Geophysical Research Abstracts, Vol. 7, 07292, 2005
SRef-ID: 1607-7962/gra/EGU05-A-07292

Patterns of surface uplift during orogenic deformation

S. Hoth (1), D. Scherler (2), N. Kukowski (1) and O. Oncken (1)

(1) GeoForschungsZentrum Potsdam, Telegrafenberg, 14473 Potsdam, Germany (shoth@gfz-potsdam.de)

(2) Department of Geography, Humboldt University Berlin, Rudower Chaussee 16, 12489 Berlin, Germany

The topographic evolution of mountain belts results from the interplay and associated feedback processes between orogenic deformation, lithospheric flexure and surface processes. It follows that the spatio-temporal distribution of either surface uplift or exhumation within mountain belts constitutes a combined "signal", which is often difficult to decompose. Whereas the climatic signal can be deduced from sediments deposited either within or outside the evolving orogen, little is known about the spatio-temporal distribution of orogenic deformation and associated surface uplift patterns. An understanding of the latter may finally help to resolve the chicken-and-egg paradox.

Based on 2D scaled sandbox-simulations, we investigate the influence of kinematic boundary conditions on the spatio-temporal distribution of surface uplift within bivergent sand-wedges. Convergence in the experiments is 350 cm ($\sim$300 km in nature) and thus similar to medium sized orogens. We simulate the non-linear deformation behaviour of upper crustal rocks by granular flow of sieved quartz sand with strain-dependent deformation behaviour with strain hardening/-softening. Digital optical image correlation (PIV) provides a time-series of the displacement field and its components and allows thus the quantification of surface uplift.

Our results indicate that the asymmetry of the convergence geometry leads to a similar asymmetry in the tectonic mass flux, evoking a segmentation of a bivergent sand-wedge into two topographic domains, one that comprises the pro-wedge and one that includes the axial zone and the retro-wedge. Given an Eulerian reference frame, surface uplift within the former domain evolves in discrete steps, which are linked to the formation of individual thrust imbricates. In contrast surface uplift within the latter

domain is characterised by a continuous and nearly concentric growth pattern. This observation is irrespective of the mechanic stratigraphy, the degree of flexure or the simulation of erosion and reflects thus the way of how material is added to the respective domain. We further found that each individual accretion cycle, i.e. the formation of a thrust imbricate consists of three phases: a thrust initiation phase, an underthrusting phase and a re-activation phase, which are associated with different locations of maximum surface uplift. Whereas maximum surface uplift is located at the toe of the pro-wedge during the first and the third phase, it is positioned in the axial zone during the second phase. Thus, each accretion cycle is associated with a surface uplift wave, which starts at the toe of the pro-wedge and migrates towards the retro-wedge. Once it has reached the latter, it jumps back to the toe of the pro-wedge and a new accretion cycle commences. It is emphasised that this surface uplift wave is best recognised if only frontal accretion, i.e. thrust imbrication is present. If basal accretion by duplex formation operates this surface uplift wave is difficult to follow within the axial zone.

Our results imply that the surface uplift signal provided by orogenic deformation might be more variable in time and space than previously assumed. The state of accretion exerts a strong control on surface uplift and may lead to a pulsed surface uplift history. The latter could be thus explained by the accretion process alone and plate kinematic reorganisations or changes of the climate regime need not to be invoked. Finally, the dominant mode of material addition to either the pro-wedge or the axial zone/retro-wedge determines the respective surface uplift histories, which therefore need not to be the same.