III. Colliding Continents Squeeze Up Mountain Ranges

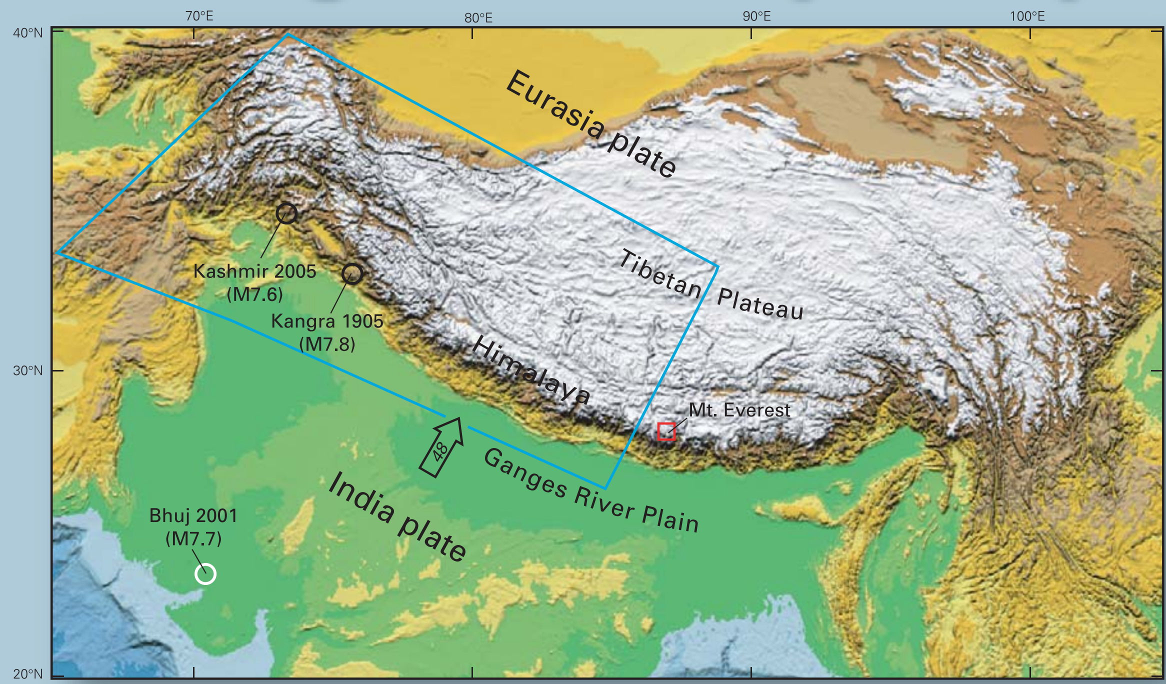

Figure 1.—Convergence of the India and Eurasia plates closed a pre-existing ocean, leading to continental collision (see paleogeographic maps and timeline below). This collision caused compression (squeezing) across a broad, diffuse boundary zone, producing Earth's highest land—the Himalaya and Tibetan Plateau. Compression is mostly taken up within the Himalaya-Tibetan region but extends far into the Eurasia plate. The approximate area of figure 2 is shown by the blue outline.

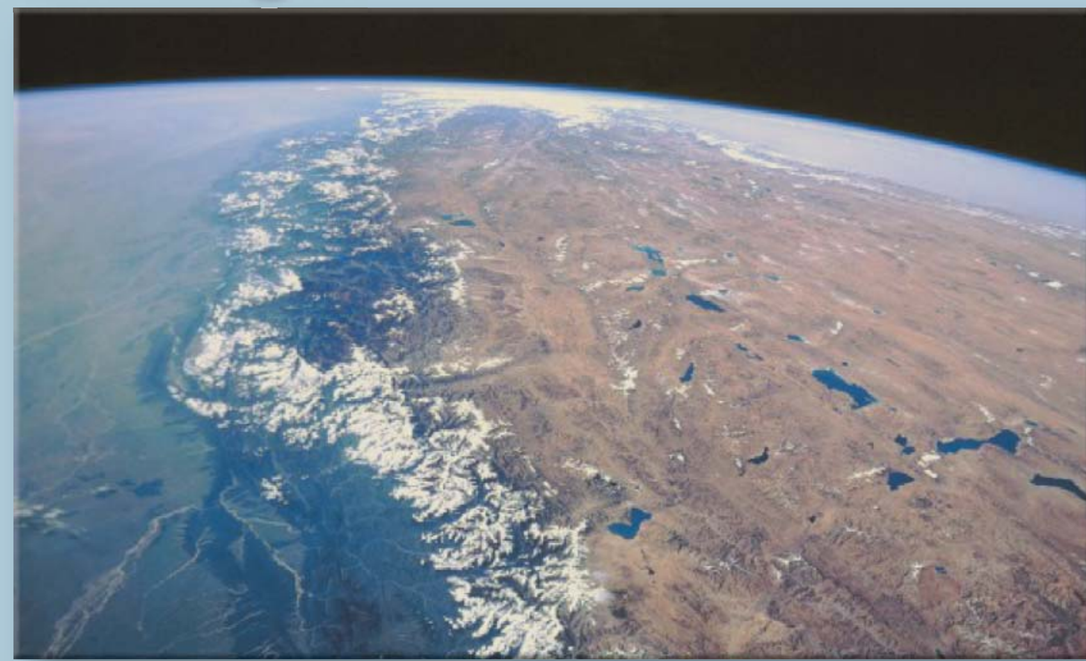

Figure 2.—View from space looking west showing (left to right): (1) the Ganges River Plain (blue area), (2) the white snow-and-cloud-covered Himalaya, with many peaks exceeding 7,300 m elevation, and (3) the Tibetan Plateau (brown, with blue lakes), at an average elevation of more than 4,880 m, higher than the Rocky Mountains. Space Shuttle image from NASA, no. STS41G–120–22.

Not all convergent plate boundaries involve *subduction* of oceanic lithosphere. When continental portions of converging plates collide, neither is subducted because both have low density and cannot easily sink deep into the denser mantle beneath. Such collision produces horizontal deformation (squeezing) and uplift of continental crust to build mountains and plateaus (figs. 1–4). "Continent-continent" collisions typically follow closure (by subduction) of a pre-existing ocean basin that formerly had separated the continents.

During collision, the crust of one plate shortens and thickens, and the adjacent plate thrusts under it, building high mountains such as the Himalaya, Alps, Caucasus, and Zagros. These regions of present-day mountain building experience frequent large and destructive shallow earthquakes (fig. 5). In some collision zones, such as those in Romania, Afghanistan, and Burma (Myanmar), earthquakes at depths greater than 60 km can occur in previously subducted oceanic lithosphere. Because of active convergence, low-density continental rocks become *sutured* together across the plate boundary, and are preserved as mountain belts in plate interiors (for example, Appalachians, Caledonides, and Urals), providing evidence of ancient, now inactive, collision zones. Unlike most subduction zones, continental collision zones produce little or no active volcanism.

The grandest of continental collision zones thrusts the India plate under the Eurasia plate, shortening and thickening the crust to produce Earth's highest mountains, the Himalaya (figs. 1–4). This deformation extends thousands of kilometers north of the Himalaya into the heart of the Eurasia plate (fig. 1), forming a *diffuse plate boundary zone* (see interpretive map of plate tectonics, on front). The deforming crust caught in the collision zone is squeezed and shoved sideways toward Southeast Asia—a process dubbed *escape tectonics*. In many collision zones, deformation is broadly distributed, highly complex, and cannot be characterized by a sharply defined plate boundary.

Figure 3.—At 8,848 m elevation, Mount Everest (*Chomolongma* in Tibetan) is the world's highest mountain. The peak is still rising a few millimeters per year as collision continues to occur. Marine fossils found in rocks high on Mount Everest attest to their large vertical uplift from the former sea floor. Photograph by Michael Searle (Oxford University), used with permission.

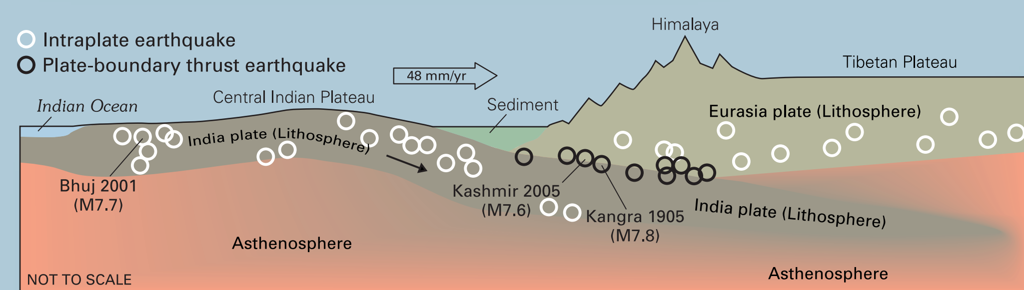

Figure 4.—Schematic diagram showing the India plate (brown) thrusting under the Eurasia plate (tan), effectively doubling the plate thickness under the Himalaya. Many destructive earthquakes occur in the foothills near the shallow thrust boundary between the two colliding plates, including the deadly M7.8 Kangra earthquake of 1905 and the devastating M7.6 Kashmir earthquake of 2005. The diagram also shows the bending by shortening of the India plate itself, which also causes earthquakes, such as the M7.7 Bhuj earthquake of 2001. Modified from Roger Bilham (University of Colorado).

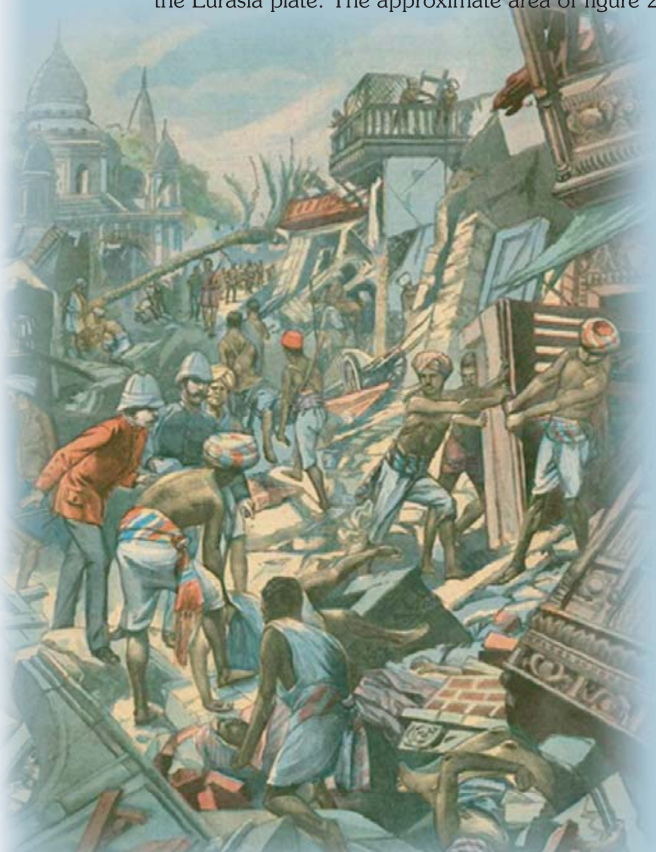

Figure 5.—1905 magazine print (from "Petit Parisien," "Supplément Littéraire Illustré," p. 144) showing rescue efforts after an M7.8 earthquake in the city of Kangra, India. Nearly 20,000 people perished, mostly in collapsed buildings and earthquake-triggered landslides. From the collection of Roger Bilham (University of Colorado).