Topographic modulation of fault kinematics in the Himalaya and Tibet

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Throughout the Himalaya and Tibet, moderate- to high-elevation strike-slip faults undergo extensional stepovers where they cross higher topography though to be pre-existing. Related seismological data have long been explained by an influential orogen-scale cross-section model where high-elevation normal faulting and low-elevation thrust faulting result from laterally-invariant horizontal tectonic stress and vertical stress that varies with topography; however, this model cannot incorporate strike-slip faulting or ~10 km wavelength topography. Therefore I introduce a 3D elastic model describing the modulation of fault kinematics by shorter-wavelength topographic stress, and show how this may tightly constrain the tectonic stress field. I then calculate the topographic stress field on the Western Nepal Fault System, and use topographic stresses and observed fault kinematics to invert for the tectonic stress field. The results yield a maximum tectonic compression of 0–0.2 ρgz and minimum tectonic compression of -0.1–0.1 ρgz, and reproduce kinematics from normal, strike-slip and thrust faults and earthquakes in and around western Nepal, including the 2015 Gorkha earthquake. This demonstrates that where vertical and a horizontal principal stress are near equal, 1-10 km scale variations in topography can change fault kinematics, and that pre-existing topography can influence the location of subsequent faults and stepovers.