Oligo-Miocene Basins in Central Tibet and Along the Indus Suture: Records of Plateau Evolution and Dynamics of Subducting Indian Continental Crust

P.G. DeCelles[1], P. Kapp[1], J. Quade[1], G.E. Gehrels[1], M. Murphy[2]

[1] Department of Geosciences, University of Arizona, Tucson, AZ 85721, U.S.A., decelles@email.arizona.edu
[2] Department of Geosciences, University of Houston, Houston, TX 77204-5007, U.S.A.

Mid-Cenozoic sedimentary basins in central Tibet and along the Indus suture zone developed under radically different environmental and tectonic conditions. In the north-central Lhasa terrane directly south of the Bangong suture more than 4 km of Oligo-Miocene fluvial, lacustrine, alluvial fan and fan-delta deposits filled the Nima basin in close association with coeval thrust faults. On the basis of sedimentological features and stable C and O isotope data, Nima basin lakes were shallow and highly evaporative. Carbonate is pervasive: as marls in lacustrine deposits, and as pedogenic carbonates in abundant highly oxidized paleosols. Biotite $^{40}Ar/^{39}Ar$ ages from tuffaceous layers and detrital zircon U-Pb ages indicate that Nima basin was active during the period 27-23 Ma, and probably for several Myr before and after. Oxygen isotope paleoaltimetry indicates that elevation in Nima basin was ~4700 m (equivalent to modern), which is consistent with abundant pollen from cool temperate species.

At the same time (late Oligocene-early Miocene) 400 km to the southwest along the Indus suture zone, the Kailas basin was filled by >2.5 km of alluvial fan, fluvial, and organic-rich deep-lacustrine deposits. The lower alluvial-fan unit lapped northward onto the Kailas magmatic complex, which consists of ~67 Ma andesitic volcanic rocks intruded by ~55 Ma granite of the Gandgese batholith (both ages from U-Pb on zircon). U-Pb zircon ages from interbedded tuffs and minimum age clusters from detrital zircons indicate that the bulk of the Kailas Formation is 26-24 Ma. Phlogopite-bearing basalt/trachyandesite layers are present in the upper half of the Kailas Formation. The southern limit of the preserved Kailas basin is folded and truncated by the north-verging Great Counter thrust (GCT) system, which carries Tethyan Himalayan strata and suture zone rocks in its hanging wall. Kailas basin fill consists of a classic upward fining ‘lacustrine sandwich’, which we interpret to be the result of deposition in a narrow, E-W elongated extensional basin. Most of the sediment was derived from the Gangdese arc to the north, but southerly-derived Tethyan clasts begin to appear in the upper part of the succession, at about the same level as an abrupt change from organic- and fossil-rich lacustrine facies to highly oxidized and evaporative fluvial and shallow lacustrine deposits. Palynological yields were poor owing to thermal maturity, but the few taxa that are present include tropical ferns and warm weather species; the temperate species so abundant in the Nima record are absent. Individual lacustrine progradational parasequences attain thicknesses >80 m, indicating very deep, large lakes. Lacustrine transgressive lags are littered with fossil fish bones, teeth and turtle scutes. Together with the abundant amorphous kerogen in profundal facies and the absence of cool climate/high elevation palynomorphs, these observations suggest (but by no means prove) that Kailas basin lakes formed at relatively low elevations under humid warm climate. In contrast, the uppermost part of the Kailas Formation is rich in lacustrine marl and paleosol carbonate nodules, similar to Nima basin deposits. The nodules yield $\delta^{18}O$ values of -12 to -16, essentially identical to those from modern-Holocene soil carbonate in the Kailas region. Thus, the Kailas record suggests initial deposition at relatively low elevations, with an abrupt transition to high elevation synchronous with activation of the GCT.

We propose that the Kailas basin formed as a rift coeval with extensional exhumation of Gangdese basement rocks that are now exposed in the footwall of the Ayi Shan detachment. The cause of extension in this region remains uncertain. However, the presence of Oligo-Miocene clastic strata along ~1300 km of the ISZ suggests that this process was regional and not isolated to the SE end of the Karakoram fault. Compilation of ages of volcanic rocks across the entire Tibetan Plateau demonstrates a 500 km northward sweep between ca. 45 and 35 Ma, followed by a southward sweep between ca. 32 and 25 Ma, coeval with opening of the Kailas basin. These magmatic sweeps may provide a rough proxy for the location of the hinge in the subducting/underthrusting Indian plate. Accordingly, the southward sweep represents the velocity of hingeline rollback through the Indian plate, and when added to the ~50 mm/yr convergence rate, would have more than doubled the subduction rate. Increased subduction rate relative to convergence rate would have driven upper-plate extension, similar to the process operating in many Mediterranean subduction zones. The southward sweep in magmatism culminated in a widespread outburst of ‘adakitic’ and high-K volcanic rocks, which have been interpreted to represent slab break-off magmatism. This break-off event would have terminated the rollback process, and the tectonic system reverted to hard-collision mode with activation of the GCT, MCT and other shortening structures regionally in Tibet and the Himalaya. Since Eocene time, therefore, there have been two episodes of slab break-off along the Indus suture: the first during Eocene release of the Neotethyan slab, and the second during early Miocene release of a large slab of Greater Indian lithosphere. These break-off events were separated in time by periods of more conventional ‘hard collision’, during which regional shortening and crustal thickening dominated. Our results hint at the possibility that Indian continental lithosphere has undergone major changes in subduction/underthrusting angle, and large-scale subduction into the mantle, imitating the behaviour of oceanic lithosphere in ocean-continent subduction zones.

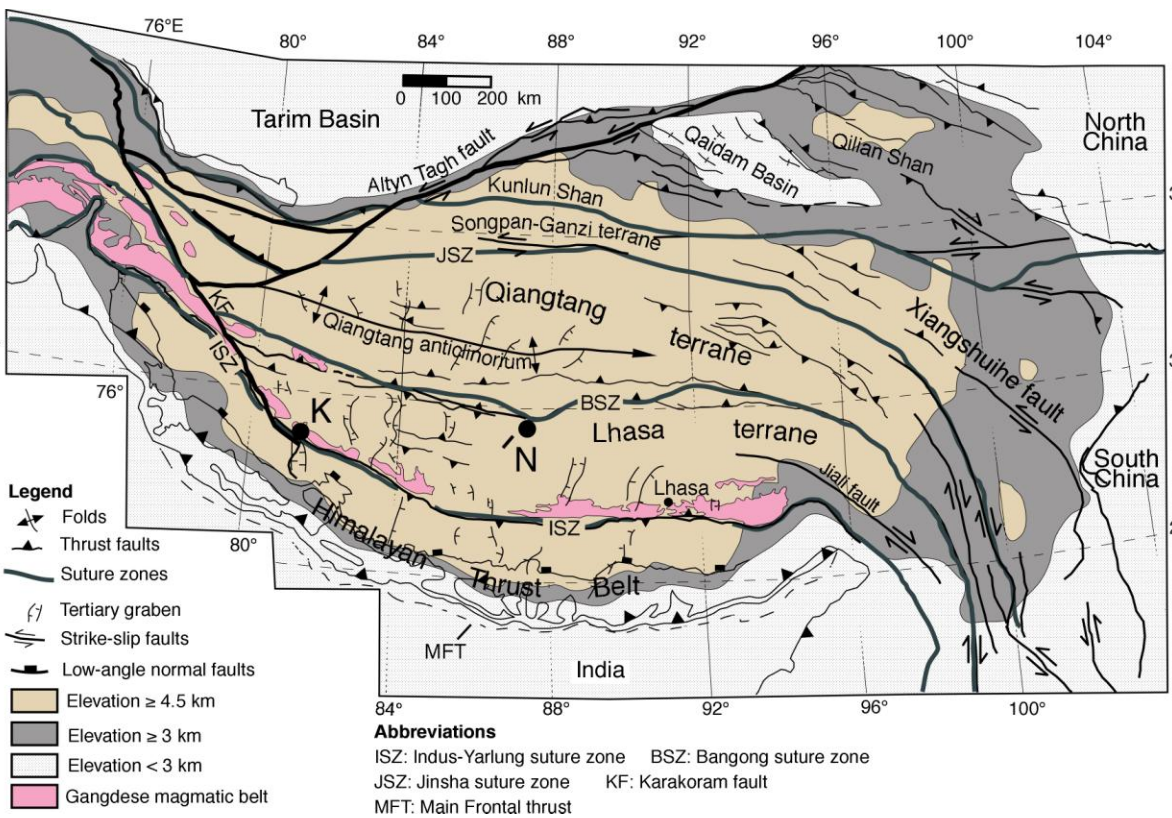

Figure 1. Tectonic and generalized topographic map of the Tibetan Plateau and Himalayan thrust belt, showing major structures and locations of Nima basin (N) and Kailas basin (K). Compiled from multiple sources, most prominently from Yin and Harrison (2000).

References

Yin, A. and Harrison, T.M., 2000, Geologic evolution of the Himalayan-Tibetan orogen, Annu. Rev. Earth Planet. Sci.28, 211-280.

Cite as: DeCelles, P.G., Kapp, P., Quade, J., Gehrels, G.E. and Murphy, M., 2010, Oligo-Miocene Basins in Central Tibet and Along the Indus Suture: Records of Plateau Evolution and Dynamics of Subducting Indian Continental Crust, *in* Leech, M.L., and others, eds., Proceedings for the 25th Himalaya-Karakoram-Tibet Workshop: U.S. Geological Survey, Open-File Report 2010-1099, 2 p. [http://pubs.usgs.gov/of/2010/1099/decelles/].