Not Very Old but Not Too Young: Thermochronological Constraints on the Age of Low-Relief Surfaces in the Western Himalaya and Southeastern Tibet

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Low-relief high-elevation surfaces occur near the dissected fringes of the easternmost and westernmost Himalaya and Tibetan Plateau, and have been interpreted as remnants of an early and more extensive surface as old as Eocene. Alternatively, the Gamugah surface in the western Himalaya has also been interpreted as evidence for the glacial buzzsaw mechanism for trimming elevations. Cooling-age data from the Gamugah surface in northern Pakistan and from the high surface located west of Nyinchi in SE Tibet suggest that neither explanation is satisfactory for these two landscapes.

Samples from both surfaces have very similar low-temperature cooling histories marked by fairly rapid cooling to near-surface temperatures in the interval ~15 to 8 Ma, as constrained by U-Th/He dating of apatite and zircon and $^{40}Ar/^{39}Ar$ dating of k-feldspar and biotite. Assuming an orogenic thermal gradient of about 30˚C/km, higher-elevation samples at both localities were within one kilometer of the surface (or much shallower) by 7 Ma. On the one hand, this observation rules out these two surfaces as being old remnants (Eocene or older). On the other hand, particularly for the Gamugah surface, the data also do not support the notion of energetic cryogenically-driven erosion operative in the Quaternary. What is required is a mechanism to drive several kilometers of rock removal in the period 15 to 8 Ma.

Together with field relationships, the cooling ages also provide interesting constraints on the morphological evolution of the Indus and Tsang Po valleys in the hinterland. Both data sets are complicated by lateral heat flow from the rapidly advecting Nanga Parbat and Namche Barwa massifs, such that low-elevation ages close to the massifs are considerably younger due to the local steepening of the thermal gradient. For the Tsangpo, the best qualitative explanation for the data is that immediately following carving of topography that was close to the current relief, further relief development was arrested by pinning of the Tsang Po's local base level by initiation of extremely fast rock uplift within the Namche Barwa massif (the spatial magnitude of the lateral heat-flow anomaly is consistent with a duration of this uplift of at least several million years). This suggests that the current southeast Tibetan landscape may be on the order of 5-7 Ma in age, with very little incision occurring on the main river channels.

In the western Himalaya near Nanga Parbat, pending verification by additional thermal modeling, the cooling data and field relationships suggest that considerable relief must have been present in the Indus Valley at 7 to 9 Ma. Samples from atop the Gamugah surface fell below temperatures of 40˚C by 7 Ma. Given that samples located fully 3 km below these closed to helium diffusion at about the same time, relief of some 2 km must have been present, sufficient to warp isotherms and thus allow coeval cooling at widely spaced elevations. This implies that a proto-Indus River valley was present at that time. However, lateral heat flow can only explain the young ages obtained from a vertical transect adjacent to the massif if bedrock were available to transmit the lateral heat flow, suggesting removal of an additional 1-2 km of rock from the Indus Valley took place by about 4 Ma, but after initiation of the Nanga Parbat uplift. These data also suggest that incision of the middle Indus Valley between Nanga Parbat and the Gamugah surface has been relatively minor over the past few million years.

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