Focal mechanisms of some earthquakes in Rhodope seismic zone

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Abstract:
The present paper contains information on the results of the fault plane solutions of the stronger seismic events in Rhodope seismic zone recorded by the National Operative Telemetric System for Seismological Information (NOTSSI). In the study new results of the present state of stress field in the central part of south Bulgaria are obtained based on evaluation of 46 earthquake focal mechanisms. The results confirm the recent seismotectonic models for southern Bulgaria.

Key words:
earthquakes, fault plane solution, faulting, geodynamics

Фокални механизми на земетресения в Родопската сеизмична зона

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Абстракт:
Настоящата работа съдържа обобщена информация за резултатите от събирането, обработката и анализа на данните и решенията на фокалните механизми на по-силните сеизмични събития в Родопската сеизмична зона, регистрирани от Националния Оперативна Телеметрична Система за Сеизмологична Информация (НОТССИ) през последните 30-на години. Получени са нови резултати за регионалното поле на тектонските напрежения върху тази част от територията на Южна България, основани на оценката на фокалните механизми на 46 земетресения. Така получените сеизмологични резултати потвърждават известни геодинамични модели за територията на Южна България.

Ключови думи:
земетресения, решения на фокални механизми, геодинамика

The focal mechanisms of earthquakes can provide important information about the fault structures and the stress field in the medium where the earthquakes occur. The source of a small earthquake is typically approximated by a double-couple point source, or focal mechanism, derived from observed P-wave first-motion polarities. A focal mechanism (fault-plane orientations and slip directions) represents two orthogonal nodal planes that divide a reference sphere around the source into four quadrants: the first motion in two of them should be away from the source (cause compression), and in the other two quadrants the first motion should be toward the source (cause dilatation). First-motion-polarities are observed at seismic stations, and the position on the focal sphere for each observation is the azimuth and take-off angle at which the ray leaves the source, is computed for an assumed hypocenter location and seismic-velocity model (Botev et al., 1996). The computing program for determining the parameters of the seismic events is an adaptation of the widespread product HYPO'71 (Solakov, 1993). A focal mechanism can then be found that best fits the first-motion observations.

The program FOCMEC (Snoke, 2009) is used for the determination of the earthquake focal mechanisms in Rhodope seismic zone. For the purposes of the present study, all the available data for focal mechanism

determinations were collected, checked, tested according to the requirements of the computing program. Input data are the polarities of the P wave (the number of input data is in the range 9 – 49), azimuth and take-off angle at which the ray leaves the earthquake source. Output data are all possible orthogonal nodal planes that separate the compressional and dilatational first motions. Some polarities were checked as waveforms (data from NOTSSI and ORFEUS database - ftp://www.orfeus-eu.org/pub/data/continuous/2012/), the strike, dip and rake are determined by FOCMEC software with accuracy up to 10 degrees and the solutions are displayed in lower hemisphere projections.

The obtained 46 well constrained fault plane solutions in Rhodope seismic zone are shown in Fig.1. The epicenters of 41 of these earthquakes are located on the territory of Bulgaria and only 5 on the boundary territory of Greece. Concerning the parameters of fault plane solutions it could be summarized that clear strike-slip mechanisms are very small number and almost all events are normal or reverse type with or without some strike-slip component. The most finally accepted focal mechanisms of shallow earthquakes are dip-slip with strike-slip component. The most obvious is the presence on a large scale of normal mechanisms decreasing from West to East Rhodopes. The normal component of dip-slip motions is predominant in Rhodopes, with the exception of the Kardzhaly area where reverse and normal mechanisms are in some balance.

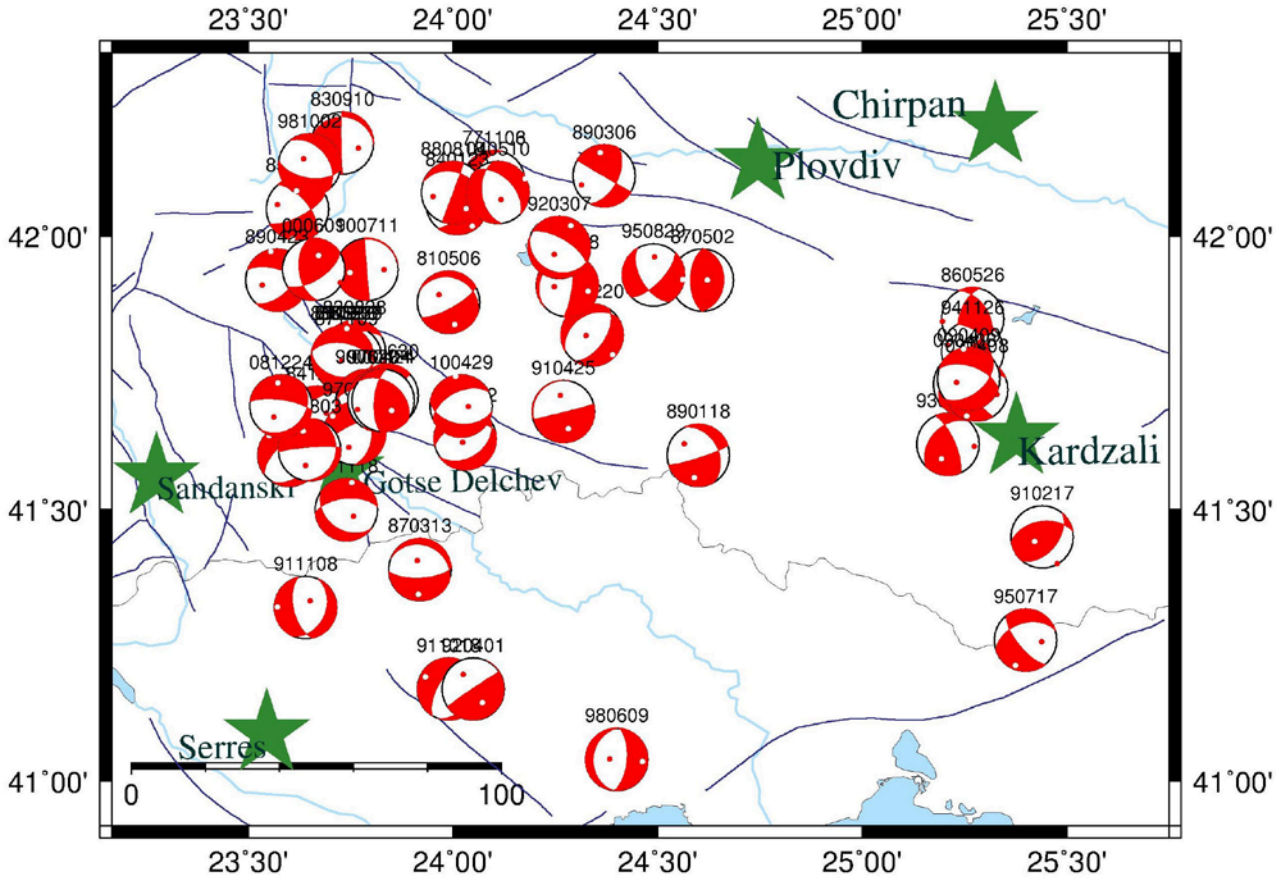

Fig.1. Graphic presentations of the fault plane solutions in the Rhodope seismic zone. (The Generic Mapping Tools - http://gmt.soest.hawaii.edu/home, the tectonic map is compiled after Barrier et al., 2004 and Georgiev et al., 2007). The stars mark the location of the cities Plovdiv, Chirpan, Sandanski, Gotse Delchev, Kardzhali and Serres.

The Rhodope seismic zone spreads between Strouma and Srednogorie zones in Bulgaria covering the Rhodope mountainous massif and the easternmost edge of the Rila mountain. The epicentres of the almost 40

earthquakes with fault plane solutions in the western parts of Rhodopes are diffused without any clusterization. The predominant slip component is normal: the solutions do not show any typical strike or dip of the nodal planes. The orientation of the nodal planes does not manifest a clear trend, although a slight tendency in the E-W direction can be suggested. The seismic activity is mainly associated with the Chepino, Dospat, Devin and Ardino depression fault systems and some smaller seismic faults which mark the boundaries between uplifted local dome structures within the Rhodopes. The fault plane solutions in the eastern part of the investigated region mark the meridian oriented boundary between central and eastern parts of Rhodopes.

The most relevant characteristic of the stress axes corresponded to the fault plane solutions in the Rhodope seismic zone is the almost horizontal orientation of the T-axes in the NNW - SSE direction for the western part of the investigated region (Fig. 2). There is no clear predominant trend of the P-axes excluding cases of subhorizontal axes where the E - W direction dominates. In many of the latter cases a strike-slip mechanism of faulting (with normal dip component) can be recognized. The plunge angle of the P-axes is larger in comparison with that one of T - axes. For the eastern part of the investigated region predominant subhorizontal orientation of the P-axes is recognized. The E - W direction of this orientation dominates here too.

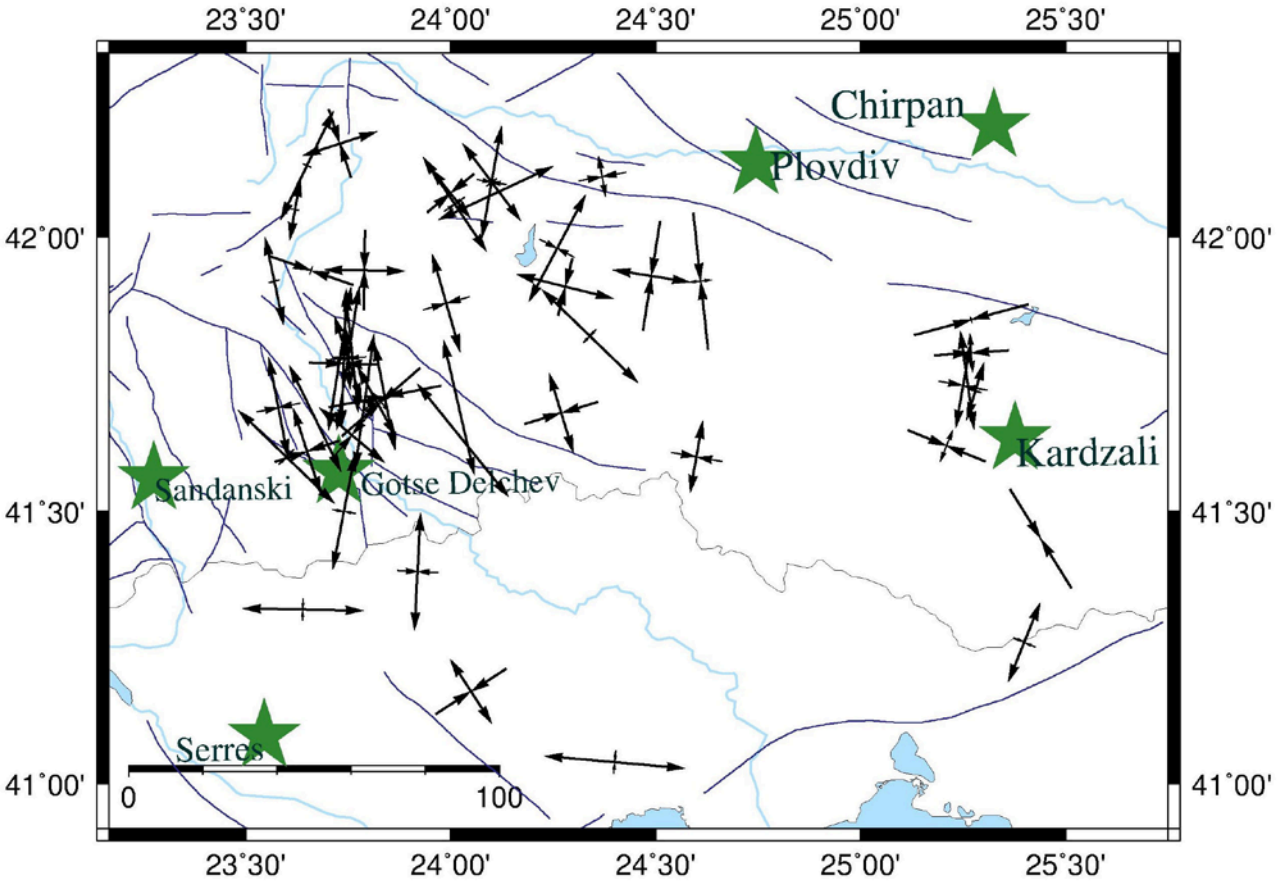

Fig.2. Horizontal projections of the individual P and T axes of the earthquakes with focal mechanisms in the Rhodope seismic zone (The Generic Mapping Tools - http://gmt.soest.hawaii.edu/home, the tectonic map is compiled after Barrier et al., 2004 and Georgiev et al., 2007). The stars mark the location of the cities of Plovdiv, Chirpan, Sandanski, Gotse Delchev, Kardzhali and Serres.

The most evident common characteristic of the stress field in Rhodope seismic zone is the domination of a normal stress regime as it is derived from orientation of the stress axes on Fig. 2. As a whole the Rhodopean

zone is characterized by a normal strike-slip regime with generally N–S oriented stress of tension with maximum compressive stress oriented E-W.

The observed sub-horizontal uppercrust extensional stresses with predominant N-S trend of the T-axes are consistent with the general trend of the regional extensional field on the territory of Bulgaria (e.g., Protopopova et al., 2013). This stress field corresponds to that found in southern Bulgaria (Van Eck and Stoyanov, 1996) and confirms the hypothesis that the quaternary movements in Balkan Peninsula region are the consequence of the long lasting extensional movements in the inner parts of the Aegean and Central Balkan regions.

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