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Tectonic control on denudation rates in the central Bolivian Andes

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Effects of a positive feedback loop between erosion and tectonics have been shown by analogue and numerical models and have been inferred from field observations at the scale of mountain ranges. We present new data from the Bolivian Andes supporting these observations, although common geomorphic parameters do not indicate a simple correlation. The upper Rio Grande segment, located between Cochabamba, Santa Cruz and Sucre, drains a major catchment in the central Bolivian Cordillera, from the Eastern Cordillera (EC) in the W, through the Interandean Zone (IAZ) and the Subandes (SA) in the E. The catchment covers an area of 58939 km^2 with an altitude range from 400 to 5150 m above sea level.
Geologically, the Bolivian Andes comprise (from W to E) the Altiplano, the EC, the IAZ and the SA fold and thrust belts. The Altiplano represents an almost perfectly closed basin with distinct barriers defined by the Western Cordillera and Eastern Cordillera. The Rio Grande does not reach the Altiplano (unlike Rio La Paz and Rio Consata) but has its western drainage divide along the high peaks of the EC that experienced a period of intense shortening between Late Oligocene and Miocene. Near Cochabamba, the EC comprises metasedimentary siliciclastic rocks of Ordovician age. These rocks are overlain by Cretaceous to Paleocene and / or Neogene sediments with an angular unconformity. The IAZ and SA form an east-vergent fold and thrust belt and comprise Paleozoic and Mesozoic units. Farther east, the structures of the SA progressively include Neogene foreland strata of the Chaco foreland basin. The Chaco basin rests on the Brazilian shield east of the Subandean Belt and forms the modern foreland basin, where the lower Rio Grande catchment is sited.
We obtained 58 cosmogenic 10Be catchment wide denudation rates for the Rio Grande catchments upstream of Abapó. They range from 7 mm/kyr to 1550 mm/kyr thus integrating at maximum over the last 10.000 years, with a mean of 262 mm/kyr. In the SA denudation rates have a significantly higher mean of 850 mm/kyr. Geomorphic (channel steepness index, hypsometric index, specific stream power, drainage density) or climatic (e.g. satellite derived precipitation) parameters do not exert a primary control on these higher denudation rates. However, the higher rates are observed mainly in Cretaceous to Neogene conglomerates and sandstones. They coincide spatially with the SA, where the rates are generally 5 – 10 times higher than in the EC and IAZ. This pattern overlaps with the observation of active deformation in the SA that is also supported by recent shallow seismicity clusters. We argue that the pattern of denudation rates in the Rio Grande is mainly tectonically controlled. The lacking correlation between geomorphic parameters and our denudation rates is potentially caused by the size of the sampled catchments where simultaneous surface processes results in an overlapping shaping of the surface and thus prevent clear morphometric signals. The influence of active deformation on geomorphic parameters in the Bolivian Andes is subject of further studies.