Geophysical Research Abstracts
Vol. 14, EGU2012-14140, 2012
EGU General Assembly 2012

Tectonic control on topographic and exhumational segmentation of the Himalaya

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Although the Himalayan range is commonly presented as cylindrical along-strike, geological structures, topography, precipitation, and exhumation rates as recorded by low-temperature thermochronology data all vary significantly from west to east. In particular, segments of the belt that are characterized by a clear topographic step between the Lesser and Higher Himalaya, associated with a peak in precipitation and focused exhumation (e.g. central Nepal, Himachal Pradesh) alternate with segments where the topography increases more linearly to the north, precipitation peaks at lower elevations and exhumation rates appear to be lower (e.g. western Nepal, Bhutan). The potential climatic or tectonic controls on these spatially variable topographic, precipitation and exhumational patterns have been widely discussed in recent years but remain unclear. The topographic step focussing rapid exhumation has been variably interpreted as being controlled by material movement over a mid-crustal ramp in the Himalayan basal detachment system (the Main Himalayan Thrust or MHT), or by recent out-of-sequence thrusting possibly triggered by strong erosional unloading. We have recently shown that the pattern of exhumation across the central Nepal Himalaya, as recorded by apatite fission-track thermochronology data, can be fit without invoking out-of-sequence thrusting and that the age pattern provides independent constraints on the geometry of the MHT. Inverting published low-temperature thermochronological datasets for west-central Nepal, east-central Nepal and the Bhutan Himalaya shows that lateral variations in the geometry of the MHT (in particular the presence or absence of a major mid-crustal ramp) strongly control the kinematics, exhumation history and the topography of the orogen. Where a major crustal ramp is present, the topography shows a steep gradient that focuses exhumation and orographic precipitation whereas the topography is gentler and exhumation less focused in the absence of a ramp. Our results therefore imply that along-strike climatic variations in the Himalaya respond to tectonics rather than driving it. The presence or absence of a mid-crustal ramp may be due to inherited structures on the underthrusting Indian Plate or, alternatively, may reflect transient behaviour of the accreting Lesser Himalayan thrust stack, which may oscillate between frontal accretion (without a ramp) or basal accretion in the presence of a ramp.