Out-of-sequence deformation and expansion of the Himalayan orogenic wedge: insight from the Changgo culmination, south-central Tibet

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The Changgo culmination, one of a series of granitic and/or metamorphic domal structures that crop out along the North Himalayan antiform, comprises a multi-phase, foliated granitic core surrounded by a polydeformed metasedimentary carapace. The carapace of the Changgo culmination consists of two structural domains. The upper domain is characterized by vertical thickening recorded as large-scale, close–to tight overturned, south-verging folds while the lower domain is characterized by a dominant transposition foliation. The contact between the meta-sedimentary cover and the granitic core is marked by a >300 m thick top-to-the north sense shear zone. The shear zone predominantly consists of mylonitized pelitic schist, but also contains 30–50 m thick lenses of sheared leucogranite. One of these leucogranite lenses has been dated as 35.35±0.37 Ma based on U–Pb SHRIMP analyses. The main phase of the igneous core of the Changgo culmination is a foliated alkali-feldspar porphyritic granite, which has been dated using spot U–Pb SHRIMP analyses as 22.78±0.91 Ma. Quartz c-axis petrofabrics measured in specimens of this foliated granite yield a top-to-the south shear sense. Undeformed aplite dykes that cut the foliated porphyritc granite yield a U–Pb TIMS monazite age of 22.08±0.19 Ma. 40Ar/39Ar cooling ages of specimens sampled from both the meta-sedimentary carapace and igneous core of the Changgo culmination range between ca. 20 Ma and 16 Ma. The cooling ages young with increasing structural depth towards the center of the culmination.

The tectonic evolution of the Changgo culmination is interpreted to comprise three main episodes.

1) Crustal thickening through folding of the carapace: This episode is equivalent to Eohimalayan events described elsewhere along the orogen and, as in those events, it is interpreted to result in prograde metamorphism and melt formation. The sheared leucogranite lenses dated at ca. 35 Ma are interpreted to have formed during this episode.

2) Horizontal stretching and extrusion of the mid-crust: Subsequent to initial crustal thickening, or perhaps as a response to crustal weakening associated with earlier deformation, the mid-crustal core of the Himalayan-Tibetan orogen was extruded southward. The transposition foliation developed in the Changgo area, which is associated with a top-to-the-south shear sense in the granite core, is thought to reflect deformation during extrusion. In many areas along the Himalaya this extrusion is coincident with significant anatexis and formation of plutons. The Changgo granite is interpreted to have formed during the later stage of this episode at 22.78±0.91 Ma. Top-to-the-south shear ended prior to the intrusion of aplite dykes at 22.08±0.19 Ma. These dykes are nonetheless deformed adjacent to the top-to-the north shear zone at the core/carapace interface. This shear zone, therefore, must have been active after the intrusion of the dykes. Deformation in the shear zone took place at 520±50°C according to quartz petrofabric analysis and likely ceased prior to cooling through a calculated muscovite closure temperature of 414±21°C at 18.43±0.25 Ma. Based on shear sense, structural position and chronology, the shear zone at the core/carapace contact is interpreted to be a branch of the South Tibetan detachment system (STDS).

3) Out-of-sequence exhumation: The late-stage evolution of the Changgo culmination is interpreted to reflect out-of-sequence deformation within the Himalayan system. In central Nepal, southward extrusion of mid-crustal material between the STDS and the Main Central thrust ceased by ca. 19 Ma as a result of insufficient gravitational potential to drive the southward expansion of the orogenic wedge. The exhumation of the Changgo culmination, shortly thereafter, is interpreted to reflect the out-of-sequence rebuilding of the Himalayan wedge. Subsequent to the exhumation of the Changgo area, in-sequence deformation began to propagate southward as reflected in the ca. 16 Ma exhumation of the Chako antiform, and then the cooling of the central Nepalese frontal Himalaya (in the Annapurna region) at ca. 14-15 Ma (Figure 1). The orogenic wedge continued its lateral growth with the development of the Lesser Himalayan duplex and the succeeding activation of the Main Boundary thrust, thereby completing the transfer of slip from the kinematically unfavorable Main Central thrust.

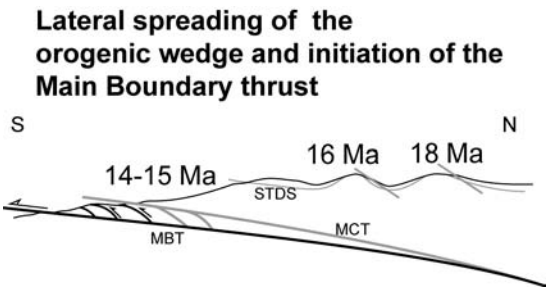

FIGURE 1. Diagram depicting the southward progression of cooling ages in the central Nepalese Himalaya. Assuming a constant rate of erosion cooling ages are interpreted to reflect the lateral spreading of the orogenic wedge after out-of-sequence rebuilding. Grey represents past structures, black represents active structures. MBT, Main Boundary thrust; MCT, Main Central thrust; STDS, South Tibetan detachment system.