The 2006 seismic activation in the Eastern Rhodopes (Mts) – Kurdjali area and some generalization on geological features in the region

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A magnitude 4.5 earthquake was identified in the National Seismological Centre of Bulgaria (NOTSSI, Geophysical Institute of Bulgarian Academy of Sciences) at 17 h 20 min GMT (19 h 20 min local time) on 20 February 2006. The hypocentral coordinates were determined by the seismologist on duty as 41.69°N, 25.48°E, 12 km. The epicenter is situated in the Eastern Rhodope Mts. area.

The seismic activity in the mountainous region of Rhodopes could be specified as being at a moderate level. The border regions of the massif are known by the relatively highest activity. This is evidenced by the earthquakes distribution for a long period of time (since the mid-18th century) as well as for the time of high sensitive seismograph network operation after 1980 (fig. 1 and fig. 2).

The previous years seismicity in the selected part of Rhodopes is possible to be traced back thanks to the catalogues by Grigorova et al. (1978), Papazachos et al. (2000) and the investigations by Babachkova and Rizhikova (1993) and Glavcheva et al. (2000). Then, the illustrations above show quite a vague seismogenesis and low activity in the area of the 2006 activation (figs. 1, 2: rectangular area to the east).

An earthquake of almost the same size as the magnitude 4.5 event of 2006 can be found on the 28 August 1936 in the macroseismic bulletin by Kirof (1941). The intensity assessments by Kirof form the data set and the equal intensity lines (isolines) in fig. 3. The drawing of this plot is extracted by the seismic information in the catalogues of the neighbors Greece and Turkey as well as by some characteristic features of the macroseismic field. Just like the 1936 earthquake, this year earthquake occurred on 20 February unexpectedly without any foreshock activity. The difference consists in the circumstance that the 2006 M 4.5 event was followed by an earthquake sequence (fig. 4).

All the earthquakes which were picked by the NOTSSI records and are expected to have been felt inside the 20 February mainshock's epicentral zone

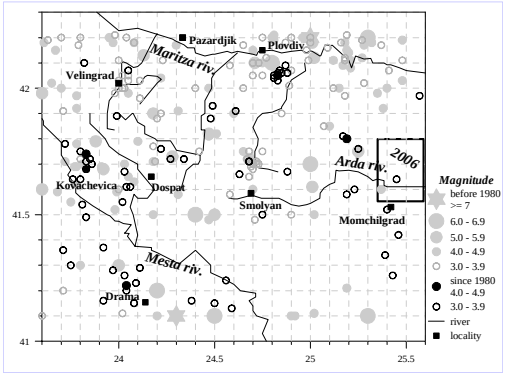


Fig. 1. Magnitude-epicentres distribution over the most active part of the Rhodopes and their borders since 1750 till the present, M≥3

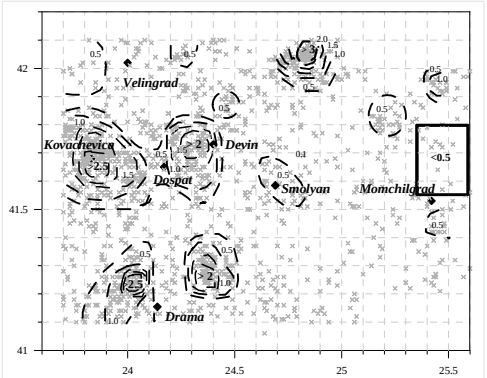


Fig. 2. Earthquake density in the period of high sensitive network in Bulgaria, since 1980, M≥1.5

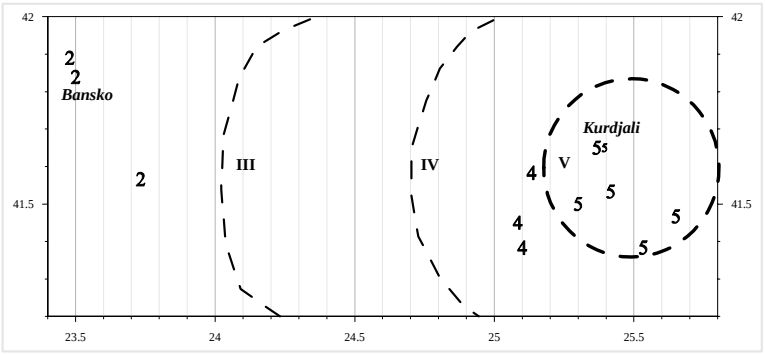
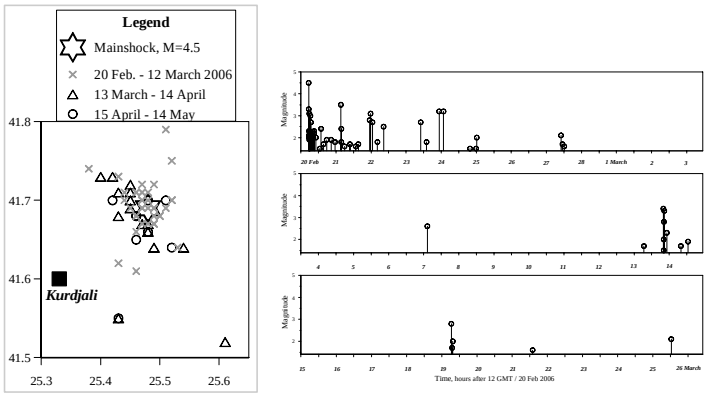


Fig. 3. Macroseismic field of the Kurdjali earthquake on 28 August 1936, 03 h 57 min local time: intensity data points according to FM (Kirof, 1941) with exception of this study's revision at the field periphery



(a) (b)

Fig. 4. Earthquake series (M≥1.4) starting on 20 Feb 2006, 17:20 GMT: (a) epicentres; (b) energy releasing

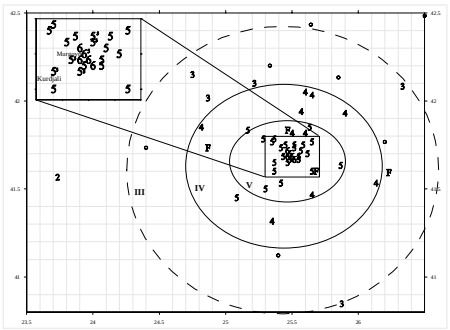


Fig. 5. Intensity field of M4.5 earthquake on 20 February 2006, 17h 20 min GMT (acc. to EMS98 in the epicentral area, MSK-64 outside of it; F — felt; o — not felt)

are shown in fig. 4. The initial four days of post-activity were uneasy concerning by the local people because of frequent shocks, seven of which with M≥3. The seismogenic process seemed to approach to the end when, four weeks after the mainshock, a new rich earthquake series started. Amongst the new events the latest two were of M≥3. The magnitude value of 3 is not mentioned in vain; it corresponds to earthquakes originated in the zone of intensity 5 or more at the main shock excitation (fig. 5). The seismic activation in the considered region increases/decreases till the present-day.

The strongest affects produced by the main shock (20 February) were announced for the community centers Perperek, Kurdjali and Chernoochene. The earthquake was felt most strongly in the villages of Murgovo, Chiflik and Gorna Krepost. The mayor of Murgovo Village (Mr. Aliosman Yusein) bore witness to local effects in the epicentral zone. At first, the people listened noise, after that strong detonation and, finally, perceived shaking. The detonation was felt at few villages around Murgovo. Several days after the main event a field investigation team of the Bulgarian Academy of Sciences, in which different specialists cooperate their efforts, inspected the epicentral area. The worst consequences were found out within the Murgovo Village and assessed as intensity 6. In this locality many of the vulnerability class A and B buildings — unreinforced, mixed bricks and simple stone on mud mortar — suffered damage grade 1 and a few (20 %) grade 2 and 3; many (60%) of the B class buildings — unreinforced, with wooden floors — suffered damage grade 1 and a few (5%) damage grade 2; and a few of vulnerability class C buildings — RC confined brick walls with RC floors — suffered damage grade 1. The same way, following the classification principles of European macroseismic scale EMS98 (Gruenthal, 1998) damages and felt effects in the epicentral region were assessed — examples of damages are presented in fig.6.

The intensity distribution at the mainshock has been compiled by three types of data, those proceeded from in–quiries by telephone (including correspondents of National Civil Protection), dissemination of written questionnaires to municipalities, the field team work and, finally, the local press. Figure 5 illustrates the results from macroseismic analysis done; the intensity outside the epicentral area is evaluated according to the scale MSK-64.

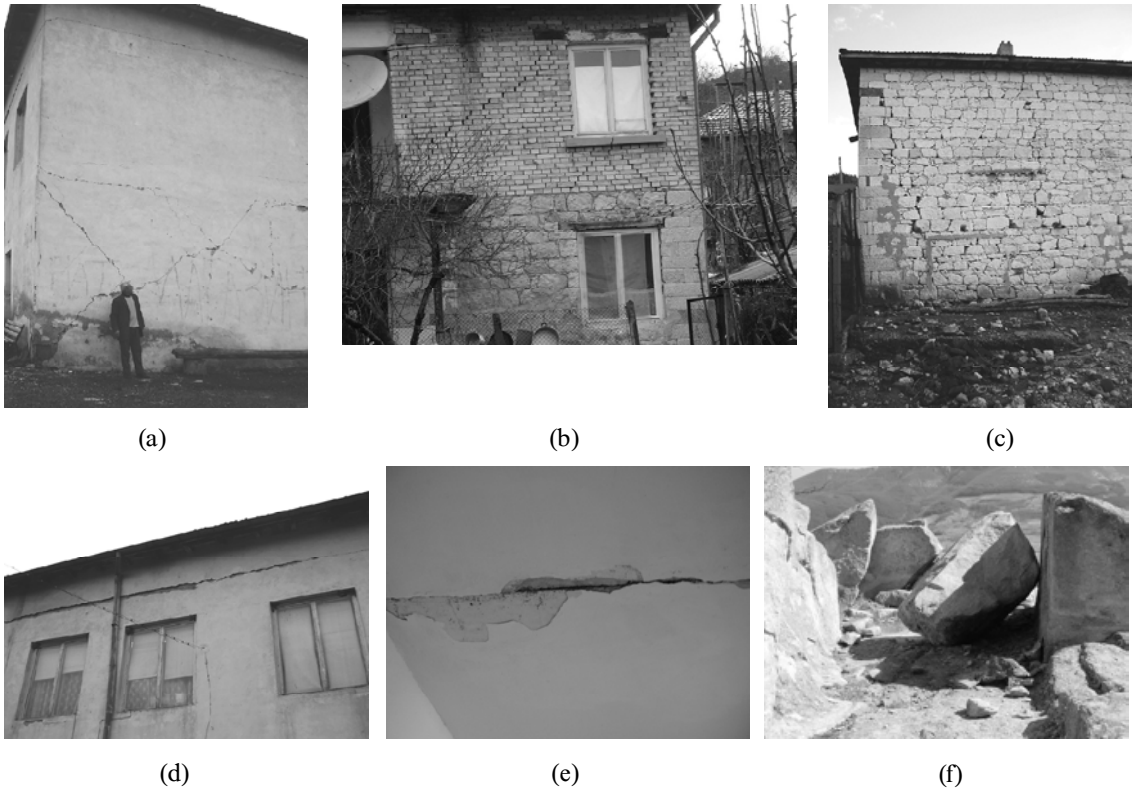


Fig. 6. Damages caused to the epicentral area by M4.5 on 20 February 2006
Murgovo Village: The Municipality building, *class B*, built in sloping terrain (a, d); Murgovo Village: *class B*, open cracks and shifting in masonry (b), Vissoka Polyana: *class A*, high level underground waters (c); Most Village: The School, *class B*, activated joint between the old and the new section of the structure (e); The ruins of ancient Perperikon: a collapsed rock block (f)

Fig. 7. Fault displacements established at the beginning of the "throne-room", Perperikon

The shaking caused rockfall phenomena along the road network within an area of 25 km radius around Murgovo Village. Landslide activations were not established. Fallen rock blocks were found even in the vicinity of Djebel Town. However, the most of fallen blocks were in unstable state before the earthquake. The extensometric point for monitoring tectonic movements (located at General Geshevo Village, near Djebel Town) does not show any influence of the earthquake swarm (Dobrev et al., 2005).

During the field examination of seismic effects we established fault structures that were not published in the existing literature till the present. Some of them can be seen at the ruins of ancient town of Perperikon that are cleared out during the last years. We found displacements at the beginning of the "throne-room" showing subsidence of the east side (block) about 15-20 cm and unclear value of strike-slip component (fig. 7). Displacements of tectonic origin were established into the Quaternary deposits at two places on the scarps of the cart-road to Perperikon. The first one marks a rupture in a probable direction 45-80°; in the second case the direction is to 120-130° with a strike-slip component.

The focal mechanism of the mainshock was determined by the National Institute of Geophysics and Volcanology, Rome, Italy (INGV). The solution gives a horizontal slip with left component 135° and a right slip in direction 55°. The analysis of tectonic stresses shows compression in direction NW-SE. The coincidence of direction 135° with the direction of Perperek River and some relief features is obvious. The transversal system 55° coincides with some tributaries of Perperek River (incl. the creek that passes through Murgovo Village). We concluded that the

main faults that were activated during the earthquake followed the directions of 55° and 135° due to following reasons:

— distribution of earthquake epicenters (fig. 4a);
— relief features;
— detonation effects (fig. 8).

Conclusions

1. The earthquake series starting on 20 February 2006 was realized in result of activation of a fault system of 135° and a transversal one in direction of 55°; it occurred in a region known by its vague and slight activity.
2. The main seismic event caused consequences in buildings corresponding to their vulnerability features. The maximum intensity is assessed by 6 EMS98. The rockfall phenomena were triggered in an area of about 25 km radius around the epicentral zone; landslide activation was not established. Terrain features unknown till now were discovered thanks to the field inspection conducted.
3. The observation period showed the work efficiency when the field team consisted of earthquake engineers and geologists additionally to the seismologists.

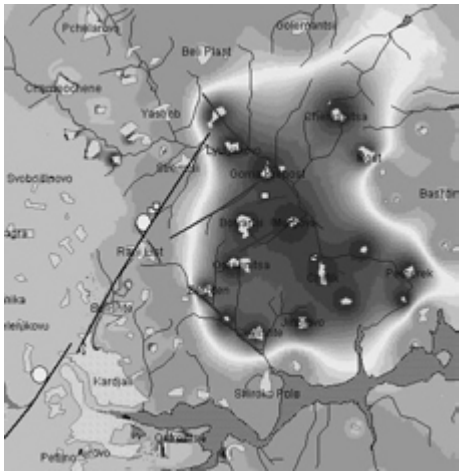


Fig. 8. Area with detonation effects marked by the dark grayish color area outlined by white line

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Сеизмична активация през 2006 г. в Източни Родопи — района на Кърджали и някои обобщения върху геоложки характеристики на района

Румяна Главчева, Николай Добрев, Кирил Хаджийски, Соня Димитрова, Бойко Рангелов

Резюме. Изследването е посветено на сеизмогенно активизиране в район на Източни Родопи, северно от Кърджали. Данни, извлечени от сеизмичната история, свидетелстват за вяла активност на тектонските движения. Показани са резултати от полево обследване на обстановката след земетресение с магнитуд 4,5.