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Andean flat subduction maintained by slab tunneling

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In two segments below the Andean mountain belt, the Nazca Plate is currently subducting sub-horizontally below South America over a distance of 200-300 km before the plate bends into the mantle. Such flat slab segments have pronounced effects on orogenesis and magmatism and are widely believed to be caused by the downgoing plate resisting subduction due to its local positive buoyancy. In contrast, here we show that flat slabs primarily result from a local resistance against rollback rather than against subduction. From a kinematic reconstruction of the Andean fold-thrust belt we determine up to ∼390 km of shortening since ∼50 Ma. During this time the South American Plate moved ∼1400 km westward relative to the mantle, thus forcing ∼1000 km of trench retreat. Importantly, since the 11-12 Ma onset of flat slab formation, ∼1000 km of Nazca Plate subduction occurred, much more than the flat slab lengths, which leads to our main finding that the flat slabs, while being initiated by arrival of buoyant material at the trench, are primarily maintained by locally impeded rollback. We suggest that dynamic support of flat subduction comes from the formation of slab tunnels below segments with the most buoyant material. These tunnels trap mantle material until tearing of the tunnel wall provides an escape route. Fast subduction of this tear is followed by a continuous slab and the process can recur during ongoing rollback of the 7000 km wide Nazca slab at segments with the most buoyant subducting material, explaining the regional and transient character of flat slabs. Our study highlights the importance of studying subduction dynamics in absolute plate motion context.