Seismicity patterns in Bulgarian area and adjacent lands recorded by NOTSSI in 2011-2015

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The present report contains generalized information about the seismic events recorded by the National Operative Telemetric System for Seismological Information (NOTSSI) of Bulgaria for the period 2011 – 2015. First of all the seismic information for this period could be accepted as a natural continuation of the tradition in NOTSSI to make an analysis of the seismicity of Bulgaria every 5 years (Botev et al., 1996, Botev et al., 2001, Botev et al., 2006, Botev et al., 2010). On the other hand the suggested information is a natural generalization and supplementation to the monthly publications of the preliminary seismological bulletin of NOTSSI. The periodic analysis and evaluation of the space, time and energy distribution of the seismicity conducted by these authors also creates a possibility of searching for correlation between selected parameters of different sorts of fields of a geophysical nature aiming to establishment of precursor anomalies.

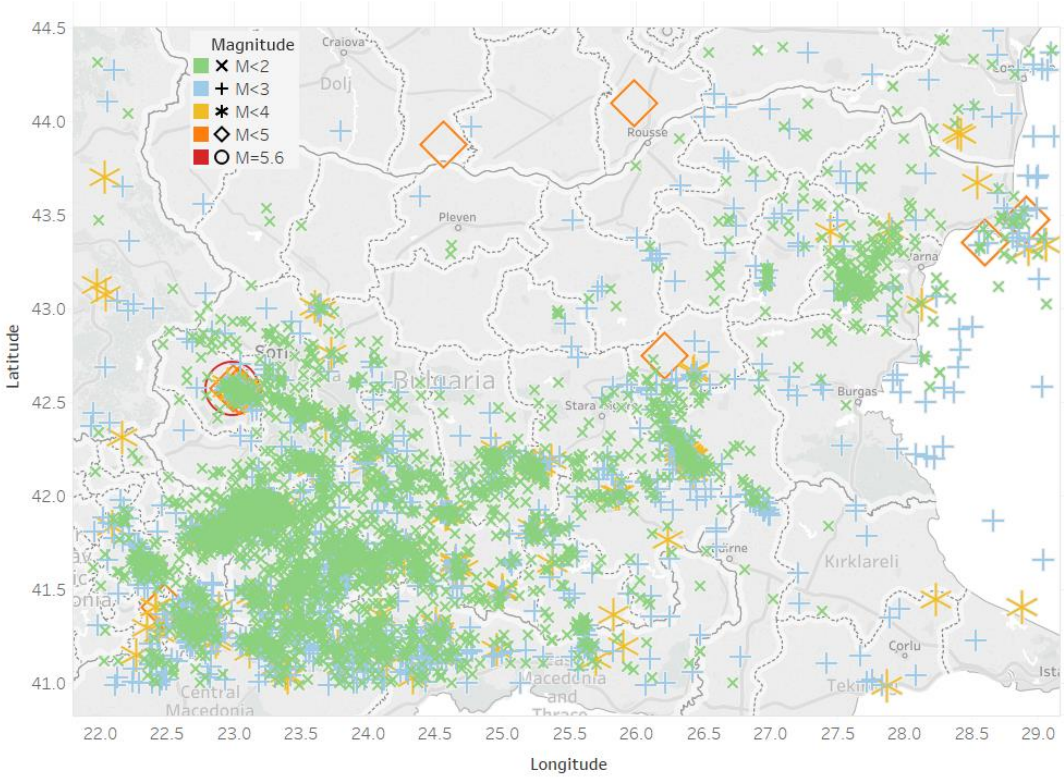

Fig.1. Epicentral distribution of the earthquakes on Bulgarian territory and the neighbour lands for the period 2011 – 2015. The size of the circles is proportional to the earthquake magnitude.

The recording and space localization of the seismic events in NOTSSI is realized by means of the new digital network (Solakov et al., 2006) consisting by 14 permanent stations all over the country and 7 local stations belonging to 2 local networks. All stations are telemetered to Sofia and equipped with various short and broad band period seismometers with high sensitivity. The routine processing and acquisition of the initial data is realized by the authors of this study in a real time duty regime. This way the main goal of NOTSSI is fulfilled, namely, the monitoring of seismicity, which will be of help to meeting cases of strong earthquakes in Bulgaria. The computing procedure for determining parameters of seismic events in NOTSSI is an adaptation of the widespread product HYPO'71 (Solakov, 1993). In the earthquake file the duration magnitude Md is computed

according to the formulas by Christoskov et all., 2011a and Christoskov et all., 2011b. The high sensitivity of the seismographs allows recording and processing of a great number of weak earthquakes with M > 0.1. The precision of the epicentral location is different and depends first of all on the specific position of the epicentre towards the geometry of the recording network.

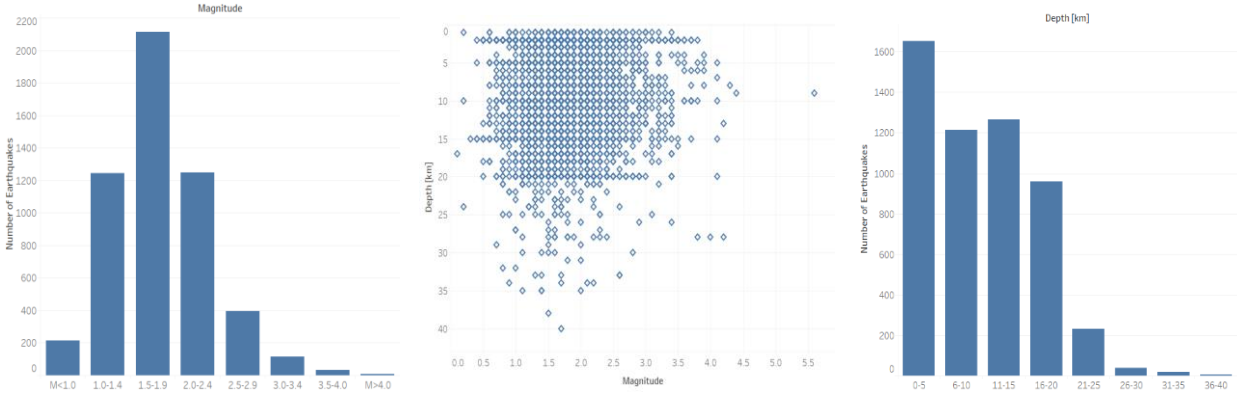

Fig.2. Magnitude and Depth distributions of the earthquakes on Bulgarian territory and the neighbor lands for 2011 - 2015.

For the last 5-years period of observations, presented in this communication, data about more 5380 events in the region with coordinates $\varphi = 41^0 - 44.3^0$ N and $\lambda = 22^0 – 29^0$ E are used. In the years 2011-2015 a relatively high seismic activity is observed - 5385 events against 4109 and 3931 for the two previous 5-years periods (Botev et al., 2002, Botev et al., 2006). The strongest earthquakes with a magnitude bigger than M=4.0 are more than those ones in the previous 5 years periods – 10 events against 6 and 3 for the previous two periods; the maximal released magnitude is M=5.6. The magnitude-frequency distribution of the earthquakes shows that the number of the events increases with the decrease of magnitude: 10 events of M > 4.0, 31 of M=3.5-3.9, 117 of M=3.0-3.4, 398 of M=2.5-2.9, 1241 of M=2.0-2.4 and so on. The abrupt diminishing of the number of earthquakes in the last three intervals determines also the registration power of the seismic stations network. In this way 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 this country territory. The hypocenters of the earthquakes are concentrated in the sub surficial 20 km depth interval; they reach down to 31-35 km depth for a several earthquakes and to 36-40 km depth only for two events in the NE part of the investigated territory. The smooth increasing in the events number with the depth's decreasing to 0-5 km is an evidence for availability of very small quantity of unidentified industrial explosions. The distribution of the events' strength (magnitude) in depth does not permit distinguishing any depth "floor"; the stronger events can be traced out within each one of the depth intervals – down to 20 km.

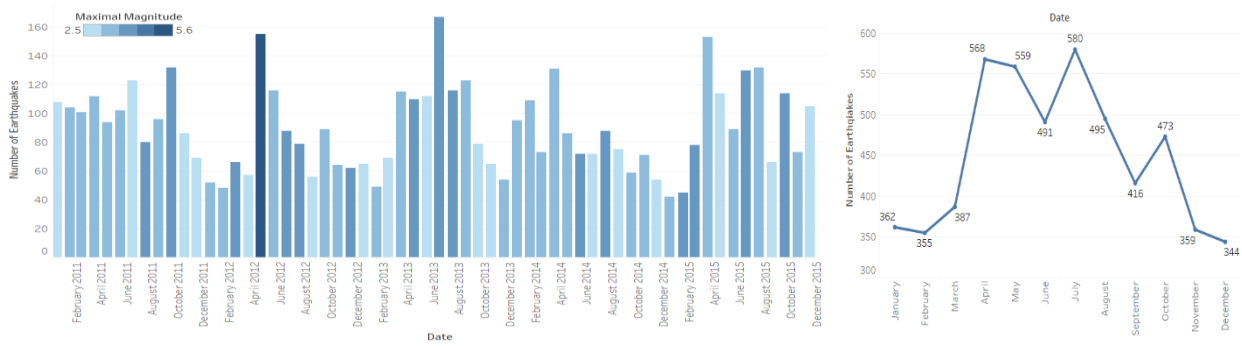

Fig.3. Month distributions of the earthquakes

Fig.3 illustrates the distribution of seismicity in time according to the number of events per months. The month distributions of the earthquakes show no uniformity in the time intervals. The biggest earthquake's amount is displayed in July 2013, when more than 160 earthquakes occurred, approximately the similar situation in May 2012 and in April 2015 is observed – 156 and 153 events respectively. The lowest earthquake quantity are in January 2012, February 2013 and January 2015 when about 40 events are released only. The energy release suggests that May 2012 is the month with maximum of energy release. The cumulative month distribution show much more high seismic activity from April to October.

The epicenters during 2011-2015 (Fig.1) show one very active south-western part of the investigated territory. The most active region of the state's territory here is the Strouma seismic zone, where the Kroupnik and Mesta earthquakes source zones are outlined. It is to be stressed also on the seismicity to the south of the Greek-Bulgarian political border where many quakes are localized along the Middle-Mesta lineament (out of Bulgarian territory). Some other polygons of activation, where not only weak quakes are observed, can be fixed in the Pernik region, in the region to northern periphery of the Sofia graben, in the eastern parts of the Northern Bulgaria (Shabla seismic zone). Other more active regions are those of Provadia, Plovdiv, Jambol and Monastery uplifts, where some of the strongest events (M>4.0) occurred.

The biggest frequency of the earthquakes in Kroupnik zone (Fig.1) is associated with the tectonic activity of Simitly quaternary depression, first of all with the activity of the Kroupnik fault. As a whole, the seismic activation here has a transversally orientation in relation to the first order Strouma fault zone. Transversal faulting process can be marked in the region of Kovatchevitza, crossing the Upper Mesta fault zone. Transversally to the Strouma fault lineament is the seismicity in the SW corner of the region, and it is associated with the Belasitza and Stroumeshnitza faults. Belasitza fault is a part of the Middle Mesta lineament, which determines the activity in the southern part (in Greek territory). The activity in Central Bulgaria is associated with: Sub-Balkan fault lineament in the northern board of Sofia depression; the faults in the southern board of the Upper Thracia depression (the north flank of Rhodopes) and Tundzha fault linement in Yambol zone. The activity in the eastern part of North Bulgaria is associated with the Kaliakra fault lineament in the shelf of Black Sea. The seismicity in Provadia region is associated with the eastern border of the Provadia depression which is crosslying to the Fore-Balkan first-order fault lineament.

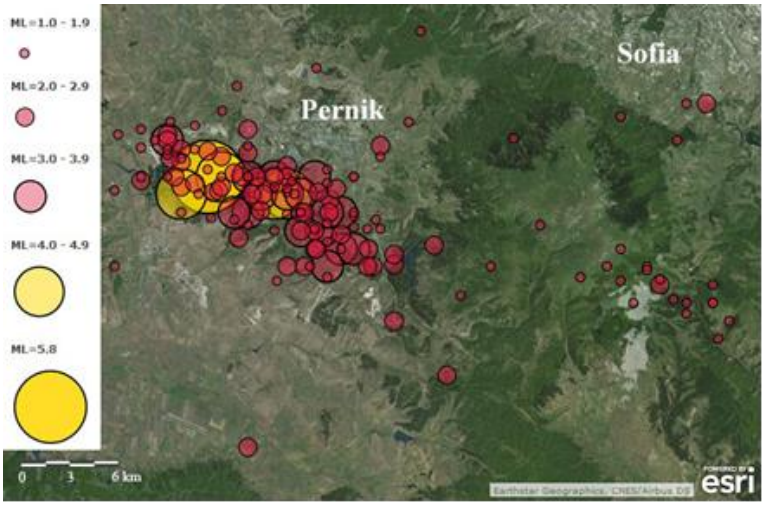

Fig.4. Epicentral distribution of the aftershocks of the maximal earthquake

The maximal earthquake (Mw=5.6, Ms=5.8) for the period 2011 – 2015 is located in the vicinity of the city of Pernik at about 25 km south-west of the city of Sofia (Fig.4). The earthquake was largely felt on the territory

of Bulgaria and neighbour countries: northern Greece, FYROM, eastern Serbia and southern Romania. No casualties and severe injuries have been reported. Moderate to heavy damages were observed in the cities of Pernik, Radomir and Sofia and their surroundings. More than 650 aftershocks were registered, most of them are microearthquakes. The modern digital network allowed providing reliable detection, fast location and precise determination of the earthquake parameters. The spatial distribution of the aftershock epicenters is presented in Fig.4, and coincides with the NW-SE trend of Pernik-Belchin fault. Consecutively the seismicity in this region is associated with the tectonic activity of Pernik-Belchin fault lineament.

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Сеизмични прояви на територията на България и прилежащите земи, регистрирани от НОТССИ през периода 2011 - 2015

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Резюме. Предлаганото научно съобщение съдържа обобщена информация на резултатите от събирането, обработката и предварителния анализ на данните за сеизмичните събития, регистрирани от Националната оперативна телеметрична система за сеизмологична информация (НОТССИ) за поредния 5 годишен период (2011 – 2015 гг). Представено е и се анализира разпределението на епицентрите на повече от 5380 земетресения (Ммин=0.1, Ммакс=5.6) за територията на България и прилежащите й земи (район с координати $\lambda = 22^0 - 29^0$E и $\varphi = 41^0 - 44.5^0$N). Отбелязана е несравнимо по-високата честота на сеизмичните събития в югозападните части на изследваната територия, свързвана преди всичко с тектонската активност на Пернишката, Крупнишката, Горно- и Средно-Местенската разломни системи. Високата сеизмична активност в източните части на територията на България се асоциира с геотектонските прояви предимно на Калиакренската, Провадийската и Тунджанската разломни системи.