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On the first of September, 1803, a violent earthquake shook northern India. Delhi's Qutab Minar, an ornate, (now) 72 meter-high tower that had served as a beacon of Muslim architectural ingenuity for the previous 600 years, lost its uppermost stories. Twenty miles southeast of Delhi, British forces who had prepared for a lengthy siege of the heavily defended the citadel of Aligarh, took advantage of the confusion and fires and captured the fort in a single day. A hundred miles to the east, palaces of Lucknow were skewed and rent, and throughout the plains of the Ganges and Jamuna, shaken villagers watched as water and sand erupted from the ground and streamed over their fields. The epicenter of all this shaking was in the Garwhal Himalaya, 100 miles to the north, where landslides engulfed entire villages, leaving only rubble from the plains of India to the Tibetan plateau.

The 1803 quake was the first great Himalayan earthquake to be described in letters, newspapers and diary entries in British India, yielding a clear picture of the broad geographic reach of this quake. But it has taken the intervening two centuries to understand why these Himalayan earthquakes occur, and why their recurrence is as inevitable and as unpredictable as the fall of fruit from a tree.

Earthquakes occur daily in the Himalaya, but most are too small to feel. Once every several months a detectable rumble marks a Richter Magnitude 4 earthquake (M4), and every few years a M5 quake (releasing thirty times the energy of an M4) brings inhabitants from their homes. Once a decade, an M6 earthquake will cause minor damage, and every several decades an M7 killer quake like the October 2004 Pakistan earthquake will collapse ten thousand dwellings in a score of towns around its epicenter. Rarer still are the truly “great” earthquakes, which release 32,000 times the energy of an M5 and send waves of destruction for many miles north and south.

What causes these inevitable quakes? One hundred and eighty million years ago, the Indian plate carrying the continent of India - at that time an island - broke away from Antarctica, rafting it northwards. Fifty million years ago, its northern shores collided with the ranges of southern Tibet, squeezing and contorting the intervening rocks upwards into what became the Himalaya.

India continues to penetrate beneath Tibet, too buoyant to sink, and its former surface can be seen in seismic images at a depth of 25 miles below parts of the Tibetan plateau. As a result this three mile-high, 1000 kilometer-wide plateau is effectively two continents thick, and the pressures and temperatures at its base cause the rocks to flow sluggishly away from India's advance, curling around India's eastern corner near Burma in a vortex of solid rock.

An enormous amount of energy is needed to sustain the plateau’s lofty elevation, and we now believe that some of this energy is the source of , and is released by, great Himalayan earthquakes. Each year, the Indian Plate advances relentlessly two inches toward Asia. It would be fine if this slippage occurred uniformly everywhere. Tragically for humans, friction in the shallowest parts of the collision clamps Asia and India together for hundreds of years beneath the Himalaya, only to be released when sufficient stress has developed to tear the rocks apart. The small earthquakes signify the continued accumulation of stress in the region surrounding future rupture, the great earthquakes alone allow the incremental northward motion of the Indian plate.

Devastating great earthquakes occurred in 1833 and 1934 near Kathmandu, in 1905 near Kangra in the western Himalaya, and in 1950 in far eastern Assam. But the frequency of these massive quakes -- four in 200 years -- is sufficient that their effects are not personally remembered by successive generations. Fifty-five years have now elapsed since the region's last great earthquake, and seismologists believe that several parts of the Himalaya could be ready to host another. The Pakistan 2005 quake, though the worst earthquake disaster in the history of the subcontinent, is merely a wake-up call for a potential future great earthquake.

There is reason now to believe that although the word 'great' is reserved for M8 earthquakes, some great Himalayan earthquakes are much more severe than others. These giant earthquakes are distinguished by the great length of the Himalaya that slips in a single event - the so-called rupture area. The 1934 M8.2 earthquake in eastern Nepal destroyed most of Kathmandu, but nine hundred years ago an earthquake nearly ten times more powerful shook the region. We infer this from an excavation of the frontal faults of the Himalaya that revealed 20 m of earthquake slip circa 1100 (carbon 14 dating), but none at all in 1934. Six hundred years ago a similar giant earthquake ruptured the Himalaya north of Delhi, and we know from Tibetan, Urdu and Arabic texts that on June 6, 1505 an earthquake damaged monasteries in Tibet and Mustang, and cities as far south as Agra, in India.

Over a period of four or five hundred years, a tremendous amount of strain energy builds up beneath the Greater Himalaya and southern Tibet, waiting to be released. But whether the resulting earthquake is an M6 or a catastrophic M8.5 depends only on the total length of the rupture. If a tough region of rocks hinders the lengthways growth of the rupture, an earthquake may not release all of its pent up energy. Rupture areas of the very largest earthquakes may exceed 300 miles along the arc, and tend to occur after "delays" much longer than the minimum needed. Today, the "elastic reservoir" of the Tibetan plateau is sufficiently mature to drive three or four M8 earthquakes. Unfortunately for planners, because the interval between quakes is inconsistent, forecasting these events is an inexact science.

Many seismologists agree that the next great Himalayan earthquake is due to occur between Kathmandu and Dehra Dun -- the central 600 kilometers of the Himalaya that last slipped in 1505. Smaller regions to the west and east are also considered primed and ready for rupture. The 2005 M7.6 Jammu/Kashmir earthquake occurred in one such region, but its magnitude was insufficient to release more than one tenth of the currently available pent up energy there. The same can be said of the 1905 M7.8 Kangra earthquake.

Earthquakes destroy more than buildings. Many of the dams being constructed in Himalayan rivers can fail, resulting in secondary damage from disastrous downstream floods, while triggering landslides that will block narrow Himalayan river gorges, creating transient upstream lakes. In the 1950 Assam earthquake, these lakes grew to many miles in length, until their natural dams burst. Villages in their path were destroyed by the resulting catastrophic floods.

Distressingly, the next great earthquake will be far more devastating than these earlier events. The population has grown more than ten times since 1803, and nearly tripled since the great earthquake of 1950. Worse yet, traditional single-story cottages of thatch and wood have been largely abandoned in favor of multiple dwelling units of concrete and steel, or bricks and mortar Unless these structures have been engineered to resist shaking, they are likely to pancake during an earthquake, trapping occupants in a mesh of rubble. Civic structures may withstand strong shaking, but the private dwellings of more than 150 million people in northern India, Pakistan Bhutan, Sikkim and Nepal, assembled at minimal cost, will not fare so well.

Estimates put the future death toll from a great Himalayan earthquake in the hundreds of thousands, but a nightime earthquake near the mega cities of the Ganges plain may result in a death toll exceeding a million. If any good can be said to come from the frequent moderate earthquakes that occur in the Himalaya, it is that they may alert local planning authorites to the devastating effects that will accompany a truly giant earthquake in the Himalaya, unless earthquake resistrant design is implemented throughout the region.