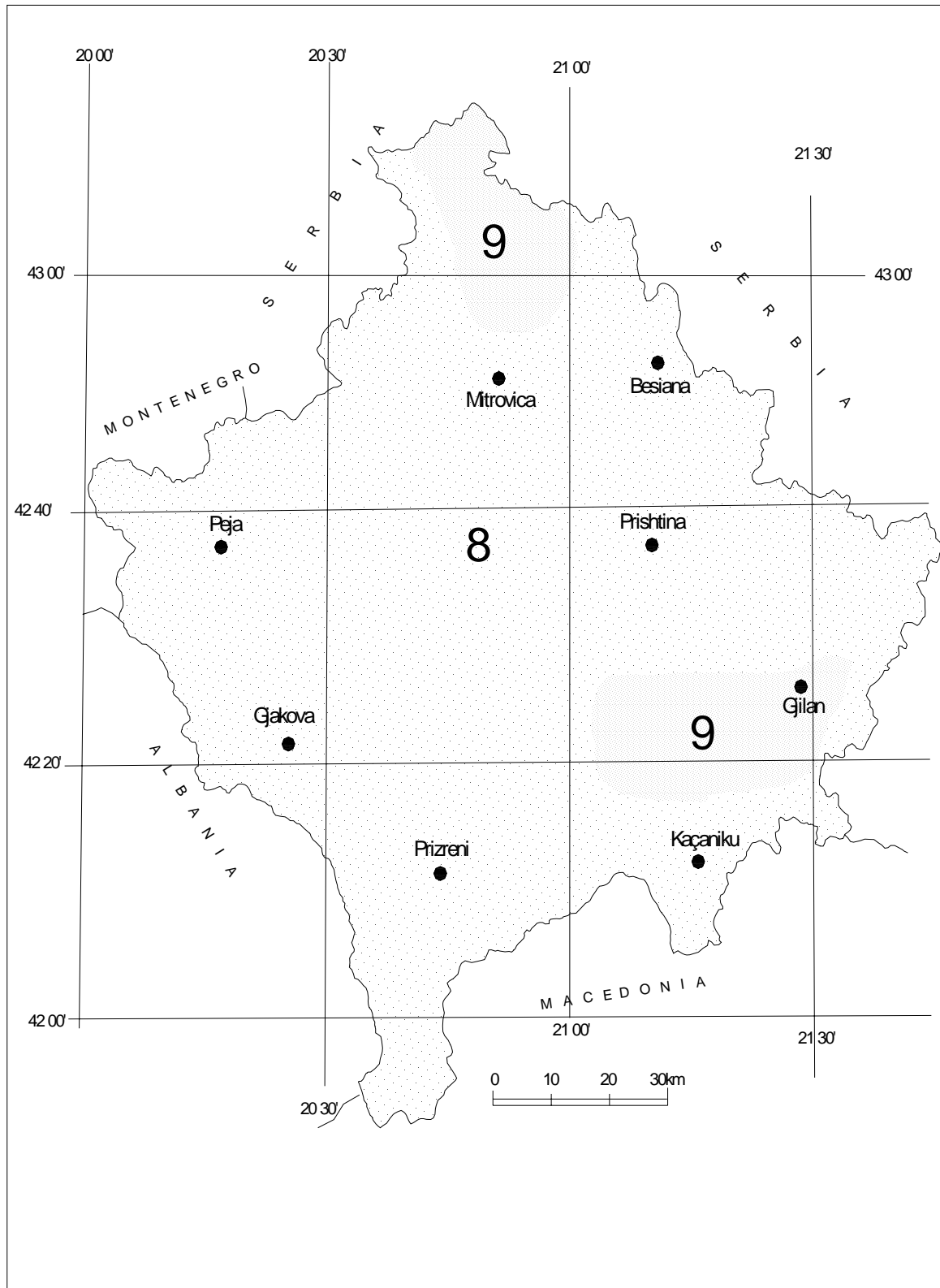


Figure 4. Hazard intensity map of Kosovo, for return period of 500 years

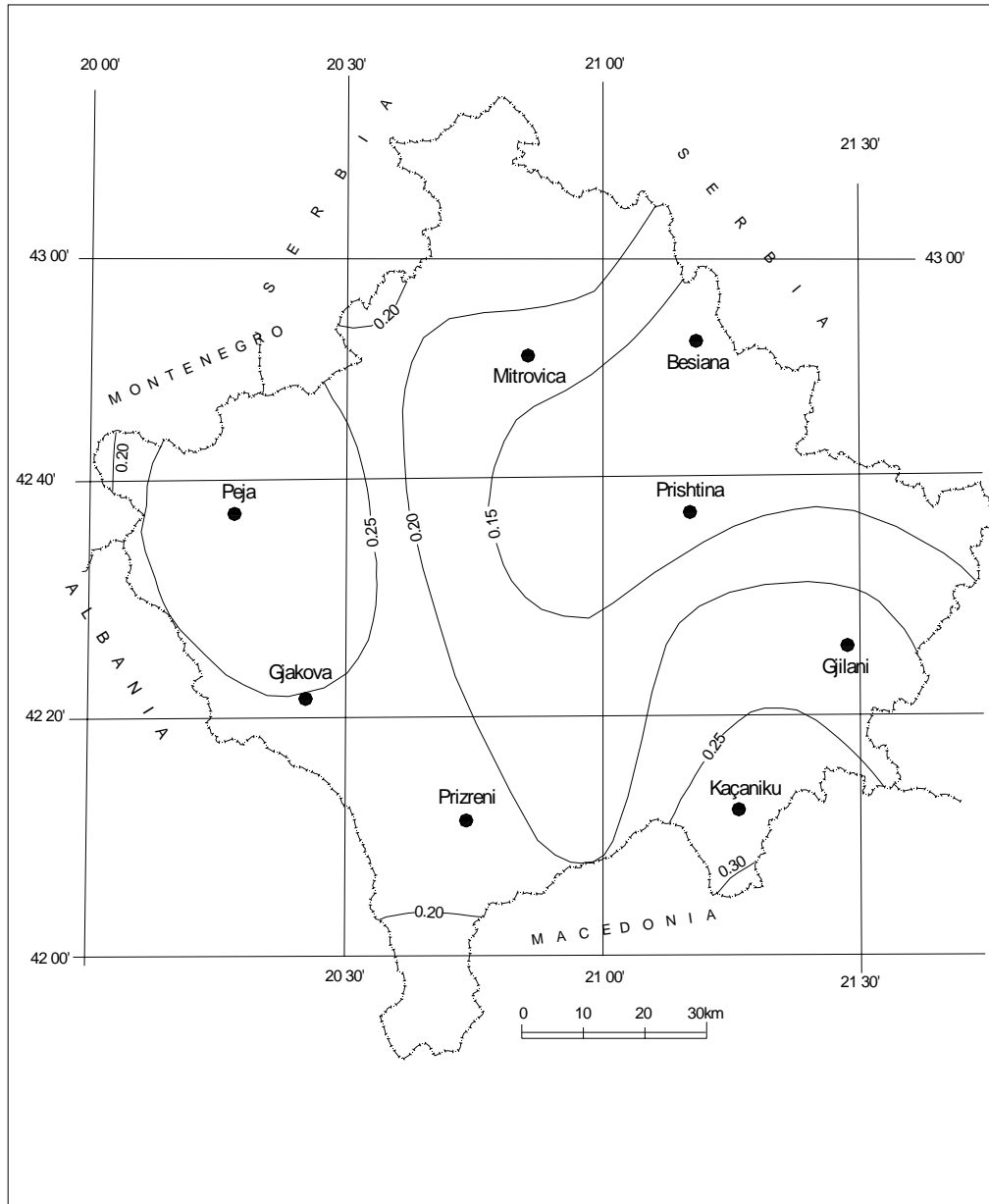


Figure 5. Seismic hazard acceleration map of Kosovo, for return period of 500 years

So, the critical belt is from 0.81s to 1.6s. With other words in the seismic zone with maximal intensity VIII scale MSK-64, there must be avoid the construction of object of 8 to 16 floors, respectively it is preferred the construction objects lower than 8 floors or higher than 16 floors in order to avoid the resonance effect.

Table 3. Critical belt of periods for Gjilani and Albaniku

T (s)	amax (m/s ²)	A (m)	Resonance effect	Intensity (MSK-64)	Settlement
0.4	1 g	0.04	4 (floors)	IX	Gjlani, Ferizaji, Vitia, Albaniku.
0.8	0.5 g	0.08	8 (floors)	IX	

From table no. 3 it is seen that in seismic zone IX scale MSK-64, the critical belt of periods are from 0.4s-0.8s, hereupon it is preferred that objects that will be constructed to be lower than 4 floors, respectively higher than 8 floors. If these preferences are applied in practice, then the possibility of destruction of buildings will be avoided as a consequence of resonance effect of earthquake. The phenomena of resonance can be occurred not only between land and structure of buildings, but also between seismic waves and land. In both cases the consequences are disastrous for the objects in the earth area in this context also it is great the lost of human life.

Conclusions

Geology of the territory of Kosovo is complicated, rocks from Precambrian to Quaternary and different tectonic structures are evident. It is fairly wealthy with profitable minerals, among the main profitable minerals we can mention Trepça Pb-Zn mines with world fame. In neotectonic structures of Kosova are distinguished:

(a) Morphostructures with tendency in upraise, presented by 13 blocks with horst shape, and ,

(b) Morphostructures with tendency in dip, represented by Basins with graben shape.

By seismic point of view, territory of Kosovo is among the most active countries of Europe, which is hit by very strong local earthquakes in the past with magnitude over 6.0 and epicentre intensity 8-9 scale.

Map of seismic hazard for the territory of Kosovo testifies that Kosovo represents a very active seismic zone with high seismic dangerousness, equally as in the neighbour countries with it. Because of this, it rises the necessity to dedicate a special care to this problem, in order that the prognosticated level of seismic hazard to be more reliable and taking into consideration also the acceptable economic level of damages of objects, in order that firstly to secure human lives, damages to be limited and structure with importance for the protection of population to be kept in work condition.

Base on the data presented, resonance phenomenon plays an important role to study in detail the conditions of Kosovo land and resonance effect.

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