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Spatial variations in relative tectonic activity in the Colca catchment inferred from geomorphic indices, Central Andes

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Present-day topography, together with drainage network in tectonically active regions are mainly the result of the ongoing tectonic deformation and climate interaction. Thus, by studying morphological features, both 1) in the field, and/or 2) quantitatively using geomorphic indices, one might deduce about spatial variations in relative tectonic activity in those areas. Extensive, and uncomplicated access to digital elevation models and GIS software essentially sustained the worldwide usage of those indices. Striking differences in topography in the Colca drainage basin has been evaluated as a possible effect of spatial variations in relative tectonic activity. This area is located in the forearc of the Nazca-South America subduction zone. Recorded high seismicity results from 1) megathrust earthquakes, 2) numerous shallow seismic events triggered by active crustal faults (mainly in the central section of the basin), and 3) volcanic microseismicity and volcanic tremors linked to two active volcanoes (Sabancaya and Misti).

To assess spatial variations in relative tectonic activity in the Colca basin we applied 1) observations from the field (i.e. identification and measurement of landforms, verification of bedrock lithology, and confirmation of knickpoints), and 2) calculation of selected geomorphic indices. Using a 30-meter resolution digital elevation model from the Shuttle Radar Topography Mission (SRTM), and digitized topographic maps we calculated the following indices: topographic swath profiles, river longitudinal profile, transverse profiles, stream-length gradient index (SL), minimum bulk erosion, hypsometric integral, low order stream gradients, drainage density, sinuosity index, etc.

The Colca River longitudinal profile shows several abrupt breaks in the slope that do not correlate with changes in bedrock lithology. Transverse profiles, together with values of sinuosity index, stream-length gradient index, river gradient, valley width to valley height ratio, indicate at least four sections along the trunk river with different valley shape, and diverse local relief. High relative erosion and vertical incision is suggested for the intermediate part, where anomaly high values of stream length gradient index and minimum bulk erosion were recorded. This confirms the field observations, as it coincides with the deepest section of the basin known as the Colca Canyon. Lack of correlation between the observed pattern and variations in bedrock lithology suggest additional tectonic forcing. Finally, the observed variations in the geomorphic indices seem to corroborate the importance of the left-lateral transpressional Incapuquio Fault System structuring the front of the Western Cordillera in southern Peru.