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Geomorphologic evidence of active tectonics in Sierra Alhamilla (eastern Betics, SE Spain)

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The analysis of drainage networks and the geomorphic indices have been broadly used as a recognition tool to characterize areas with active deformation. Here we present new geomorphic data of the Sierra Alhamilla anticlinorium. Geomorphic qualitative and quantitative analyses were conducted in order to detect present tectonic activity in the area and to define the tectonic controls on the current relief.

The eastern Betics Neogene to Quaternary basins occur in synclines among E/W- to ENE/WSW-elongated antiformal ridges where the metamorphic basement is exhumed at the footwall of folded extensional detachments. These antiformal ridges and associated strike-slip and reverse faults were formed during latest Miocene N/S and NNW/SSE shortening. The most important recent faults in the study area are the Carboneras sinistral fault with NNE/SSW to NE/SW strike, the conjugate Gafarillos dextral E/W to WNW/ESE-oriented fault and the North Alhamilla reverse fault (NARF) that bounds and controls the northern mountain front of Sierra Alhamilla.

Qualitative observations were carried out on the drainage network, spatial distribution of drainage basins and their geometric relationships, and, finally, on topographic and longitudinal stream profiles. Quantitative geomorphic analyses were done employing the following geomorphic indices: mountain front sinuosity, basin asymmetry factor, basin hypsometric curves and integral, ridge-line profiles and finally the SLk index. These analyses were performed with the aid of several maps such as the SLk and the minimum bulk erosion map. The geomorphic analyses conducted suggest that Sierra Alhamilla is tectonically active.

Recent activity along the North Alhamilla reverse fault produces an important uplift of the northern slope of the ridge, and seems to be responsible for the occurrence of a high SLk anomaly in the northern front of the ridge. Other indicators of this activity are the northwards asymmetry of the entire ridge, low Smf index values of the northern front, the “foot-rejuvenation” of the northern slope streams that are characterized by convex and concave-convex profiles, and finally the occurrence of basins with convex and S-shaped hypsometric curve shape with high bulk erosion values.

The junction between the NARF and the South Gafarillos fault (SGF), which is characterized by a dextral transpressive regime, seems to produce a high SLk anomaly that bounds the eastern termination of the Alhamilla ridge. The low Smf index values of the southern front, the southwards migration and asymmetry of the basins, the stream “rejuvenation” and reorientation close to the SGF, and the convex stream longitudinal profiles as well, support uplift of the southern block with respect to the NARF-SGF system as well as a present activity of the SGF.

The high SLk anomalies occurring on the southern slope of the ridge are probably due to the Pliocene-Quaternary high-angle normal faults. The geomorphic evidences of such a tectonic control are: a) low Smf index values of southern mountain front segments congruently oriented with respect to the normal faults; b) the northwards asymmetry of the entire ridge; c) the northwards advance and “head-rejuvenation” of the basins located on the central part of the southern slope; d) longitudinal stream profiles in the southern slope that locally show concave-convex profiles with nick points; e) and finally, the basins in this area show maximum bulk erosion values.