Geologic Hazards Photos Volume 1
Faults

Faults

Through the study of faults and their effects, much can be learned about the size and recurrence intervals of earthquakes. Faults also teach us about crustal movements that have produced mountains and changed continents. Initially a section of Earth�s crust may merely bend under pressure to a new position. Or slow movement known as seismic creep may continue unhindered along a fault plane. However, stresses often continue to build until they exceed the strength of the rock in that section of crust. The rock then breaks, and an earthquake occurs, sometimes releasing massive amounts of energy. The ensuing earth displacement is known as a fault.

Faults vary in length from a few centimeters to hundreds of kilometers across. Displacements of one side of the fault over the other vary from fractions of a meter to many kilometers. In many cases the displacement is not confined to a single fracture but is distributed throughout a fault zone. Many faults do not rupture the surface, but when the surface is broken, the fault line is visible as a fault trace or outcrop.

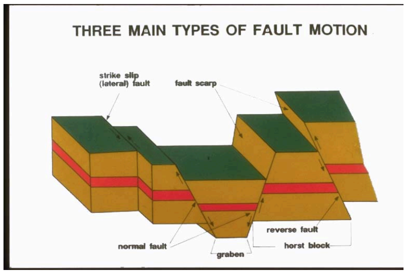
Vertical or horizontal movement may occur along a fault plane. Sometimes both vertical and horizontal movement occur simultaneously. Faults are named according to the type of movement that has occurred. The term slip is used to indicate relative displacement across the fault. When the vertical movement along the fault plane roughly matches the horizontal movement, the fault is called an oblique-slip fault. When the movement along the fault plane is generally horizontal, it is a strike-slip fault. These are also called lateral faults. A left-lateral fault is one in which the side opposite a person facing the fault has been displaced to the left, and a right-lateral fault is one in which the movement has been to the right. Offset streams are found along active strike-slip faults. A transform fault is a zone of lateral movement along which the ridges and rises have been offset and along which the displacement suddenly stops or changes form and direction. Lateral displacement occurs on the fault only between spreading areas; no displacement occurs outside of this.

When the movement along the fault plane is predominately vertical, it is a dip-slip fault. There are sub-classifications within this category. A normal fault occurs when the earth above the fracture moves down in respect to the earth below the fracture. A reverse fault occurs when the rocks above the fracture move up with respect to those below. A reverse fault with an angle of less than 45 degrees is called a thrust fault. Thrust faults are generally characterized by older rocks resting on younger rocks, although in some cases younger rocks may be thrust over older rocks.

There are features in the landscape which are brought about by vertical faulting. A scarp is the upthrown side of a fault, i.e., where the block of earth has moved up exposing a fresh rock and soil face. A scarp resembles a low, linear cliff face. Because fault movement involves the sliding of one block past another, many fault surfaces are smoothly polished and grooved. These features, called slickensides, provide one clue to the direction of fault slippage of the most recent event. Miners obtaining mineral riches trapped along fault zones have given names to the two block sections on opposite sides of the vertical fault. The footwall is the block section beneath the miner's feet and the hanging wall is the section above his head.

Sometimes a section of Earth's crust is under pressure from horizontal forces in opposite directions. A horst is a long plateau or table-like formation, formed from a single elongated block which has been forced up under such pressure between two normal faults. When an area of the crust is being stretched apart, two normal faults may occur separated by a block of rock that falls into a lower position. This is called a graben. It is characterized by a long trough bounded by normal fault scarps on either side.

Slide Set Images

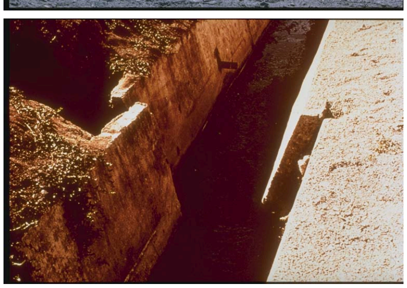


Fault block diagram Diagram showing the three main types of fault motion. (See main introduction of faults for more detailed information on the fault types.)

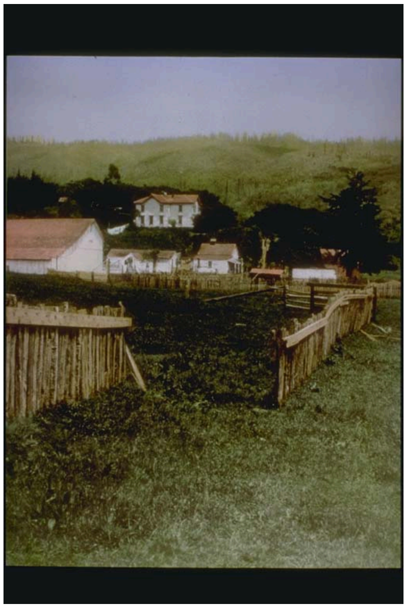
Aerial view of San Andreas fault Right-Lateral Strike-Slip Faults View southeast along the San Andreas zone. A linear valley has been eroded along the main trace of this right- lateral strike-slip fault. The black line at the right is not a fault but a fence line against which tumbleweed has collected. Location: Carrizo Plain area, San Luis Obispo County, California. [Photo credit: R.E. Wallace, U.S. Geological Survey.]

View of cross section of San Andreas fault Right-Lateral Strike-Slip Faults View to the east of the Highway 14 road cut that transects the San Andreas fault zone. Since 1994, California Transportation has cut smooth the portion of the San Andreas that bisects Highway 14, creating a spectacular view of the compressional forces in the area. The Northridge, California, earthquake (January 17, 1994) narrowed the San Fernando Valley by 9 cm and raised the top of the hills to the north by approximately 38 cm. The earthquake resulted in increased compression along the San Andreas fault. In this view, a subsidiary fault transects the fold in the right half of the photo. [Photo credit: Clifford E. Harwood, Encino, CA.]

Second view of cross section of San Andreas fault Right-Lateral Strike-Slip Faults View to the right (south) of photo 3 along the San Andreas fault zone. In this area, the displacement is not confined to a single fracture but is distributed throughout the zone, and includes many folds as well as several faults. Two subsidiary faults offset the layers and form the two �legs� of a triangle. [Photo credit: Clifford E. Harwood, Encino, CA.]



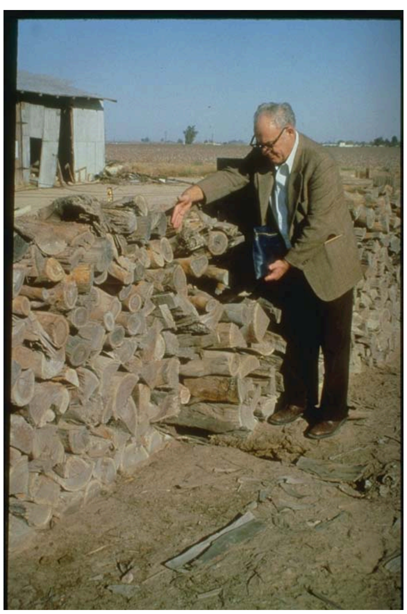
Drain offset caused by seismic creep Right-Lateral Strike-Slip Faults Drain offset produced by seismic creep along the San Andreas fault at the Almaden Winery in central California. The winery is also experiencing offset walls, bent and broken pipes, etc., due to seismic creep. Motion along the fault is mostly strike-slip. [Photo credit: University of California, Berkeley.]



Fence offset produced by 1906 San Francisco earthquake Right-Lateral Strike-Slip Faults The fence was offset 2.6 m by the magnitude 8.2 earthquake of April 18, 1906, San Francisco, California. The section of the San Andreas fault shown here is 0.8 km north of Woodville. The photo is looking northeast. The lateral or strike-slip fault offset is large; however, the trace is nearly invisible. This earthquake, together with the fire that followed, resulted in more than 3,000 deaths and 400 million dollars of property damage. [Photo credit: G.K. Gilbert, U.S. Geological Survey. Photo has been colorized.]

Collapse of John Muir School on Pacific Avenue from the 1933 Long Beach earthquake. [Photo credit: W.L. Huber.]

En echelon fractures along Imperial fault Right-Lateral Strike-Slip Faults The Imperial fault east of El Centro, California, shows characteristic right stepping en echelon fractures. The rupture on the fault during the magnitude 6.9 earthquake of October 15, 1979, in Imperial Valley, California, extended from about 4 km north of the international border to about 4 km south of Brawley. Maximum lateral displacement was about 55 cm in the Heber dunes, and maximum vertical displacement was 19 cm southeast of Brawley. The earthquake injured 19 people, and damaged more than 2,000 homes and businesses in the Imperial Valley. Property damage was estimated at $30 million. [Photo credit: University of Colorado.]



Offset of woodpile along Imperial fault Right-Lateral Strike-Slip Faults Offset of woodpile shows right-lateral strike-slip offset of fault. The rupture occurred on the fault during the Imperial Valley, California, earthquake of 1979. (See prior caption.) [Photo credit: G. Reagor, U.S. Geological Survey.]

Offset of rows in plowed field Right-Lateral Strike-Slip Faults A fault trace crosses a plowed field. The trace was produced by the same earthquake in the Imperial Valley. The agricultural industry suffered heavy losses from damage to canals, irrigation ditches, and subsurface drain tiles disturbed by the movement along the Imperial fault. [Photo credit: G. Reagor, U.S. Geological Survey.]

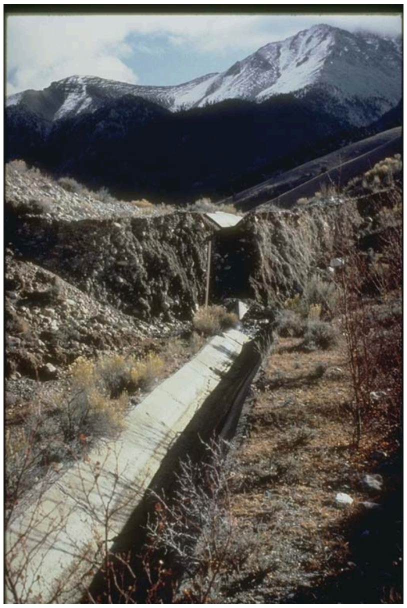
Offset of cement-lined ditch in Guatemala Left-Lateral Strike-Slip Faults Offset of a cement-lined ditch by the left-lateral strike-slip Motagua fault resulting from the earthquake of February 4, 1976, in Guatemala. The Motagua fault is part of the transform fault system between the North American and Caribbean plates and comprises the northern boundary of the Caribbean plate. The North American plate is moving 2.2 cm per year to the west along this boundary. The observed surface rupture along the Motagua fault was 320 km. Displacement across the fault was almost entirely horizontal with the strike-slip component ranging up to 3.4 m and averaging 1.1 m. Vertical displacements were less than 30 percent of the horizontal displacement. Faults caused extensive damage to underground facilities as well as to surface structures. [Photo credit: U.S. Geological Survey.]

Deformation of rows by 1976 earthquake Left-Lateral Strike-Slip Faults Rows in the cultivated field west of El Progresso, Guatemala, deformed by the earthquake of February 4, 1976. The thick, saturated, unconsolidated deposits have yielded by plastic deformation rather than rupture along the left- lateral strike-slip fault. This quake resulted in the deaths of 23,000 people and $1.1 billion dollars in property damage. [Photo credit: U.S. Geological Survey.]

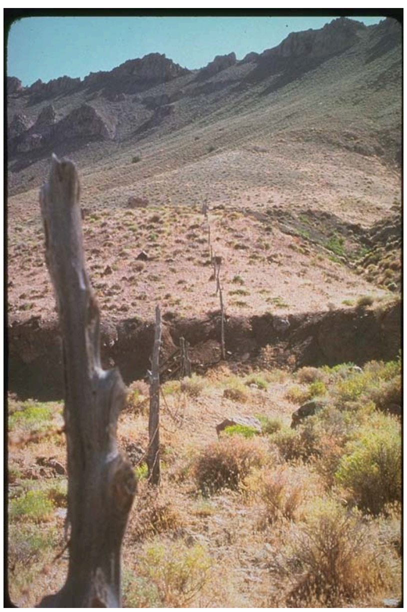
Tree bisected by fault in Guatemala Left-Lateral Strike-Slip Faults This tree was killed by movement along a strike-slip fault through its center, during the same Guatemala earthquake. This was the largest strike-slip event in North America since 1906. [Photo credit: U.S. Geological Survey.]

Fault scarp near Hebgen Lake, Montana Normal Faults This fault scarp near Hebgen Lake, Montana, after the magnitude 7.1 earthquake of August 18, 1959, shows a dip-slip movement of 5.5 to 6.0 m. Since the earth above the fracture moved down in respect to the earth below the fracture, the fault is known as a normal fault. Such faults result from extension or stretching of the rock layers. Maximum vertical displacement was 6.4 m observed near Red Canyon Creek. Considerable cracking and shifting of roadways, and the destruction of much timber, caused damage exceeding $11 million. In Yellowstone National Park new geysers started erupting, and large steaming cracks, resulting from massive slumping, were observed after the quake. [Photo credit: National Geophysical Data Center.]

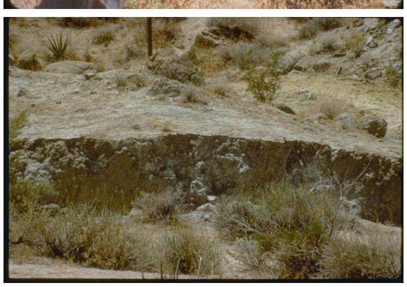
Fault scarp caused by Borah Peak, Idaho earthquake Normal Faults This section of the normal fault scarp was produced by the earthquake of October 28, 1983, at Borah Peak, Idaho. It is 678.8 m northwest of the alluvial fan head on Rock Creek. Nearly vertical slickensides on the fault surface are visible on the lower half of the scarp. The scarp is 2.5 m high at this location. The earthquake killed two children in Challis, Idaho, and caused $12.5 million in property damage. [Photo credit: R.C. Bucknam, U.S. Geological Survey.]



Fault scarp and horizontal offset near Dickey, Idaho Oblique-Slip Faulting The magnitude 7.2 earthquake of October 28, 1983, near Borah Peak, Idaho, produced this fault. The scarp and fracture zone are located on Rock Creek, near Dickey, Idaho, and Double Springs Pass Road. The wooden pole is 1.9 m high. This normal fault shows characteristics of oblique-slip, where there is both vertical and horizontal displacement. The horizontal movement is left-lateral. The fault scarp extended for more than 35 km, with vertical displacements up to 2.5 m observed between MacKay and Challis, Idaho. [Photo credit: G. Reagor, U.S. Geological Survey.]

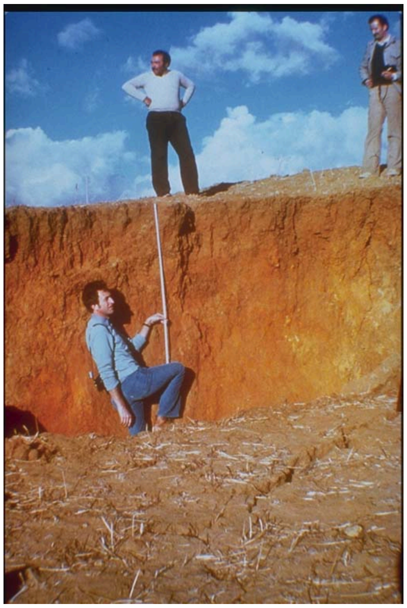


Oblique-slip fault scarp near Pleasant Valley, Nevada Oblique-slip fault produced during the 7.7 magnitude earthquake of 1915, Pleasant Valley, Nevada. The strike-slip component is shown by the offset of the fence. [Photo credit: U.S. Geological Survey.]

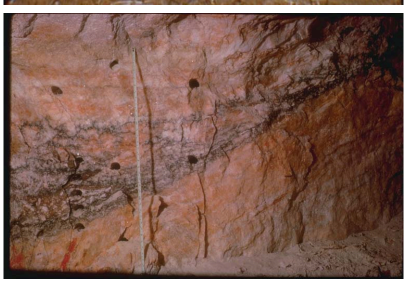


Oblique-slip fault scarp at Flamingo Heights, California Oblique-slip fault scarp at Flamingo Heights produced by the June 28, 1992, Landers, California earthquake. Sections of the fault slipped a maximum of 5.5 m horizontally and 1.8 m vertically. The surface rupture was almost 70 km long. In the Landers area, there was about 3 m of right-lateral strike-slip movement. [Photo credit: Lindie R. Brewer, U.S. Geological Survey.]

Reverse fault near Clark County, Montana Reverse and Thrust Faults A view of the French reverse fault in a roadcut on the west side of French Gulch just south of the Sun River in Lewis and Clark County, Montana, as it appeared in 1966. This reverse fault places the lower beds of the Castle Reef Dolomite (light gray) onto the Flood Shale member of the Blackleaf Formation (dark gray). The fault dips 60� W, and the overlaying strata dip about 50� W. The black shales beneath the fault are badly crumbled, whereas the carbonate beds above it are undisturbed. [Photo credit: M.R. Mudge, U.S. Geological Survey.]



Blind thrust fault scarp at El Asnam, Algeria Reverse and Thrust Faults The fault scarp from the earthquake of October 10, 1980, at El Asnam, Algeria, shows a 3-m vertical offset on a blind thrust fault. The movement along this fault results from compression. When the thrust layers encounter opposition at depth, they are forced up vertically, producing a vertical scarp. The scarp extends for kilometers along the landscape of El Asnam. This 7.3 magnitude earthquake killed 5,000 people and caused severe damage. [Photo credit: H.C. Shah, Stanford University.]



Under-thrust fault from nuclear test Reverse and Thrust Faults Under-thrust fault resulting from the Gnome explosion, a nuclear test, in Eddy County, New Mexico, 1962. The fault parallels bedding of the lower plate, following a thin clay seam that normally lies 1.6 m above basal clay-like halite at left. The cavity is to the right. Scale is .9 m long. [Photo credit: L.M. Gard, Jr., U.S. Geological Survey.]

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