14 India Plate Motion and Deformation

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About 200 million years ago, when the supercontinent Pangaea began to break apart, the landmass we today know as India existed as a large island off the coast of Australia. The Indian plate began to move northward, moving as much as 9 cm/year and eventually ramming into the Eurasian plate. The collision marked the beginning of the formation of the Himalaya Mountains as Earth's crust buckled and heaved upward. Today, the Indian plate continues to move to the northeast at roughly 5 cm/year, pushing the Himalayas higher as the Indian plate underthrusts the Eurasian plate. It is this interaction which causes frequent earthquakes in the Himalaya and adjoining region. Earthquakes occur in the peninsular India too, but they are infrequent and are of relatively less magnitude in comparison to those of the Himalaya. Because of its large population and susceptibility to damage from earthquakes and tsunamis, the seismological research in India has taken a prominent role. Although, we are still far from the science of predicting earthquakes, the progress in seismology has been steady and rapid. In comparison to other disciplines of science, science of earthquakes, "seismology" is relatively a younger subject. Although H.F. Reid discovered the elastic rebound theory in 1910, following the 1906 San Francisco earthquake, real research in seismology, explaining the earthquake occurrence, started only after 1960's, after the Plate Tectonics hypothesis was proposed. Within the framework of plate tectonics, it was proposed that the entire globe consists of at least seven major plates which are continuously in motion and it is their interaction which causes earthquakes. This theory provided a basic framework for research in seismology. In late sixties earthquake recording observatories were set up worldwide. This was the time when data based research in seismology actually started. It took another thirty years for discovering instruments which could measure mm level plate motion. This led to the development of yet another sub-discipline "Tectonic Geodesy". Tectonic Geodesy revolutionised the seismological research, as we could measure the continental motion, as hypothesised in Plate tectonics, we could quantify the evidence of strain accumulation and its release, and several other earthquake related processes.

Here in this presentation, I will present a brief summary of the work done on Indian plate motion and its deformation. Although an analysis of GPS data across the Indian subcontinent has provided evidence that Indian plate moves at a velocity of 54 mm/year in the northeast direction (at Hyderabad), the internal deformation of the Indian plate is very low (<1-2 mm/year) and the entire plate interior region largely behaves as a rigid plate. But then how do the earthquakes occur in the plate interior regions? It has been suggested that deformation rates are generally very low and localized in intraplate regions. The seismicity migrates and deformation rate varies with time. For example, GPS measurements in the Godavari failed rift region within the stable India plate indicate very localized deformation . Elsewhere, all along the region, deformation is very low (<1.5 mm/year). Similarly, in the Koyna Warna region, a site known for reservoir triggered earthquakes, the deformation again is low and occurs within or close to the fault zones.

In contrast to the plate interior regions, the plate boundary regions deform quite rapidly which also lead to frequent earthquake occurrences. Himalayan convergent plate margins and the Andaman Sumatra subduction zones are the example where evidence of strain accumulation and release have been documented. Continuous monitoring of crustal deformation and plate motion in these regions have led us to understand the earthquake occurrence processes, their recurrence intervals, identification of relatively higher seismic hazard zones, etc.