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Neotectonic and recent fault activity in NE Croatia: evidences from DEM based morphometry, structural analysis of 2D seismic sections and 2D GPR mapping

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Relief is often classified as polyphasic phenomena, which shows multiple tectonic overprints and produces unique physiographic characteristics of the certain part of Earth's surface. Analysis of three-dimensional properties and origin of landscape often implies multidisciplinary quantitative approach connecting active tectonic processes with climate and erosion features trough available data from field of geology, seismology, geochronology and tectonic geomorphology, etc. In this work, identification of neotectonic and recent active faults in Bilogora Mt. of NE Croatia was performed by combined DEM based morphometric analysis and structural analysis of 2D seismic sections, supplemented by 2D mapping with GPR.

Bilogora Mt. area is a Pliocene-Quaternary transpressional morphostructure or a positive flower structure (Prelogović *et al.*, 1998*)* genetically linked with the tectonic evolution of the Drava depression and its SW prolongation (Bjelovar sub-depression). According to our data, this structure is related to the tectonic inversion of the NW-striking Drava Basin Boundary Fault (DBBF), which is an initially normal fault, which later turned into dextral strike-slip fault. Bilogora Mt. area is predominantly composed of highly deformed clastic Pliocene-Quaternary sediments of the 3rd depositional megacycle of the SW Pannonian Basin in Croatia (Velić *et al.*, 2002; Saftić *et al.*, 2003). Recent tectonic activity in the area is confirmed by moderate seismicity (VI°-VIII° MCS, $3.5 \leq M_L \leq 5.6$). Fault plane solutions in the northwestern part indicate NE-SW directed S_{hmax} and NE- to S-SW-dipping seismogenic structures characterized by strike-slip and reverse motions (Herak *et al*., 2009).

Computer-based morphometry using DEM (10m resolution) was performed by ESRI ArcMap 9.3.1. software with available extensions (CalHypso, Spatial Analyst, ArcHydro 1.1 and StPro.) and Matlab software. Study area, divided into 131 drainage basins, was analysed by relief and basin morphometry (elevation and slope distribution, hypsometry, asymmetry factor), and longitudinal stream profile morphometry (maximal concavity, distance from the source, concavity factor, steepness index, and concavity index).
Morphometry results points to several drainage basins affected by recent on-going tectonics. These drainage basins and streams are located: i) between towns of Koprivnica and Pitomača in the NW part, and ii) between towns of Virovitica and Daruvar in SE part. Furthermore on-going tectonics was cross-checked by a set of 2D seismic sections and boreholes using Schlumberger Petrel Seismic to Simulation software. As a result, 3D structural depth model was constructed, with 6 stratigraphic horizons and fault planes active during the Neogene and Quaternary times. Morphometrically recognized on-going tectonics in the NW part of Bilogora Mt. area correlate well with subsurface fault-related folds formed in hangingwalls of normal-inverted and newly formed reverse faults, displacing the base Pliocene-Quaternary horizon and propagating towards the surface. Pliocene and Quaternary vertical offset along these faults varies between 20 and 490 m, indicating slip rate of 0.1 mm/year. By application of empirical geometrical fault-scaling, relationships of Wells & Coppersmith (1994), we estimate that some of the analysed faults could generate earthquakes with magnitudes up to 6.86, which are greater, than historically reported. The same faults could generate maximal vertical surface displacement < 1.46 m per seismic event.

Landscape response to ongoing tectonic activity was additionally studied by 2D mapping with Malå ProEx Georadar (RTA antenna with 50 MHz) at 6 selected locations. At three locations in the NW part, a vertical offset of very shallow stratigraphic horizons are confirmed to reach 0.5 m and the most recent tectonic activity by even surface-braking faults was also confirmed.

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