BULGARIAN ACADEMY OF SCEINCES
GEOLOGICAL INSTITUTE "STRASHIMIR DIMITROV"

Report

on field survey after May 22, 2012 Pernik earthquake

June 6, 2012

Part 1

Coseismic geological effects

related to May 22, 2012 Pernik earthquake, Western Bulgaria

Alexander Radulov, Marlena Yaneva, Stefan Shanov, Valentin Nikolov, Konstantin Kostov, Nikolai Nikolov, Vladimir Hristov[1], Nikolai Dobrev, Asen Mitev (Geophysics - Engineering Ltd.)

On May 22, 2012 at 3:00 AM local time, a shallow earthquake of Mw 5,6 (EMSC) hit Pernik region in Western Bulgaria. The hypocenter was at 10 km depth (NOTSSI-BAS). The earthquake caused damages on many buildings in Pernik (80 000 residents) and villages around the town. Damages occurred also in the Bulgarian capital Sofia, which is 20 km away from Pernik. This earthquake surprised people. The last strongly felt earthquake in Pernik was in the distant 1965, on January 29 at 1:30 AM local time. The maximum intensity of the 1965 earthquake was VII (MSK).

The epicentral area of the May 22 earthquake has not been studied for active faults. In a study on geodetic velocities in W Bulgaria in 2005, V. Kotzev et al. wrote "A significant region of extension to SW of the Sofia graben suspiciously coincides with the Pernik fault[2] (this fault should be defined and mapped much better)"[3].

1 Vladimir Hristov will prepare report on groundwater chemical composition changes.

2 *Pernik fault* has no geological meaning.

Soon after the earthquake, available focal mechanisms from abroad were similar (figure 1.1). Two suspected fault lines were consistent with a fault plane that has strike=124°, dip=49°, and rake=-104° (USGS focal mechanism). These two fault lines run along the NE borders of the Pernik basin and the Radomir basin (figurte 1.2). The strike of the line at Radomir basin is 133°, and the strike of the line at Pernik basin is 128°. EMSC and USGS located the epicenter in the Pernik basin, and NOTSSI-BAS located it very close to the fault line in the Radomir basin.

We visited the area of Radomir on the day of earthquake. Degraded scarps in a floodplain and alluvial fans were identified along the suspected fault line. However, we did not observe any fresh ground cracks or other coseismic effects that might be related to the earthquake in the night. After field work finished, we saw that the NOTSSI-BAS had shifted the epicenter in the Pernik basin. Strong rain started in the afternoon and continued next days. Rain destroyed very important occurrences on the ground surface.

A week later, from May 29 to June 1, we visited the other suspected fault line along the NE border of the Pernik basin. The fault line is defined by scarps between Upper Cretaceous volcano-sedimentary rock and Oligocene terrigenous sediment, scarps in Upper Cretaceous volcano-sedimentary rock, linear valleys, deeper channel incisions in elevated block, widen valleys in downthrown block, and water springs and wells. The fault line is positioned between Viskyar village and Divotino village (figure 1.2). We interpret this scarp as an exhumed fault line scarp, which is renovated.

Ground cracks were observed in two localities – SE from Viskyar village and N from Meshtitsa village. The map of observed features is shown on figure 1.3. Localities in KML file are available at http://www.geology.bas.bg/seismo/Coseismic%20geological%20effects%20Pernik%20Mw%205.6%20earthquake.kmz.

South-east of the Viskyar village the ground cracks are organized in three lines. All the cracks are in wet topsoil. Crack width is between 0,5 and 6 cm, depth is less than 12 cm, and length between 0,3 and 3,0 m. Shorter cracks tend to be straight, and longer cracks form slight bends. Small amount of cracks displaces the ground surface. Cracks with vertical displacement are less opened (0,5-1,5 cm). Maximum observed vertical displacement is 5 cm. All cracks are orientated

3 V.Kotzev, R.Nakov, B.C.Burchfiel, N.Dimirov. 2005.Crustal Motion in Central West Bulgaria from Triangulation and GPS Data. - Comptes rendus de l'Acade'mie bulgare des Sciences, Vol 58, No6, pp.699-704.

along the fault strike. The two shorter sections where cracks have appeared are positioned along the crest of the fault line scarp. Sag ponds are alined in between these two sections. The third, longest crack section lies at the base of the fault line scarp. Here, cracks are positioned on the top or in the upper slope of small scarplet between a road and an agricultural field. We relate all cracks near Viskyar village to the fault slip on May 22. Crack origin is not certain.

The other area where ground cracks are observed is located in the Ralevska river floodplain, northward Meshtitsa village. Crack morphology is similar but they are wider (up to 8 cm) and vertical displacement is not observed. We did a resistivity profile to verify relationship between cracks and fault (figure 1.4). We interpret the vertical zone between meter 80 and meter 90 from the profile as a medium that hosts a syn-depositional fault. That zone separates parts of different stratification pattern. The uppermost higher resistivity layer (more than 20 Ω.m) corresponds to Holocene fluvial deposits which base is positioned at different elevations across the fault. The cracks in the Ralevska floodplain should be related to very limited fault slip, which has not reached the ground surface. Ground cracks most probably represent tensional fissures diverged from the main fault and an antithetic fault.

Conclusions

On May 22, 2012 at 3:00 AM, a normal fault, which ground surface trace runs between Viskyar village and Divotino village, ruptured.

Coseismic ground cracks have appeared along the fault trace.

Fault experiences repeated earthquakes. The fault is recognizable from morphotectonic features. However, it has been recognized AFTER the event.

Fault ruptured on May 22nd is one of the smallest active faults in the region. Other larger faults exist. They are not studied by modern approaches. Their maximum credible magnitudes and recurrence intervals are unknown.

Lesson to be learned

Geological and geodetic data are basis for the earthquake hazard assessment. Active faults should be recognized and characterized to ensure that earthquake hazard in a certain area is adequately assessed.

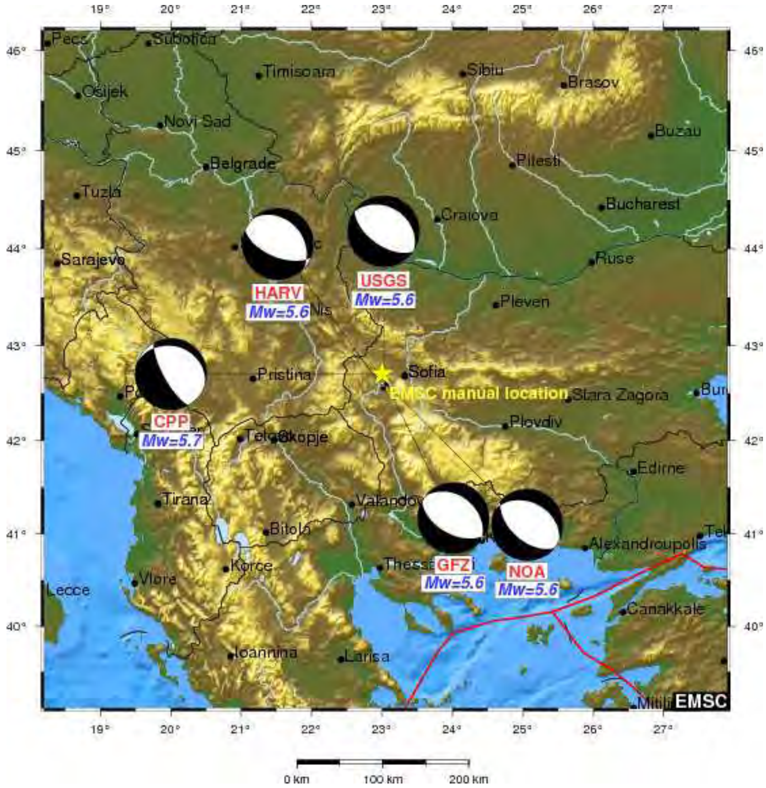

Figure 1. Focal mechanisms of the May 22, 2012 Pernik earthquake. Source EMSC (http://www.emsc-csem.org/)

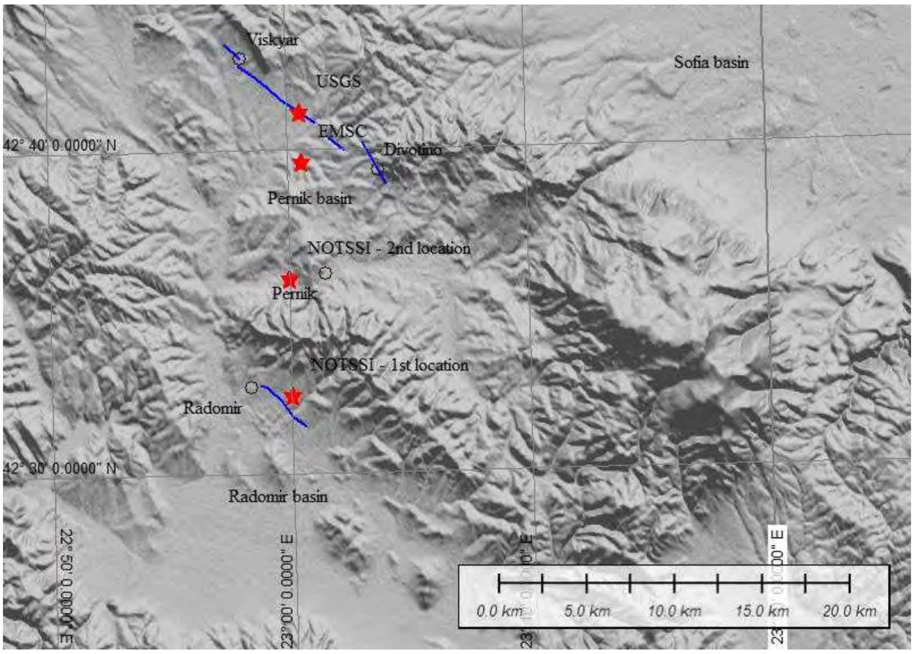

Figure 2. Different estimates of the May 22, 2012 epicenter (red stars) and visited suspected fault lines (blue lines).

Figure 3. Map of observed coseismic geological effects. Red lines show position of ground cracks. Black line: position of the resistivity profile.

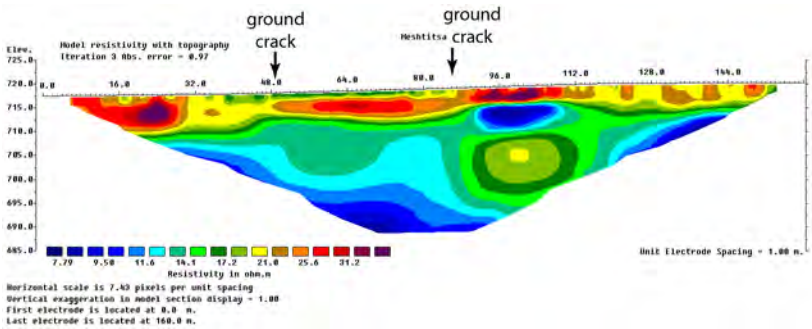

Figure 4. Resistivity profile on the Ralevska floodplain. Profile orientation SSW-NNE. SSW at the left-hand side.

Photo 118. Ground crack in the Ralevska floodplain. Scale is 8 cm high. 42.682746°/ 23.016906°

Photo 72. Ground crack with vertical displacement. 42.704152°/ 22.976076°

Photo 75. Maximum observed vertical displacement 5 cm. 42.703895°/ 22.976501°

Photo 78. Small active alluvial fan along the line where cracks with displacement were observed.

42.703264°/ 22.977720°

Part 2

Secondary seismic effects

Nikolai Dobrev, Plamen Ivanov, Boyko Berov, Miroslav Krastanov

(Department of Geohazards)

After the earthquake, epicentral area was visited by specialists engineering geologists with purpose to understand the secondary effects caused by the earthquake. The inspection was partly hampered by continuous rainfalls. These rains, on the one hand were blotting out visible surface traces of the earthquake and the other were acting as a destabilizing slope stability factor.

Landslides

In the region of Pernik, deep-seated landslides occurred mainly in open pit coal mines. In areas outside the coal exploitation, the landslides are predominantly shallow. The mechanism of movement is usually rotational of earthflow type. The examination of slopes at villages of Rudartsi, Kladnitsa and Studena, parts of Pernik and SW slopes of the Viskyar Mountain found that the landslides affect mainly road sections.

Landslide movements at road section Rudartsi-Kladnitsa triggered on May 27. A 20 meter stretch of roadway is damaged, the maximum subsidence is about 0.5 m (figure 2.1). There is a dangerous area above it, where deformations just have started. There are also 6 additional parts of road with older deformations developed in road embankment materials (figure 2.2).

Figure 2.1. Landslide damaged section of road Rudartsi-Kladnitsa (GPS point 664).

Figure 2.2. Location of landslide along the road Rudartsi-Kladnitsa and possible unstable sites

Other deformations have been also identified during the inspection on the road Pernik-Meshtitsa at 0.7-1.0 km before the Meshtitsa village (figures 2.3 and 2.4). The road passes through an old dormant landslide. The newest reactivations have started at left and right landslide flanks

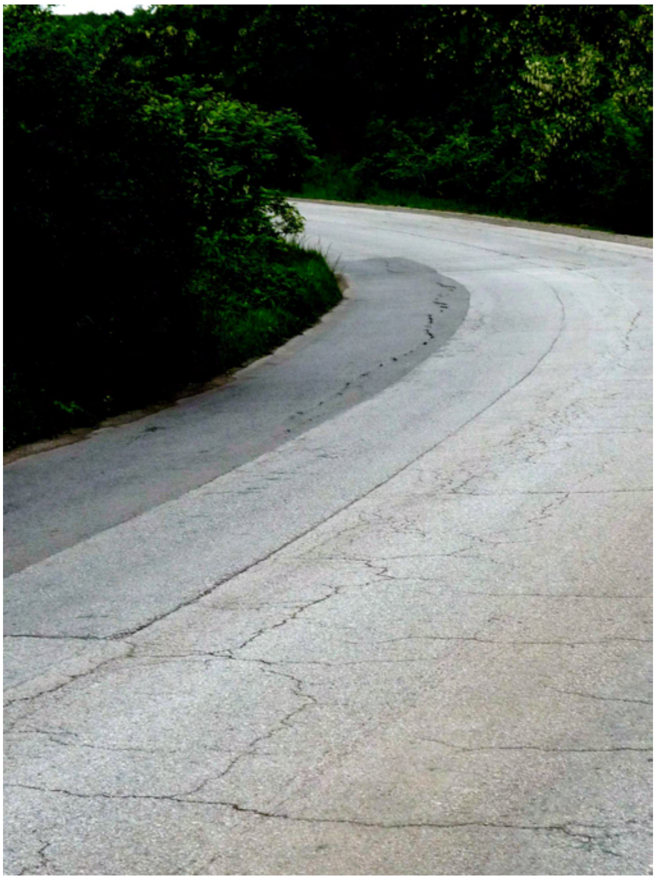

Figure 2.3. Fresh cracks at road Pernik-Meshtitsa (picture at GPS point 693)

Figure 2.4. Landslides at road Pernik-Meshtitsa. Actication was detected in the two side landslides

Information for a landslide activation during the earthquake near the Lyulin village was obtained from a local resident. During the inspection we established a deformed (subsided) road section only 10 meters long. However there were no clear signs of recent movement of the landslide, despite the presence of some smaller fresh scarps and typical folded forms. Similar traces were found at the neighboring larger landslide (in South), located on the end of the village.

On the west side of the road to the village of Rasnik, we estableshed a landslide with sizes: ~110 meters wide and max. 60 m long (figures 2.5 and 2.6). It is developed into extremely gentle slope inclination – just 3°. The landslide is of earthflow type, almost his entire body falls in marshy terrain. The body of the landslide is situated on the fault line scarp.

We have examined the lower terraces of the Struma River and other rivers in the Pernik valley. Flood plain of the Struma is the widest in Kralev Dol and Studena. There were no traces of soil liquefaction. The lower terraces of Struma river was swept over by high waters released from Studena Dam because of the danger of overflowing due to continuous rainfalls.

Figure 2.5. Small landslide scarp near Rasnik Village

Figure 2.6. Satellite image of the gentle landslide and the visible fault trace (red arrows)

Hydrogeological anomalies

During the earthquake, there is evidence of turbidity of water in some villages and springs. This has occurred in Byala Reka, Divotino and Meshtitsa. These is information on the occurrence of a strong smell of sulfur is in the spring of Rudartsi and in a well in the village of Divotino. Information on turbidity of water about two weeks before the earthquake is recorded for the village of Studena.

Acknowledgement

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