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Andean subduction orogeny: feedbacks between tectonics, relief evolution and global climate

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The Andean subduction margin, largest tectonic relief on the Earth (13 km vertically from the trench to the Altiplano) has a stepped morphology, which results of the evolution over the past 50 Myr of two parallel flat-ramp thrust systems, at the – previously unidentified – West Andean Thrust (WAT), and at the subduction interface. The evolution of those thrusts appears concomitant with increasing aridity in the Atacama Desert, which keeps a large-scale record of interplaying tectonics and Cenozoic climate change. The coastal morphology is dominated by the Atacama Bench, a giant uplifted terrace at 1-2km asl. Geomorphic and climatic data, numerical experiments of drainage formation are consistent with the development of a flat Atacama morphology close to sea level, interrupted at $\leq$10 Ma by tectonic uplift prevailing to the present. This suggests recent trench-ward relief growth by incorporation of the coastal Atacama Bench to the Andes reliefs. Thrust splay structures and other complexities above the subduction interface may explain this relief growth, as well as the distribution of asperities under the oceanward forearc, and the down-dip segmentation of coupling and seismicity on the megathrust. Combining those results with geological knowledge at the scale of the whole Central Andes, we show that the Andean orogeny results from protracted processes of bivergent crustal shortening in a wide region squeezed between the rigid Marginal Block and the S America Plate. The overall growth curve of Andean orogeny over the past 50 Myr appears synchronous with the onset of the "ramp-shaped" temperature decrease since the Early Eocene climatic optimum. Andean growth and global cooling may have operated under the same forcing mechanism at plate-scale, involving viscous flow in the mantle. But Andean growth appears modulated by climatic feedbacks causative of stepwise reductions of erosive power over the Andean margin. The first of such events is coeval with Late Eocene cooling and promoted the eastward propagation of deformation towards the continent interior. The second one, coeval with Late Miocene cooling, is associated with the establishment of hyper-aridity in the Atacama Desert, and is responsible of a tectonic "freezing" which promoted since the triggering of subduction of the Brazilian craton, the Andean bivergent growth, and rapid uplift throughout the Andes–Altiplano.

Armijo R., Lacassin R., Coudurier-Curveur A., Carrizo D., Coupled tectonic evolution of Andean orogeny and global climate, Earth Science Reviews, 143, 1-35, doi:10.1016/j.earscirev.2015.01.005, 2015.