Seismic hazard, continental deformation and mantle recycling associated with the Himalayan continental subduction zone

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The continued northward motion of India since the closure of the Tethys Ocean has uplifted the Himalaya Mountains and the Tibetan plateau. In the past two decades, numerous geophysical experiments conducted in the Himalayas and Tibet have discovered that Indian continental lithosphere is being subducted beneath the Himalayas and southern Tibet in a relatively coherent and simple geometry [e.g. Ni and Barazangi, 1984; Zhao et al., 1993], and that this geometry is not much different from that observed along oceanic subduction zones. We recognize that many medium-sized thrust-type events and great Himalayan earthquakes (magnitude greater than 8) have occurred along the Main Himalayan Thrust [e.g. Ni and Barazangi, 1984]. However, a large cluster of mantle earthquakes (70-90 km in depth) was found beneath the High Himalayas [Figure 7, Sheehan et al., 2008]. Both large and great earthquakes post immense seismic hazard for hundreds of millions of people who live in the Himalayas and its foreland (India, Nepal, Bhutan and Bangladesh).

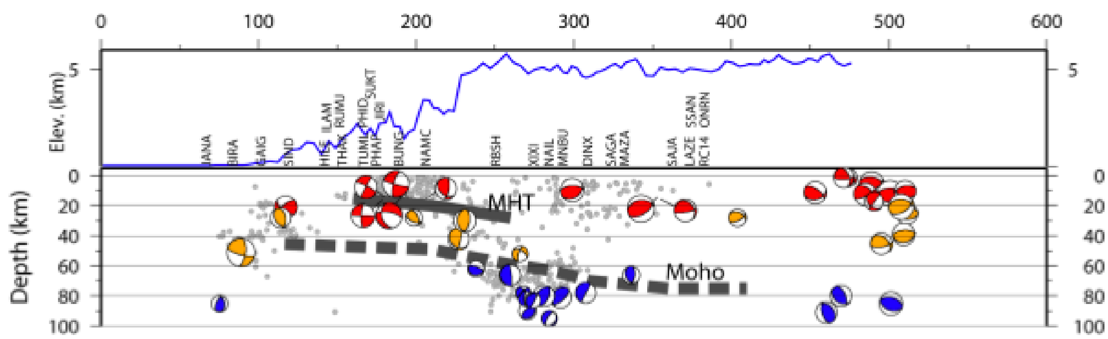
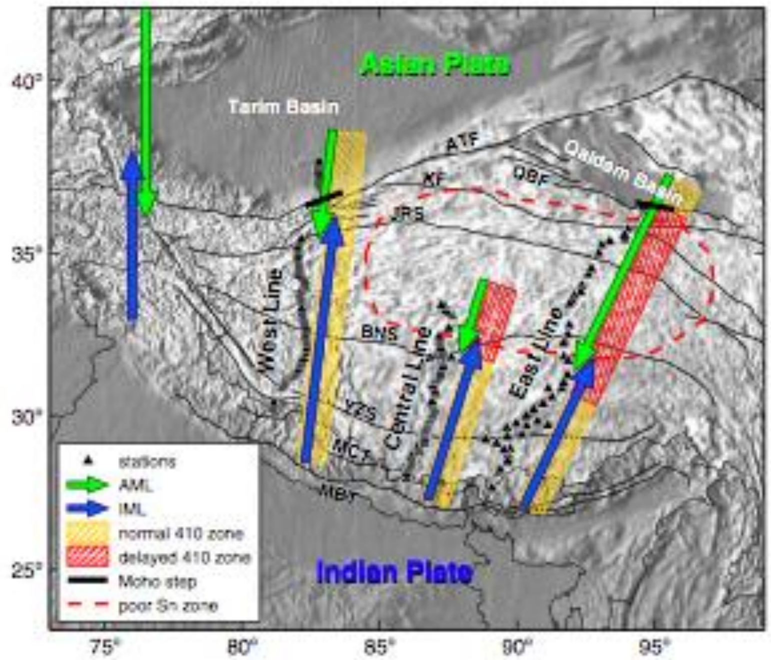


Figure 7. Cross section showing seismicity and focal mechanisms. Grey lines denote Main Himalayan Thrust (MHT) and the Moho from Schulte-Pelkum et al. (2005). Regional topography is plotted above the seismicity with approximate locations of the HIMNT stations.

At present, what we have learned is that there are seismic gaps along two-thirds of the Himalayas, which, when combined with a geodetic convergence rate of ~1.8 cm/yr, suggest that one or more M=8 earthquakes may be overdue [Roger Bilham, Earthquake in India, http://cires.colorado.edu/~bilham/Erice.htmnce]. A region of abnormally high seismicity occurring in western India appears to be related to plate fragmentation. Apparent fragmented suducting Indian plate beneath southern Tibet is recently imaged from finite-frequency tomography [Liang et al., 2010]. Searching the connection between the fragmented Indian plate beneath the Himalayas and southern Tibet is crucial in understanding the earthquake gaps and seismic characteristic of the greater Himalayas.

The subducted Indian continental lithosphere reaches to central Tibet, but there are E-W variations. In the east, near 92°E, the subducted Indian continental lithosphere reaches about 200 km north of the Zangbo Suture [Li et. al., 2008; Zhao et al., 2010], in central Tibet it reaches Bangong Nujiang Suture (BNS) and in western Tibet it reaches Jiansha-River

Suture (JIS) (See Figure below).



The leading edge of the subducted Indian lithosphere has different dipping geometry [Tilmann et al., 2003; Li et al., 2008] and it has a back-arc that is reminiscent to oceanic back-arc. Convection and associated partial melting has produced significant post-collisional potassic and ultra-potassic volcanism in the Tibetan plateau. The subducted continental lithosphere may be delaminated and mixed with the asthenosphere. Hence, Tibet is the best place to study how much continental material is being recycled back into the asthenosphere.

References:

Li et al., Phys. Earth Planet. Sci. Lett., 157, 2008.

Liang et al., abstract, AGU Fall Meeting, 2010.

Ni, J., and M. Barazangi, J. of Geophy. Res., 1147, 1984.

Sheehan et al., J. of the Nepal Geol. Soc., 38, 2008.

Tilmann et al., Science, 1424, 2003.

Zhao, J., PNAS, 2010.

Zhao, W. et al., Nature 366, 557, 1993.