Tectonic and climatic controls of growth and shape of the Himalayan foreland fold and thrust belt: A numerical study

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According to the critical taper model, there are three processes that determine the morphology of foreland fold- and-thrust belts: (1) the removal of material by erosion; (2) the accretion of material, determined by sedimentation and plate convergence rates; and (3) steady-state critical growth, determined by the rheological properties of the materials that comprise the wedge. The Himalayan orogeny provides a unique opportunity to study collisional orogens and active fold-and-thrust belts (FTB) in an environment where processes 1 and 2 (above) vary systematically along strike. The Siwalik Group consists of synorogenic sediments of Miocene to Pleistocene age, and constitutes the presently active foreland FTB of the Himalayan orogen. Recently constructed balanced cross-sections revealed two important observations concerning foreland FTB morphology across the Himalayan arc: (1) west to east increase in strain and strain rate correlates with plate convergence rates, and (2) annual rainfall amounts are inversely correlated with FTB morphology. From these observations, it was proposed that surface properties exert more control on wedge morphology than tectonic processes in the Himalayan FTB. In this study we use critical taper model to numerically test the relative contribution of surface processes on the morphology of the present-day foreland FTB of the Himalaya. Internal parameters such as: friction, both along the wedge (μ) and decollement fault plane (μb); the Hubbert-Rubey fluid pore ratio, both within the wedge (λ) and along the basal decollement (λb); and the critical taper ($\alpha+\beta$) were held constant. Key parameters including: thickness of accreted material (T), depth of the decollement (D), rock erodibility (K) and material flux (vT) were varied within the range of observed values along-strike of the Himalayan FTB. Comparison between experiments allows for the estimation of model sensitivity to each parameter individually. The calculated critical taper morphology and growth rate are consistent with those observed in the Himalayan FTB, indicating that it develops in accordance with the critical Coulomb wedge theory. Comparative analysis of parameters indicates that within a narrow range of high values of the erodibility factor K, climatically induced erosion is the principal control on Himalayan foreland FTB morphology. Conversely, when the erodibility factor (K) is low, tectonic accretion of the material (vT) is the dominant growth parameter.

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