On the Seismotectonics of SW Bulgaria by seismological and geodetic data

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Върху сеизмотектониката на Югозападна България по сеизмилогични и геодезични данни
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Абстракт: Представят се резултати от сеизмологичния и геодезичен мониторинг в Югозападна България. Специално внимание се отделя на моделирането на полето на напреженията и деформациите. На базата на съвместния анализ на данните за скоростите на придвижване, деформациите и напреженията, са получении нови резултати за деленето и взаимодействието на земекорните блокове в изследвания район.

Central Balkan region is well known by its high seismicity: since I century BC at least 10 events with magnitude M ≥ 6 have been occurred on its teritory and the adjacent lands. The strongest known event is the earthquake of April 4, 1904 with a magnitude Ms 7.8 (Christoskov and Grigorova,1968; Meyer B. et al.,2007); it occurred in the Krupnik source zone. On the picture of the Fig.1., an isoseismal map of this earthquake is presented together with some seismotectonic characteristics of the region of interest. Macroseismic data show that the most significant damages and losses of lives were located in the area Krupnik-Pehchevo-Kochany.

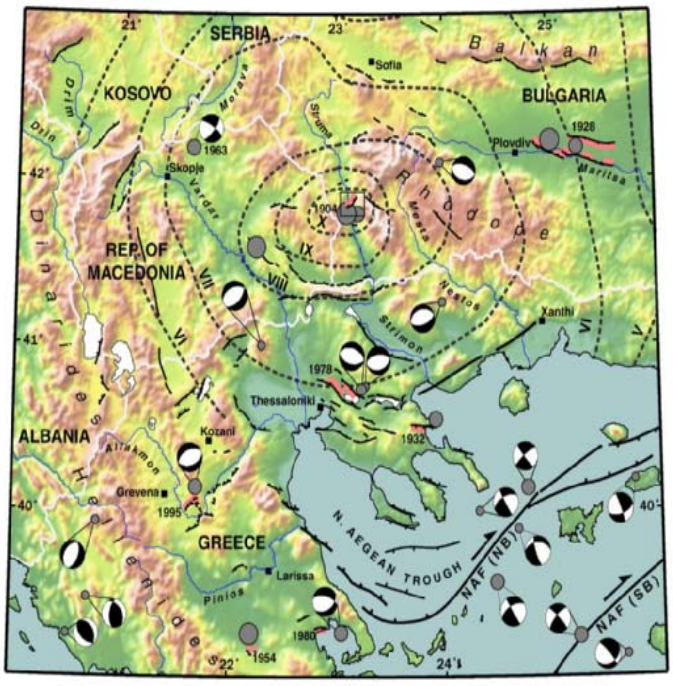


Fig.1. Seismotectonic map of the region wit the isoseismal curves of 1904 event

For the time after 1928 grey circles present the epicenters of earthquakes with fault plane solutions available and magnitude 5 < Ms < 7 (Meyer et al., 2007). The focal mechanisms of the earthquakes are taken from the catalogue CMT of Harvard University.

Instrumental seismicity registered by modern National seismological network of Bulgaria (started in operation in 1980) is presented on Fig.2., by means of the epicentres of events with magnitude M>3.0, for which the highest level of completeness is reached (Solakov &Simeonova,1993; Botev et al., 1993-2008; Botev et al., 2010) . The picture of the seismicity and many papers (Botev et al., 1991-2006; Botev,2000;) show that the ***Central Balkan region*** is the zone with highest level of the frequency of earthquakes not only for South-western Bulgaria.

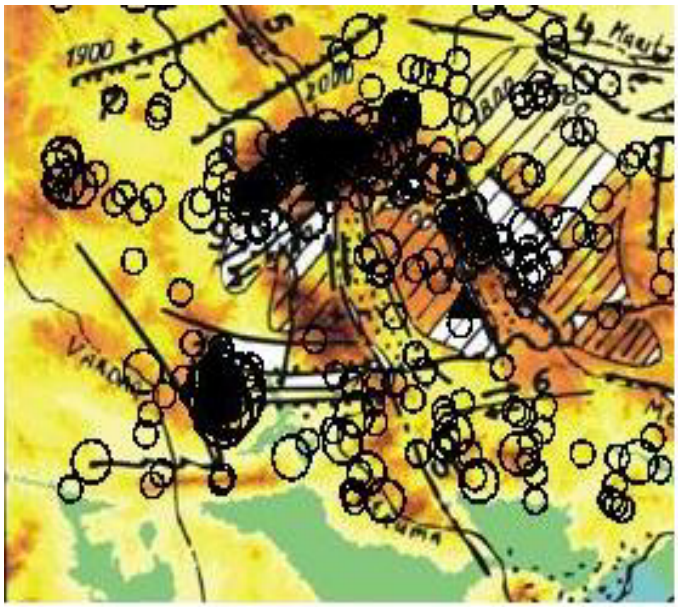


Fig. 2. Map of the instrumentally registered events with magnitude M>3.0 after 1980.

The reliable fault plane solutions of the events with magnitude M>3.0 after 1980 are presented on Fig.3. Calculated focal mechanisms of the earthquakes (Botev et al., 2006) show that the earthquakes are caused by the tectonic activation of predominantly normal faults, situated around the Krupnik source zone.



Fig.3. Map of the reliable fault plane solutions of the events in SWBulgaria after 1980

As well as the Krupnik zone is the zone with the biggest regional significance in SW Bulgaria, special multidisciplinary investigations have been performed namely here by Geophysical institute, Geological institute and Central Laboraory of Geodesy (CLG) of Bulgarian Academy of Sciences (BAS). Special attention is paid to the geodetic analysis in order to constrain the kinematics and dynamics of this region using present-day GPS and precise levelling data.

The local geodetic network in the Krupnik region is designed for monitoring the horizontal crustal block motion. The original configuration consists of 16 points with and the first GPS measurements are performed during the period 1984-1992, but horizontal motions are not revealed. Precise GPS measurements started in 1995 by means of many times measuring of the classical points and correlations with other measurements. One idea about the geodetic network and the distribution of geodetic points of measurements in SW Bulgaria could be assumed by the picture on Fig.4 and Fig.5. Geodetic data constrained the recent crustal motions along the Krupnik fault and confirmed its tectonic activity. They also show that the region is undergoing the extension and are in agreement with the seismotectonic and geological information. The field of seismotectonic deformations is generally characterized by predominance of NW-SE horizontal extension. From NE to SW the direction of extension changed gradually to WNW-ESE.

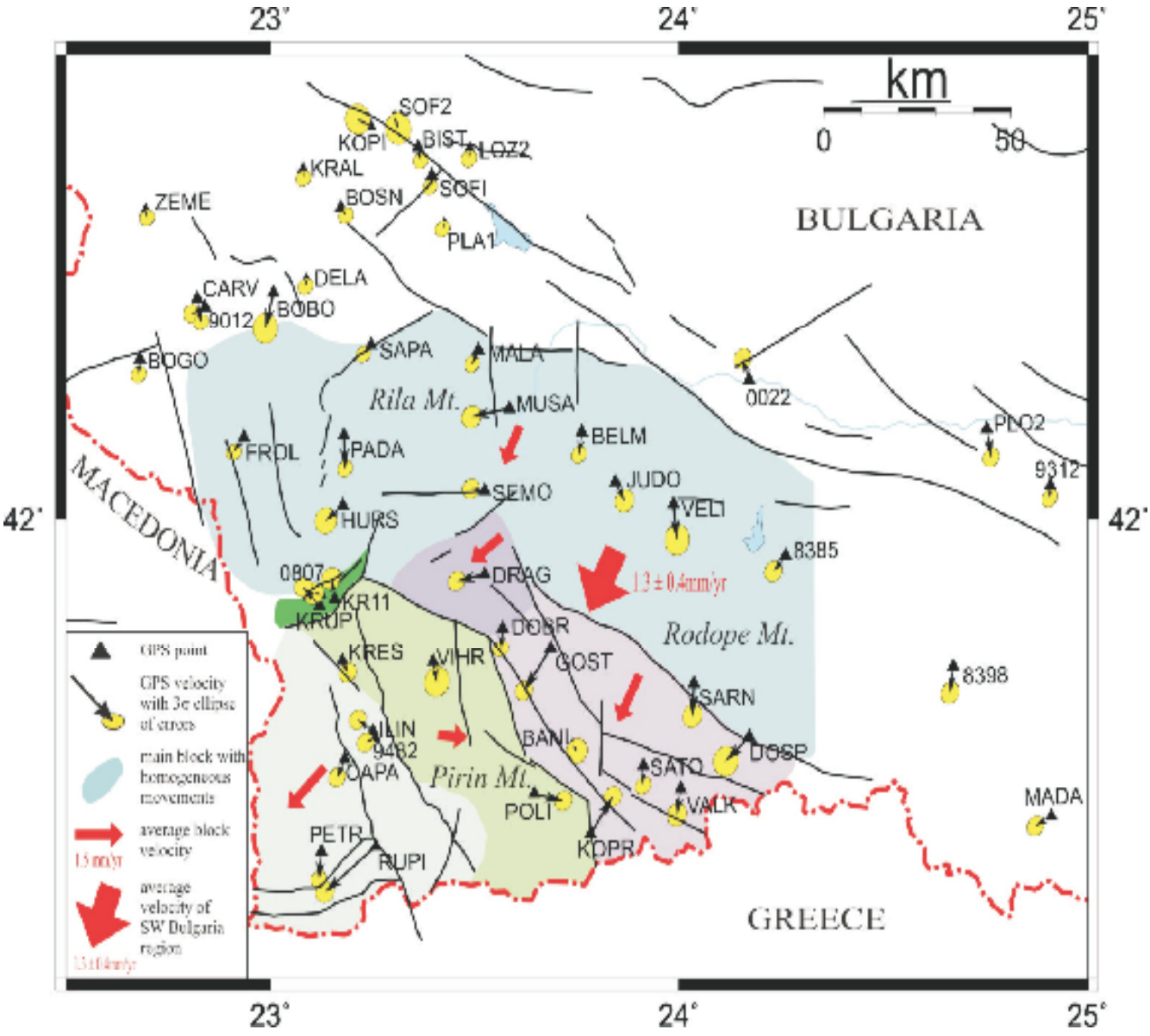


Fig. 4. Results of GPS monitoring of SW Bulgaria area

Analysing the results of the focal mechanism inversion, the region can be divided into four zones – Krupnik, Rila, Mesta and Belasitsa (Fig.5, red color arrows). Krupnik, Rila and Belasitsa zones are characterized by a strike-slip stress regime with relevant normal component and with maximum compressive stress oriented E-W. A strike-slip stress regime with relevant normal component affects the Mesta zone, but the maximum compressive stress is oriented ENE-WSW. The maximum compressive stress for all zones is accompanied by strong dipping. The minimum stress is almost horizontal and oriented N-S for Krupnik, Rila and Belasitsa zones and NW-SE for Mesta zone. The final results of stress tensor inversion for SW Bulgaria show that the maximum compressive regional stress is subvertical with approximately E-W direction. The minimum stress is almost horizontal and oriented N-S. The significant strike-slip component in the normal faulting stress field affecting the region is the consequence of the movements induced by strong subhorizontal movements along the North Aegean Trough and the North Anatolian fault. The normal stress regime, as a result of geological and tectonic processes, agrees with the interpretation of the present-day extensional regime characterizing the back-arc conditions. It should be pointed out that the strain obtained from the horizontal velocity is related to the Earth's surface and is obtained for each triangle of the GPS network. While the regional stress tensor obtained from the inversion of the focal mechanisms is computed by minimizing the differences between observed and resolved slip direction. Generally, the coincidence between geodetically obtained strain and seismically determined stress tensors in SW Bulgaria is very good.



Fig. 5. Comparison between the results for geodetic strain in SW Bulgaria and the mean stress tensors

On the base of the complex analysis of the contemporary seismicity, geodetic modeling and fault plane solutions modeling we can conclude that the present tectonic activity in the SW Bulgaria is associated very well with the main geodynamic processes in the central part of Balkan region. The obtained results constrained the complicated tectonic model of SW Bulgaria and contribute to understand the dominant regional extension N-S regime. Summarizing the presented data it is evident that movements exist between the following horsts and grabens: Pirin horst and Sandanski graben, Kresna horst and Simitli graben and Beslet horst and Dospat graben.

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