VII. Transform Faults—Where Plates Scrape Horizontally Past Each Other

Figure 1.—Map of California showing the main fault (heavy red line) and the less active strands (thin red lines) that together compose the San Andreas fault system. This system is part of a long, diffuse continental transform plate boundary that accounts for about 75 percent of the motion between the Pacific and North America plates (see fig. 2). USGS imagery enhanced by Joel E. Robinson.

Plates slide horizontally past each other along *transform* plate boundaries. Transforms occur both on land and in the ocean basins, linking spreading ridges and other plate boundaries. They typically produce shallow earthquakes, with accompanying ground faulting and generally little or no volcanic activity. Two well-known continental examples are the North Anatolian fault (Turkey) and the San Andreas fault system (California). The San Andreas system is a family of related faults in a *diffuse plate boundary zone* (see interpretive map of plate tectonics, on front); this and similarly broad zones elsewhere also can be described as consisting of one or more *microplates*. Although most of the motion between the North America and Pacific plates occurs along the San Andreas fault itself, substantial movements also involve many smaller faults in a wide zone from western Nevada to offshore California (figs. 1, 2). Sudden movements within this system have produced many damaging earthquakes, including the famous M7.8 San Francisco shock of 1906 (fig. 3 and table 3, no. 9), the M7.1 Imperial Valley earthquake of 1940 (fig. 4), and the M6.7 Northridge jolt of 1994 (table 3, no. 23).

The surface expressions of continental transform plate boundaries depend largely on the orientation of the boundary in relation to the direction of plate motion across the boundary. For the San Andreas system, faults that veer to the left (or to the west when looking north) of the direction of Pacific plate motion produce compressive (squeezing) deformation and uplift, thus forming mountains such as the Transverse Ranges in southern California (figs. 1, 2). This deformation also splinters the western fringe of the North America plate, forming a microplate extending from the San Andreas fault to smaller faults east of the Sierra Nevada. Conversely, fault segments that veer to the right cause extensional ("pull-apart") deformation and subsidence, producing topographic lows, such as the Salton Sea in southern California (figs. 1, 2). Strands of the San Andreas fault with trends that more closely parallel plate motion directions show smaller scale features, such as offsets of stream channels (fig. 5) or rows of trees (fig. 4). Natural or manmade features also can be shifted by slow fault movements (*fault creep*), rather than by sudden lurches associated with earthquakes.

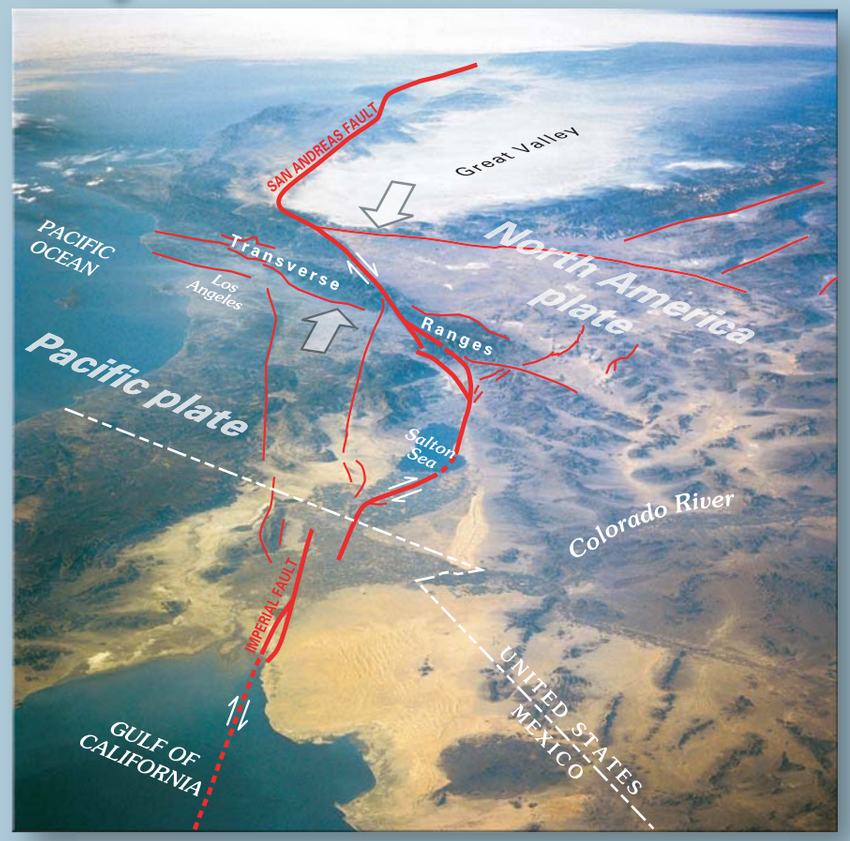
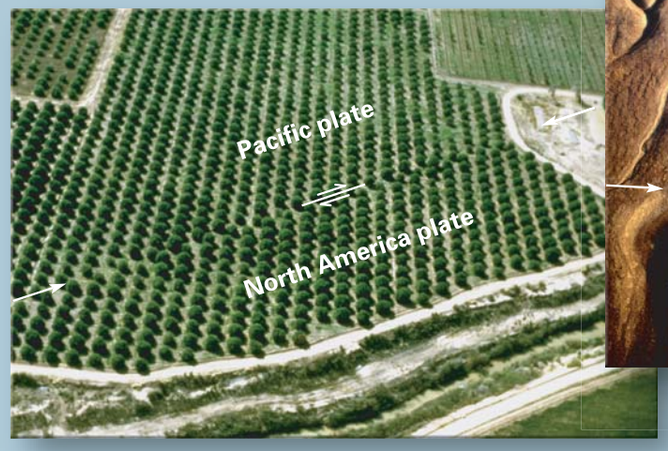


Figure 2.—View from space looking northwest showing a part of the San Andreas fault system (main fault shown by heavy red line, less active faults shown by thin red lines). Major surface expressions of the transform plate motion in this zone (white block arrows) depend on the interplay between fault orientation and direction of plate motion. Image from NASA, no. STS103–701–39; faults drawn by Michael Rymer (USGS).

Figure 3.—View down Sacramento Street in San Francisco showing building damage caused by the earthquake of 1906. Smoke in background is from approaching fires that were ultimately more damaging than the shaking itself. Photograph by Arnold Genthe (American 1869–1942); silver gelatin print; image 200 x 329 mm ($7^{7}/_{8}$ x $12^{15}/_{16}$ in). Courtesy of Fine Arts Museums of San Francisco, Museum Collection A046248.

Figure 4.—Rows of orange trees were offset 6 m by sudden slip on the Imperial fault (part of the San Andreas fault system) during the M7.1 Imperial Valley earthquake of 1940. Photograph by John S. Shelton, 1959, used with permission.



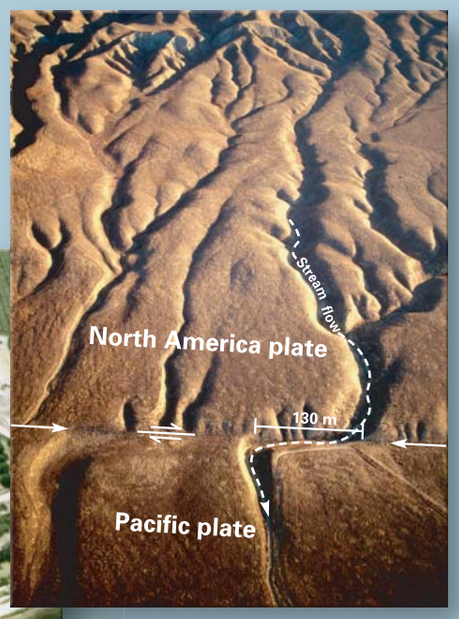


Figure 5.—Aerial view of the stream channel of Wallace Creek offset by San Andreas fault motion on the Carrizo Plain, central California. The fault shifted the creek on the North America plate to the right by 130 m over a period of several thousand years. A single great earthquake in 1857 caused about 9.5 m of this motion. Photograph from Collier (1999), used with permission.

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