DATA AND ANALYSIS OF THE EVENTS RECORDED BY NOTSSI IN 2007

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Abstract. A map of epicenters of 1152 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. Expert generalized analysis of the seismicity over the territory of Bulgaria and its very adjacent lands (with more than 620 localized events) is proposed. Catalog of earthquakes with magnitude M>2.5 is applied.

Key words: Balkan Peninsula, Bulgaria, seismicity

The present scientific communication contains generalized information on the results of collection, processing and analysis of the data about the seismic events recorded by the National Operative Telemetric System for Seismological Information (NOTSSI) in 2007. The expanded information about the realized seismicity is suggested as a natural generalization and supplementation of the monthly compilations 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 during 2007 is realized by means of the new digital network (Solakov et al., 2005). 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 , 1993). 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 focal mechanism parameters are obtained by means of a program FOCMEC (Snoke,2009). The high sensitivity of the 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. The parameters of seismic 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.

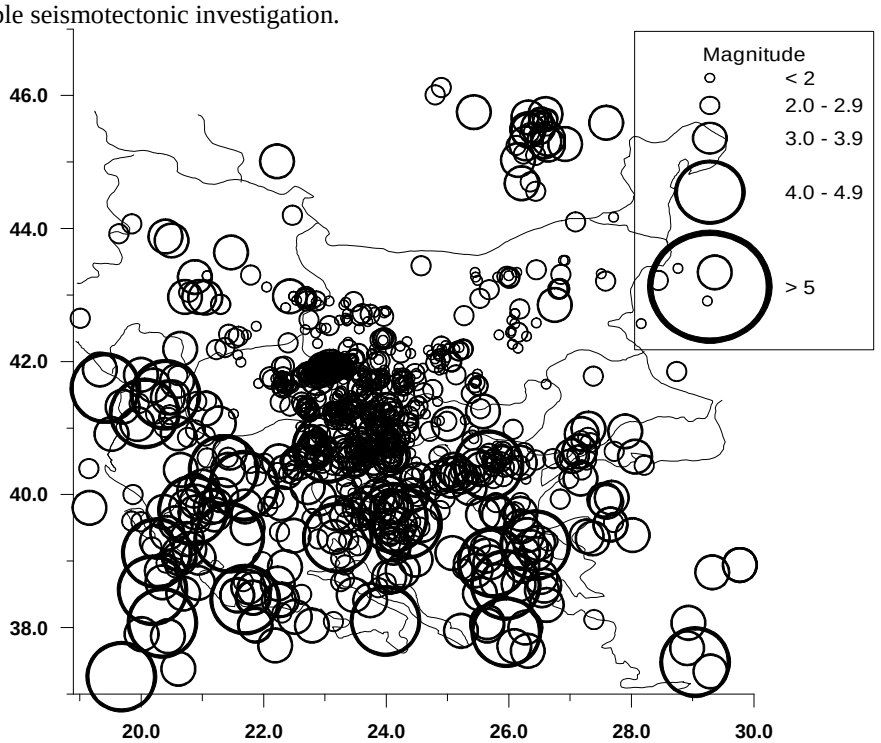

Fig.1. Map of epicenters in Central Balkans during 2007.

For the period of observations presented in this communication, the primary data about 2000 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 1152 of all registered earthquakes are in the Balkan Peninsula region outlined by geographic latitude 37^0 - 47^0 N and longitude 19^0 - 30^0 E. The epicenters of the earthquakes differentiated by magnitude levels are plotted on Fig.1. The

number of the events in the magnitude interval M=1-1.9 is 477, in M=2-2.9 - 451, in M=3-3.9 - 200, in M=4-4.9 – 23 earthquakes.

As a whole, the seismic situation in the study part of the Balkans during 2007 is characterized by relatively low activity (1152 events against 1424 in 2006 and around 1100- 1300 for most of the previous years). It can be noted that the observed tendency of relative decrease in the activity compared with the former years is partly due to the low level of earthquake activation in Bulgaria, Romania and Marmara Sea.

The strongest event outside Bulgaria during the study period occurred in the Macedonia/Albania boarder region on 16th April 2007 with magnitude M=4.9. According to the Euro-Mediterranean Seismological Centre, the earthquake magnitude was determined between 4.6 and 5.5, nevertheless it was not felt on the territory of Bulgaria. Out of the earthquakes caused by sources situated in the neighboring territories only two were felt. Their origins were in Aegean Sea and the source energy was assessed by magnitudes a bit greater than 4. Their influence was very slight, with intensity up to III degree EMS.

As a whole, events with M<3.0 which occur outside Bulgaria are difficult to be localized by the national seismological system; consequently, not all of them have been marked on the scheme in Fig.1.

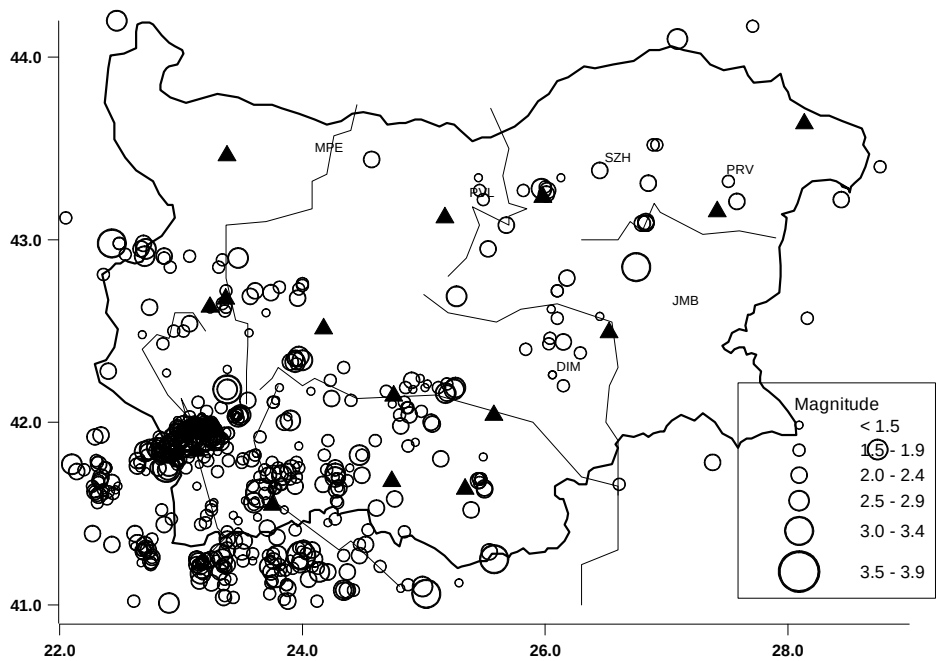

Fig.2. Map of epicentres in Bulgaria and adjacent lands during 2007

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

Table 1. List of earthquakes with M ≥ 2.5 in Bulgaria and adjacent lands during 2007

Date	Time	Coordinates	H,km	M	Imax
20070114	23:04:52	42.95 22.71	5	2.5	
20070123	06:59:40	41.74 22.89	20	2.5	
20070123	07:32:47	41.76 22.90	20	2.6	
20070130	19:16:54	41.96 23.18	15	2.5	
20070131	08:00:27	42.01 23.90	2	2.8	IV
20070216	23:16:45	41.18 24.14	10	2.7	
20070219	01:26:13	41.86 22.80	15	2.6	
20070219	21:34:02	41.06 25.02	1	3.0	
20070219	21:34:04	41.10 24.99	10	2.9	
20070221	14:13:39	42.33 23.94	18	2.5	II-III
20070308	09:47:09	41.27 23.79	20	2.6	
20070310	14:58:05	41.01 22.90	11	2.5	
20070312	01:48:27	41.85 28.74	13	2.5	
20070317	00:59:49	41.15 23.78	9	2.9	
20070317	22:37:07	43.28 25.97	12	2.6	III
20070326	02:42:31	41.84 22.93	20	2.6	
20070407	20:41:30	41.96 23.21	9	2.5	
20070410	03:15:50	41.25 25.58	10	3.0	IV
20070415	15:37:45	42.16 25.18	7	2.5	
20070420	21:33:19	42.91 22.70	2	2.5	
20070425	21:03:01	41.85 22.74	20	2.5	
20070428	00:01:40	41.70 24.27	16	2.8	
20070428	00:49:20	41.72 24.27	20	2.7	
20070429	15:43:30	42.34 24.00	20	2.5	
20070505	21:27:41	41.98 23.02	2	2.8	
20070506	21:36:12	42.03 23.47	12	2.9	
20070510	11:51:55	42.19 25.26	5	2.5	
20070510	11:51:55	42.18 25.25	7	2.7	IV
20070512	13:45:52	42.85 26.75	15	3.2	III-IV
20070515	13:09:06	41.98 23.20	9	2.7	IV
20070517	05:50:12	42.04 23.49	20	2.6	II-III
20070517	21:52:04	41.21 23.73	20	2.5	
20070518	16:16:31	44.20 22.47	20	2.5	
20070619	22:24:47	41.77 22.10	20	2.5	
20070628	12:57:45	42.18 23.38	7	2.9	IV-V
20070715	04:57:30	41.27 23.99	16	3.2	
20070727	23:24:34	41.97 23.10	18	2.7	III
20070729	10:13:00	41.20 23.17	7	2.7	
20070731	17:43:21	42.90 23.47	8	2.5	
20070803	06:39:06	41.82 24.47	18	2.7	
20070803	19:32:40	41.61 23.65	7	3.4	IV-V
20070804	02:56:23	41.56 23.60	11	2.5	
20070811	06:25:08	41.25 23.34	7	2.6	
20070818	10:32:03	41.75 22.88	20	3.1	
20070821	22:49:37	41.88 22.91	3	2.5	

Date	Time	Coordinates	H,km	M	Imax
20070904	13:13:58	41.08 24.34	20	2.5	
20070905	08:18:45	42.36 23.97	15	2.5	
20070914	13:13:02	41.28 23.32	10	2.5	
20070914	19:58:17	41.92 23.08	8	3.3	IV-V
20070915	14:40:35	41.88 22.98	20	3.1	III
20070926	07:15:56	41.84 22.70	7	2.7	
20070926	11:47:01	41.85 22.88	20	2.9	
20071004	23:47:40	42.98 22.43	8	3.1	
20071014	14:43:42	44.10 27.09	15	2.6	
20071017	04:49:33	41.90 23.21	16	2.7	III
20071026	17:25:35	42.69 25.27	20	2.5	II
20071113	09:37:27	41.17 23.16	5	2.7	
20071121	20:27:50	41.71 23.83	10	2.6	
20071211	17:15:15	42.11 25.16	9	3.1	IV-V

On the territory of Bulgaria a relatively low degree of activity of weak earthquakes is observed during 2007 - 623 events against 818 in 2007 and 600-700 for most of the previous years. The earthquakes of a magnitude higher than 3.0 are in a lower amount - 9 events compared with the averaged number of about 20-30 for most of the all previous years (and 31 for 2006). The maximum realized magnitude M=3.4 is lower too than the maximum magnitude in the course of previous years; its usual value used to be about 4.0 and more.

As usually, the largest concentration of epicenters is marked in the southwestern part of the territory presented in Fig.2. The Kroupnik seismic source, known with the strongest crustal earthquakes in Europe (M=7.8, 7.1) for the last 160 years (Christoskov and Grigorova, 1968). In 2007 about 50 events of M<3.0 and only two of M≥3.0 occurred in this region. The 14 September event with M=3.3 is felt on Blagoevgrad region by intensity of IV-V EMS. The strongest earthquake for the all Bulgarian territory is with magnitude M=3.4, it is felt in Gotce Delchev region (eastern slopes of Pirin mountain) by intensity of IV-V EMS.

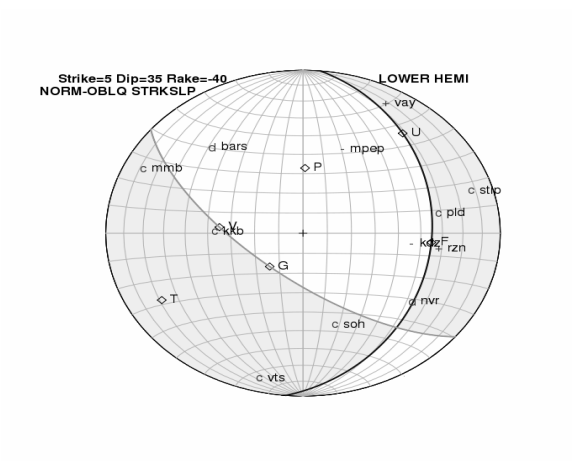

Fig.3. Focal plane solution of the stronger Kroupnik earthquake (14.09.2007)

The Bulgarian seismic sources in 2007 were much more inactive than during the previous year. They produced less than 20 earthquakes affecting different localities in this country by intensity of up to IV-V degrees EMS. Eight cases of magnitudes between 2.7 and 3.4 aroused shocks of intensity four or a bit more: 6 of them originated in South-Western territories and two only in Maritsa seismic zone. In the rest part of the 2007 felt events caused excitation of lesser intensity. The prevailing number of them was caused by small dislocations in Rila-Rhodopean Region; two of them showed a certain seismic activity in the Central and Eastern part of the Balkan Mountain. In comparison with the year 2006, a small earthquake (M 2.6) reminded of activity in the Gorna Oryakhovitsa zone in March 2007.

For the determination of the earthquake mechanism is used program FOCMEC. Input are polarities of the P wave. In the double - couple focal mechanism are included 12 first motion polarities data from seismological stations in Bulgaria and surrounding area taken from NOTSSI and ISC database (ftp://www.orfeus-eu.org/pub/data/continuous/2006/) - Fig.3. The solution is displayed on lower hemisphere. The polarities from ISC (BARS, STIP, NVR) are not check as waveform. The polarities from seismological stations KDZ, RZN, MPE and VAY are very poor and the solution is with poor quality. The fault plane solutions of the rest events are with very bad quality because of a low number of polarities.

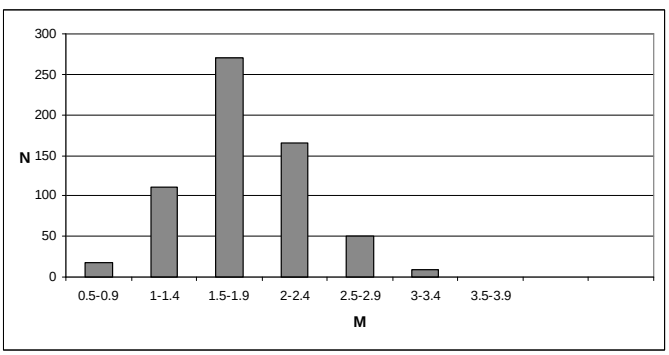

Fig.4. Magnitude - frequency distribution of the earthquakes

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.

The magnitude-frequency distribution for the entire data set is presented in Fig.4. The number of localized events increases with the magnitude decreasing: for M=3.5-3.9 is 0 events for M=3.0-3.4 is 5 events, for M=2.5-2.9 - 50, for M=2.0-2.4 - 165 and so on. The abrupt diminishing of the number of earthquakes in the first two intervals (M<1.5) in Fig.4 determines also the registration power of the seismic stations network.

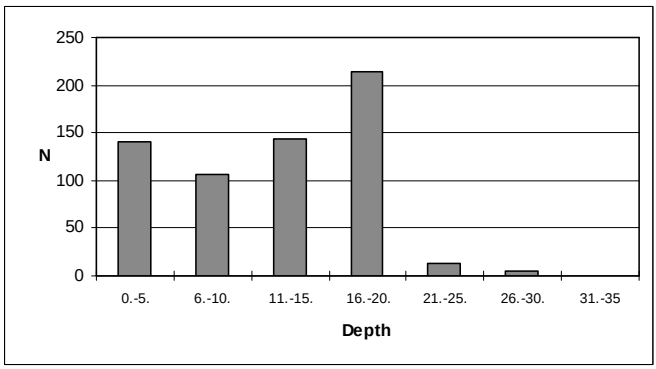

Fig.5. Depth - frequency distribution of the earthquakes

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.

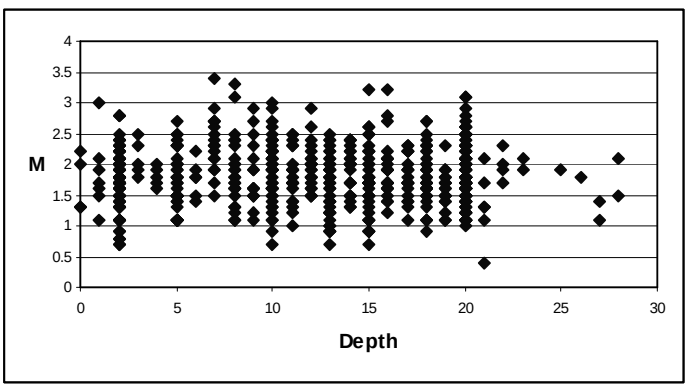

Fig.6. Magnitude - depth dependence

The picture of the depth distribution in Fig.5 shows that the majority of events occur down to 20 km depth. It is possible the established predominating depth (from 0 to 5 km) to be also due to the presence of unidentified industrial explosions. In the same time the number of events in the interval 15-20 km is bigger. The magnitude distribution of the events in depth (Fig.6) don't permits to note some differentiation of depth "floors" with the increase of magnitude - the maximums can be traced out for all of the depth interval from 2 to 20 km.

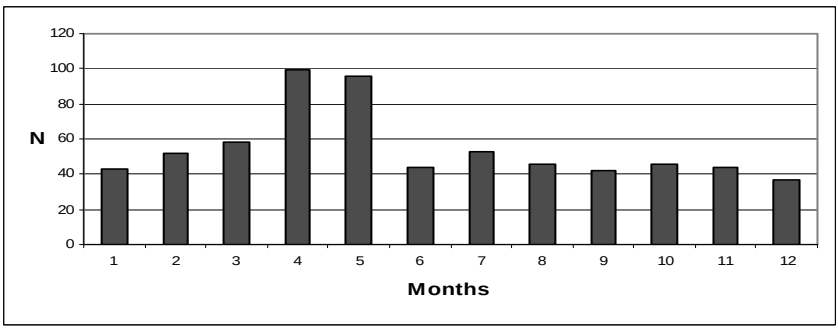

Fig.7. Time distribution of the earthquakes.

Fig.7 illustrates the distribution of seismicity in time according to the number of events per months. The biggest earthquake's amount is displayed in April, when about 100 earthquakes occurred, the similar situation in May is observed- 96 events. The lowest earthquake quantity is in December, 37 events. The energy release suggests that in August, when only 46 events occurred, is the month with maximum of energy release. Some other strongest events occurred in September and December.

Additionally, about 700 distant earthquakes have been recorded in the period under study, as well as more than 400 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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Данни и анализ на сеизмичните събития регистрирани от НОТССИ през 2007

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Резюме. Предлаганото научно съобщение съдържа обобщена информация за резултатите от събирането, обработката и анализа на първичните данни за сеизмичните събития, регистрирани от Националната Оперативна Телеметрична Система за Сеизмологична Информация (НОТССИ) през 2007 г. Представена е карта на епицентрите на общо 1152 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 (623 сеизмични събития в район с координати $\lambda = 22^0$ - 29^0E и $\varphi = 41^0$ - 44.5^0N). Предлага се и каталог на земетресенията с магнитуд M>2,5. Сеизмогенните прояви се обсъждат по зони, сравнени със съседни периоди време.