Fault-generated landforms in the eastern part of Simitli graben (SW Bulgaria): a tectonic geomorphology approach

Разломно свързан релеф в източната част на Симитлийския грабен (ЮЗ България): опит за анализ на тектонската геоморфология

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Simitli graben is being intensively studied during the last years, but dispite this there are no tectonic geomorphological researches for this seismically active area. Our approach uses quantitative data and metrics extracted from digital elevation models, analysis of sub-meter resolution satellite imagery (DigitalGlobe data at Google Earth), as well as field surveys. The purpose of our study is to assess how the relief in the eastern part of Simitli graben was influenced by the reported active faults and also to check graben bounding faults (e.g. Zagorcev, 1975; Dobrev, 2005; Tranos, 2008).

We processed two sets of digital elevation models (DEMs) with resolution of 15 m and 30 m. They were created after digitalization of 50 000 and 25 000 scale topographic maps. Twenty three drainage basins were delineated using the ArcGIS Spatial analyst tools. They cover the traces of reported active faults – Krupnik, Gradevo and Elovitsa (Ganas et al., 2005). Morphometric analysis included calculation of regional geomorphic indices using the two DEMs and the delineated watersheds. The calculated geomorphic indices are the Stream Length – Gradient Index ("SL Index"), hypsometric integral, basin elongation, basin assimetry, basin shape, ratio of valley floor width to valley height. We also used recently introduced IAT index (Hamdouni et al., 2008) to categorise studied watersheds to four classes of relative tectonic activity. All basins are characterized with values of the ratio of valley floor width to valley height index and hypsometric integral that are indicative of deep valley incisement and young relief. Local peaks in SL indices are observed in all of the basins. They are common in the uppermost reaches of the streams (Keler and Pinter, 2002) but anomalously high SL indices are also found where rivers cross some prominent fault zones. The analysis of derived metrics is in accordance with the published data about the active Krupnik fault. In this area we were able to differentiate another fault zone, situated SE of the trace of the Krupnik fault which also could be characterised as youthful or even active structure. This tectonic zone is traced from N 41.8391 E 23.21669 to N 41.899727 E 23.236047. It was informally named "zone of Topographic front 2" (ZTF2) and approximately coincides with the southern part of Osenovski fault of Zagorcev (1975). Significantly, the highest values of IAT index have been calculated for the basins that are crosscut or situated next to these faults. The ZTF2 fault has an overall strike of 25° and an average dip of about 45° NW. Despite the deeply incised valleys and steep slopes the fault slip surface was observed just in a single spot (N 41.84507; E 23.2209). The surface itself is polished, but it lacks striations and tool tracks. The hanging wall is severely deformed, hydrothermally altered and it is cut by deeply incised gulleys. ZTF2 is a nice example of tectonic inheritance because the fault is exploiting the pronounced anisotropy related to the solid-state fabric within the granitoids of North Pirin pluton. Despite the lack of kinamatic data, geomorphology of the area is unambiguously indicating that ZTF2 is a normal fault.

Our research is also focused on the faults within the basin of Gradevo river. There are opposite views on the position, geometry and kinematics of SW-NE trending fault/s usually named Gradevo fault (Zagorcev, 1975; Dobrev, 2005; Ganas et al., 2005; Tranos et al., 2008).The reason to focus on this area is also a "weak signal" we received from the analysis of metrics and the landscape. Except probably some local deviations, geomorphic indices point to low to moderate tectonic activity that can well be explained with regional uplift during Quaternary.

We also put all the old map data in GIS and checked the DEM of the area and its derivatives (shaded relief, slope map, etc.) for possible lineaments. Detected features were delineated and exported to KML file format and further explored with Google Earth.

This procedure allowed us to pin down the places where there was strong possibility to find fault-related rocks. The coordinates of these places were transferred to hand-held GPS receiver and checked during the field work. Despite our efforts, we were unable to confirm the existence of Gradevo fault in the vicinities of the village of Gradevo. But further to the NE we found major and yet not described fault zone which was traced for several kilometers (N 41.9248 E 23.22408 – N 41.96004 E 23.24117). The zone is built by tectonic breccia, ultracataclasites and a gauge layer. Its footwall is severely deformed and the width of the damage zone is reaching tens of meters. In exposures around the village of Dolno Osenovo a principal movement zone is well-defined by up to 2 m thick grey matrix-supported breccia and ultracataclasite/gauge layer. These tectonites display consistent dip to the west and rarely observed Riedel shears in the gauge indicate westward shear. Despite the local control on the geometry of the Miocene-Quaternary cover the described extensional zone is inactive – in the village of Dolno Osenovo the associated tectonites are displaced by late strike-slip fault. Nevertheless high SL indices as well as knick points, aligned saddles are indicating pronounced geomorphological expression of this fault zone.

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