Results from geodynamic studies in the Krupnik-Kresna region for the period 2002-2005

Ivan Georgiev[1], Dimitar Dimitrov[1], Lyubka Pashova[1], Emil Botev[2], Stefan Shanov[3], Gabriel Nikolov[3], Krassimir Matev[1]

[1] Central Laboratory of Geodesy, Bulgarian Academy of Sciences, 1113 Sofia, Acad. G. Bonchev str., bl. 1;
E-mail: ivan@bas.bg
[2] Geophysical Institute, Bulgarian Academy of Sciences, 1113 Sofia, Acad. G. Bonchev str., Bl. 3
[3] Geological Institute, Bulgarian Academy of Sciences, 1113 Sofia, Acad. G. Bonchev str., Bl. 24

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Introduction

The region along the line Kochany-Pehchevo-Krupnik-Brezhani in Eastern Macedonia and South-western Bulgaria is one of the most active parts of the high seismic North Aegean area. About 10 strong historic earthquakes (magnitudes higher than 6.0) had occurred in this zone. The strongest shallow earthquake in South-eastern Europe in the last two centuries occurred in the Krupnik-Kresna area on 04. 04. 1904 with magnitude ~7.8. It is well known as Krupnik earthquake. Macroseismic data show that the most significant damages and losses of lives were located in the area Krupnik-Pehchevo-Kochany (the last two are in Republic of Macedonia). This line coincides with the WSW-ENE-oriented Krupnik fault. This fault was also a source zone for 1949, 1950 and 1953 earthquakes with moderate magnitudes (Shanov et al., 2001).

Krupnik-Kresna seismogenic zone, object of this study, ranges $41.8^0 \le \varphi \le 42.1^0$ and $22.9^0 \le \lambda \le 23.3^0$. The main goal is to establish the geodynamic settings on the basis of geodetic, geophysical and geological investigations. Special attention is paid to the geodetic analysis to constrain the kinematics and dynamics of this region using GPS and precise levelling data.

GPS network in the Krupnik-Kresna region

The local geodetic network in the Krupnik-Kresna region is designed for monitoring the horizontal crustal motion at the junction of Krupnik and Struma faults. The network is established in 1983-1984 (Милев и др., 1984). The original configuration consists of 16 points with pillars and enforced centring devices as average distance between points is approximately of 1-2 km. Angle, EDM and GPS measurements are performed during the period 1984-1992, but horizontal motions are not reported yet (Милев, 1999).

Data for vertical velocities and their analysis are published by Milev (Милев и др., 1984; Милев, 1999). Despite that levelling data are available only for the first-order levelling line Dupnitza—Dospat, conclusions have been made about the vertical movements of the tectonic blocks, which are not crossed from this line.

In early 2002 the reconnaissance of the network shows that some of the points are destroyed. For monitoring of horizontal motions six points — two on the southern side and four from the northern side of the Krupnik fault are chosen for GPS observations (fig. 2).

Results from new GPS measurements analysis

The six points were measured in the successive GPS campaigns from 2002 till 2004. Observation sessions are designed in 3 hours and minimum two times in different days. The elevation mask was 10 degrees and the measurement interval was 15 seconds.

Details about GPS data processing are given by Georgiev and Dimitrov (2006). The obtained horizontal velocities of the points are plotted in fig. 2 along with the 3σ error ellipses. All velocities are relative to Eurasian plate.

Reanalysis of the precise levelling data

Data from the precise levelling of the First order levelling line Dupnitsa-Dospat in four available epochs — 1956, 1978, 1986 and 2000, are used for determination of vertical velocities. The levelling line crosses the horizontal network and is parallel to the Struma fault.

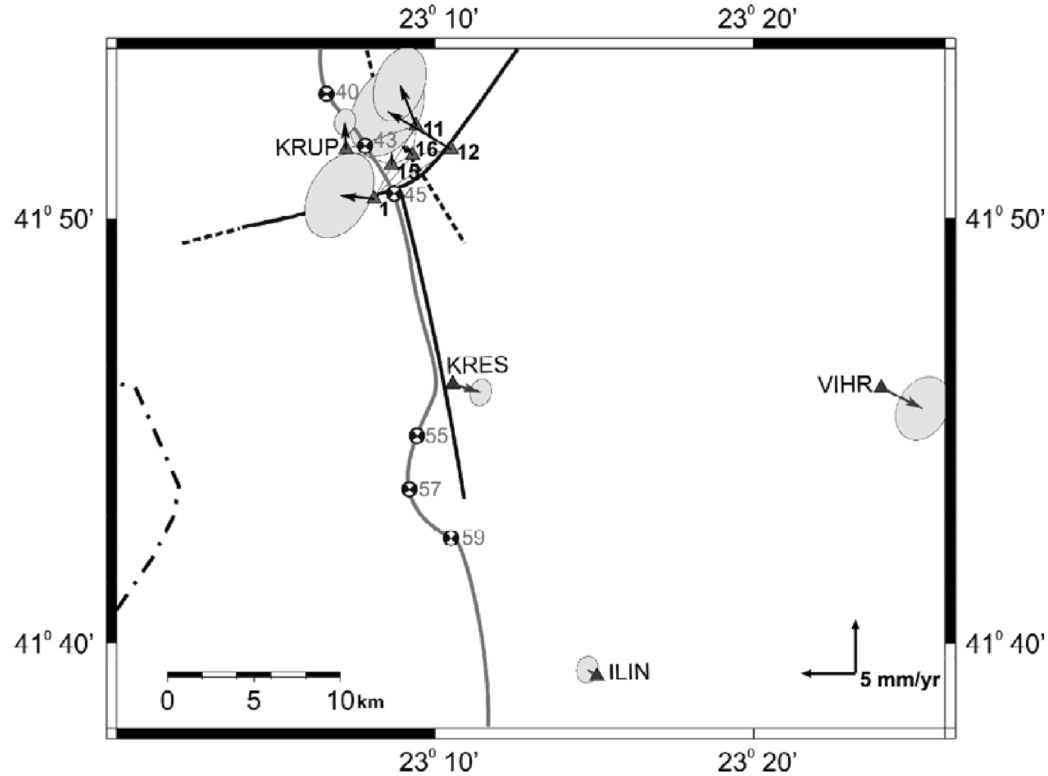

Fig. 1. Extension regime in the Krupnik-Kresna region

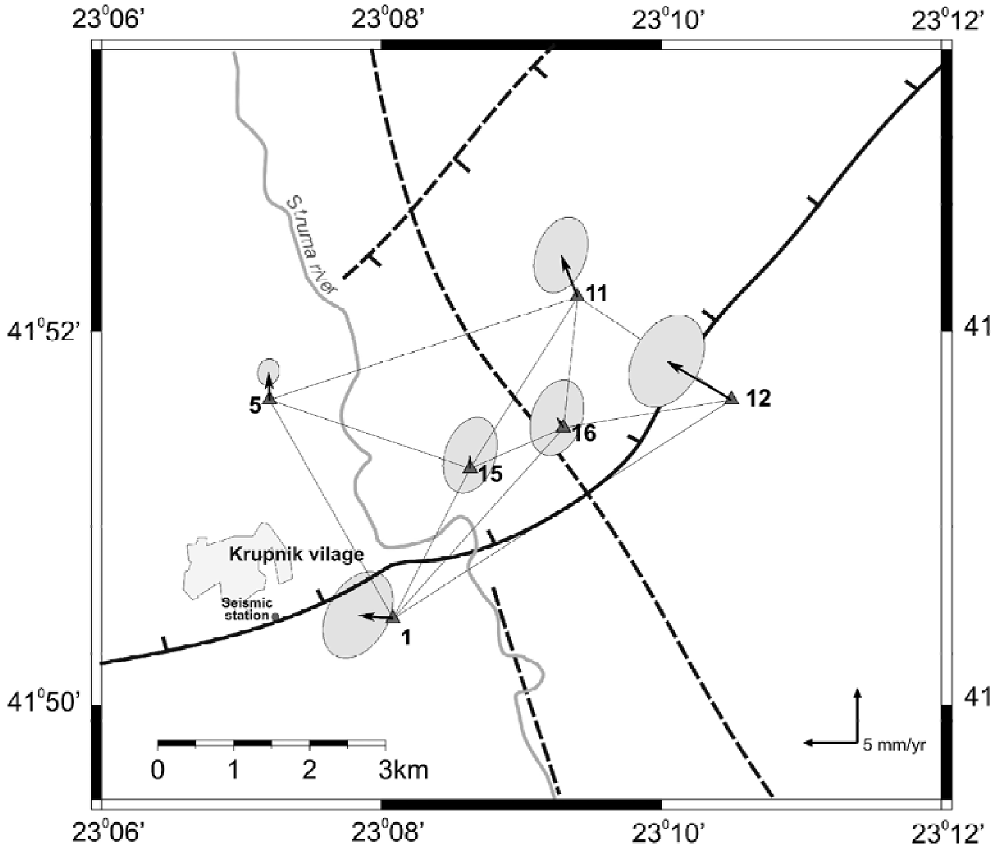

Fig. 2. GPS velocities of points from the local network in the Krupnik region

In the 52-km long section Barakovo-railway station (r. s.) Pirin of this line there are 9 benchmarks with heights in three epochs. Their height differences are calculated relative to the Barakovo benchmark for three periods — 1956—1978, 1978—2000, 1986—2000 and 1956—2000.

In figure 3 the topographic profile of the section Barakovo — r. s. Pirin is shown and the location of the Krupnik fault is also drawn. As it can be seen on the figure, during the period 1956—1978 the height differences are greater than in the second period 1978—2000 and are completely positive. The vertical velocities for the first period are within the range from 0.6 to 1.6 mm/yr. For the second period the velocities are within the range from —0.9 to 0.4 mm/yr.

Figure 3 shows also that there is a change in the height of the benchmarks from two sides of the Krupnik fault for epochs 1978, 1986 and 2000 relative to the first one 1956. The benchmark on the north side of the fault — r. s. Krupnik is subsided 17 mm (vertical velocity is — 0.7 mm/yr). The benchmark located on the roadman's lodge south of the fault is uplifted with 12 mm (vertical velocity is 0.5 mm/yr).

The results published by Milev (Милев и др., 1984; Милев, 1999) are based on precise levelling from few epochs — from 1956 to 1992. Comparing our results with before-mentioned we found the following differences: the vertical velocities from our study are two-three times less than those reported by Milev (Милев, 1999); we did not find alteration of signs of the vertical movements along the levelling line south of the crossing of the fault as those published by Milev (Милев, 1999).

Vertical movements along the same levelling line for the period 1986—2000 are reported by Dimitrov et al. (2001). Even that the reference benchmark and more of the benchmarks along the profile are different, the obtained results for height differences are practically the same as in this study. Nothing can be sad about the Struma fault activity because the levelling line is parallel to the fault.

Activity at the Krupnik fault from geodetic, seismotectonic and geological data

The average horizontal velocities obtained for GPS sites in Southwestern Bulgaria show a southeast motion of the whole region relative to stable Eurasia (Georgiev et al., 2006). We consider this motion as a consequence of the right-lateral strike-slip along the North Anatolian fault (NAF) with east-west orientation. Along with the southeast motion of SW Bulgaria, some of the graben structures show different directions of motion because of their deepening through the surrounding faults. That is true also for the Simitly graben. Deviations from this southeast motion are also manifested along the normal faults which is a result of the general extension in the region (fig. 1).

The normal motions to the north-north-west along the Krupnik fault result in horizontal motion of sub-

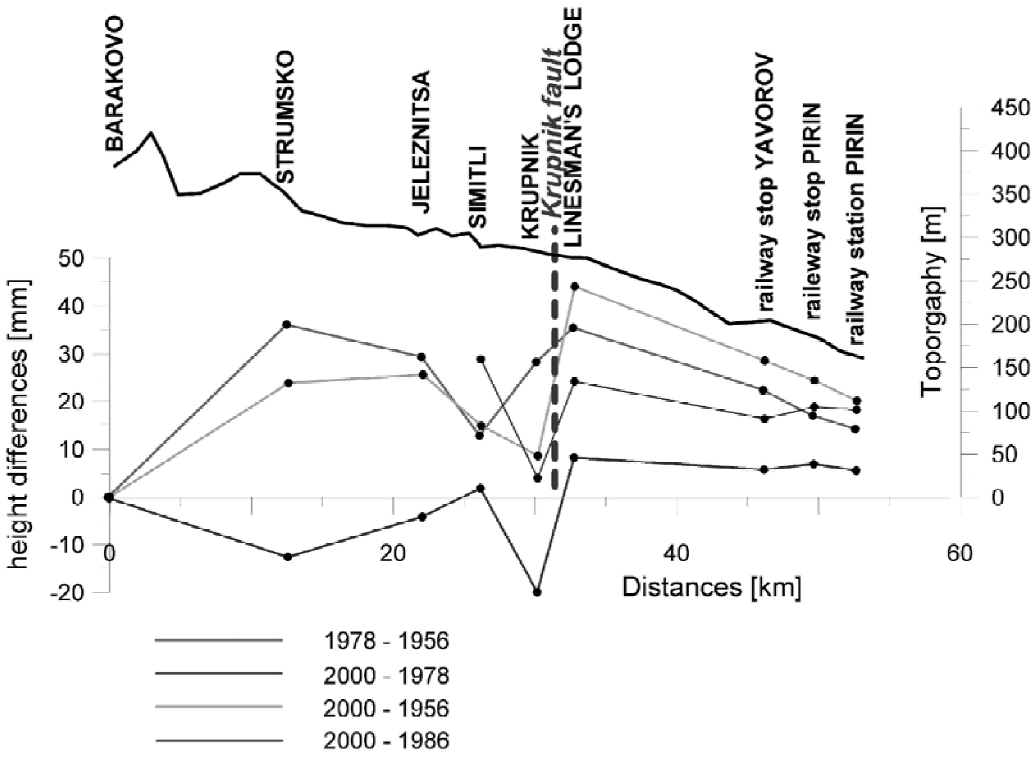

Fig. 3. Levelling profiles crossing the Krupnik fault

siding block in the same direction. This statement, determined by geological data, is confirmed by GPS-obtained velocities of the sites. The points 5 and 11 of the local network (fig. 2) show that the Simitly graben is moving north-north-west. Comparison of these velocities with the velocities of KRES, ILIN and VIHR (fig. 1) confirms clearly the extension of the region.

Points 1 and 12, located on the southern border of the fault, are very close to the zone of faulting and that is the reason that the horizontal velocities have also north-west direction. When the network is established, the intervisibility between the points has been sought for. The points are monumented nearly at the top of the granben's slope. The behaviour of these points is due not only from the northern block movement, but also by gravity motions along the slope of the Simitly graben.

From the leveling profile (fig. 3) an important inference can be draw: there is uplift to the south and subsidence to the north of the Krupnik fault exactly as suggested by the geological data. The fault divides the area, into southern and northern with opposite tendencies of vertical motions respectively.

Conclusions

Geodetic data constrained the recent crustal motions along the Krupnik fault. The important result is that the Krupnik fault is undoubtedly recently active. The geodetic results confirmed the geological hypothesis of the extensional regime of the Krupnik-Kresna region. Orientation of the extension is NNW-SSE, perpendicularly to the Krupnik fault, as at the same time the SW Bulgaria region is moving towards SSE with velocity of about 2 mm/yr relative to stable Europe.

References

Dimitrov D., I. Georgiev, E. Botev. 2001. New results from geodetic monitoring of the Kroupnik-Kresna seismotectonic area (South-West Bulgaria). — *Geologica Balc.*, *31*, 1—2, 99—100.

Georgiev, I. D. Dimitrov, L. Pashova, S. Shanov, G. Nikolov, E. Botev. 2006. Geodetic constraints on kinematics and dynamics in South-western Bulgaria. — *Geodesy*, *17*, 70—84.

Georgiev, I., D. Dimitrov. 2006. Assessment of horizontal velocities at South-western Bulgaria by GPS. — *Geodesy*, *17*, 15—34.

Shanov, S., K. Kurtev, G. Nikolov, A. Boykova, B. Rangelov. 2001. Seismotectonic Characteristics of the western periphery of the Rhodope Mountain region. — *Geologica Balc.*, *31*, 1—2, 53—66.

Милев, Г., В. Връблянски, Р. Симеонова. 1984. Съвременни движения в района на Кресненското дефиле и Крупнишкия разлом. — В: *Проблеми на геологията на Югозападна България*. София, Техника, 72—79.

Милев, Г. 1999. Обобщение на резултатите от геодезическите измервания и изследвания в района на Струмската разломна зона — пресичането на Струмския и Крупнишкия разлом. — В: *Симпозиум „Геодинамични изследвания свързани със земетресенията от 1904 г. в Крупник-Кресна"*, Благоевград, 27—28 април 1999 г., 155—166.

Резултати от геодинамични изследвания в района на Крупник-Кресна за периода 2002-2005

Иван Георгиев[1], Димитър Димитров[1], Любка Пашова[1], Емил Ботев[2], Стефан Шанов[3], Габриел Николов[3], Красимир Матев[1]

Резюме. Крупник-Кресна е една от най-активните в сеизмично отношение области на Северно-Егейската сеизмична зона. В статията са представени накратко основните резултати от геодинамичните изследвания, проведени за периода 2002—2005 г. от Централната лаборатория по висша геодезия, Геологическия и Геофизичния институти при БАН. Установените от геодезическите измервания съвременни хоризонтални и вертикални движения на земната кора са в съответствие с геоложките и сеизмотектонските модели. Геодезическите данни потвърждават екстензионния режим в посока ССЗ-ЮЮИ, перпендикулярно на Крупнишкия разлом.