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Using bedrock thermochronometer systems to constrain fold-thrust belt geometry and kinematics, insight from the eastern Himalayas, Arunachal Pradesh, India.

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One of the first order questions regarding a cross-section representation through a fold-thrust belt (FTB) is usually "how unique is this geometrical interpretation of the subsurface?" The proposed geometry influences perceptions of inherited structures, decollement horizons, and both rheological and kinematic behavior. Balanced cross sections were developed as a tool to produce more accurate and thus more predictive geological cross sections. While balanced cross sections provide models of subsurface geometry that can reproduce the mapped surface geology, they are non-unique, opening the possibility that different geometries and kinematics may be able to satisfy the same set of observations. The most non-unique aspects of cross sections are: (1) the geometry of structures that is not seen at the surface, and (2) the sequence of thrust faulting. We posit that integrating sequentially restored cross sections with thermokinematic models that calculate the resulting subsurface thermal field and predicted cooling ages of rocks at the surface provides a valuable means to assess the viability of proposed geometry and kinematics. Mineral cooling ages in compressional settings are the outcome of surface uplift and the resulting focused erosion. As such they are most sensitive to the vertical component of the kinematic field imparted by ramps and surface breaking faults in sequential reconstructions of FTB. Because balanced cross sections require that the lengths and locations of hanging-wall and footwall ramps match, they provide a template of the ways in which the location and magnitude of ramps in the basal décollement have evolved with time. Arunachal Pradesh in the eastern Himalayas is an ideal place to look at the sensitivity of cooling ages to different cross section geometries and kinematic models. Recent studies from this portion of the Himalayan FTB include both a suite of different cross section geometries and a robust bedrock thermochronology dataset. The multiple published cross-sections differ in the details of geometry, implied amounts of shortening, kinematic history, and thus exhumation pathways. Published cooling ages data show older ages (6-10 Ma AFT, 12-14 Ma ZFT) in the frontal portions of the FTB and significantly younger ages (2-5 Ma AFT, 6-8 Ma ZFT) in the hinterland. These ages are best reproduced with kinematic sequence that involves early forward propagation of the FTB from 14-10 Ma. The early propagation combined with young hinterland cooling ages require several periods of out-of-sequence faulting. Out-of-sequence faults are concentrated in two windows of time (10-8 Ma and 7-5 Ma) that show systematic northward reactivation of faults. Quantitative integration of cross section geometry, kinematics and cooling ages require notably more complicated kinematic and exhumation pathways than are typically assumed with a simple in-sequence model of cross section deformation. While also non-unique, the updated cross section geometry and kinematics highlight components of geometry, deformation and exhumation that must be included in any valid cross section model for this portion of the eastern Himalaya.