PRELIMINARY DATA ON THE EVENTS RECORDED BY NOTSSI IN JANUARY – JUNE 2004

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Abstract. A map of the epicenters of 583 earthquakes that occurred in the Balkan Peninsula sector outlined by latitude $\varphi = 37^0$- 47^0N and longitude $\lambda = 19^0$-30^0E is presented. A generalized analysis of the seismicity over the territory of Bulgaria and its adjacent lands (with 330 localized events) is proposed.

Key words: Balkan Peninsula, Bulgaria, seismicity

The present scientific communication contains generalized information on the results of collection, processing and preliminary analysis of the initial data about the seismic events recorded by the National Operative Telemetric System for Seismological Information (NOTSSI) in the first half-year of 2004. The expanded information about the realized seismicity is suggested as a natural generalization and supplementation of the monthly publications of the preliminary seismological bulletin of NOTSSI. The analysis and evaluation of the space, time and energy distribution of the seismicity, periodically been made, open up possibilities for searching for time correlations with the parameters of different geophysical fields aiming to find out eventual precursor anomalies.

The recording and space localization of the seismic events in NOTSSI is realized by means of standard type seismographs S-13 "Teledyne Geotech" in 21 stations spread over the territory of Bulgaria (Christoskov et al., 1987). The routine processing and acquisition of the initial data is organized in a real time duty regime. The operations are fulfilled by the authors of this communication. In such a way the main goal of NOTSSI, namely the seismicity monitoring in order to help the authorities' and social reaction in case of earthquakes felt on the territory of the country, is realized.

The computing procedure for determining the parameters of the seismic events is an adaptation of the widespread product HYPO'71 (Solakov and Dobrev, 1987). The energy parameters of the events are presented mainly by the magnitude M calculated according to

the record's duration by the formula (Christoskov and Samardjieva, 1983)

$$M = 1.92 + 2.72\log\tau - 0.026\Delta$$

The high sensitivity of seismographs allows recording and processing of a great number of long distance earthquakes. As a result of the achieved experience in the authors interpretation work, different magnitude's lower threshold for successful determination of local, regional and long distance earthquakes is established: M=1.5 for the territory of Bulgaria, M=3.0 for the central part of the Balkans, M=5.0 for long distance events. The precision of the epicenter's determination is different; except on the distance it depends also on the specific position of the epicenter in relation to the recording network.

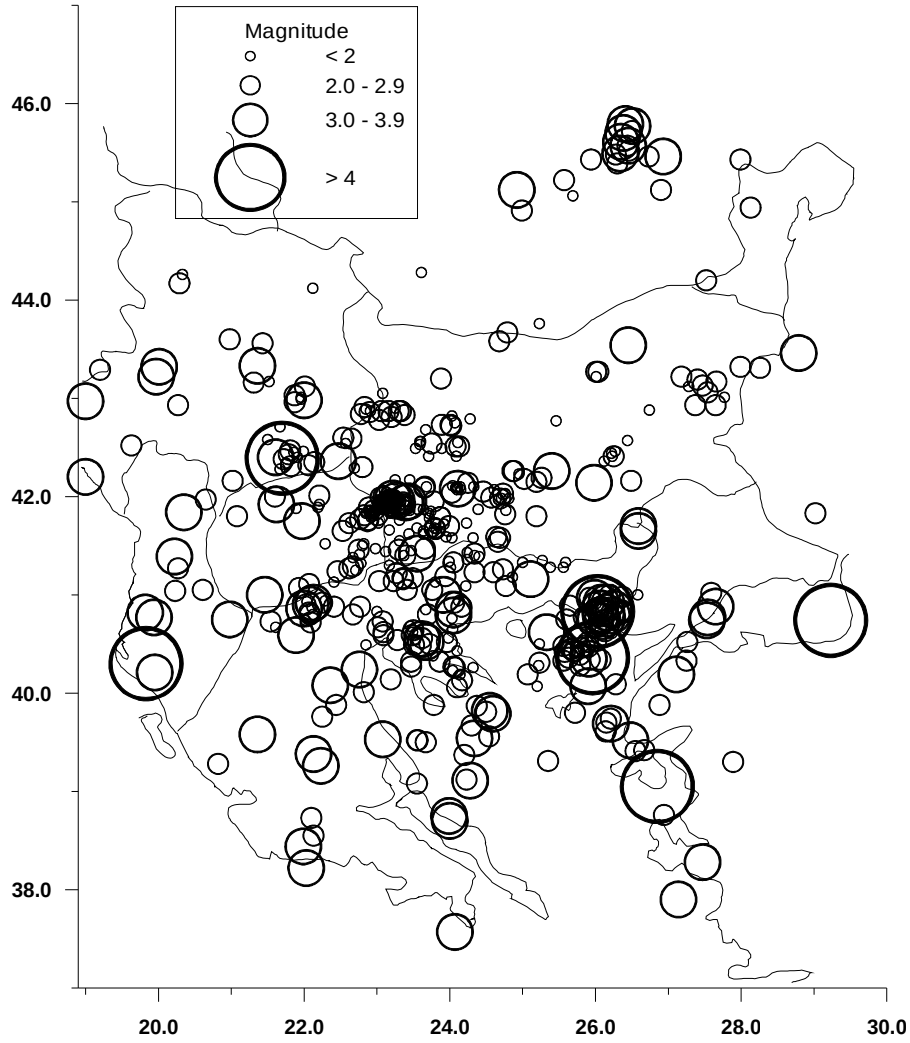

Fig.1. Map of epicenters in Central Balkans during January - June 2004.

The parameters of events occurring at a distance more than 100-150 km outside the territory of Bulgaria should be accepted only informatively and cannot be used for responsible seismotectonic investigation.

For the six-month period of observations presented in this communication, the primary data about more than 1000 local, regional, distant earthquakes and industrial explosions on the territory of Bulgaria are recorded, classified and processed (as a work bulletin) in NOTSSI. After comprehensive analysis of the records and application of the above mentioned calculation procedures it is established that 583 of all registered earthquakes are in the Balkan Peninsula region outlined by geographic latitude 37^0 - 47^0N and longitude 19^0 - 30^0 E. The epicenters of the earthquakes differentiated by magnitude levels are plotted in Fig.1. The number of the events in the magnitude interval M=1-1.9 is 239, in M=2-2.9 - 254, in M=3-3.9 - 84, in M=4-4.9 – 6 earthquakes.

As a whole, the seismic situation in the study part of the Balkans during the first half-year of 2004 is characterized by high activity as can be seen in Fig. 1 (583 events against 858 and 798 for the half-year periods of 2003). The strongest earthquakes outside Bulgaria are observed as follows: near the Aegean coast of western Turkey by Lesvos island (14 March, M=4), in South Albanian territory (7 April, magnitude nearly 5), in the Marmara Sea eastern region (16 May, M=4.1), in Vranya vicinity, Serbia (14 May, M=4). No one of these earthquakes caused visible excitation in Bulgaria. The greatest activity is registered in the NE Aegean Sea region where a magnitude 4.7 earthquake (15 June) was supervened by an earthquake swarm in the end of June (M max=4.2); some of these Aegean seismic events were slightly felt (maximum intensity III MSK) in the Kurdjali town district.

On the territory of Romania the earthquake activity is evident in the Vrancea region and the areas neighboring to the Eastern Carpathians. The earthquake magnitude there does not exceed 3.8. It is reasonably to mention that small earthquakes in the western part of Romanian territory are difficult to be localized by the national network.

The activity on the territory of continental Turkey is not high as in preceding intervals considered by these authors. Weak earthquakes prevail to occur along the Dardanelle strait, so as along the Aegean Turkish coast. Northern Greece is characterized by the well known high frequency of seismic events. The two or three earthquakes with a magnitude between 3 and 3.5 occurring there are not felt in Bulgaria. On lands in the west from Bulgaria, no more than 5 earthquakes are of a magnitude higher than 3 (maximum 3.6); all they are not felt in Bulgaria.

Fig.2 illustrates the seismicity just in the territory of Bulgaria and nearby lands (φ = 41^0 - 44.5^0N, λ = 22^0 - 29^0E). The earthquakes are shown differentiated by magnitude intervals. The seismic stations are also noted in the figure by triangles. The parameters of the relatively stronger earthquakes are presented in Table 1.

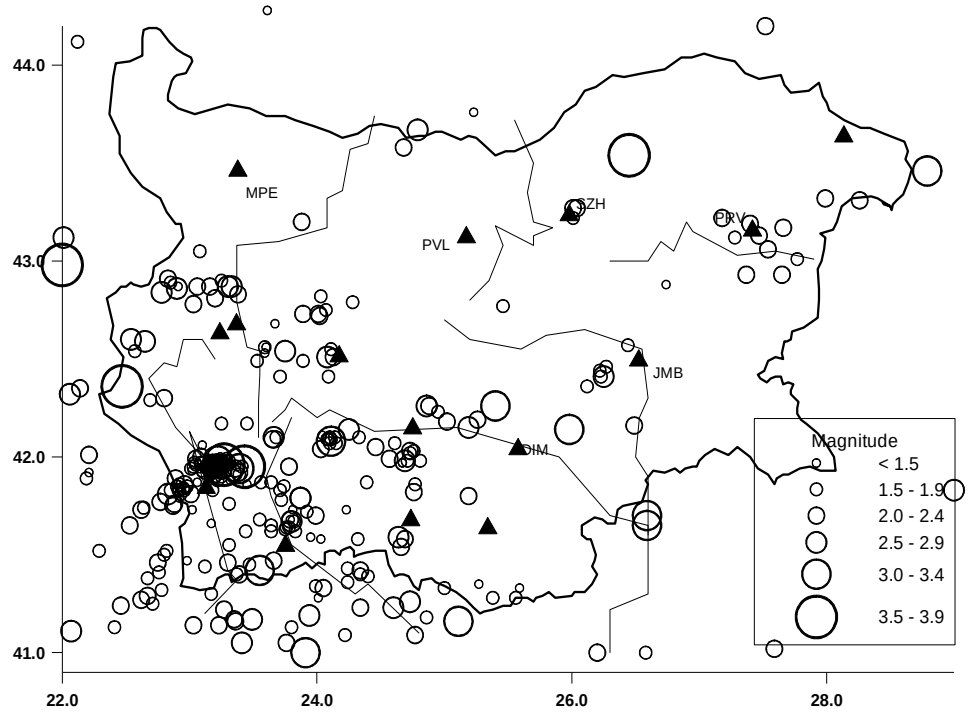

Fig.2. Map of epicenters in Bulgaria and adjacent lands during January - June 2004.

A relatively low activity of weak earthquakes is observed during these 6 months – 330 events against 494 and 430 for the two half-year periods of 2003. The earthquakes with a magnitude higher than M=3.0 are in normal amount - 16 events compared with the averaged number of about 10-15 for most of the all previous half-years. The maximal realized magnitude is M=3.9 so that the released energy quantity is much lower than in the previous half-year period (maximum magnitude 4.4).

As usually, the largest concentration of epicenters is marked in the southwestern part of the territory presented in Fig.2. To remember, many years ago the quantitative prevalence of the seismic activity in SW Bulgaria was evidenced for the period 1931-1970 (Grigorova and Glavtcheva, 1976). The highest activity (density of seismic manifestations) can be marked in the Kroupnik seismic source, as in the previous six months. Therein about 60 events with M<3.0 and 3 with M>3.0 occurred since the beginning of January until June inclusive. The strongest of them (on 27 June) is with a magnitude M=3.9 and is felt with maximum intensity of V MSK in the town of Razlog (Blagoevgrad district). At the same time, this is the strongest event in Bulgaria for the period under investigation. A little earlier (26 April), a magnitude 3.7 earthquake caused an impact of 4 degree MSK on Blagoevgrad city. The Kroupnik source is known with the strongest crustal earthquakes in Europe (M=7.8, 7.1) for the last 150 years (Christoskov and Grigorova, 1968).

The list of the strongest seismic events in the study period of time contains two more earthquakes. One of them (M=3.5), not felt, occurred on 12 June near Bosilegrad,

Bulgaria-Serbia border area. The second one (M=3.8, 14 May) occurred in close vicinity to the town of Razgrad, Loudogorie highland, and was felt as 5 MSK shock by its citizens.

More than 20 small seismic events (magnitude up to 2.5) specified the Sofia seismic zone. An unusual activation is to be underlined along the south flank of the Western Stara Planina Mnt. The Maritsa zone is a space of low activity in this period. Some small activation can be established in the contact area of Thracian Lowland and the Western Rhodoppi. For the sake of comparison with the previous half-year period when the M4.4 earthquake was felt with intensity VII according to the MSK scale, now the Provadia zone demonstrates scarce activity.

Table 1. List of the earthquakes with M > 2.5 in Bulgaria and adjacent lands during January - June 2004

Date	Time	Coordinates	H	M
20040103	17:15: 4	41.17 23.49	17	2.8
20040104	19: 2:59	42.84 22.78	1	2.5
20040104	19:21:48	42.86 22.90	10	2.6
20040107	8:31:21	41.79 23.87	2	2.6
20040120	7:23:34	41.26 24.73	2	2.7
20040123	13:20:38	42.54 23.75	9	2.5
20040123	23: 1:42	41.00 23.91	10	3.0
20040129	12:53:15	41.19 23.94	9	2.5
20040206	1:37: 4	42.10 23.66	2	2.5
20040208	20:49:36	41.59 24.64	7	2.8
20040213	18:54:50	42.26 25.40	9	3.0
20040215	1: 1:21	43.67 24.79	16	2.5
20040217	2: 4:18	43.12 22.01	2	2.5
20040229	22:48:36	41.96 23.22	2	2.5
20040301	18:36:42	42.51 24.08	20	2.5
20040312	1: 4:44	41.81 22.83	12	2.7
20040319	19:13:26	41.11 22.07	10	2.5
20040320	20:22:40	42.59 22.65	1	2.7
20040320	23:15:17	42.60 22.54	4	2.6
20040329	12:23:47	42.26 24.86	8	2.5
20040409	14:27:50	42.98 22.00	5	3.6
20040421	1:56:53	41.05 23.41	6	2.5
20040421	5:35:23	42.15 25.19	5	2.7
20040421	11:37:17	42.87 23.33	3	2.5
20040422	0:13: 4	42.32 22.06	2	2.6
20040426	2:10:46	42.14 25.98	15	3.1
20040426	11:58:11	41.98 23.22	5	3.1
20040426	12: 0:22	41.94 23.25	2	2.9
20040426	13:22:21	41.96 23.27	8	3.7
20040430	3: 4:42	41.23 24.60	14	2.9
20040503	11:59:39	42.87 23.30	8	2.6

20040505	3:44:10	41.65 26.59	14	3.0
20040505	3:44:11	41.70 26.59	16	3.0
20040510	3:17:40	42.08 24.11	8	3.4
20040514	11: 9:35	43.54 26.45	3	3.8
20040519	23: 2: 4	41.98 24.69	10	2.6
20040524	13:27:31	42.41 26.25	12	2.8
20040607	5:53: 2	43.46 28.79	5	3.0
20040609	14: 7:11	41.16 25.11	8	3.2
20040610	12:45:38	41.42 23.55	11	3.3
20040612	0:10:33	42.36 22.47	20	3.5
20040616	4:34:56	42.14 24.25	4	2.7
20040624	13:29:12	41.83 29.00	14	2.5
20040627	4:25:28	41.67 23.80	20	2.6
20040627	11:54: 8	41.95 23.43	9	3.9
20040627	12: 6:58	41.94 23.39	15	3.2

A detailed analysis of seismicity in the individual seismic zones is hard to be fulfilled because of the insufficient quantity of events and the narrow magnitude range of the earthquakes. The joint statistics of all the events in Fig.2 characterize predominantly the seismicity parameters of the southwestern part of the territory under investigation.

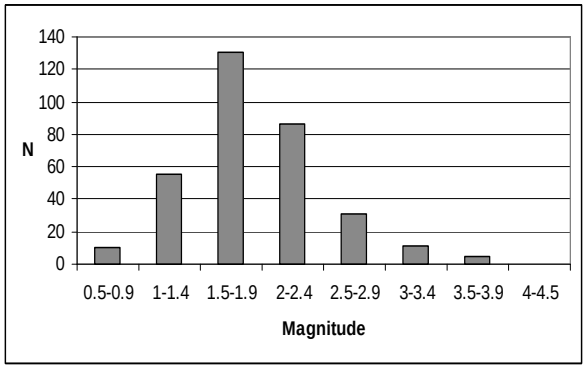

Fig.3. Magnitude - frequency distribution of the earthquakes

The magnitude-frequency distribution for the entire data set is presented in Fig.3. The number of localized events increases with the magnitude decreasing: for M > 3.5 the number of events is 5, for M=3.0-3.4 it is 11, for M=2.5-2.9 - 31, for M=2.0-2.4 - 86 and so on. The abrupt diminishing of the number of earthquakes in the first two intervals (M<1.5) in Fig.3 determines also the registration power of the seismic stations network. Taking the latter into account, it can be supposed that the magnitude sample for levels with M > 1.5 is comparatively closer to the reality for the bigger part of the Bulgarian territory.

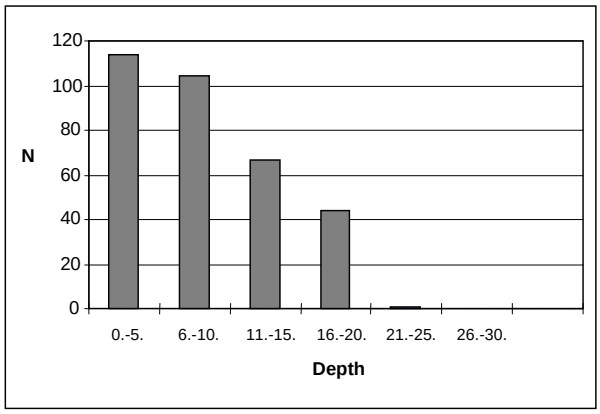

Fig.4. Depth - frequency distribution of the earthquakes

The picture of the depth distribution in Fig.4 shows that almost all earthquakes occur down to 20 km depth. The layers in the above 10 km, however, generate the predominant part of events. It is not to be excluded among the superficial events some unidentified industrial explosions to have been kept.

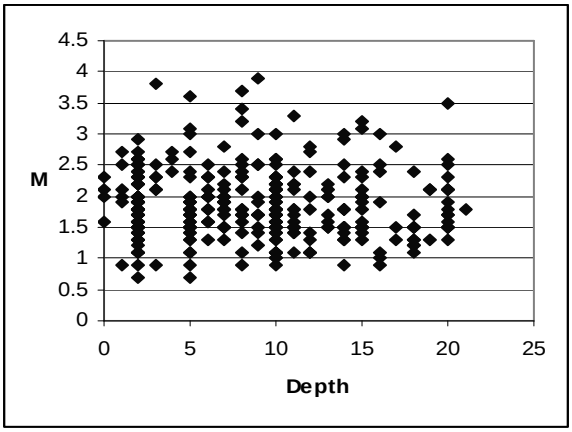

Fig.5. Magnitude - depth dependence

The magnitude distribution of the events in depth (Fig.5) does not permit any categorical differentiation of depth "floors" with the increase of magnitude - some tendency can be traced out for the formation of a very broad band maximum in the depth interval 3 - 9 km.

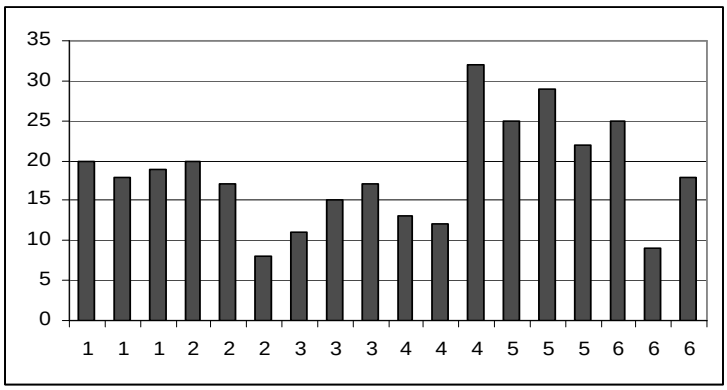

Fig.6. Time distribution of the earthquakes during January - June 2004.

Figure 6 illustrates the distribution of seismicity in time according to the number of events per decade. The biggest earthquake's amount is displayed in the second half of the period – starting from the last decade of April till the first decade of June inclusive. The lowest earthquake quantity is in the last decade of February – 8 events only.

Figure 7 shows the energy release in time through the earthquake magnitude time distribution. Obviously, the energy released during the second half of the study period is considerably more than before.

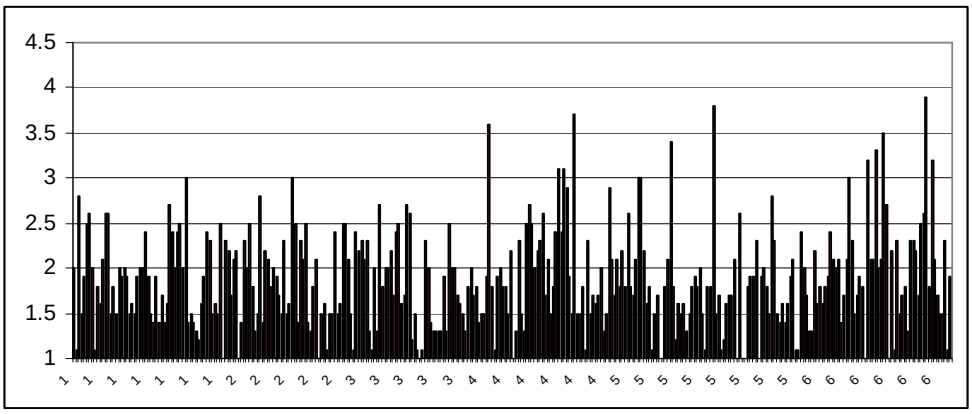

Fig.7. Magnitude-time distribution of the earthquakes during January - June 2004

Additionally, about 170 distant earthquakes have been recorded in the period investigated period, as well as more than 80 industrial explosions, processed and classified in the preliminary monthly bulletins. In order to identify the artificial seismic sources the methodical approach described by Deneva et al. (1988) and some information about the quarry sites in Bulgaria have been used.

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Предварителни данни за сеизмичните събития регистрирани от НОТССИ през януари - юни 2004

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Резюме. Предлаганото научно съобщение съдържа обобщена информация на резултатите от събирането, обработката и предварителния анализ на първичните данни за сеизмичните събития регистрирани от Националната оперативна телеметрична система за сеизмологична информация (НОТССИ) за първото полугодие на 2004 г. Представена е карта на епицентрите на общо 583 земетресения в частта от Балканския полуостров, ограничена от географска ширина 37^0 - 47^0 N и дължина 19^0 - 30^0 E. По-подробно се анализира сеизмичността за територията на България и прилежащите й земи (330 сеизмични събития в район с координати $\varphi = 41^0$ - 44.5^0N, $\lambda = 22^0$ - 29^0E).