4.8.1. SEISMOLOGIC INVESTIGATIONS

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At the territory of Serbia and Montenegro, intensive seismological investigations started after Skopje earthquake in 1963, particularly during periods of Montenegro (1979) and Kopaonik Mt. (1980) earthquake. Significant development in this exploration was made within international project "Study of seismic activity of Balkan peninsula" (UNDP/UNESCO, 1974).

In Serbia and Montenegro, intensities of earthquakes have been up to 9^0 MCS. By analysis of seismotectonic, geomagnetic, gravimetric and adequate seismic maps, the following units are distinguished (Fig. 4.8.1.1.):

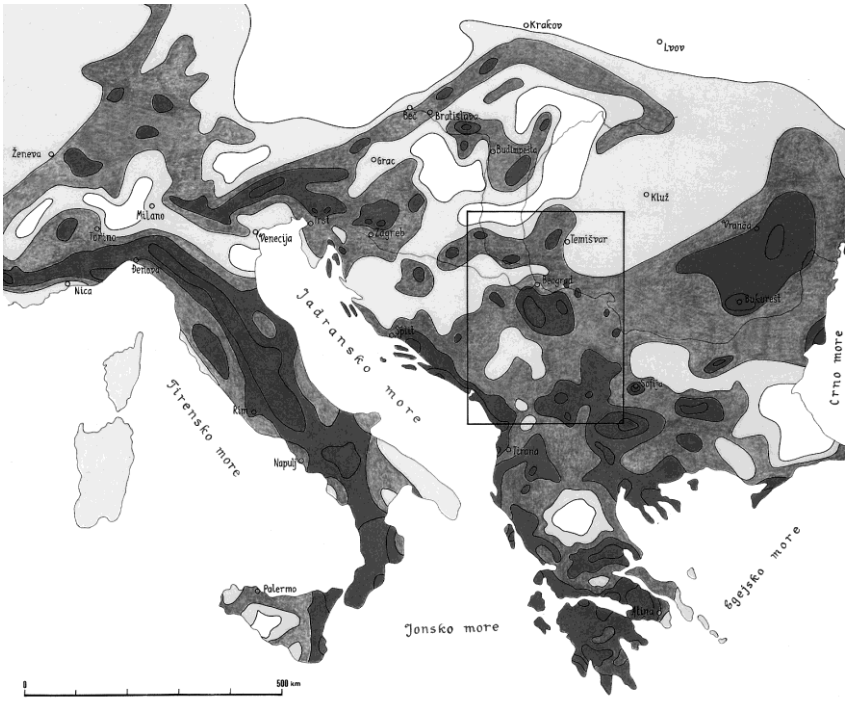

Fig. 4.8.1.1. Seismic map of Serbia and Montenegro. Earthquake intensities are given in MCS (Mercalli, Cancani, Sieberg) I-XII scale (Sikosek, 1994)

1. **The Adriatic coastal zone (8-9^0 MSK)**
2. **Vojvodina (Kanjiza, Becej, Novi Sad, Ruma) (8^0 MSK)**
3. **Western Serbia (Loznica, Krupanj, Bajina Basta) (8^0 MSK)**
4. **Central Serbia (Rudnik, Kopaonik, Kraljevo, Lazarevac, Arandjelovac) (8-9^0 MSK)**
5. **The Velika Morava river region (Svilajnac, Jagodina, Stalac) (8-9^0 MSK)**

6. **Eastern Serbia (Golubac, Negotin) (8^0 MSK)**
7. **Area between the rivers Nisava and S. Morava (Dimitrovgrad, Bosiljgrad, Nis, Vranje) (8-9^0 MSK)**
8. **Kosmet (Pec, Prizren, Urosevac, Lipljan, Pristina) (8-9^0 MSK).**

Earthquake intensity hazards in Serbia and Montenegro in respect to the percentage of the national territory, are the following: 6^0 MSK – 13%, 7^0 MSK – 59%, 8^0 MSK – 23%, 9^0 MSK – 5%, or about 87% of the territory of Serbia is vulnerable to destructive earthquakes, which calls for paraseismic codes and standards in the housing and building projects (Fig. 4.8.1.1.).

In order to evaluate harmful effects caused by recent geodynamic processes and occurrences for the period 1975-1997, data of Federal Bureau for statistics on financial resources spent from the side of Republic Serbia in order to reclaim damages are used:

a. Diagram of financial resources spent to repair damages caused by *earthquakes* is shown in Fig. 4.8.1.2a. Damages from 1983 of 198.40 million USD are partly related to Kopaonik Mt. earthquake. Value of 160.13 million USD, for 1980, is referring to duty of Serbia for Montenegro earthquake from 1979.

b. Damages caused by *land sliding* were highest in 1977 (23.93 million USD) and 1981 (23.35 million USD) (Fig. 4.8.1.2.(b)). It is known that total damages caused by landslides are much higher than presented values, particularly during periods of instability proceeding to the earthquake.

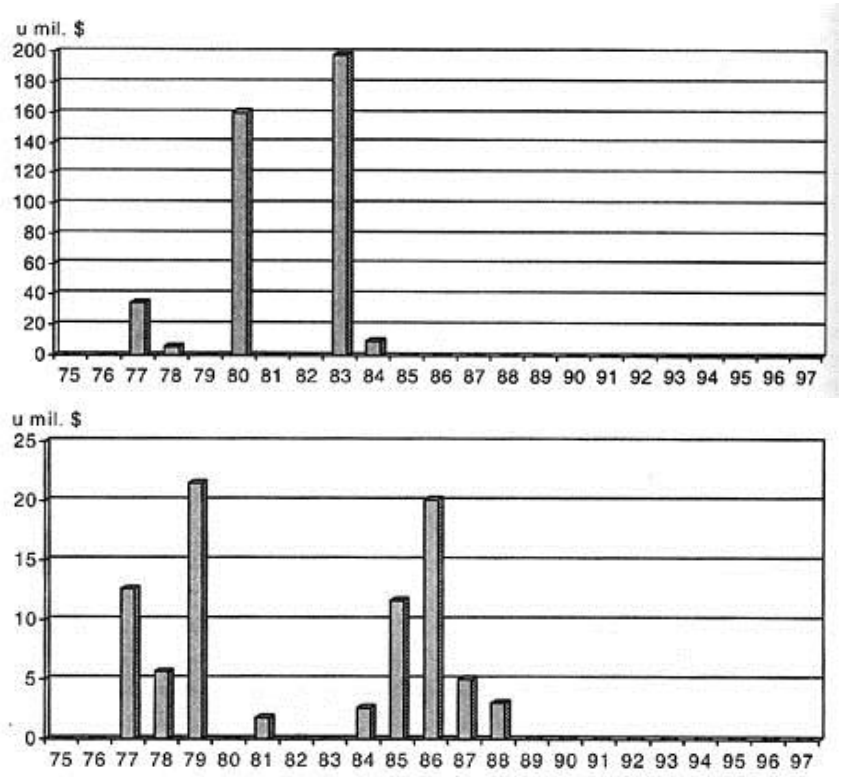

Fig. 4.8.1.2. Diagrams of values of damages caused during 1975-1997 by earthquakes (a) and landslides (b)

In Vojvodina and Posavina, layers of fine and silty sands are existent, related to *liquefaction* by appropriate seismic earthquake, being transformed into liquid stage (area of Novi Beograd and Sava amphitheater). In Serbia, occurrences in soil after strong earthquakes identical with liquefaction are distinguished in the Morava alluvial plain, along coastal parts of the Danube near Veliko Gradiste, etc.

The strongest earthquake at the territory of Montenegro in the last century ocurred on April 15, 1979. Magnitude was ML=7.0, with epicenter 15 km southern from Bar-Ulcinj coastal region. The coast was completely devastated (IX degree MCS), causing death casualties. During the earthquake, liquefaction process was expressed at several localities of Adriatic coast in Montenegro and Skadar lake coast, causing intensive damages (destroying the "Fjord" hotel in Kotor, etc.). Generally, that area is defined as vulnerable to liquefaction.

The similar seismo-hydrogeological effects (landslides, avalanches and liquefaction) occurred during the event that occurred 10 km eastern from Bar town in 1968, ML=5.8).

At the territory of Serbia and Montenegro, the highest *seismic activity* is characteristic of Dinaridic seismogenous block (Montenegro and SW Serbia), with over 70% events. At the area of the block, disastrous earthquake in 1979 is famous of numerous victims and outstanding damages, initiating detailed complex geological and seismological investigations. Similar case is with Kopaonik Mt. earthquake from 1983. It is interesting to note the trial to apply hydrogeoseismological method of earthquake prediction at the monitoring station, near epicentral zone at Kopaonik Mt. However, monitoring period 1985-1989 was period of seismic inactivity. Development of seismology in Serbia and Montenegro is with long and rich tradition, but new seismological map, as a basis for analysis of seismic hazard and risk is necessary.

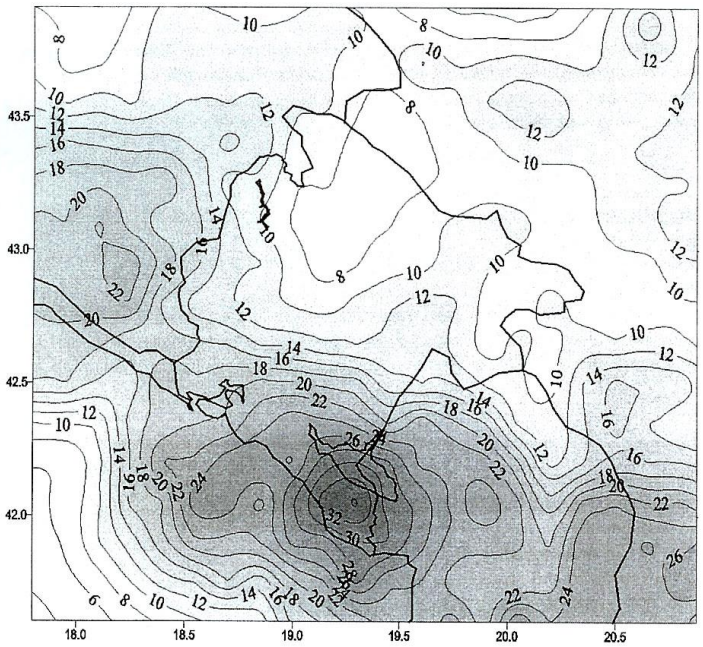

Fig. 4.8.1.3. Seismic hazard of Montenegro for the return period of 200 years with maximum horizontal acceleration (expressed in % of g) and the probability of occurrence 70% (Glavatovic, 2004)

During the period 1983-1986, seismic regionalization, as well as detailed microzonation of all urban environments of the territory of Montenegro, were carried out (Fig. 4.8.1.3.). The strong earthquakes caused by intensive tectonic processes, predominantly occurring in the coastal part of the territory, produce destructive effects in the form of landslides, avalanches and soil liquefaction (Glavatovic, 2004).

Because of high seismic hazard at the southern part of Montenegro, various measures including registration, assessment and categorization of all seismo-geological phenomena in the region, are planned. In order to perform disaster mitigation in the region of southern Montenegro and NW Albania, it is necessary to determine adequate kinematic model of the rigid frame of that region, using GPS monitoring of tectonic mobility.