

Climate-Driven versus Tectonic-Driven Asymmetry of an Orogenic Wedge: Examining Mechanisms for Focused-Denudation Using Geomorphic Indexes

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The location of mountain ranges at a global scale is directly related to the position and type of plate boundaries. The highest and most rugged relief of the present world topography corresponds to mountain ranges developing near active plate boundaries. Evolution of orogens not only depends on tectonic forces but also on the result of the feedback between tectonics, isostasy, surface, and atmospheric processes. Variable erosion across orogenic belts resulting from precipitation gradients can play an important role in focusing exhumation and deformation consequently affecting the morpho-tectonic geometry of an active mountain range. Few studies address the influence of climatic factors in the large-scale morpho-tectonics of orogens although mountain ranges record the interactions between climatic and tectonic processes. Some of the reasons for this lack of research in the climate signature in morpho-tectonics range from the high complexity of climate systems to the unknown temporal extent in the geologic past of current climate patterns.

Our analyses focus on the Eastern Cordillera of the Northern Andes a symmetrical, doubly-verging tectonic wedge with an asymmetrical topographic profile. Although the dichotomy between tectonic symmetry and geomorphic asymmetry is not unique in the world, this area provides an excellent case study to quantify the influence of a strong precipitation gradient in the surface and tectonic processes across an orogen, and give insights in determining whether the steady state geometry of a wedge is climate- or tectonic-driven. Across this cordillera, there is a present east-west precipitation gradient ranging from 8 m/yr to 2 m/yr. If this precipitation gradient has remained constant since the beginning of the Andean uplift, we can use present conditions and examine the ways in which climate patterns, erosion and tectonics influence the geometry and kinematics of uplift in this Cordillera.

We have determined geomorphic indices, mapped major folds and regional stratigraphic sequences, and constructed structural cross sections for a swath profile across the cordillera. Although the location and focal mechanism of earthquakes for this swath show that the bounding faults of the tectonic wedge are currently active, we did not find significant earthquake activity inside the wedge. However, location of knickpoints, concavity and steepness calculations, and long river profiles are very different for the east and the west flank of the cordillera. Low steepness values, weak correlation between knickpoints locations and fault traces, and relatively smooth river profiles are common in the west flank of the cordillera. High steepness values, knickpoints aligned along fault traces, and multi-step river profiles are characteristic of the east flank. The strong coupling between geomorphic and structural elements in the east and the weak coupling in the west may be due to a different kinematics across the tectonic wedge. We suggest that in the west flank deformation occurs as slip along the frontal fault without any internal deformation, and that deformation in the east flank is partitioned between internal strain, and slip along out-of- sequence hinterland faults, and the frontal fault.