Seismicity patterns in Bulgarian area and adjacent lands recorded by NOTSSI in 2001-2005

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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 2001 — 2005. 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., 2002). 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 (Botev et al., 2002—2006) 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.

The seismic events localization in NOTSSI during the considered period of time is realized by means of recordings in 14 permanent stations all over the

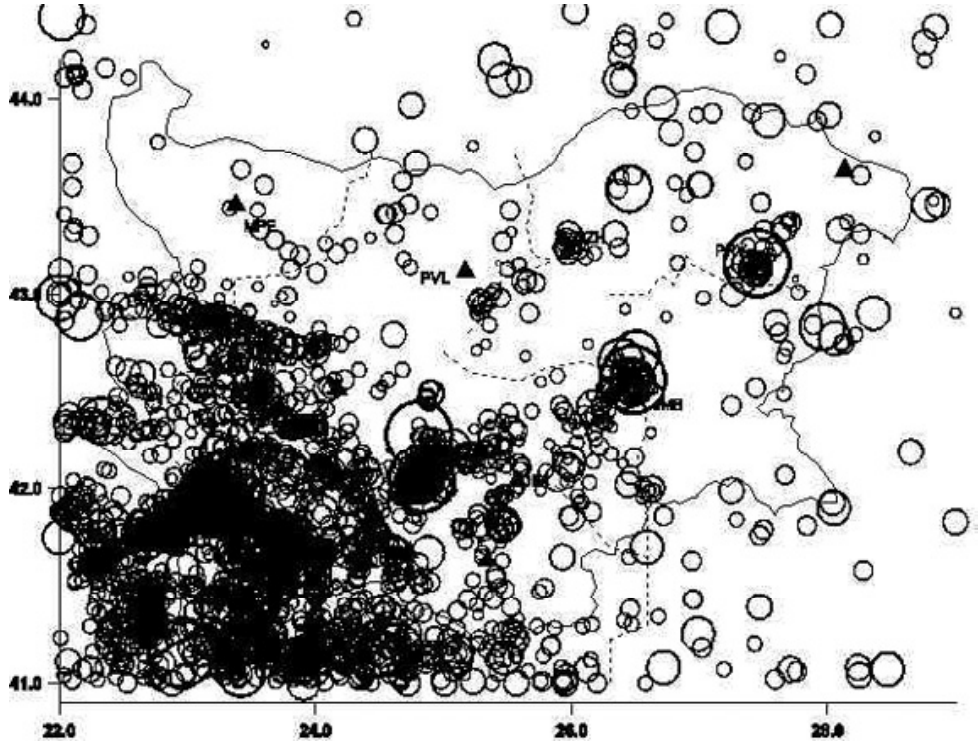

Fig. 1. Epicentral distribution of the earthquakes on Bulgarian territory and the neighbour lands for the period 2001—2005. The size of the circles is proportional to the earthquake magnitude.

country and 7 local stations belonging to 2 local networks. All stations are telemetered to Sofia and equipped with Teledyne-Geotech S-13 short 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, Dobrev, 1987). In the earthquake file the duration magnitude Md is computed according to the formula by Christoskov and Samardjieva (1983). 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.

For the consecutive 5-years period of observations, presented in this communication, data about more then 4100 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 2001-2005 a relatively high seismic activity is observed — 4109 events against 3931 and 2928 for the two previous 5-years periods (Botev et al., 1996; Botev et al., 2002). The strongest earthquakes with a magnitude bigger than M=4.0 are more than those ones in the previous 5 years periods — 6 events against 3 and 2 for the previous two periods; the maximal released magnitude is M=4.4. The magnitude-frequency distribution of the earthquakes shows that the number of the events increases with the decrease of magnitude: 6 events of M > 4.0, 22 of M=3.5-3.9, 89 of M=3.0-3.4, 365 of M=2.5-2.9, 1008 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 subsurficial 20 km depth interval; they reach down to 30-35 km depth for a few events mainly in the SW part of Bulgarian 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.

The epicenters during 2001-2005 (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 only weak quakes are observed, can be fixed in the inner part of the Rhodope Mountain, in the region to the east of the Iskar river valley (to the south of Sofia town), around the northern periphery of the Sofia graben, in the central parts of the Northern Bulgaria (Gorna Oryakhovitza seismic zone). Other more active regions are those of Plovdiv, Jambol and Provadia, where some of the strongest events (M>4.0) occurred and the epicentres form elongation zones with E-NE orientation.

Generalizing, the following epicentral areas can be identified in the period 2001-2005 tracing the territory of Bulgaria from the north to the south and from the west to the east: the Gorna Oryakhovitza zone with E -NE oriented alignments of epicenters in Veliko Tarnovo and Strazhitza areas (Mmax = 2.9) in Central North Bulgaria; the E-NE oriented Provadia zone with the magnitude 4.4 earthquake in 2003 (Dimova et al., 2004) in North-eastern Bulgaria; the Sofia zone in the Central West Bulgaria (Mmax=3.3) — with diffuse seismicity and well outlined active Sub Balkan fault lineament; the Maritza zone which is situated in the framework of central Srednogorie (Mmax=4.3 in 2002, Krumovo area); the Yambol epicentral zone in the northeastern Srednogorie (Mmax=4.3 in 2001, s. Dimitrova, 2003); the most active zone, Kroupnik zone, with more then 30% of the Bulgarian seismic events (Mmax=4.1); the Mesta epicentral zone with NW oriented epicentral distribution (Mmax=3.8), Middle-Mesta zone with Mmax=4.3 in Belasitza area and Rhodopean zone (Mmax=3.2). The activity of the northern part of the Pirin Mountain should be outlined in this period. It is worth reminding here that a seismogenic activation in the Pirin's interior has been noticed on occasion of the magnitude 5, 1972, earthquake series (Grigorova, Glavcheva, 1975). The epicenter distribution in three cases of activity remarkable for the investigated period is shown in figs. 2 (a,b,c). Chronologically, two earthquake series took place in Yambol seismic zone in August 2001. The activation lasted for 3 months. The Krumovo case was an earthquake activation on the north flank of Rhodopes in April-May 2002. The Provadia seismic zone known by manifestations of moderate strength became a space of activation for a short time in December 2003 — January 2004.

The biggest frequency of the weak earthquakes in Kroupnik zone is associated with the tectonic activity of Simitly quaternary depression, first of all with the activity of the Kroupnik fault. The seismic process spreads in ENE direction to the town of Razlog and in the West to the faults of the Delchevo graben in Macedonia. As a whole, the seismic activation there has a transversally orientation in rela-

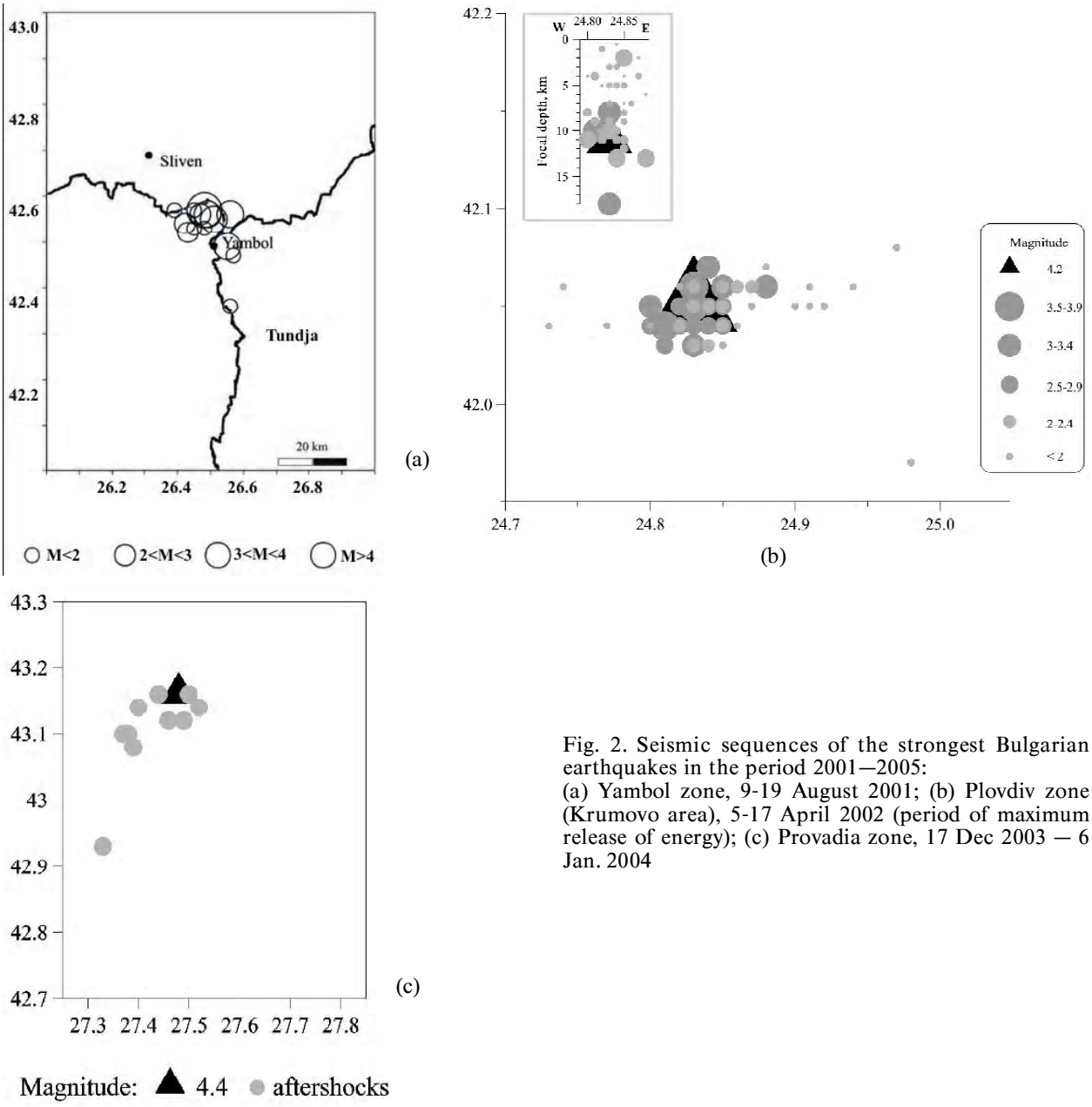

Fig. 2. Seismic sequences of the strongest Bulgarian earthquakes in the period 2001—2005:
(a) Yambol zone, 9-19 August 2001; (b) Plovdiv zone (Krumovo area), 5-17 April 2002 (period of maximum release of energy); (c) Provadia zone, 17 Dec 2003 — 6 Jan. 2004

tion 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 central part of North Bulgaria is associated with the eastern border of Strazhitza depression and the southern one of the Ressenski trough. 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.

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Сеизмични прояви на територията на България и прилежащите земи, регистрирани от НОТССИ през периода 2001—2005 г.

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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 (2001—2005 г.). Представено е и се анализира разпределението на епицентрите на повече от 4100 земетресения (Ммин=0.5, Ммакс=4.4) за територията на България и прилежащите ѝ земи (район с координати = 22^0—29^0 E и φ = 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 Крупнишката, Горно- и Средно- Местенската разломни системи. По силните земетръсни серии, довели до много сериозен обществен отсвук в Ямболско (2001), Пловдивско (2002) и Провадийско (2003), се свързват с проявите на разломните системи съответно по Тунджанската долина, южния борд на Горно Тракийската низина и източния на Провадийската депресия.