4.8.2. SEISMOTECTONIC INVESTIGATIONS

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For tectonic earthquakes, which are typical for the territory of Serbia and Montenegro, the main sources of energy are tectonic stresses caused by the NW subduction of the African under the European plate (Fig. 4.8.2.1.). The Adriatic massif, as a promontory of Africa, is pushed between the Apennines and the Dinarides along collision-compression faults developed across the Adriatic coast. The stresses are transmitted to the hinterland from the subduction zone and the faults. In the nearest, primary compression zone (I), about 250km wide, foci occur of earthquake magnitudes from 7.5 to 6.5 and intensities from 9^0 to over 10^0 MSK. In the second (II) zone, at distances from 250 to 400 (460) km, earthquakes of magnitudes from 6.4 to 5.7 and intensities from 9^0 to 8^0 MSK are likely to occur at seismo-active faults. In the third (III) zone, the most distant one, earthquakes can have magnitudes up to 5.6 and intensities in epicenter to 8^0 MSK.

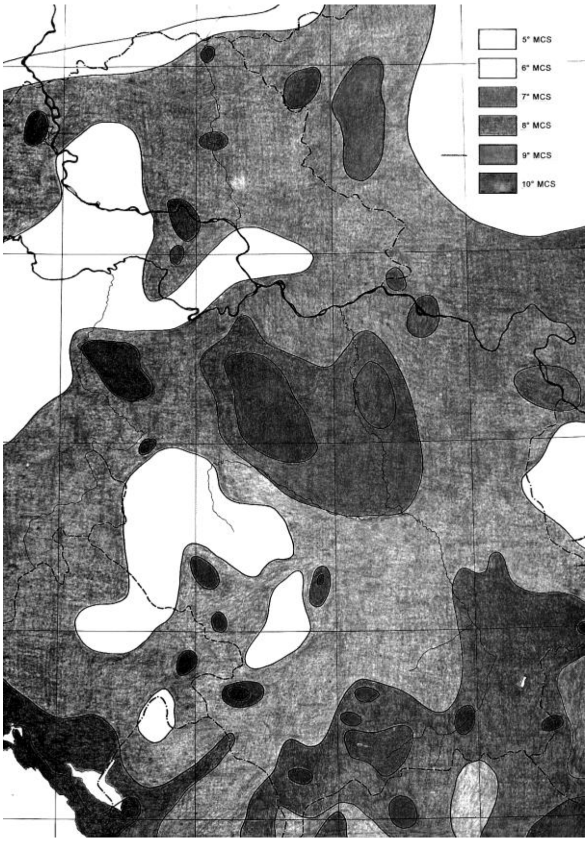

Fig. 4.8.2.1. Seismic map of Serbia and adjoining regions (Geological Atlas of Serbia, 1997)

Young (neotectonic) faults of this territory have general strike directions NW-SE, NE-SW, N-S and W-E, dividing it into blocks of different vertical movements and forming a network of seismogenic faults. Recent vertical movements of these blocks amount from -2 mm/yr to +6 mm/yr. The foci of past and future shocks are associated with the faults bounding on blocks. Seismogenic structures are mainly concentrated in the Adriatic coast or marginally on Neogene depressions, where vertical displacements vary between -1 mm/yr and +1 mm/yr.

There are 116 recognized seismogenic faults: 70% in the Dinarides and Vardar zone, 14% in Pannonian region and the Serbian-Macedonian massif, and 16% in the Carpatho-Balkanides. In the Table 4.8.3.1., capacities of the seismic energy in relation to the distance from the primary collision contact (I,II,III), the length (L, km), the maximum magnitude that can be generated (M), and respective intensity in epicenter (I_0). Numbers in the Table 4.8.3.1. correspond to the table are the same as those on the seismotectonic map (Fig. 4.8.2.2.).

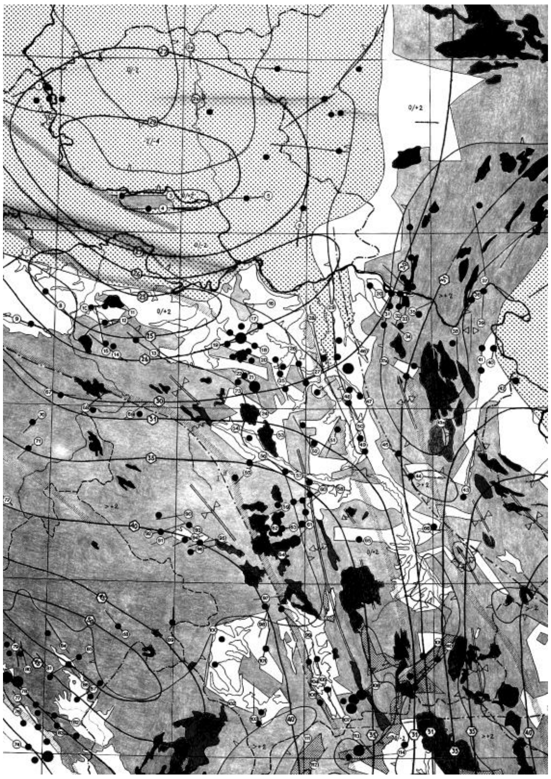

Fig. 4.8.2.2. Seismotectonic map of Serbia and adjacent regions (Geological Atlas of Serbia, 1997)

Table 4.8.3.1. Capacities of seismic energy of 116 recognized seismogenic faults in relation to the distance from the primary collision contact (I, II, III), the length (L, km), the maximum magnitude that can be generated (M) and respective intensity in epicentre (I_0).

No.	*Location*	*Zone*	*L (km)*	*M*	*I_0*
1	Beli Manastir	II	25	5.9	8.3
2a	Tisa – N. Knezevac	II	15	5.3	7.4
2b	Tisa – N. Becej	II	22	5.7	8.1
3	Fruska Gora N	II	25	5.9	8.3

4	**Fruska Gora S**	**II**	**25**	**5.9**	**8.3**
5	**Perlez**	**II**	**20**	**5.6**	**8.0**
6	**Alibunar**	**II**	**20**	**5.6**	**8.0**
7	**Tinja**	**II**	**30**	**6.1**	**8.7**
8	**Lopare**	**II**	**35**	**6.3**	**9.0**
9	**Spreca**	**II**	**30**	**6.1**	**8.7**
10	**Loznica**	**II**	**12**	**5.0**	**7.0**
11	**Tekeris**	**II**	**20**	**5.6**	**8.0**
12	**Jadar**	**II**	**8**	**4.5**	**6.0**
13	**Osecina**	**II**	**20**	**5.6**	**8.0**
14	**Krupanj**	**II**	**22**	**5.7**	**8.0**
15	**Jagodnja**	**II**	**15**	**5.3**	**7.4**
16	**Ralja**	**II**	**17**	**5.4**	**7.6**
17	**Kosmaj**	**II**	**12**	**5.0**	**7.0**
18	**Barosevac**	**II**	**17**	**5.4**	**7.6**
19	**Lazarevac**	**II**	**18**	**5.5**	**7.7**
20	**Bukulja**	**II**	**18**	**5.5**	**7.7**
21	**Belanovica**	**II**	**15**	**5.3**	**7.4**
22	**Vrbava – Ljuljaci**	**II**	**10**	**4.8**	**7.2**
23	**Takovo**	**II**	**10**	**4.8**	**7.2**
24	**Rudnik**	**II**	**23**	**5.8**	**8.2**
25	**Topola**	**II**	**20**	**5.6**	**8.0**
26	**Smed. Palanka**	**II**	**19**	**5.5**	**7.8**
27	**Raca**	**II**	**15**	**5.3**	**7.4**
28	**Velika Morava W**	**II**	**30**	**6.1**	**8.7**
29	**Velika Morava E**	**II**	**30**	**6.1**	**8.7**
30	**Tribrod**	**II**	**17.5**	**5.1**	**7.1**
31	**Golubac**	**III**	**20**	**5.3**	**7.4**
32	**Turija**	**III**	**17**	**5.0**	**7.0**
33	**Brnjica**	**III**	**17**	**5.0**	**7.0**
34	**Zvizd**	**III**	**10**	**4.5**	**6.2**
35	**Dobra**	**III**	**12**	**4.7**	**6.5**
36	**Dunav – Cerna**	**III**	**25**	**5.5**	**7.8**
37	**Sip**	**III**	**12**	**4.7**	**6.5**
37a	**Zagubica**	**III**	**10**	**4.5**	**6.2**
38	**Porecka reka**	**III**	**14**	**4.8**	**6.7**
39	**Miroc**	**III**	**18**	**5.1**	**7.1**
40	**Jabukovac**	**III**	**10**	**4.5**	**6.2**
41	**Timok – Salas**	**III**	**25**	**5.5**	**7.7**
42	**Negotin**	**III**	**17**	**5.0**	**7.0**
43	**Timok – Knjazevac**	**III**	**18**	**5.1**	**7.1**
43a	**Sumrakovac**	**III**	**18**	**5.1**	**7.1**
44	**Sokobanja**	**III**	**18**	**5.1**	**7.1**
45	**Cestobrodica**	**III**	**12**	**4.5**	**6.5**
46	**Mlava**	**II**	**17.5**	**5.1**	**7.1**
47	**Svilajnac – Sedlare**	**II**	**30**	**6.1**	**8.8**
48	**Velika Morava**	**II**	**25**	**5.9**	**8.3**
49	**Paracin**	**II**	**20**	**5.6**	**8.0**
50	**Juhor**	**II**	**20**	**5.6**	**8.0**
51	**Jagodina**	**II**	**17**	**5.4**	**7.6**

52	Gledici	II	18	5.5	7.7
53	Mrcajevci – Gruza E	II	10	4.8	7.2
54	Mrcajevci – Gruza W	II	12	5.0	7.0
55	Mataruska banja	II	15	5.3	7.4
56	Moravski rov –	II	12	5.0	7.3
57	Kraljevo	II	15	5.3	7.4
	Moravski rov–	II	17	5.4	7.6
58	Vrnjacka banja	II	15	5.3	7.4
59	Trstenik	II	18	5.5	7.7
	Zeljin Goc				
61	Ploce	II	22	5.7	8.1
62	Raska	II	18	5.5	7.7
63	Josanicka banja	II	18	5.5	7.7
64	Djerekare	II	30	6.1	8.7
65	Prokuplje	II	12	5.0	7.0
66	Nis	II	12	5.0	7.0
67	Han Pijesak	I	20	5.6	8.0
68	Osat	I	20	5.6	8.0
69	Bajina Basta	I	15	5.3	7.4
70	Podromanija	I	16	5.4	7.5
71	Praca	I	15	5.3	7.4
72	Treskavica	I	30	6.1	8.7
73	Bileca	I	25	5.9	8.3
74	Jadranski obod	I	85	7.4	10.5
75	Igalo	I	30	6.1	8.7
76	Bjela	I	32	6.2	8.8
77	Budva – Tivat	I	55	6.8	9.7
78	Kotor	I	35	6.3	9.0
79	Grahovo I	I	25	5.9	8.3
80	Grahovo II	I	15	5.3	7.4
81	Cevo	I	18	5.5	7.7
82	Virpazar	I	20	5.6	8.0
83	Sutorman	I	25	5.9	8.3
84	Niksic	I	18	5.5	7.7
85	Danilovgrad	I	25	5.9	8.3
86	Zeta	I	15	5.3	7.4
87	Podgorica	I	25	5.9	8.3
88	Kolasin	I	12	5.0	7.0
89	Berane	I	20	5.6	8.0
90	Zlatar	I	12	5.0	7.0
91	Jadovnik	I	8	4.5	6.2
92	Ursula	I	6	4.2	5.8
93	Stavlje	I	8	4.5	6.2
94	Sjenica	I	15	5.3	7.4
95	Vapa	I	8	4.5	6.2
96	Duga Poljana	I	18	5.5	7.7
97	Banjska	I	13	5.1	7.2
98	Zubin Potok	I	18	5.5	7.7
99	K. Mitrovica	I	10	4.8	6.7
100	Pec	I	25	5.9	8.3

101	**Dobro Polje**	**I**	**10**	**4.8**	**6.7**
102	**Djakovica**	**I**	**12**	**5.0**	**7.0**
103	**Drim**	**I**	**20**	**5.6**	**8.0**
104	**Kosovo Polje**	**I**	**25**	**5.9**	**8.3**
105	**Lipljan**	**I**	**20**	**5.6**	**8.0**
106	**Stimlje**	**I**	**20**	**5.6**	**8.0**
107	**Urosevac**	**I**	**25**	**5.9**	**8.3**
108	**Vitina**	**I**	**22**	**5.7**	**8.1**
109	**Vranjski rov NW**	**II**	**15**	**5.3**	**7.4**
110	**Vranjski rov SE**	**II**	**17**	**5.4**	**7.6**
111	**Rov Pologa W**	**I**	**20**	**5.6**	**8.0**
112	**Rov Pologa E**	**I**	**15**	**5.3**	**7.4**
113	**Skopska Crna Gora**	**I**	**18**	**5.5**	**7.7**
114	**Skoplje**	**I**	**30**	**6.1**	**8.7**

Seismotectonic map of Montenegro containing only main tectonic and neotectonic lineaments is presented in Fig. 4.8.2.3. The map was made on the basis of the data of seismogenic zone distribution during the last century, but also according to the focal mechanism solutions for strong earthquakes during the last 20 years. It is noticeable that NW-SE reversal faulting is predominant, while dominant stress vector is directed to NE with azimuth 35 degrees and with very small dipping angle of 15 degrees (Glavatovic, 2004).

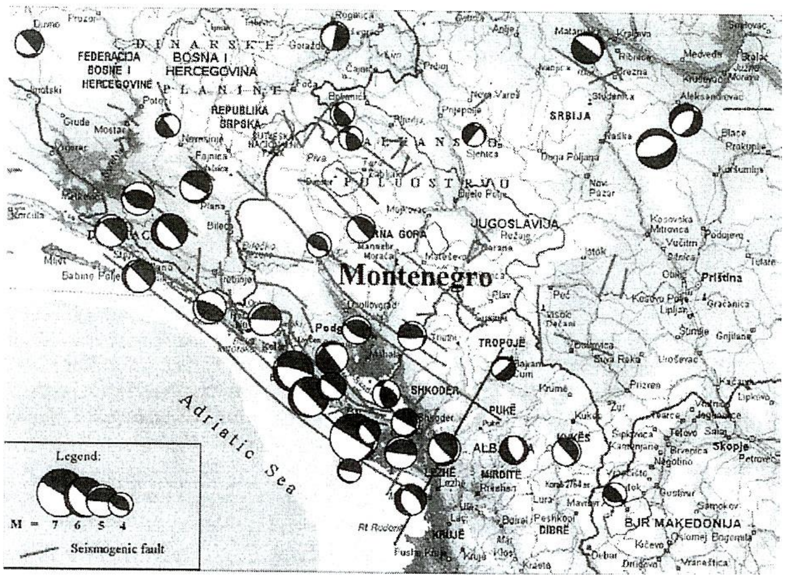

Fig. 4.8.2.3. Focal mechanism solutions for strong earthquakes occurred at southern Dinarides in the period 1979-2000 (Glavatovic, 2004)

Main part of the southern Dinarides, particularly the coastal belt, is almost totally covered by numerous seismic zones characterized by seismic potential of very different level. Predominant amount of seismic energy is dissipated in the continental part of Dinarides and near to the Adriatic coast, while central part of the Adriatic micro-plate (in the southern part of the sea) is practically aseismic. That seismic inactivity is explained by presence of very thick complex in the southern Adriatic (sediments

approach depth of 25 km), but also of rigid, relatively thick basalt plate in the deep part of the sea.

According to seismological analysis of earthquake data, as well as of reflection seismics data for oil exploration at the southern Dinarides and southern Adriatic, the whole thick sediment complex is under intensive tectonic activity. Tectonic processes are performed through dense net of faults and fault systems, mostly oriented in direction of Dinarides, and relatively gentle dipping toward the land. Dip of the fault plane usually increases in its shallower parts, where these structures have abrupt and have subvertical dip (Fig. 4.8.2.4.).

Neotectonic processes in the region of southern Dinarides, which are manifested by intensive seismic activity, are correlated with the parts of the Earth's crust, forming silicate rocks (so-called: granitic layer), but also much bellow the bottom boundary of sedimentary complex. Basalt layer in the deeper parts of the Earth's crust is seismically inactive. The hypocentral depth at the SE part of the line in Fig. 4.8.2.4. is greater then in the central and NW parts. The deepest seismoactive level is located along the line: northern Albania (above Skadar lake) – Podgorica – Danilovgrad – Golija Mt. and further to the northwest.

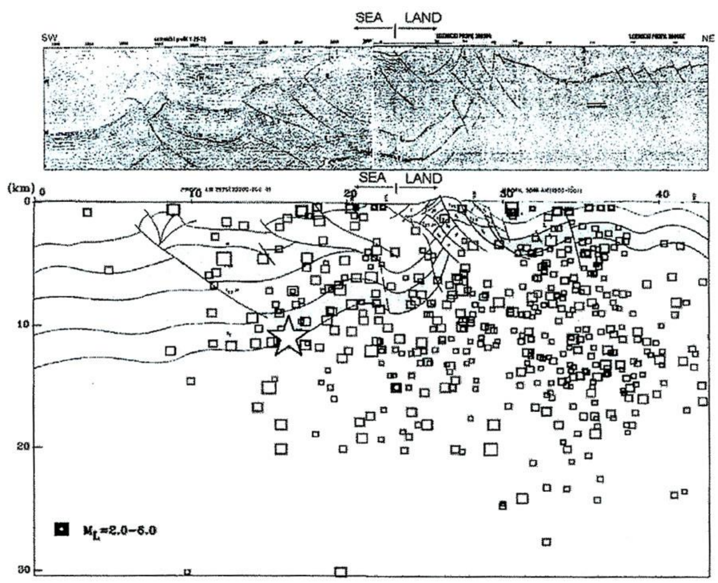

Fig. 4.8.2.4. The hypocentral line for strong earthquakes at the southern part of Montenegro coastal area (Petrovac town), with seismic line (upper part), the corresponding geological interpretation (Dragasevic, 1996) and the position of focus of the destructive April 15, 1979 earthquake (star) (Glavatovic, 2004).