The Cenozoic Subduction History of Greater Indian Lithosphere Beneath Tibet

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India and Asia have converged thousands of kilometers since Eocene time, but where and how this convergence was accommodated remain enigmatic. We propose that the Eocene and younger history of deformation, exhumation, basin development, and magmatism in Tibet can be explained in the context of large-magnitude northward subduction of Greater Indian lithosphere beneath Asia.

Collision of the Tethyan Himalaya with Asia was underway by ~52 Ma. This was followed by a high-flux event within the Gangdese arc along the southern margin of Asia that peaked at 51 Ma and shows a systematic younging trend toward more juvenile zircon ϵHf values between 52 and 47 Ma (from -6 to +15). We attribute this high-flux event to collision-induced removal of Asian lithosphere.

Between 47 and 38 Ma, magmatism swept >400 km north of the Indus-Yarlung suture (IYS) and shows a systematic younging trend toward more evolved zircon ϵHf values (from +15 to -20). We interpret this magmatism to mark underthrusting of Greater Indian lithosphere to as far north as central Tibet. Low-temperature themochronologic studies indicate that large parts of central Tibet underwent relatively rapid, but low-magnitude exhumation at 48 ± 5 Ma. Both the northward magmatic sweep and regional exhumation in central Tibet may be explained by rapid northward underthrusting of Greater Indian lithosphere. Central Tibet has undergone less than 2-3 km of exhumation since ~45 Ma, suggesting that the low erosion rates and low relief that characterize the modern central Tibetan plateau were achieved by this time.

Between 38 and 20 Ma, magmatism swept back southward toward the IYS. During Oligo-Miocene time, the IYS underwent localized extension and likely elevation loss, as recorded by the development of the Kailas Basin under a relatively warm and wet climate and the exhumation of the Ayi Shan metamorphic core complex in SW Tibet. The southward magmatic sweep and localized extension along the IYS are explained by rollback of the Greater Indian slab.

At ~18 Ma, Indian slab breakoff permitted renewed northward underthrusting. This threw the IYS back into contraction, as manifested by the Great Counter thrust system, and corresponds to a regional rapid and large-magnitude (6-8 km) exhumation event across much of the India-Asia collision zone. Post-18 Ma northward underthrusting of Indian lithosphere also produced a northward sweep in magmatism that in turn shows a systematic younging trend toward more evolved ϵHf values (+10 to -15). Northward underthrusting of Indian lithosphere ultimately initiated E-W extension in Tibet at 15-8 Ma, as the influx of Indian crust thickened the Tibetan crust as fast or faster than it was thinned by E-W extension and eastward crustal flow.

The proposed history suggests that more than half of the total convergence between India and Asia since Eocene time (>1500 km) was accommodated by northward subduction of Greater Indian lithosphere beneath Asia. The latter is consistent with kinematic restorations of Cenozoic deformation in Asia (showing <1000 km of Eocene to Present N-S shortening) and recent paleomagnetic results (indicating that >1500 km of post-52 Ma convergence was accommodated south of the IYS). It does, however, raise questions about the magnitude of shortening in the Himalaya (is it grossly underestimated?) and/or the nature of Greater Indian lithosphere (was it entirely continental?).

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