

Engineering Seismology and Seismic Hazard – 2019

Lecture 3

Earthquakes and Faults

Valerio Poggi

Seismological Research Center (CRS)

National Institute of Oceanography and Applied Geophysics (OGS)



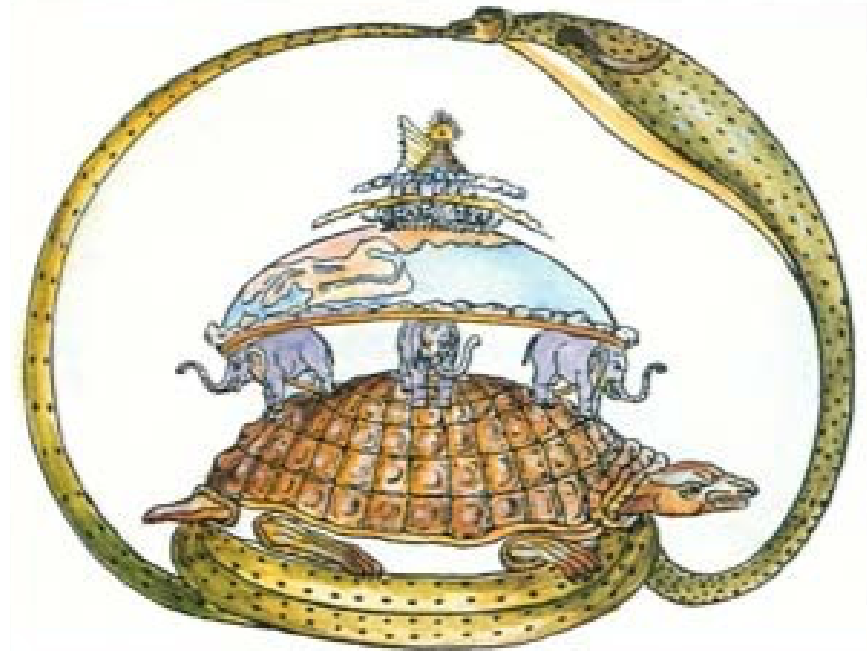
Earthquake Mythology

Japan: a great catfish, or Namazu, lies curled up under the sea, with the islands of Japan resting on his back. A demigod, or Daimyojin, holds a heavy stone over his head to keep him from moving. Once in a while, though, the Daimyojin is distracted, the namazu moves, and the Earth trembles.



Earthquake Mythology

India: The earth is held up by 4 elephants that stand on the back of a turtle. The turtle is balanced on top of a cobra. When the animals move, the earth trembles and shakes



New Zealand: Mother Earth has a child within her womb, the young god Ru. When he stretches and kicks as babies do, he causes earthquakes.

Earthquake Mythology

Siberia: A god named Tuli drove an earth-laden sled pulled by flea-infested dogs: when the dogs stopped to scratch, the earth shook.



This only myth and folklore.

However, the phenomenon was scientifically analyzed starting only from the beginning of the 18th century....

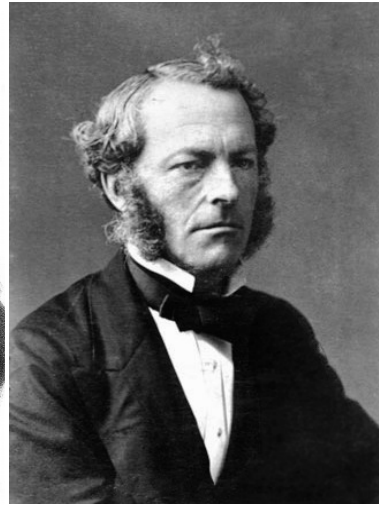
Early Studies 1800's:



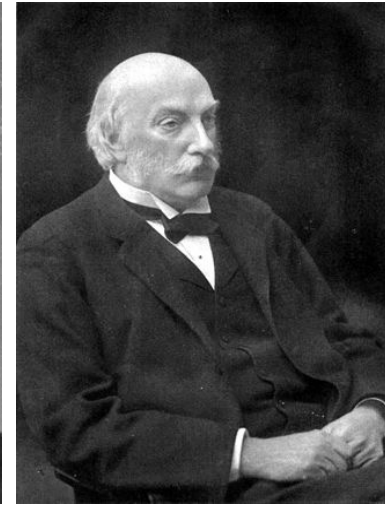
Augustin
Louis Cauchy



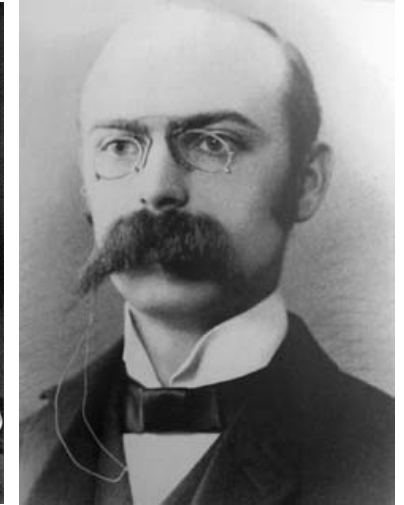
Siméon Denis
Poisson



Sir George
Stokes



John William
Strutt, 3rd
Baron Rayleigh



Augustus
Edward Hough
Love

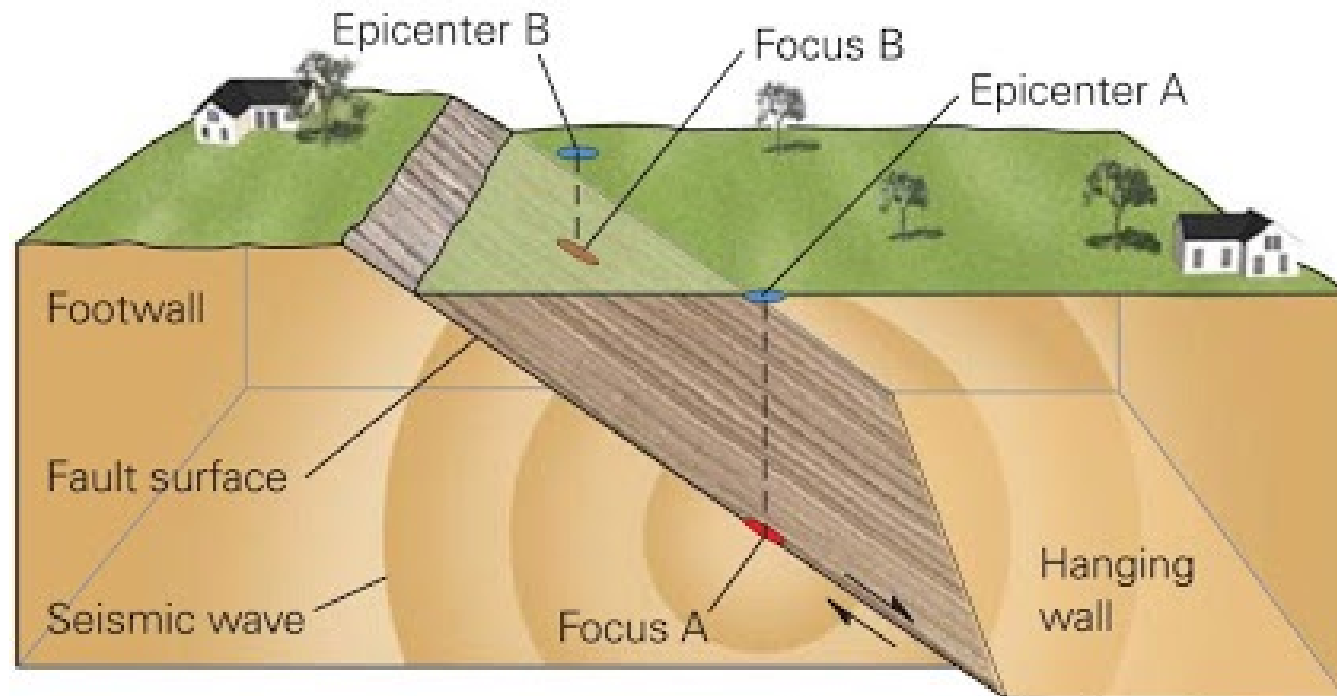
Elastic wave propagation theory was developed “ahead” of any observations (no seismometers!).

Major waves (body waves and surface waves) were deduced **mathematically** and only subsequently corroborated by observations.

What is an Earthquake?

Earthquake describes both:

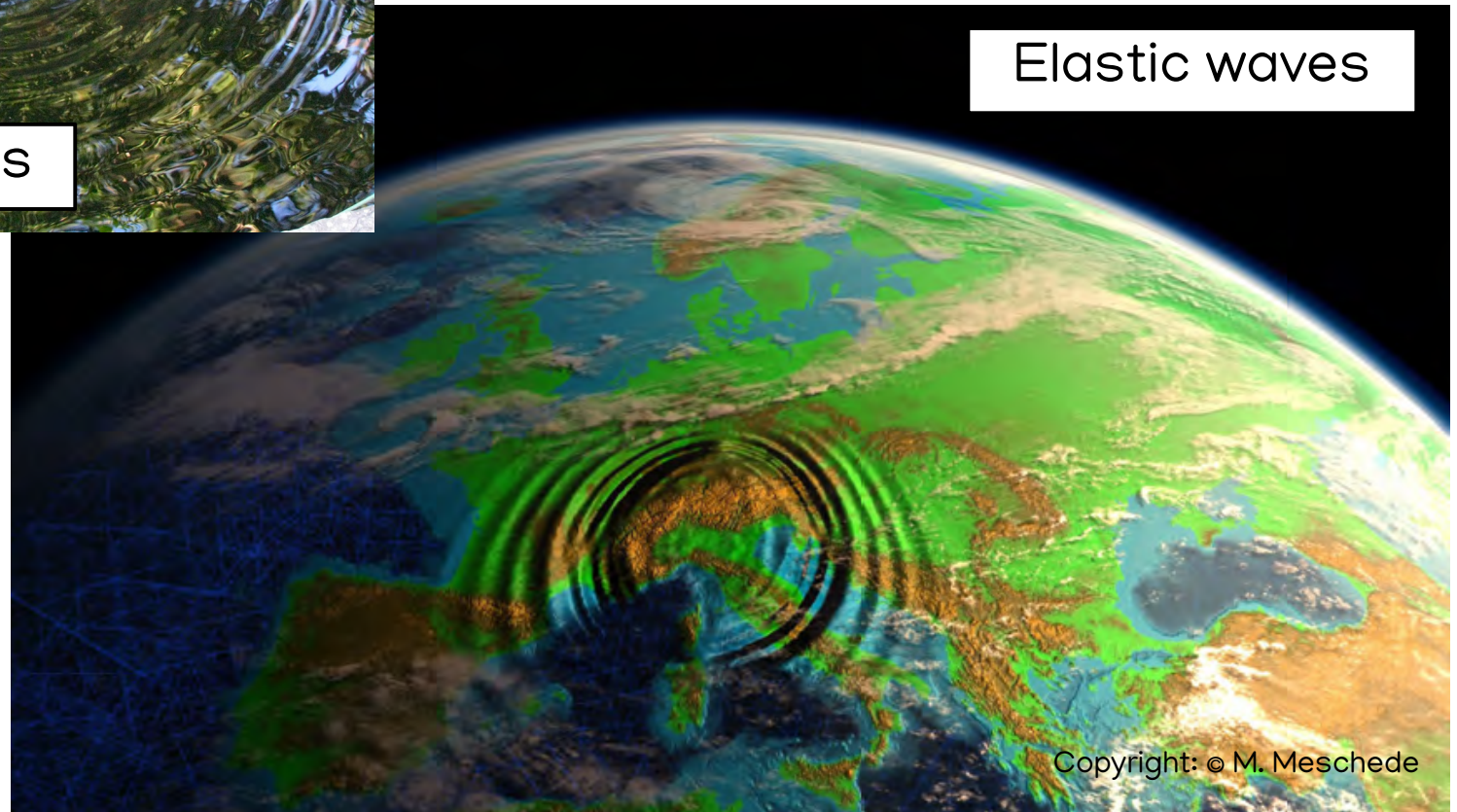
- Sudden movement of the earth's crust caused by the release of stress accumulated along geologic faults, volcanic activity or other sudden stress changes (natural or artificial) in the Earth (**CAUSE**).
- the resulting ground shaking and radiated seismic energy (**EFFECT**)



What is an Earthquake?



The phenomenon shares **some** similarities with the generations of ripples by trowing a stone in a pond.



What Causes an Earthquake?



Meteorites

The largest earthquakes on Earth must have been triggered by meteorite impact!



What Causes an Earthquake?



Nuclear Explosions



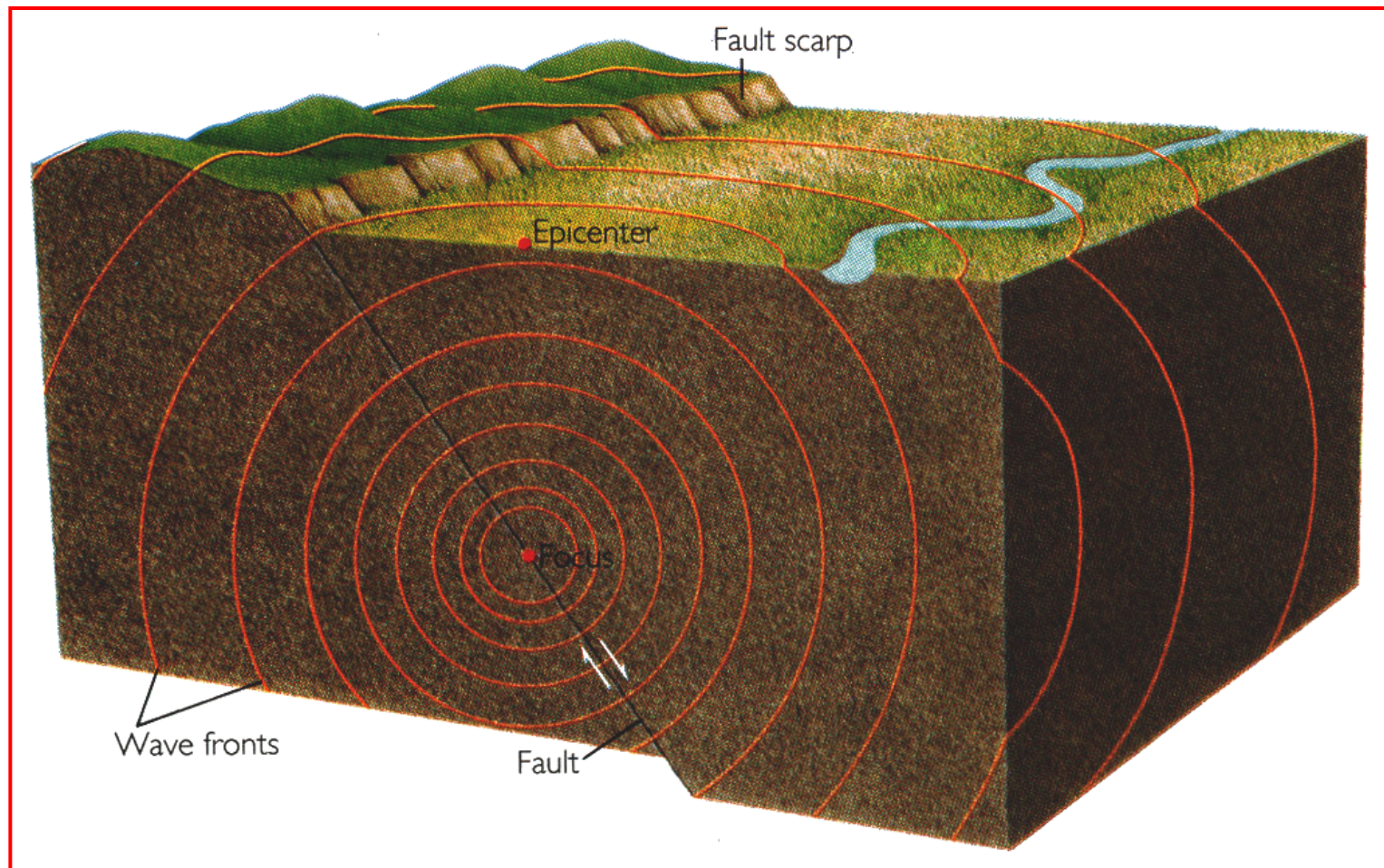
What Causes an Earthquake?

Volcanoes



Faults

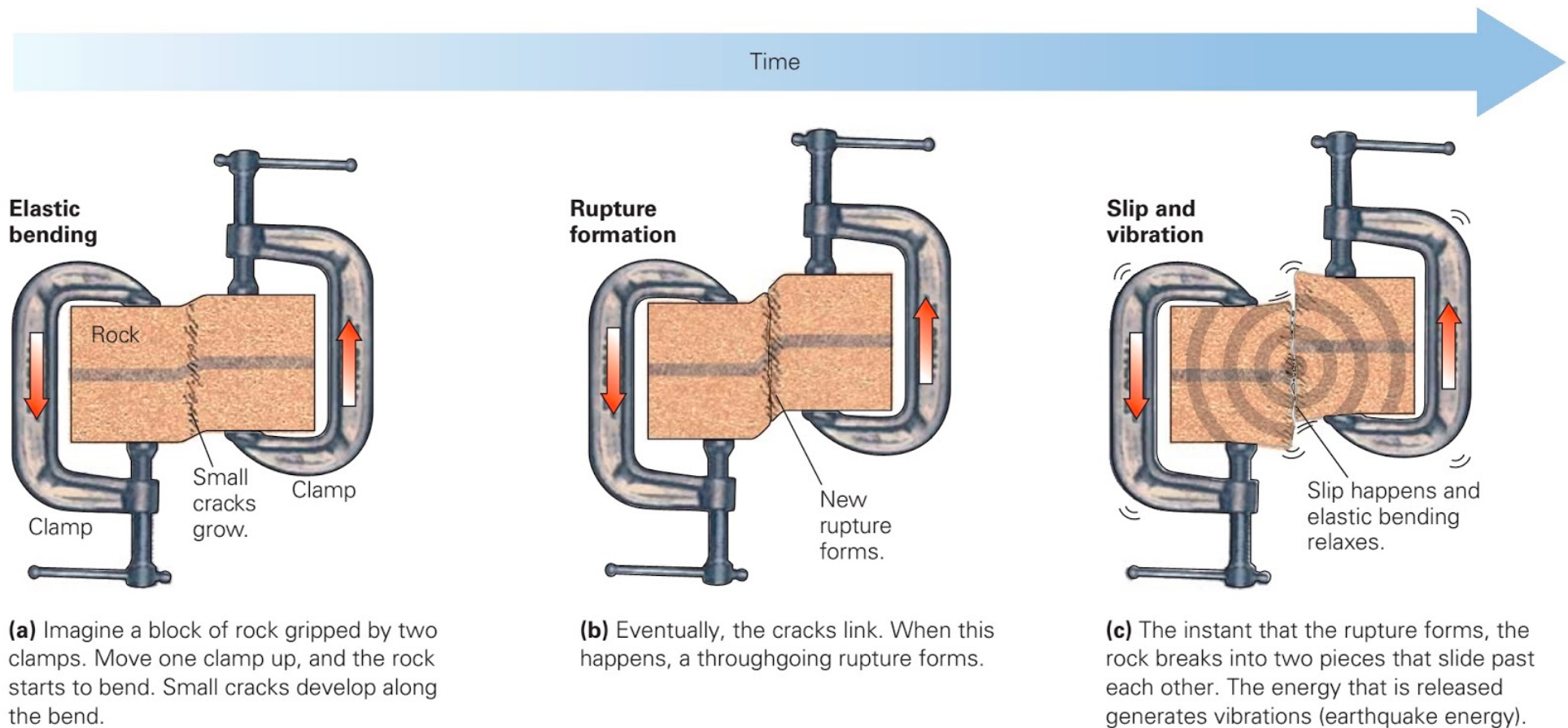
Nowadays the association between faulting and Earth vibrations is part of common knowledge.



Elastic Rebound Theory

The earthquake generation process can be intuitively expressed by the elastic rebound theory.

Reid postulated his theory in 1906, while surveying the areas damaged by the 1906 San Francisco earthquake.

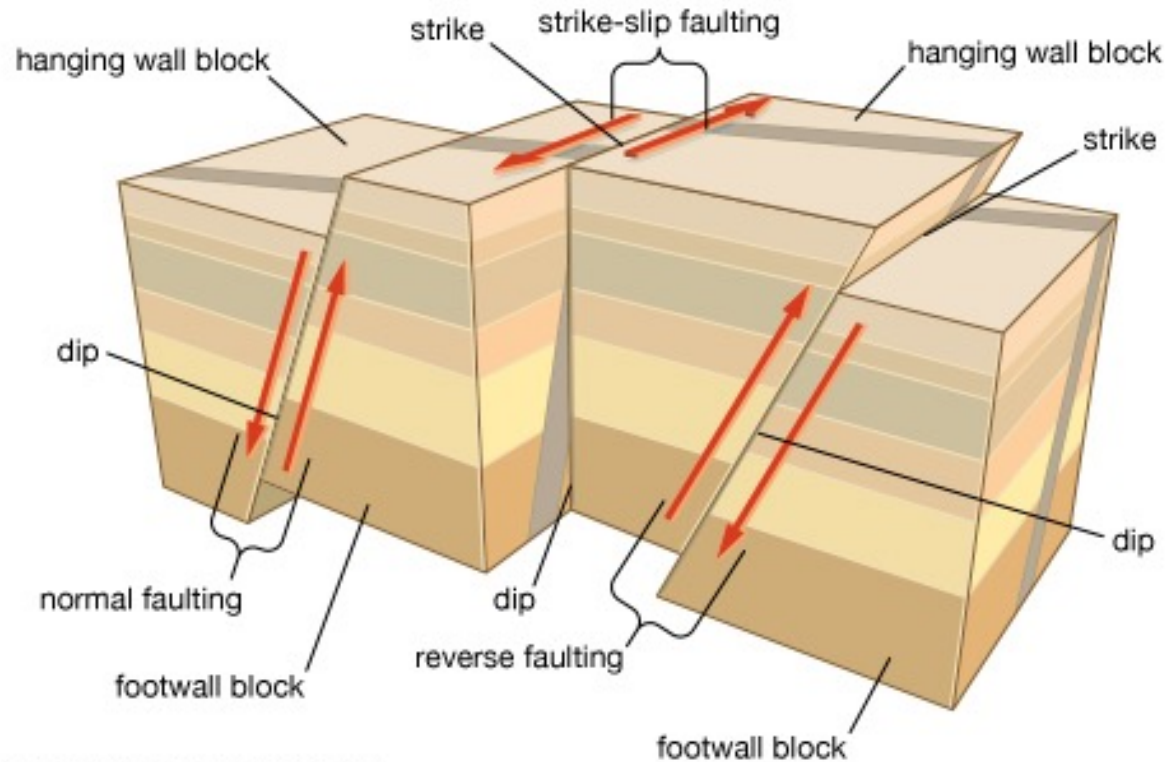


(a) Imagine a block of rock gripped by two clamps. Move one clamp up, and the rock starts to bend. Small cracks develop along the bend.

(b) Eventually, the cracks link. When this happens, a throughgoing rupture forms.

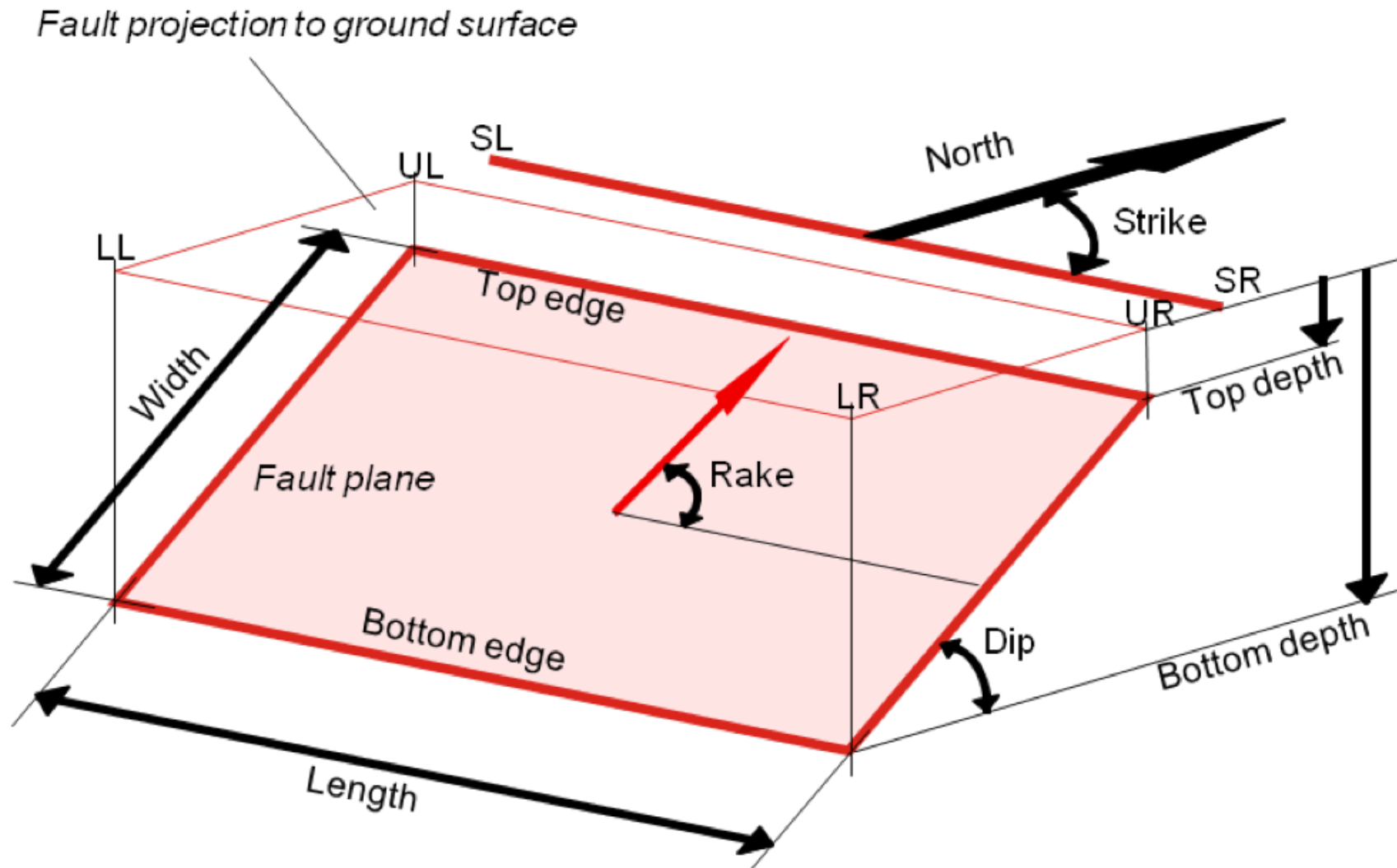
(c) The instant that the rupture forms, the rock breaks into two pieces that slide past each other. The energy that is released generates vibrations (earthquake energy).

Fault's Anatomy



- **Fault Plane:** surface where the movement taken place within the fault
- **Hanging Wall:** the rock mass resting on the fault plane
- **Footwall:** the rock mass beneath the fault plane
- **Slip:** relative displacement of formerly adjacent points on opposite sides of a fault, measured on the fault surface

Geometrical Parameters

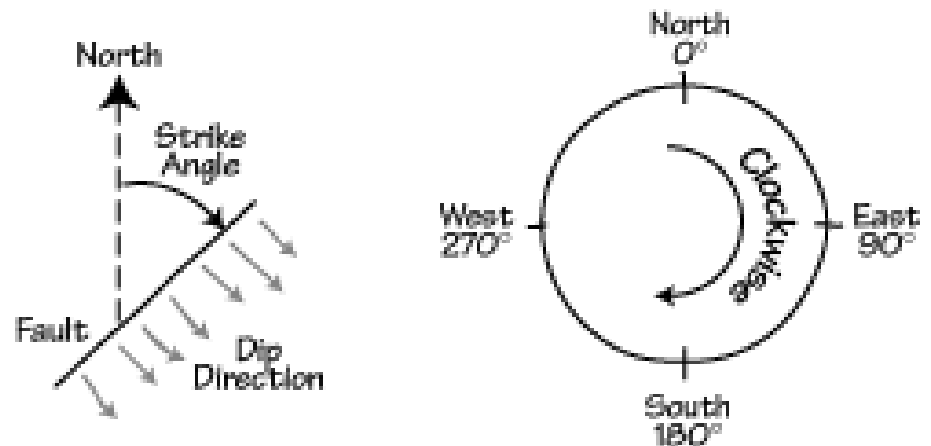
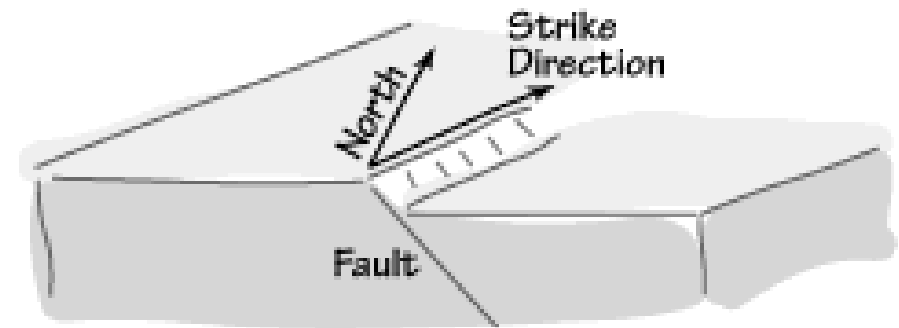
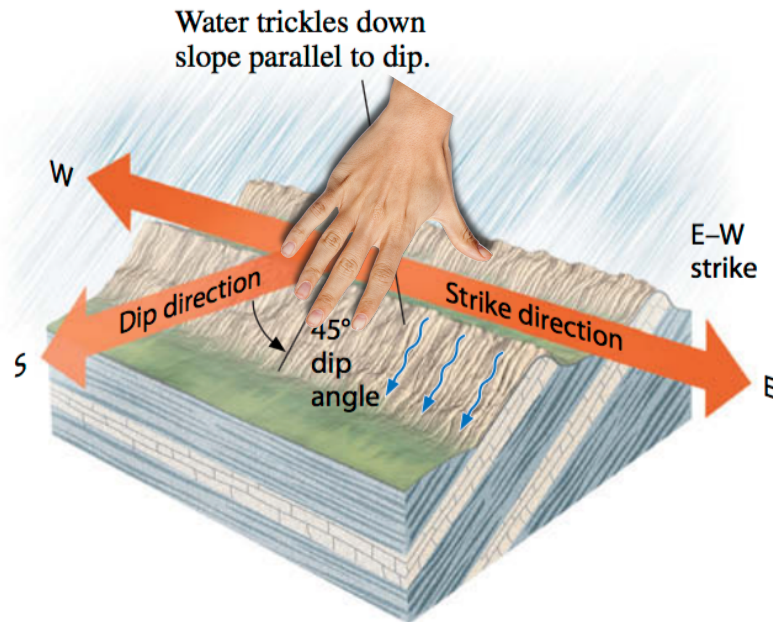


Strike

Strike Angle:

The strike is the compass direction of a rock layer along the line of its intersection with a horizontal surface.

Strike Values: 0 – 360°

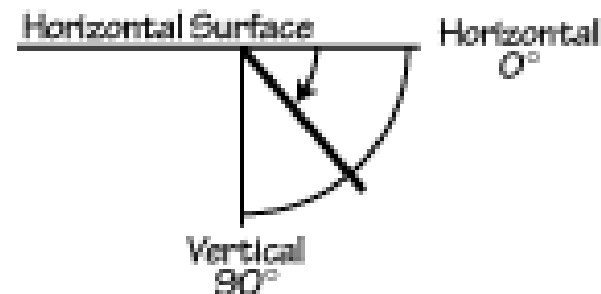
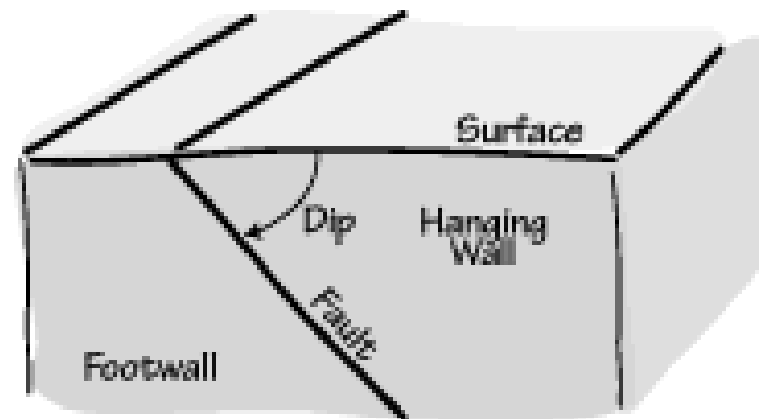


Dip

Dip Angle:

The dip is the angle and direction of the steepest descent of a rock layer from the horizontal, measured at right angles to the strike.

Strike Values: $0 - 90^\circ$

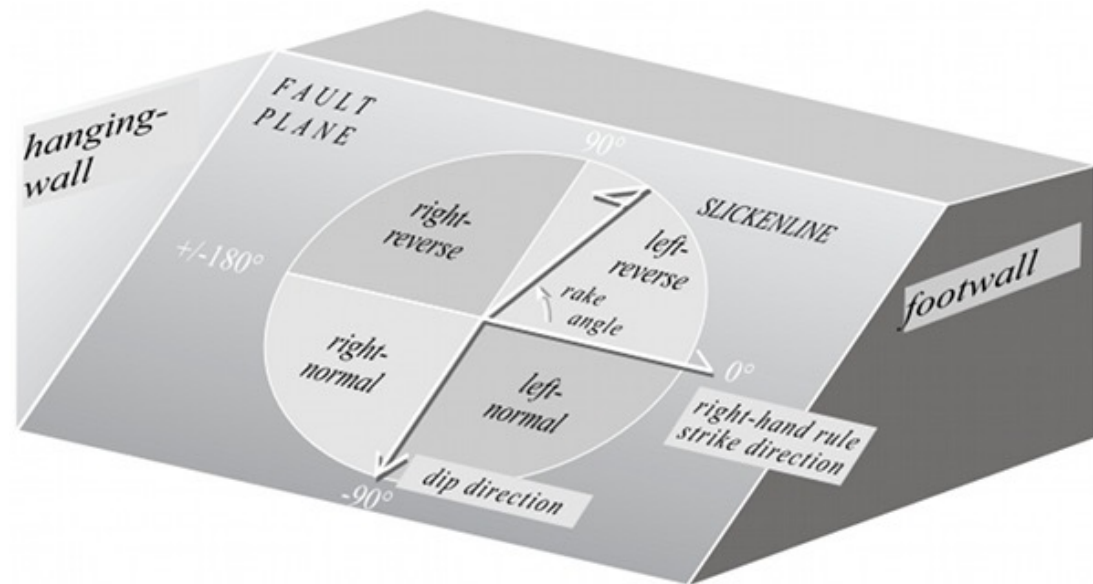


Rake

Rake angle:

The angle between the strike and the slip direction measured in the counter clockwise direction on the fault plane

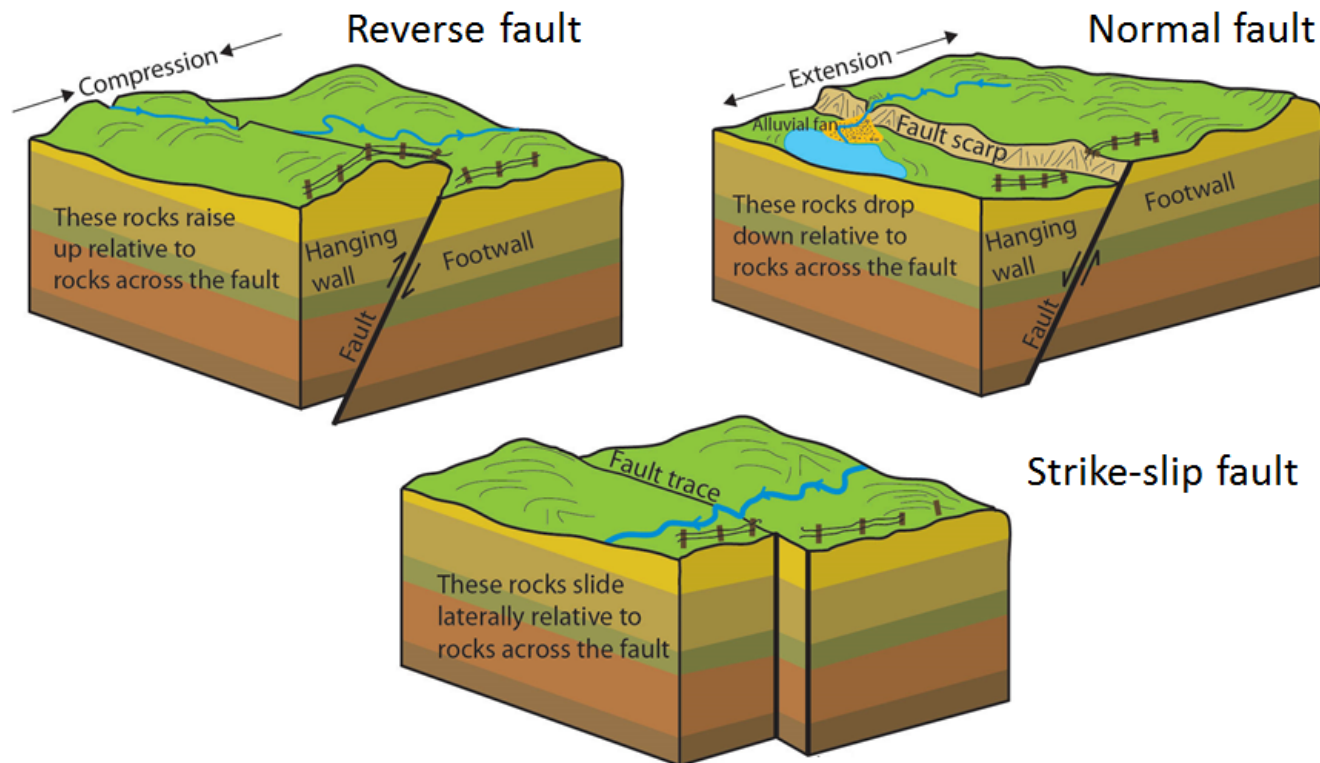
Rake Values: $180^\circ - 180^\circ$



Fault Classification

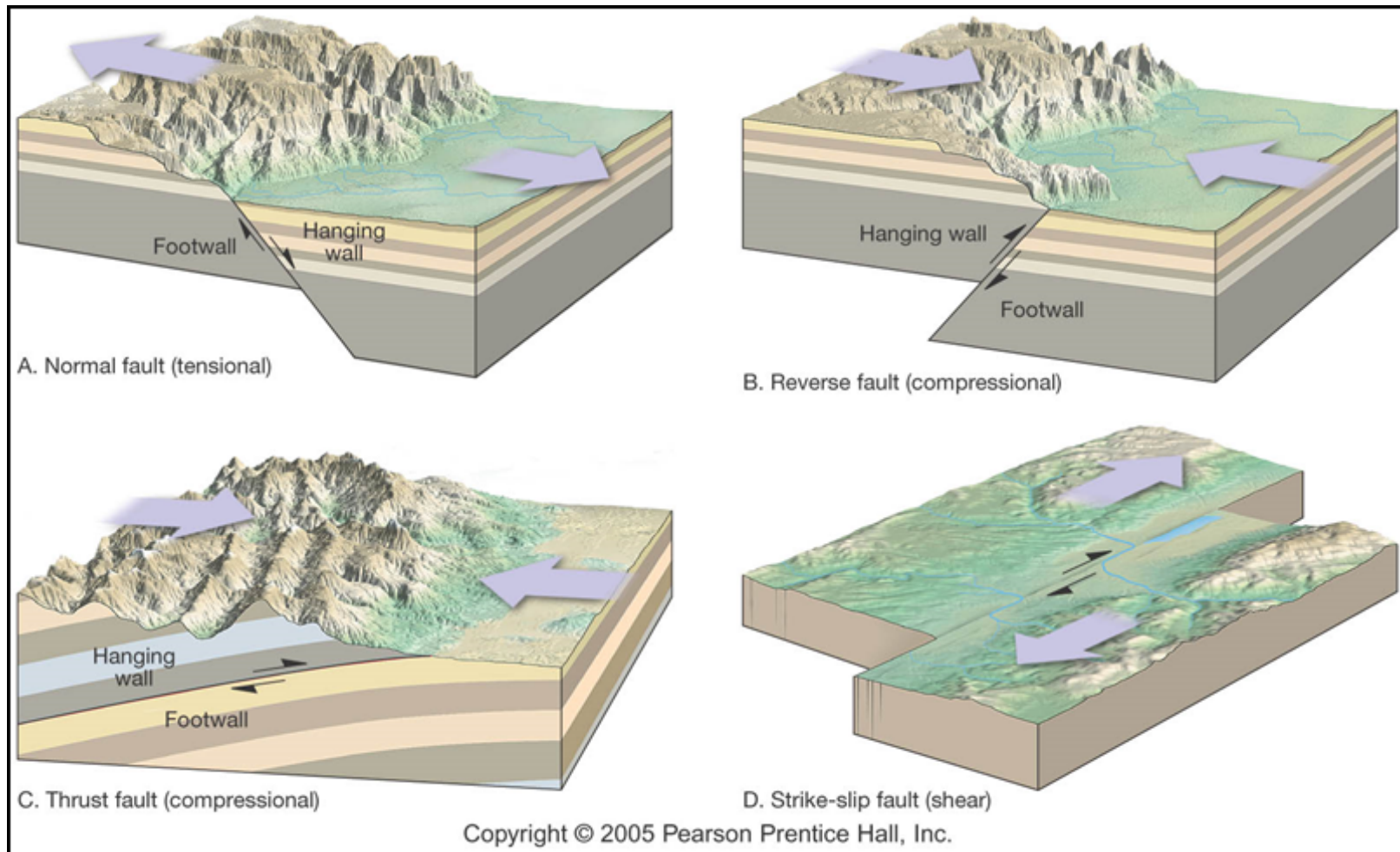
Faults classified on the basis of the relative movement between the two blocks they separate.

- Dip-slip faults: the slip direction is parallel to the dip direction
- Strike-slip fault: the slip direction is parallel to the strike direction
- Oblique-slip faults: intermediate between the previous two

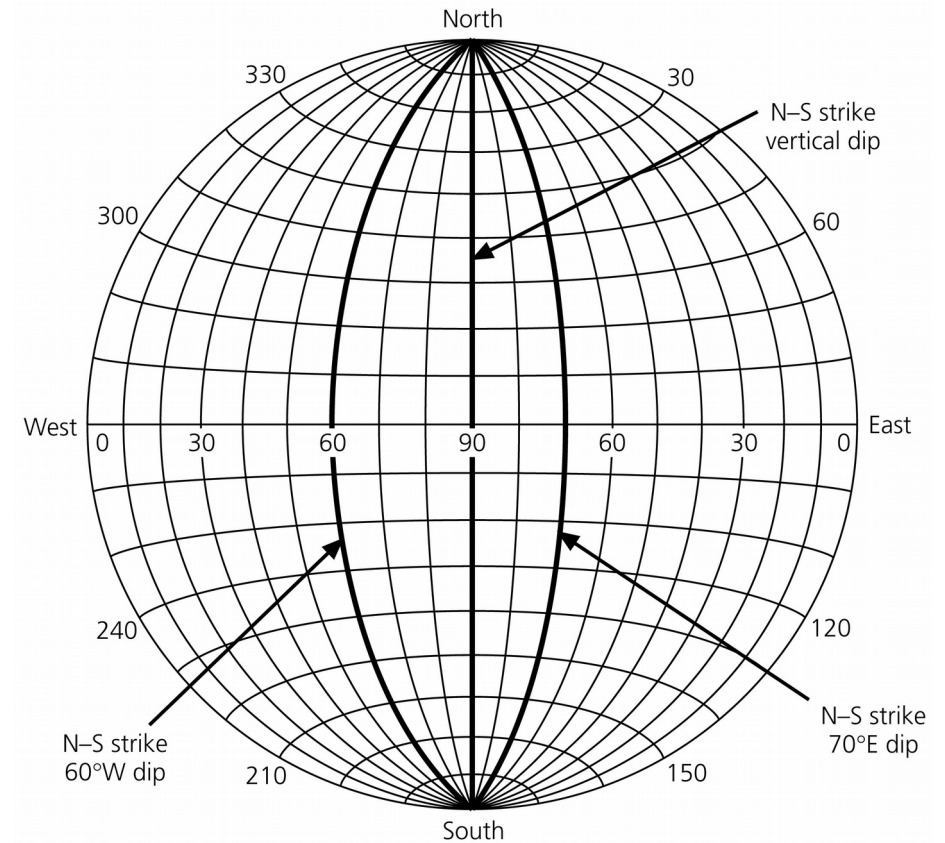
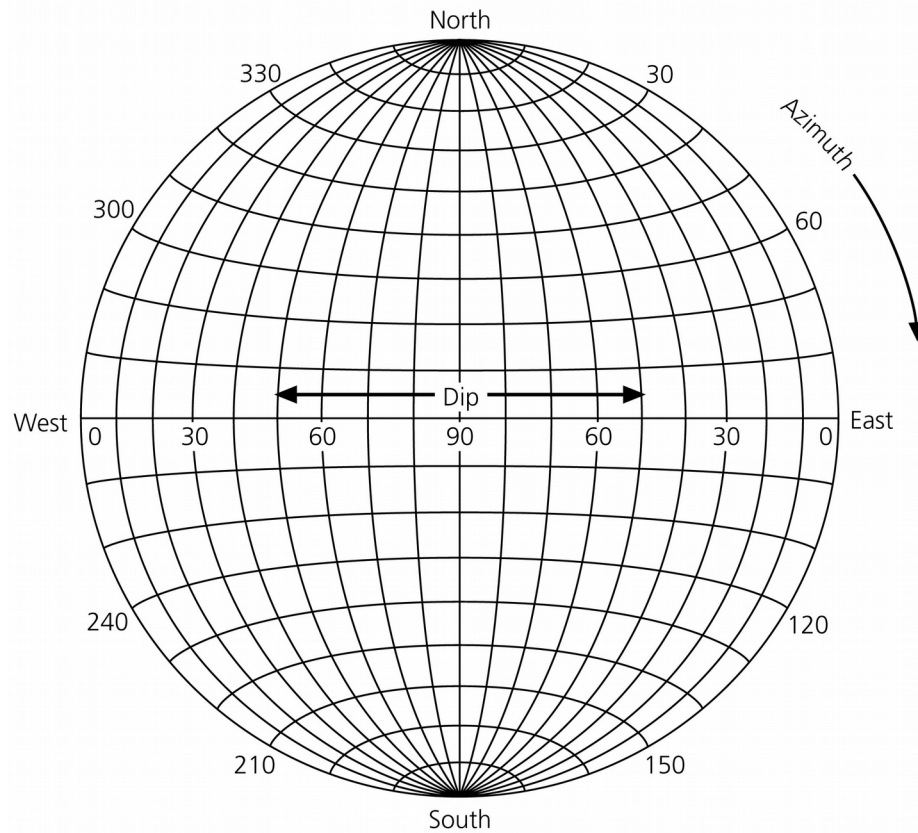


Fault Surface Expression

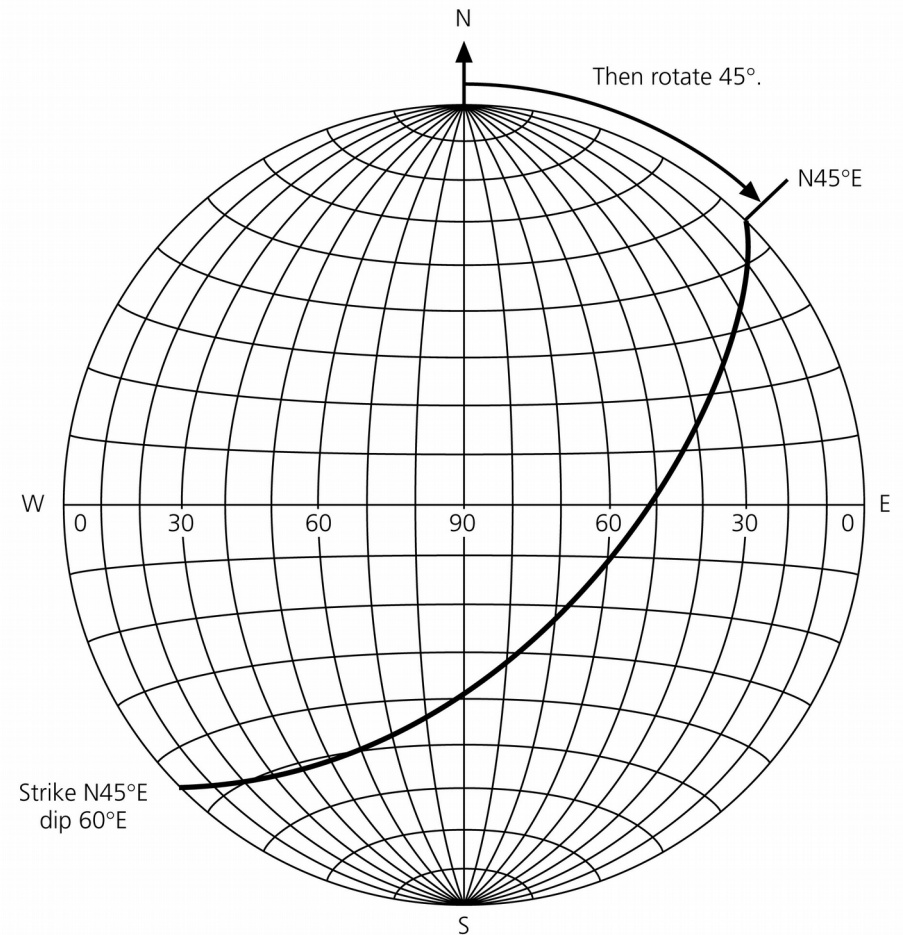
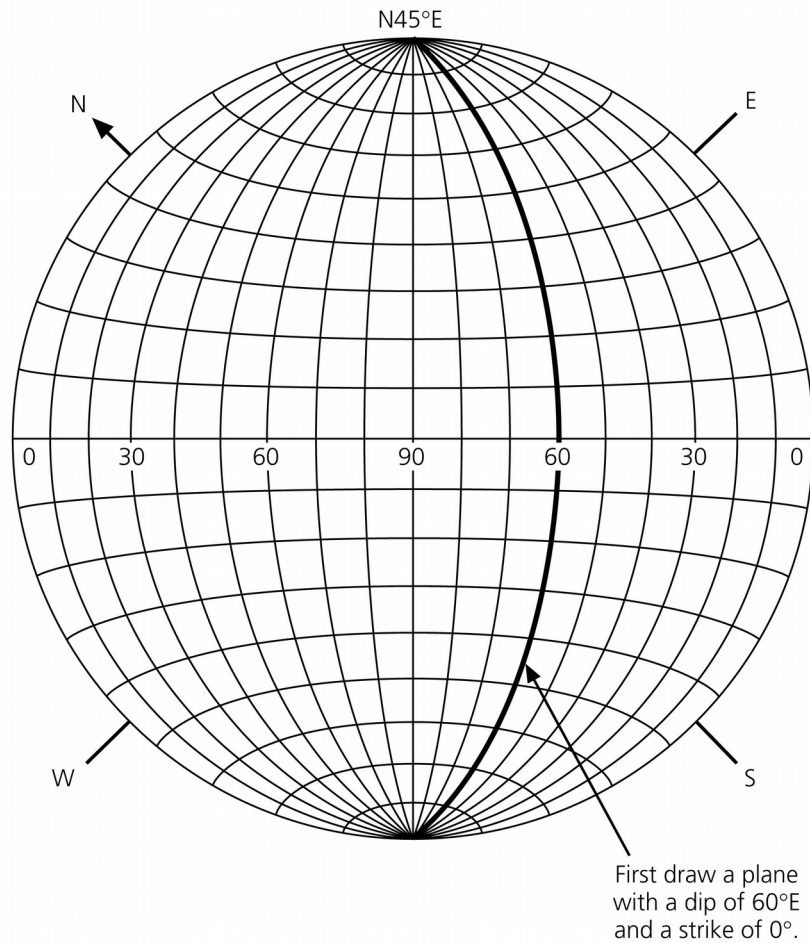
However, faults are not always easy to characterize from the surface. In many cases, they don't even have a surface expression.



Stereographic Projection



Stereographic Projection



Title

Text