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Horizontal subduction zones, convergence velocity and the building of the Andes

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The relationship between the uplift of the Andean Cordillera and plate kinematics has been debated for several decades. In the one hand, some authors note that the building history of the Andean orogeny has been largely controlled by the trenchward motion of South America, and by the convergence velocity between the oceanic plate and overriding continent. In the other hand, others remark that the Andes relief results in stresses acting on the neighboring plates, which may affect the kinematics of tectonic plates. Both hypotheses are supported by temporal correlations between Andean tectonics, uplift and plate kinematics around South America. Here, we focus on the appearance of horizontal slab segments. We argue that horizontal subduction zones largely modify both the overriding plate tectonic regime and the dynamics of oceanic subduction.

The Andes show remarkable latitudinal variations in both the maximum and mean elevation, the orogen width, and crustal shortening, despite the fact that Cenozoic plate velocities at trench have been roughly similar in the Central and Southern Andes north of the Nazca-Antarctica-South America triple junction. This first-order observation evidences that plates velocities close to the trench is not the only parameter controlling the growth of the chain. Authors either proposed that the hyper-arid climate on the Pacific side of the Andes, or the width of the retreating slab and the lateral distance between the Central Andes and the lateral edges of the slab, may have further compressed that part of the overriding plate and triggered the uplift of Central Andes. Paleomagnetic data suggest that the bending of the Bolivian orocline, however, essentially appeared in Eocene-Oligocene times. The analysis of magmatism suggests that a horizontal subduction zone, which may result from the subduction of an oceanic plateau coming from the Juan Fernandez hot-spot, occurred below the Central Andes at that time. During Cenozoic times, the age of the Nazca plate dramatically decreased and its overall buoyancy may have become neutral. Second order features like oceanic plateaus may thus have become important enough to switch the buoyancy to positive. Lithospheric scale analogue experiments confirm, indeed, that the appearance of horizontal subduction zones may result from the subduction of large buoyant oceanic plateaus. Experiments also suggest that horizontal subduction results in higher interplate friction, involving tectonic rotations and shortening in the overriding plate above the flat-slab segment.

Thus, we propose that the building and segmentation of the Andes may largely result from the Cenozoic subduction of horizontal slab segments below South America. In turn, the appearance of horizontal subduction zones may have exerted a strong control on the convergence velocity at trench, and more generally on regional plate kinematics.