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Exhumation, crustal deformation, and thermal structure of the Nepal Himalaya derived from the inversion of thermochronological and thermobarometric data and modeling of the topography

Frédéric Herman,[1,2] Peter Copeland,[3] Jean-Philippe Avouac,[1] Laurent Bollinger,[4] Gweltaz Mahéo,[5] Patrick Le Fort,[6] Santaman Rai,[6,7] David Foster,[8] Arnaud Pêcher,[6] Kurt Stüwe,[9] and Pierre Henry[10]

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[1] Two end-member kinematic models of crustal shortening across the Himalaya are currently debated: one assumes localized thrusting along a single major thrust fault, the Main Himalayan Thrust (MHT) with nonuniform underplating due to duplexing, and the other advocates for out-of-sequence (OOS) thrusting in addition to thrusting along the MHT and underplating. We assess these two models based on the modeling of thermochronological, thermometric, and thermobarometric data from the central Nepal Himalaya. We complement a data set compiled from the literature with 114 $^{40}Ar/^{39}Ar$, 10 apatite fission track, and 5 zircon (U-Th)/He thermochronological data. The data are predicted using a thermokinematic model (PECUBE), and the model parameters are constrained using an inverse approach based on the Neighborhood Algorithm. The model parameters include geometric characteristics as well as overthrusting rates, radiogenic heat production in the High Himalayan Crystalline (HHC) sequence, the age of initiation of the duplex or of out-of-sequence thrusting. Both models can provide a satisfactory fit to the inverted data. However, the model with out-of-sequence thrusting implies an unrealistic convergence rate ≥30 mm yr^{-1}. The out-of-sequence thrust model can be adjusted to fit the convergence rate and the thermochronological data if the Main Central Thrust zone is assigned a constant geometry and a dip angle of about 30° and a slip rate of <1 mm yr^{-1}. In the duplex model, the 20 mm yr^{-1} convergence rate is partitioned between an overthrusting rate of 5.8 ± 1.4 mm yr^{-1} and an underthrusting rate of 14.2 ± 1.8 mm yr^{-1}. Modern rock uplift rates are estimated to increase from about 0.9 ± 0.31 mm yr^{-1} in the Lesser Himalaya to 3.0 ± 0.9 mm yr^{-1} at the front of the high range, 86 ± 13 km from the Main Frontal Thrust. The effective friction coefficient is estimated to be 0.07 or smaller, and the radiogenic heat production of HHC units is estimated to be 2.2 ± 0.1 μW m^{-3}. The midcrustal duplex initiated at 9.8 ± 1.7 Ma, leading to an increase of uplift rate at front of the High Himalaya from 0.9 ± 0.31 to 3.05 ± 0.9 mm yr^{-1}. We also run 3-D models by coupling PECUBE with a landscape evolution model (CASCADE). This modeling shows that the effect of the evolving topography can explain a fraction of the scatter observed in the data but not all of it, suggesting that lateral variations of the kinematics of crustal deformation and exhumation are likely. It has been argued that the steep physiographic transition at the foot of the Greater Himalayan Sequence indicates OOS thrusting, but our results demonstrate that the best fit duplex model derived from the thermochronological and thermobarometric data reproduces the present morphology of the Nepal Himalaya equally well.

[1] Tectonics Observatory, California Institute of Technology, Pasadena, California, USA.
[2] Earth Sciences Department, ETH Zurich, Zurich, Switzerland.
[3] Department of Earth and Atmospheric Sciences, University of Houston, Houston, Texas, USA.
[4] Département Analyse Surveillance Environnement, CEA, DAM, DIF, Arpajon, France.

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[5] Laboratoire des Sciences de La Terre, UMR 5570, Ecole Normale Supérieure de Lyon, Université de Lyon 1, CNRS, Villeurbanne, France.
[6] Institut Dolomieu, Université Joseph Fourier, Grenoble, France.
[7] Now at Department of Geology, Tribuhvan University, Kirtipur, Gandhi Bhawan, Kathmandu, Nepal.
[8] Department of Geological Sciences, University of Florida, Gainesville, Florida, USA.
[9] Institut für Geologie, Universität Graz, Graz, Austria.
[10] CEREGE, Europole de l'Arbois, Aix-en-Provence, France.