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SEISMIC PROFILE WITHIN THE PIRIN MOUNTAIN (SOUTHWEST BULGARIA)

Abstract: Pirin Mountain (N 41.46; E 23.24) is the second highest morphounit in Bulgaria and the third highest one within the Balkan Peninsula. The tectonics position in the eastern part of the Balkans determines the peculiarities of seismic activity. The article focuses on the seismic picture within the study area for the statistical period 1965-2018 using the free earthquake catalogue of USGS Seismic Hazard Program. For this purpose, in order to better reflect the results of the survey, different contemporary new GIS based maps were prepared. This is one of the main merits of the proposed study.

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INTRODUCTION

Pirin Mountain is the second highest mountain in Bulgaria (Vihren peak- 2914 m) and the third highest one in the Balkan Peninsula. It a component part of the Rila-Pirin Mountains Range (*Tzankov* et al., 2017), which besides the Rila, Pirin and Slavyanka mountains in Bulgaria also includes the series of little mountains in Northern Greece (almost to the Aegean coast).

Prirn Mountain represents a crystalline horst located in northwest–southeast direction. The total area of the Pirin Mountain is 2585 кm2. It has a length of 70 km and a width of approx. 30-35 km. The average altitude is 1033 m. The topography is predominantly high mountainous. The alpine zone occupies 32% of the total area. The submeridional horst of the Pirin Mountain traditionally divided into North, Middle and South parts (*Nikolov* et al., 2013).

Geographically, Pirin Mountain occupies an intermediate position within the Balkan Peninsula. Given that the Pirin lands are sufficiently close to the main tectonic processes in the Aegean region. This inevitably affects the nature of seismic activity in the Pirin region.

The main goal of the proposed study is to present the results of the seismic activity analysis within the Pirin Mountain for the statistical period 1965-2018. Several new GIS based seismic maps of the surveyed lands were created for this purpose.

STUDY AREA

The study area covers the territory of the Pirin Mountain. Pirin Mountain (N 41.46; E 23.24) is situated in Southwestern Bulgaria (Fig.1). It bordered to the north with the Rila Mountain (through the

Predel Saddle (1170 m) and the Matnitsa River valley), to the south it reaches the Slavyanka Mountain and Stargach Mountain. To the west bordered with the Struma River Valley and to the east with the Mesta River Valley.

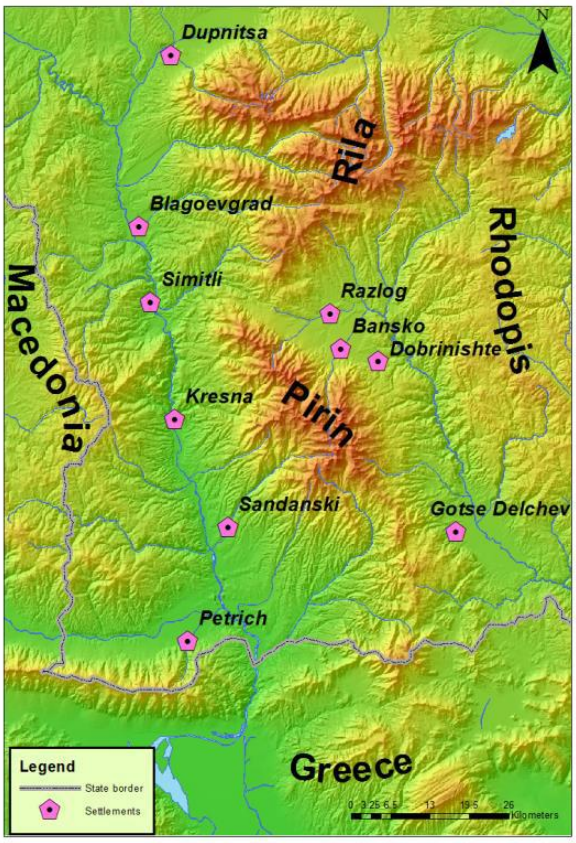

Figure 1 Geographic position of the Pirin Mountain in the eastern part of the Balkan Peninsula

METHODS AND DATA

The proposed study is based on the contemporary morphotectonics concept for the eastern part of the Balkan Peninsula in connection with the transcontinental collision between Gondwana (African plate) and Neo Europe (Eurasian plate). The theoretical foundations of these ideas are set out in several publications (*Tzankov* et al., 2015, 2016, 2017, 2018). In the course of the earthquakes analysis in the Pirin Mountain, a free earthquake catalog of the USGS Seismic Hazard Program (online available from https://earthquake.usgs.gov/earthquakes/search/) for the statistical period 1965-2018 was used. The seismic data visualization was performed using a free GIS software QGIS.

SEISMIC PROFILE WITHIN THE PIRIN MOUNTAIN FOR THE 1965-2018 STATISTICAL OF PERIOD

TECTONIC PRECONDITIONS FOR THE SEISMIC ACTIVITY

In seismic terms the Pirin Mountain lands are part of the Aegean seismic zone of the Alpine-Himalayan seismic belt. In its length realize 5-6% of earthquakes around the world (*Koronovskiy*, 2003). The Aegean region is one of the most active parts of the Mediterranean region in geodynamic sense. Seismicity here is a specific reflection of the processes in the Earth's crust and the uppermost part of the Earth's mantle. The concentration of seismic events around the Aegean Sea is much higher than in platform and mountain regions of Europe, North Africa and the Middle East.

In tectonics sense the surveyed lands are subject to ongoing intercontinental collision between the Eurasian (Neo Europe) and African (Gondwana) plates (Fig.2) (*Dewey* et al., 1989; *Le Pichon* et al., 1988; *Royden* and *Burchfiel*, 1989; *Argnani*, 2006; *Tzankov* et al., 2015, 2016, 2017, 2018). In the region of the Aegean Sea the tectonics situation is further complicated by the movement of Arabian plate to the northwest (Dewey & Sengör 1979;

Sengör et al. 1985, 2005; Hubert-Ferrari et al. 2002; 2009). This process activates the North Anatolian transform fault and further increases seismicity in the Aegean region. A significant part of created in these processes seismic energy is "released" in the areas of the Middle Struma complex morphostructural passage and the Middle Mesta complex morphostructural passage, which surrounds the Pirin Mountain from the east and west. This explains the increased "secondary" seismic activity in the relevant parts of Southwest Bulgaria (*Tzankov* et al., 2016, 2017).

Figure 2 Main tectonic processes in the Eastern Mediterranean region (GIS data: USGS)

SPATIAL DISTRIBUTION OF EARTHQUAKES WITHIN THE PIRIN MOUNTAIN

In spatial terms, earthquake events are concentrated mainly on the periphery of the mountain (Fig.3). In the central parts of the Pirin Mountain for the last 50 years seismic activity is almost not registered. The seismic events here are related to the activity of the fault structures along the valleys of the Struma and Mesta rivers. With the highest density of seismic epicenters are the lands along the Krupnik fault (located between the Pirin Mountain and Rila Mountain). With this fault is associated the strongest instrumental earthquake in continental Europe (occurred on April 4, 1904). Its magnitude is estimated at 7.8 (*Christoskov* and *Grigorova*,1968). In this area, besides one of the most powerful seismic phenomena across Europe, about 30% of the contemporary low seismicity in Bulgaria is generated (*Botev* et al., 2013).

Pirin Mountain is characterized by a moderate frequency of earthquakes. For the period 1965-2018, the low magnitude earthquakes dominated. Only few stronger earthquakes (M≥4) occurred. For this period, the strongest earthquake occur in 2016 (with epicenter in the area of Ploski village, Sandanski municipality) and has magnitude of 4,3 (Fig.3). For the study period the average magnitude is 2,8.

With regard to the focal depth, 79% of the earthquakes occurred at a depth of up to 20 km. The deepest seismic event occurred at a depth of 49 km (Fig.4). The average focal depth for the study period is 10,8 km.

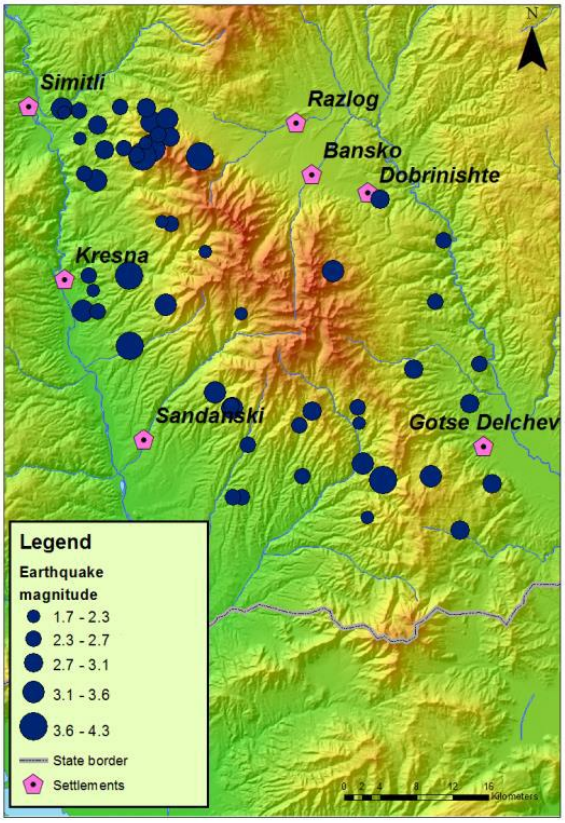

Figure 3 Distribution of earthquakes in the Pirin Mountain by magnitude for the period 1965-2018 (Seismic data source: USGS Seismic Hazard Program, online available from https://earthquake.usgs.gov/earthquakes/search/)

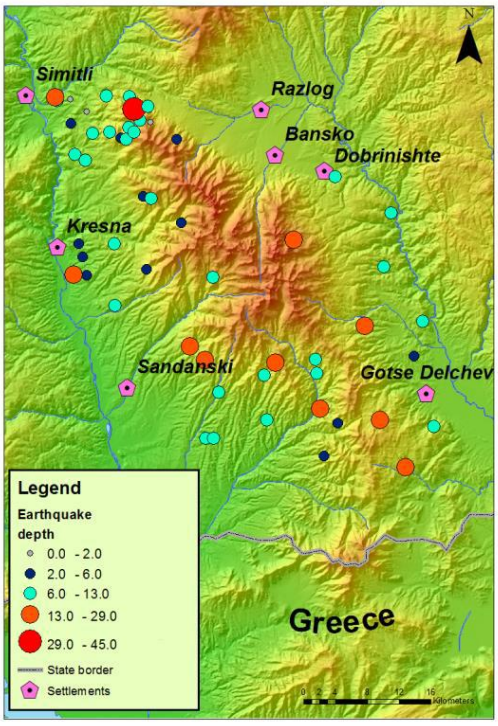

Figure 4 Distribution of earthquakes in the Pirin Mountain by focal depth for the period 1965-2018 (Seismic data source: USGS Seismic Hazard Program, online available from https://earthquake.usgs.gov/earthquakes/search/)

The contemporary seismic activity in the Pirin Mountain concentrates mainly on the western and southeastern edges of the mountain (Fig.5).

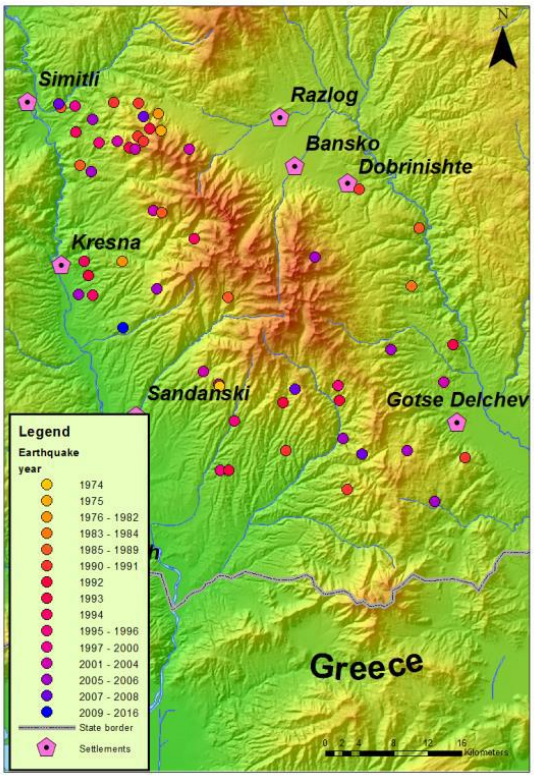

Figure 5 Distribution of earthquakes in the Pirin Mountain by years for the period 1965-2018 (Seismic data source: USGS Seismic Hazard Program, online available from https://earthquake.usgs.gov/earthquakes/search/)

RESULTS AND DISCUSSION

The results obtained in the course of the study can generally be summarized as follows:

1) The seismic phenomena within the Pirin Mountain are concentrated mainly on the periphery. The seismic energy is released mostly along the Krupnik fault, along the Middle Struma complex morphostructural passage and along the Middle Mesta complex morphostructural passage. The rest of the mountain is almost seismically no active.

2) For the period 1965-2018, low magnitude earthquakes prevail. The strongest earthquake event is 4,3.

3) The earthquakes in the Pirin Mountain have a maximum focal depth of 45 km, dominated by the depths of up to 20 km (shallow to very shallow earthquakes). This is an attestation of the totally crustal nature of seismic events.

4) Over the last decade there has been an increase in seismic activity in the Pirin Mountain, which is also reflected in the magnitude of earthquakes. Moreover, for the period 1965-2018 all the stronger earthquakes (M≥4) occurred in the last 10 years.

In general, the Pirin Mountain shows an absolute similar seismic profile compared to the neighboring positive mountain morphounits located to the north, west and east (Rila Mountain, Rhodope Mountains, Bregalnitsa Mountains Range). The mountains located to the south (the range of medium-high mountain units in northern Greece) have a lower seismic activity. The similarity in seismicity is absolutely justified, given the nature of the tectonic processes operating in the region.

CONCLUSION

The conducted study reflects the results in relation to the seismic activity analysis within the Pirin Mountain. In general, Pirin Mountain is characterized by moderate seismic activity. Seismic phenomena are mostly weak and occur at a small depth. This is conditioned by the nature of the tectonic processes that create them. The results obtained and the new seismic maps developed in connection with this offer a better interpretation of the geodynamic situation in the southwestern part

of Bulgaria and in the eastern part of the Balkan Peninsula as a whole. This, in turn, may serve as the basis for various comparative studies in the future.

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