PRELIMINARY DATA ON THE EVENTS RECORDED BY NOTSSI IN JULY – DECEMBER 2004

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Abstract. A map of epicenters of 692 earthquakes that occurred in the Balkan Peninsula sector outlined by latitude $\varphi = 37^0 - 47^0$N and longitude $\lambda = 19^0 - 30^0$E is presented. Expert generalized analysis of the seismicity over the territory of Bulgaria and its adjacent lands (with more than 403 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 second 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 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.

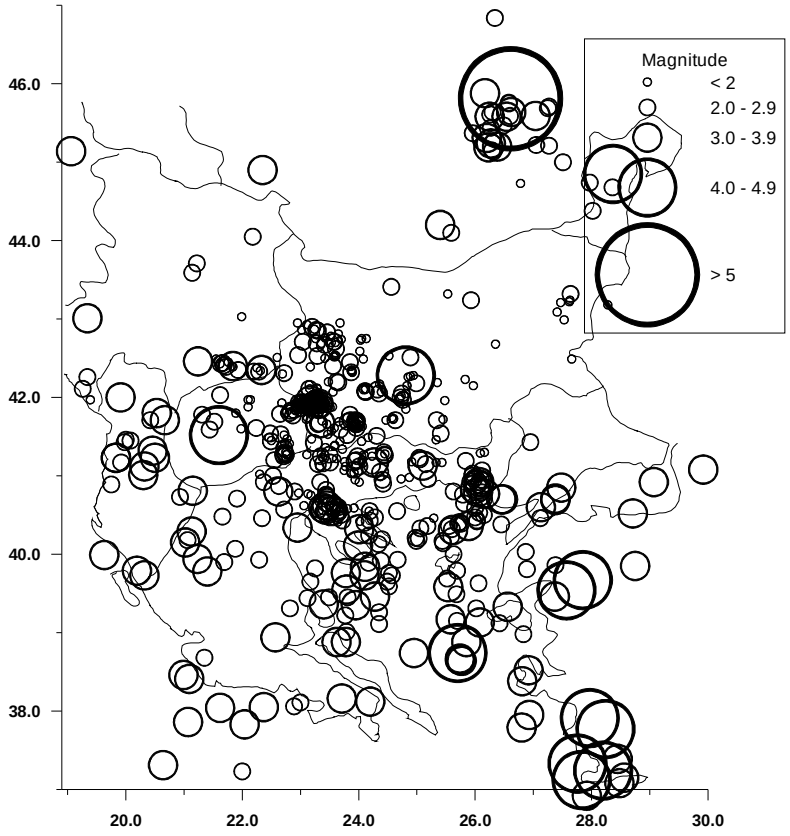

Fig. 1. Map of epicenters in Central Balkans during July – December 2004.

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.

For the six-month period of observations presented in this communication, the primary data about more than 1200 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 692 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 320, in M=2-2.9 - 260, in M=3-3.9 - 100, in M=4-4.9 – 11 and in M=5-5.9 – 1 earthquakes.

As a whole, the seismic situation in the study part of the Balkans during the second half-year of 2004 is characterized by relatively high activity (692 events against around 500- 600 for most of the previous half-years). It can be noted that the observed tendency of relative increase in the activity compared with the former half-year is partly due to the earthquake activation in Northern Greece and the NE Aegean Sea.

The strongest event outside Bulgaria during the study period occurred on the territory of Romania (Vrancea region) on 27th October 2004. According to the Euro-Mediterranean Seismological Centre, the earthquake magnitude was determined between 5.7 and 6.2. The macroseismic intensity in Bulgaria reached up to VI EMS. Effects of V-VI or VI degree appeared in some settlements along the Danube River as well as in South Dobrogea, the area to the North of Dobrich Town where traces of former seismic impacts had not been completely removed. The Vrancea activity during the considered period (Fig.1) is expressed by smaller earthquakes only 2 of which are felt with intensity III EMS in the town of Silistra.

The seismic activity on the territory of continental Turkey is high as usual - at least 7 earthquakes with magnitude $M \geq 4.0$ are observed. The activity develops at about 100 km inland and parallel to the Aegean coast. The contact area of Northern Greece is characterized by the well known high frequency of low magnitude seismic events. Strongest events are localized to the NNW of Thessaloniki and in the Khalkidiki region. Many earthquakes of a magnitude lower than 4 take place in the regions of Albania, Kossovo and Macedonia. One of them, the October 2004 Central Macedonia earthquake, was of a magnitude M=4.0; it did not attack Bulgaria.

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 illustrates the seismicity just in the territory of Bulgaria and nearby lands ($\varphi = 41^0$ - 44.5^0N, $\lambda = 22^0$ - 29^0E). 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.

On the territory of Bulgaria a relatively high degree of activity of weak earthquakes is observed during these 6 months - 403 events against 330 in the first half-year of 2004 and around 350 for most of the previous half-years. However the earthquakes of a magnitude higher than 3.0 are in smaller amount - 8 events compared with the averaged number of about 10-15 for most of the all previous half-years. The maximum realized magnitude in Bulgaria is M=4.0; for the sake of comparison, the strongest Bulgarian earthquake of the previous 2004 half-year is of M=3.9.

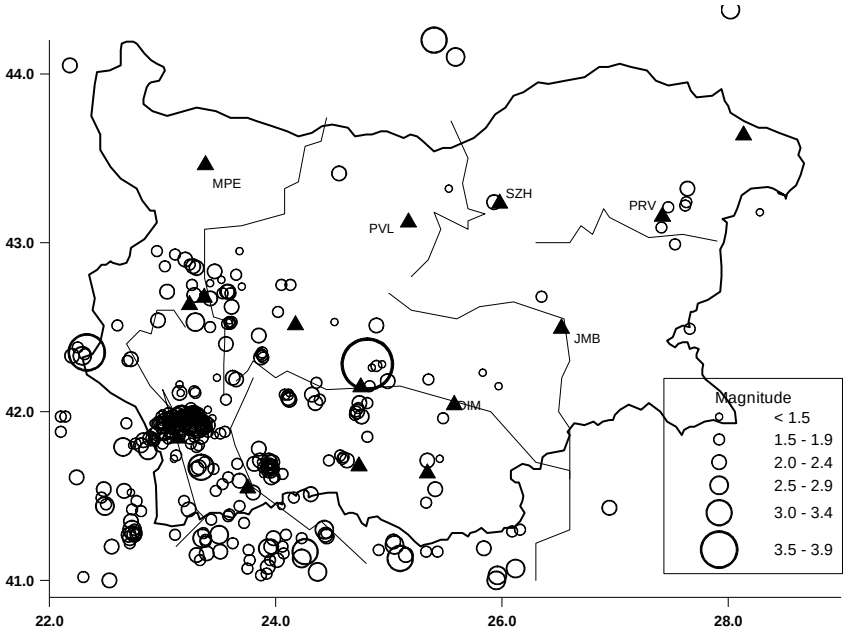

Fig. 2. Map of epicentres in Bulgaria and adjacent lands during July – December 2004.

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), is the most active one (the same has been proved for the entire territory of SW Bulgaria by Grigorova & Glavtcheva, 1976 and Grigorova, Christoskov et al., 1980). It is worth noting that in July-December 2004 more than 100 events of M<3.0 and only 2 of M>3.0 occurred in this region. The strongest earthquake was of a magnitude M=3.4 and felt on 3 November with maximum intensity of III EMS in the region of Blagoevgrad; fortunately, highest intensity is not possible to be evidenced because of sparsely populated mountainous territory.

A very slight activity of the opposite lying northeastern part of Bulgarian territory can be outlined in this period. Several earthquakes of a magnitude around 3 are noticed around the southern slopes of Rhodoppi Mountain in Greek territory. Conversely, the northern flank of the same massif shows very slight seismogenic activity in two limited areas, the one coinciding with the 1928 Plovdiv epicenter. In the former half-year the other 1928 hypocentral area (Tchirpan-Parvomay) was activated.

The Sofia seismic zone is characterized by about 30 small seismic events and only one of a magnitude M=3.0. During the considered second half-year the seismic activity in Sofia zone is at a lower level than during the first 2004 half-year, at that being more dispersed over the territory.

The strongest event in Bulgaria for the whole study period occurred on 10th September in the Maritsa seismic zone. The earthquake was of a magnitude M=4.0 being felt with maximum intensity V EMS in the Plovdiv vicinity. As a whole the seismic activity of Bulgarian territory during the second half of 2004 is relatively low and without

occurrence of seismic sequences like these ones characterizing the previous several years – Yambol one (2001), Krumovo (2002), Provadia (2003).

Table 1. List of earthquakes with M ≥ 2.5 in Bulgaria and adjacent lands during July – December 2004

Date	Time	Coordinates	H,km	M
20040701	05:51:37	41.03 25.96	20	2.7
20040701	10:02:02	41.21 25.05	20	2.5
20040701	18:40:38	41.00 25.95	7	2.5
20040701	23:42:35	41.92 23.31	14	3.1
20040724	13:29:11	44.10 25.59	21	2.5
20040726	15:25:16	41.19 23.93	10	2.7
20040804	09:03:41	41.67 23.34	16	3.1
20040807	22:08:21	42.35 22.33	1	3.6
20040807	22:19:15	42.33 22.29	20	2.5
20040810	12:23:30	42.53 23.29	15	2.8
20040813	23:56:30	41.13 25.10	2	3.1
20040830	04:33:33	41.05 24.37	15	2.7
20040905	17:20:43	41.90 23.31	20	2.6
20040909	17:59:24	41.44 22.49	10	2.7
20040910	17:46:03	42.28 24.81	15	4.0
20040913	16:25:50	44.38 28.02	2	2.8
20040918	03:14:22	44.20 25.40	20	3.1
20040923	15:53:56	41.97 23.29	2	2.5
20041001	19:28:43	41.13 24.23	9	2.5
20041001	22:04:42	41.27 23.50	10	2.9
20041005	22:19:22	41.77 22.87	11	2.6
20041006	07:18:38	41.30 24.43	8	2.7
20041008	15:28:34	41.30 22.73	7	2.8
20041023	11:35:23	41.66 23.95	5	2.7
20041024	06:48:53	41.79 22.65	7	2.6
20041030	07:32:06	41.07 26.12	11	2.6
20041103	04:18:35	41.96 23.17	16	3.4
20041126	13:20:30	41.25 23.35	8	2.7
20041214	23:18:46	41.17 24.26	20	3.0
20041219	16:11:40	41.94 23.03	15	2.5

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.

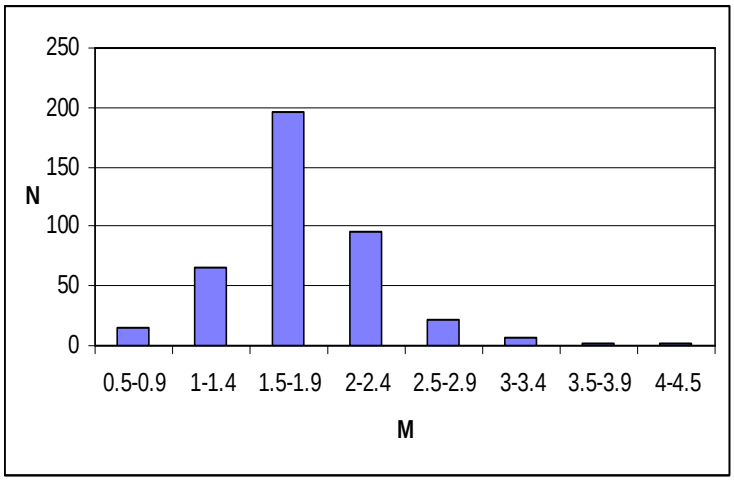

Fig. 3. Magnitude - frequency distribution of the earthquakes

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 > 4 the number of events is 1, for M > 3.5 it is 1, for M=3.0-3.4 - 6, for M=2.5-2.9 - 22, for M=2.0-2.4 - 95 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.

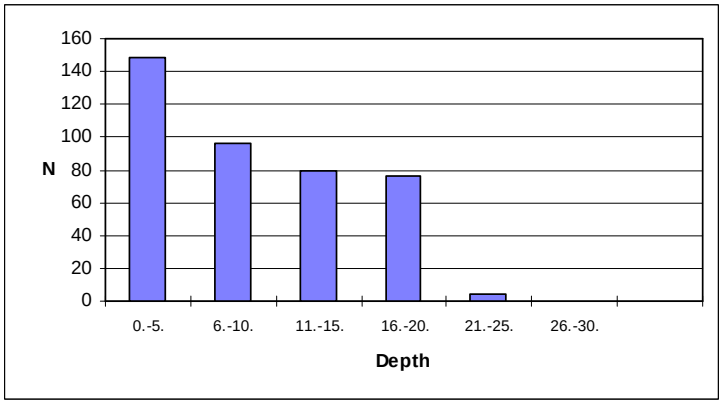

Fig. 4. Depth - frequency distribution of the earthquakes

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.

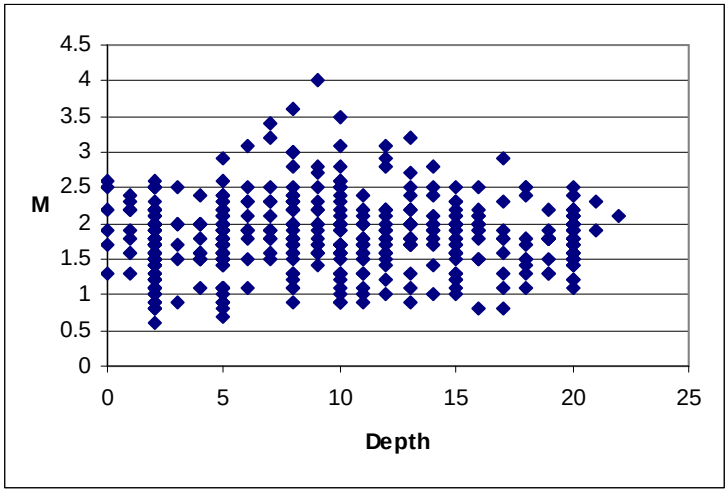

Fig. 5. Magnitude - depth dependence

The picture of the depth distribution in Fig.4 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. 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 5 - 14 km.

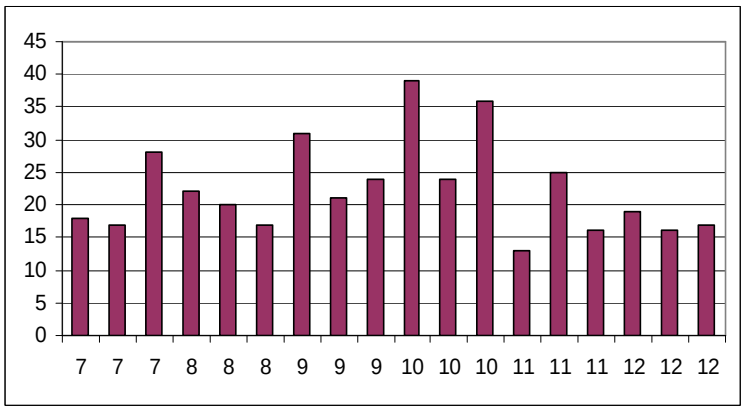

Fig. 6. Time distribution of the earthquakes during July – December 2004.

Fig.6 illustrates the distribution of seismicity in time according to the number of events per decade. The biggest earthquake's amount is displayed in September-October; the increase in October, 99 events as a whole, is followed by only 54 earthquakes in November. The lowest earthquake quantity is in December, 52 events.

Figure 7 shows the energy release in time through the earthquake magnitude-time

distribution. It suggests that September the month when the strongest event occurred is comparable with July - August in relation to the energy release. The released energy amount in the next three months is a bit lower.

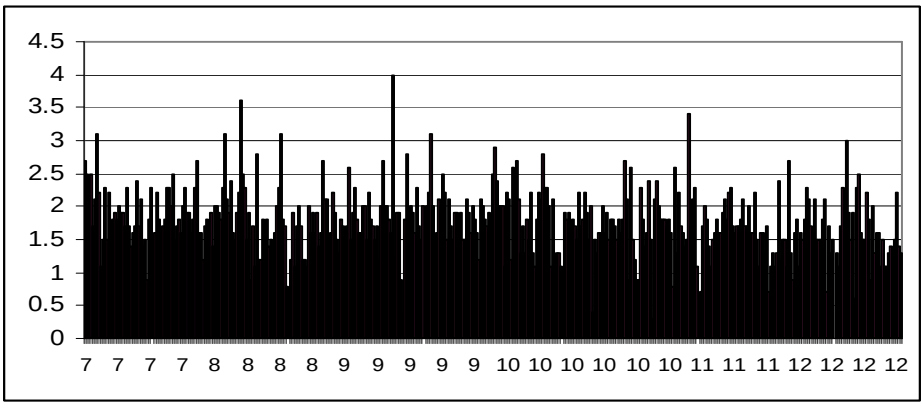

Fig. 7. Magnitude-time distribution of the earthquakes during July – December 2004

Additionally, about 210 distant earthquakes have been recorded in the period under study, as well as more than 90 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.

References

Christoskov L. and E. Grigorova, 1968. Energetic and space characteristics of the destructive earthquakes in Bulgaria since 1900. *Izv.BAS, vol XII* (in Bulgarian).

Christoskov L. and E. Samardjieva, 1983. Investigation on the duration of the seismic signals like a energetic characteristic of the earthquakes. *BGJ, vol.IX, N1* (in Bulgarian).

Christoskov L. et al., 1987. Real time and background data processing in the Bulgarian seismological network. *Proc. Xx gen. Assembly 1986, Kiel.* , Zurich.

Deneva D. et al., 1988. On the discrimination between industrial explosions and weak earthquakes using records of local seismics networks. *Proc. of conference in Liblice, 1988,* Praha.

Grigorova E., L. Christoskov et al., 1980. Seismic lineaments and activity of the seismogenic layers of Bulgaria. In: Geodynamics of Bulgaria. Sofia, Technics, 25-36.

Grigorova E. and R. Glavtcheva, 1976. Seismic activity and expected K maximum within the territory of Bulgaria. *Proc. Seminar of the Seismic Zoning Maps, Skopje, 27 oct. - 4 nov. 1975*, UNDP/UNESCO Surv. Balk. Reg., Skopje, v. I, 206-215.

Solakov D. and Tch. Dobrev, 1987. Program for determination of main parameters of the earthquakes. *BGJ, vol.XIII, N4* (in Bulgarian).

Предварителни данни за сеизмичните събития регистрирани от НОТССИ през юли - декември 2004

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Резюме. Предлаганото научно съобщение съдържа обобщена информация за резултатите от събирането, обработката и предварителния анализ на първичните данни за сеизмичните събития, регистрирани от Националната Оперативна Телеметрична Система за Сеизмологична Информация (НОТССИ) за второто полугодие на 2004 г. Представена е карта на епицентрите на общо 692 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 (403 сеизмични събития в район с координати $\lambda = 22^0$ - 29^0E и $\varphi = 41^0$ - 44.5^0N). Сеизмогенните прояви се обсъждат по зони, сравнени със съседни периоди време.