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Importance of continental subductions for the growth of the Tibetan plateau

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How and when the Tibetan plateau developed has long been a puzzling question with implications for the current understanding of the behaviour of the continental lithosphere in convergent zones. Tibet initially resulted from the accretion of the Gondwana continental blocks to the southern Asian margin during the Palaeozoic and Mesozoic eras. These successive accretions have potentially favoured the creation of local landforms, particularly in southern Tibet, but no evidence exists in favour of the existence of a proto-Tibetan plateau prior to the Cenozoic. Moreover, before the India-Asia collision, the Tibetan crust had to be sufficiently cold and rigid to transfer the horizontal forces from India to northern Tibet and localize the deformation along the major strike-slip faults. However, these successive accretions associated with subductions have contaminated the Tibetan lithospheric mantle and largely explain the potassium- and sodium-rich Cenozoic magmatism. Another consequence of this contamination by fluids is the softening of the Tibetan lithosphere, which favoured intra-continental subductions. The timing and the geochemical signatures of the magmatism and the palaeo-altitudes suggest the early growth of the Tibetan plateau. By the Eocene, the southern plateau and the northern portion of Himalaya would be at an altitude of approximately 4000 meters, while the central and northern Tibetan plateau was at altitudes of approximately 2000 to 3000 meters at the Eocene-Oligocene transition. From all of these data, we propose a model of the formation of the Tibetan plateau coupled with the formation of Himalaya, which accounts for more than 2000 km of convergence accommodated by the deformation of the continental lithospheres. During the early Eocene (55-45 Ma), the continental subduction of the high-strength Indian continental lithosphere dominates, ending with the detachment of the Indian slab. Between 45 and 35 Ma, the continental collision is established, resulting in the thickening of the internal Himalayan region and southern Tibet and the initiation of intra-tibetan subductions. By 35 Ma, the southward subduction of the intra-tibetan Songpan-Ganze terrane ends in slab break-off and is relayed by the oblique subduction of the Tarim accommodated along the Althyn, Tagh. Southward, the dextral Red River Fault accommodated the southeastward extrusion of the Indochina block. During the Miocene, specifically, between 25 and 15 Ma, the Indian slab undergoes a second break-off, while the central part of Tibet is extruded eastward. Northward, the continental subduction beneath the Qilian Shan continues. Discontinuous periods of magmatic activity associated with slab detachments play a fundamental role in the convergence process. These periods lead locally to a softening of the mid-crust by magma heat transfer and to the granulitisation of the lower crust, which becomes more resistant. We propose that due to these alternating periods of softening and hardening of the Tibetan crust, the rheological behaviour of the convergence system evolves in space and time, promoting homogeneous thickening periods alternating with periods of localised crustal or lithospheric deformations.