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Earthquake mechanics in slowly deforming intraplate settings: a seismotectonic study of a 2010 Kraljevo seismic sequence (Internal Dinarides, Serbia)

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The western Balkan Peninsula, situated in the area of the Cenozoic Dinaric orogen, hosts some of the strongest and most destructive earthquakes in Europe, either historical or instrumentally recorded ones. However, the seismicity distribution, earthquake focal mechanisms and GPS studies of the shortening between the Adriatic microplate and the Pannonian basin, suggest that most of the deformation is accommodated within the External Dinaric fold-and-thrust belt, leaving behind the Internal Dinarides being described as a 'locked' area, seismically relatively inactive. In contrast to that, several relatively strong and destructive earthquakes have been recorded in the Internal Dinarides, far from the area of the most active deformation. Although most of these earthquakes were highly destructive and even caused fatalities, none of them gained much attention, hence the seismogenic potential of these seismic zones remained poorly constrained. One of such seismic zones is located near the town of Kraljevo in central Serbia, and was characterized by a seismic sequence that started with a magnitude (mb) 5.3 Kraljevo earthquake on 3rd November 2010.

The main aim of this study is to determine and discuss seismotectonic characteristics of the 2010 Kraljevo seismic sequence. We tried to constrain causative faults of the main shock and the strongest aftershocks and to propose a model of strain redistribution during this seismic sequence. For these purpose, catalogue data about earthquakes as well as new focal mechanisms calculated for this study, were used. A fault pattern of the research area was determined using stereoscopic SPOT images and digital elevation model. The timing of faults' activity and their kinematics were constrained by a combined approach of tectonic geomorphology and the analysis of reflective seismic profiles.

The results show that the main earthquake of the sequence is most likely released along the NW – SE striking sinistral fault, referred to as the Sirča fault, situated about 5 km north of the city of Kraljevo. Deformational pattern of geomorphological features indicates that this fault presumably consists of several strike-slip segments, with the cumulative displacement that does not exceed a few kilometers. With the assumption that the fault was active since the Late Miocene ($\sim$ 9 Ma), it appears that the maximal slip rate along the most active segment of the Sirča fault is no more than 0.4 mm/yr. Focal mechanisms of the strongest aftershocks suggest an important amount of vertical displacements along the causative faults of these earthquakes. This can be explained by the activation of shallower segments of the existing strike-slip faults; on seismic profiles these segments can be interpreted as flower structures.

These results show a good agreement with our present day understanding of the active tectonic processes in the Dinarides, which describes the Adria – Dinaric convergence as the main factor controlling tectonic deformation within the entire region. However, we strongly argue that local strain redistribution along the pre-existing structures plays a significant role in earthquake generation in the Internal Dinarides, as well.