Investigations of the 22 may 2012 earthquake in Pernik, Bulgaria

E. Botev, D. Dimitrov, I. Georgiev, V. Protopopova

Abstract:

On 22nd of May 2012 an earthquake with magnitude Ms=5.8 occurred in the town of Pernik about 20 km SW from the capital Sofia causing moderate damages in a wide area including the main city. According to the reports of the seismological agencies and the rapid determination of Bulgarian national seismic network the depth of the event is shallow - about 10 km. The epicentre of the shock is in an area which is relatively quite for the last 120 years minimum. The orientations of the fault plane solutions and distribution of the aftershock epicenters coincide with the NW direction of Pernik-Belchin fault tectonic line. As a result, a dislocation model using Okada definitions based on the complex analysis of the dataset is proposed.

On 22nd of May 2012 at 00:00 GMT Bulgarian national seismological network (NSN) – Fig.1, maintained and served by National Institute of Geophysics, Geodesy and Geography (NIGGG) of Bulgarian Academy of Sciences (BAS) registered strong earthquake in the region of Pernik town, with epicenter at about 3 km to the southwest of the city center. The earthquake was recorded very well by the all 25 stations (15 permanent seismic stations and three local networks) of NSN. The modern digital network allowed to provide reliable detection, fast location and precise determination of all parameters of the earthquake that caused many damages in Pernik region and was felt on the almost whole territory of Bulgaria.

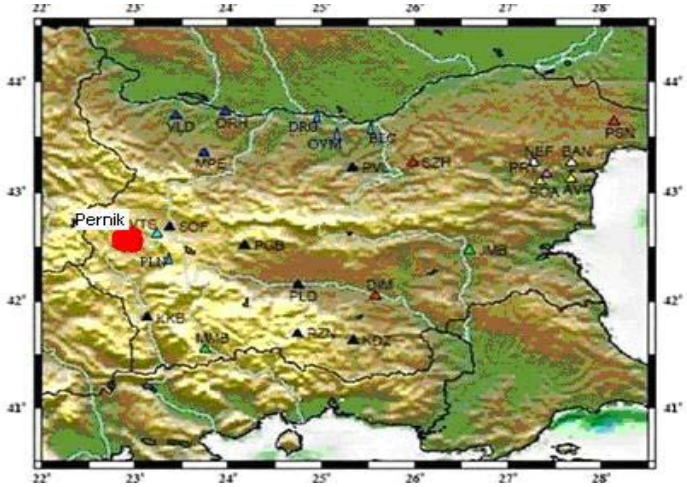


Fig.1. Epicenter of Ms=5.8 Pernik earthquake with the station location of Bulgarian NSN

The maximum realized magnitude of this earthquake is Ms=5.8 (Mw=5.6), the depth is 9 km and the geographical coordinates are 23.00 in eastern longitude and 42.58 in northern latitude. According to the rapid evaluations of the Bulgarian seismic network the earthquake occurred about 20 km SW from the capital Sofia causing moderate damages in a wide area including the main city. The seismic history of Bulgaria evidences that the epicentre of the shock is in an area which is relatively quite as minimum for the last 200 years. This is the highest Bulgarian earthquake in comparison with the maximum magnitude in the course of previous more then 80 years. The strongest Bulgarian event for these eight decades caused no so strong macroseismic effects – the maximum intensity is VII-VIII degree of MSC scale - in the town of Pernik, close to Bulgarian capital Sofia. The same maximal degree of the damages is observed in the village Divotino, situated in several kilometers to NE from Pernik. There are many damages corresponding to VII degree of MSC in the other villages situated NE from Pernik along the line Meshtica – Rudarcy line, which is parallel to Pernik-Belchin fault line (Fig.2). The relatively high degree of the felt intensity in these villages is explained by the specific peculiarities and orientation of the fault plane to the NE from Pernik, where some very small surface manifestations are observed in some locality along the line mentioned above.

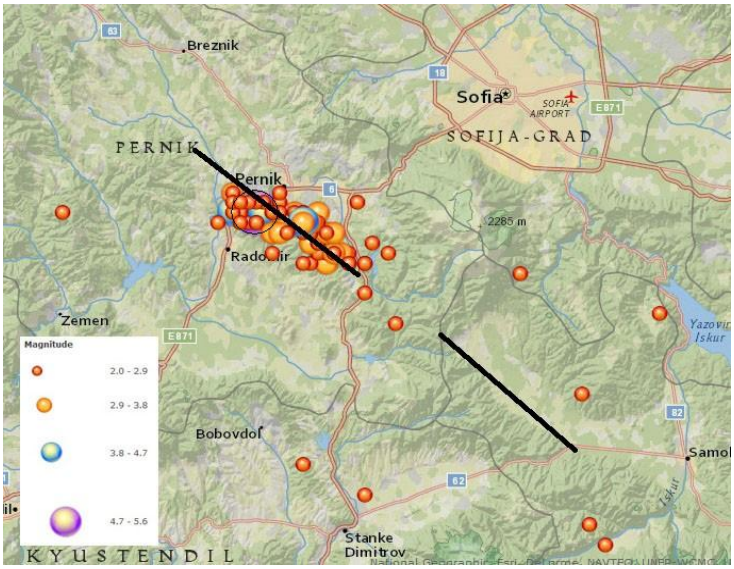
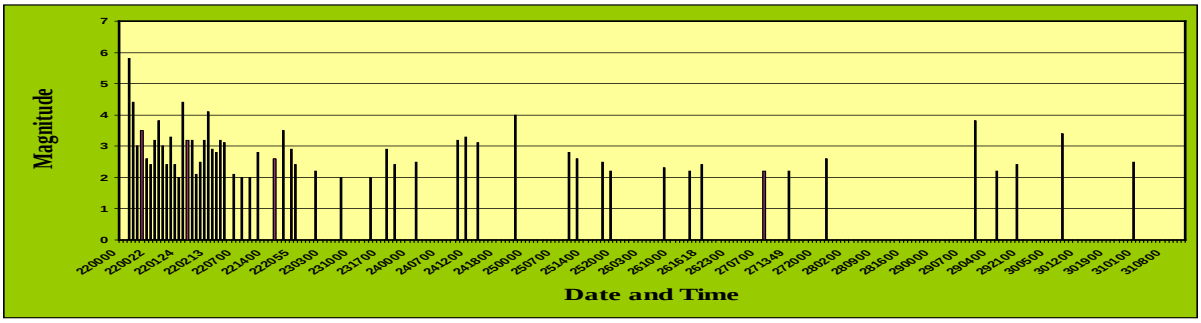
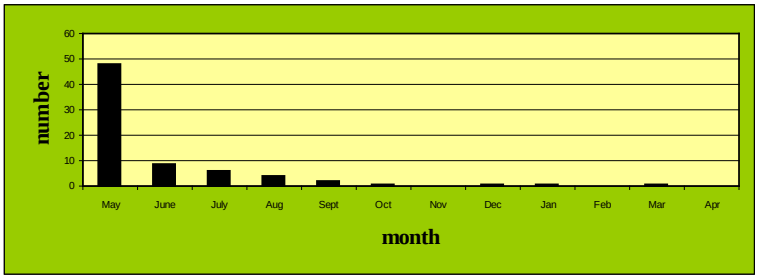


Fig. 2. Epicentral distribution of the felt events along Pernik-Belchin fault line

The main shock is felt very significantly on the territory of the whole West Bulgaria, clear enough in Central Bulgaria and slightly in some regions of eastern parts. The maximal intensity in Sofia region is VII degree MSC. Such strong Pernik earthquake has not been mentioned before during the whole seismic history of the country. The last significant event is the earthquake with magnitude M = 4.5 during 1965 (Catalog of NIGGG, Sofia, 1978). There is no one event with magnitude M>3.0 since the high sensitive NSN started operation. The seismic patterns are analogous to each other referring to the energy released; the seismic shocks however occur more frequently in the vicinity of Pernik town (Fig.2). The Pernik-Belchin fault line may hardly be identified as seismogenic structures because of their slight activity. Regardless of generating earthquakes rarely, the considered northeastern section of Pernik-Belchin fault demonstrates presence of seismogenic potential. The earthquake hypocenters are concentrated in the subsurficial layer of 15 km. It is not to be neglected the seismogenic potential of the underlying ten kilometers between 15 and 25. Finally, several cases of a small magnitude show that the seismogenic depth in Pernik region might reach to 30 km.



a.



b.

Fig. 3. Time distribution of felt events: **a.)** magnitude values for May; **b.)** months number for a year

During the first day the main shock is followed by more then 30 events with maximum M=4.4, causing moderate damages in a wide area including the main city. The relatively short duration and low frequency of the aftershock sequence (Fig.3) of this event does not increase significantly the relatively low number of all seismic events in Bulgarian territory during whole 2012. The strongest of the secondary shocks is with magnitude M=4.4 (Fig.3), the events with M > 4.0 are only four, with M > 3.0 – 15 events only and all the rest events are microearthquakes with magnitude M <3.0 – about 630. Regardless of the low energetic level more then 70 events are felt in the region of Pernik. Some aftershock events made many additional damages on the country houses in Divotino and Meshtitca villages.

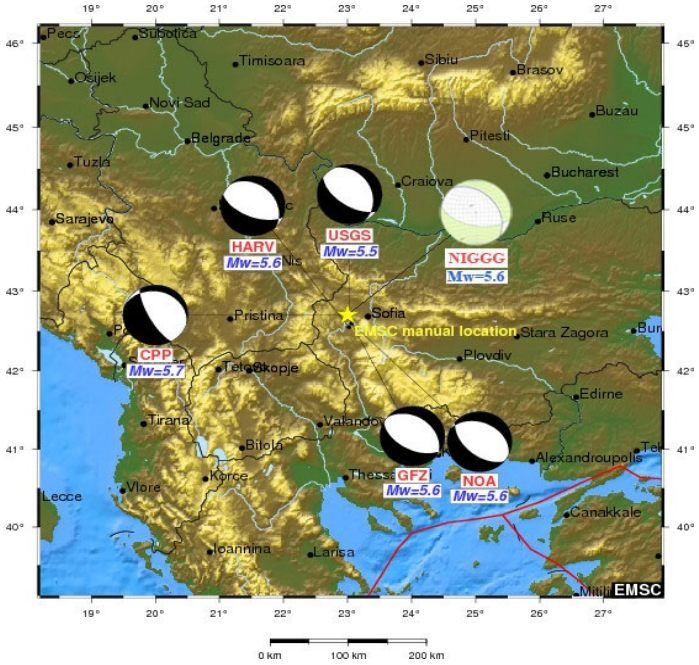


Fig. 4. Fault plane solutions of 22.05.2012, Mw=5.6, main shock

Fault plane solutions for 22.05.2012 main earthquake with magnitude Ms = 5.8 (Mw=5.6) are obtained by the various world networks from the results of the analysis of 88 world seismic station records (http://www.emsc-csem.org/). Twenty three first motion polarities data from seismological stations in Bulgaria and surrounding area are included in the double - couple focal mechanism solution of NIGGG (Botev et al., 2013). All polarities are check as waveforms, the strike, dip and rake are determined in accuracy up to 10 degree and the solution is displayed in lower hemisphere on the Figure 4. The earthquake is characterized as a normal faulting, with very small strike-slip component. The fault plane solutions of the some other events are with bad quality because of a low number of polarities first of all. All fault plane solutions are conformed to each other and the most of all focal mechanism parameters are with much closed values. According to these parameters it is clear that the main earthquake is a jerk normal fault movement caused by extensional regional tectonic stresses with northeast – southwestern orientation. The fault line run along the north-eastern borders of the Pernik basin and has strike=124°, dip=49°, and rake=-104° as average parameters . The energy released by the fault mechanics movement during this Mw=5.6 earthquake is 3 x 10**17 [N/m]. The surface manifestation of the fault is expected to be located between Viskyar village and Divotino village line and its direction is oriented to the north-west. Not so clear ground cracks were observed in two localities – in south-eastern direction from Viskyar village and in northern direction from Meshtitsa village and their amplitudes do not exceed 2-3 cm.

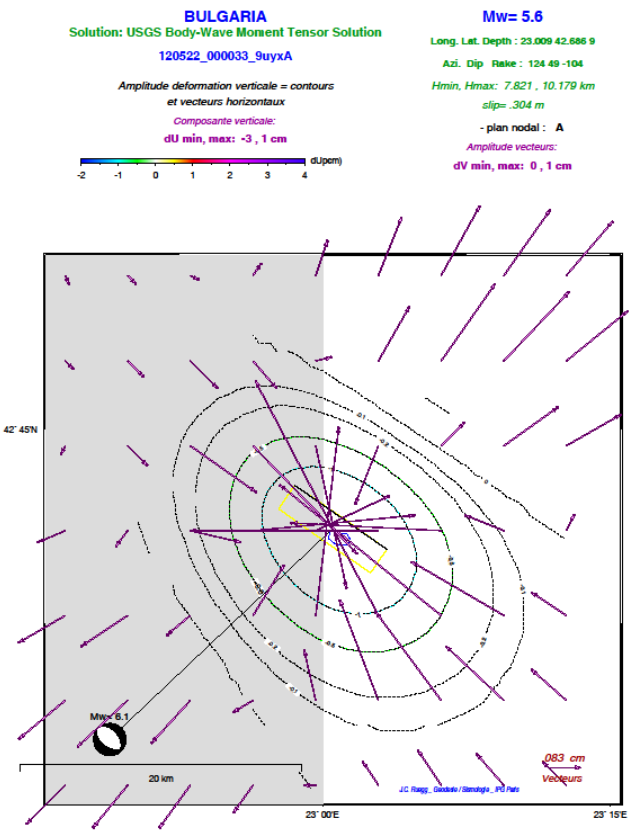


Fig. 5. Model of theoretic vertical (izolines) and horizontal (arrows) co-seismic movements

Some geologic, seismotectonic and field investigations information is used to calculate a model of theoretical vertical and horizontal co-seismic movements according Okada definition (1985). Model solution (Fig.5) demonstrates a normal faulting along a hidden fault plane with azimuth orientation of 124°, deep angle 49° and depth of the started point of movement about 9 km. The value of movement in the hypocenter is about 30 cm without any theoretical long line manifestations on the surface. Only some episodes of vertical movemets are obtained for limited surface points – with about 3 cm for down lift and 1 cm for uplift. Theoretical horizontal movements are insignificant and reach maximal value about 8-9 mm. Because of the continuous and active rainfalls after the main shock only some not so clear evident effects caused by the surface manifestation of the earthquake were recognized – the maximal vertical amplitude of the crucks is about 2-3 cm.