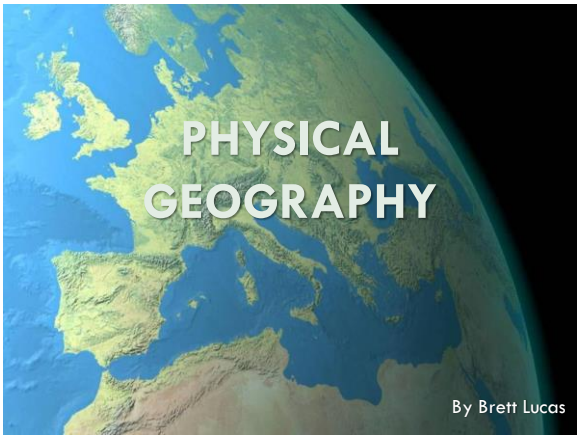


INTERNAL PROCESSES

Internal Processes

- The Impact of Internal Processes on the Landscape
- From Rigid Earth to Plate Tectonics
- Plate Tectonics
- Vulcanism
- Diastrophism
- Folding
- Faulting

The Impact of Internal Processes on the Landscape

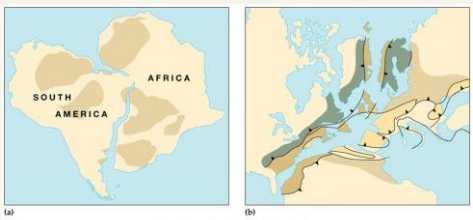
- Until mid-20th century most scientists thought Earth's continents and ocean basins were fixed rigidly in place.
- The theory of plate tectonics, which explains the origin and nature of continents and ocean basins, became accepted by virtually all scientists during the last quarter of the twentieth century.
- Scientists now realize that internal forces of unimaginable strength create ocean basins and shape the continents.

From Rigid Earth to Plate Tectonics

- Wegener's Continental Drift
  - Pangaea and its breakup

From Rigid Earth to Plate Tectonics

- Some of Wegener's Evidence
  - Transatlantic connection – rock types and geological history



From Rigid Earth to Plate Tectonics

- Wegener's flaw – no plausible propelling mechanism
- The mesosaurus fossils

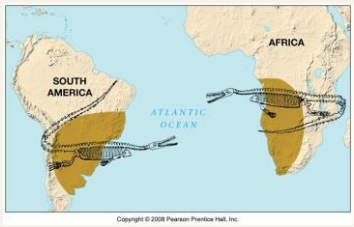
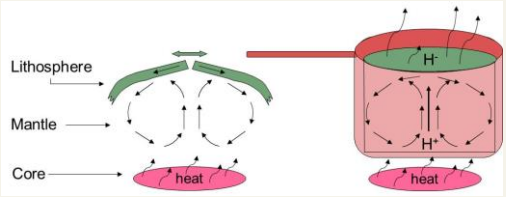
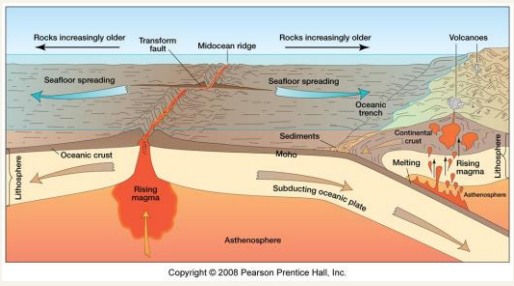


Plate Tectonics

- Convection: The missing propelling mechanism
  - Movement of mass due to changes in its density caused by gain or loss of heat



Seafloor spreading



Age of the ocean floors based on paleomagnetism

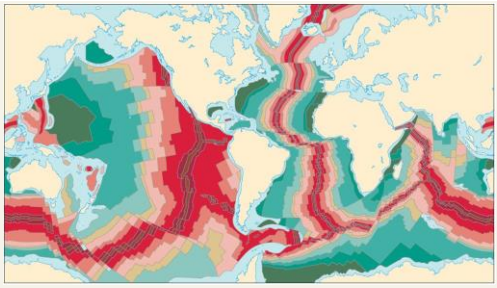


Plate Tectonics

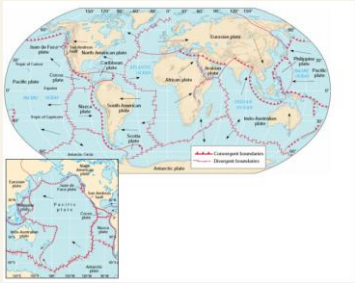
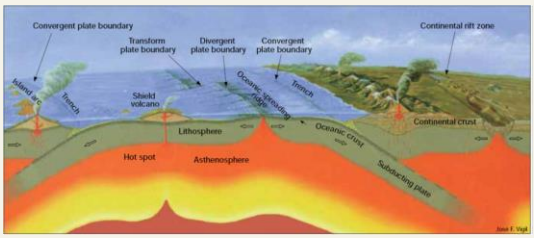


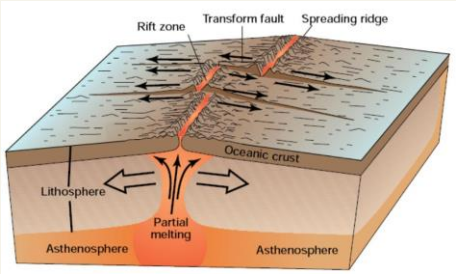
Plate Tectonics

Plate Boundaries

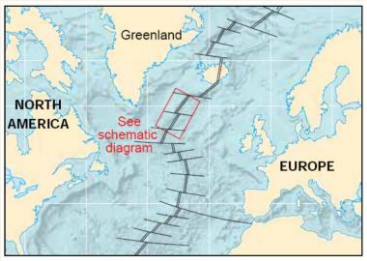
- Types of Plate Boundaries
  - divergent, convergent and transform



Divergent Plate Boundaries

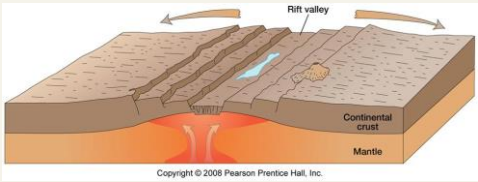


Divergent Plate Boundaries



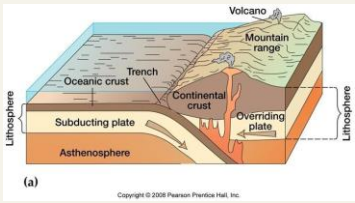
Rift Valley Formation

- Begins on a continent (East African Rift Valley)



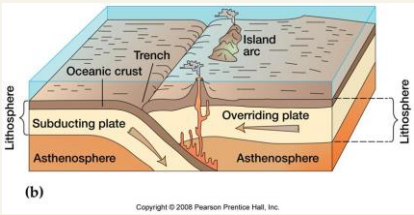
Convergent Plate Boundary

- Subduction trenches next to continents ("slab pull")
- Destructive boundary: Rock is destroyed via subduction
- E.g., Andes Mountains and Cascade Range



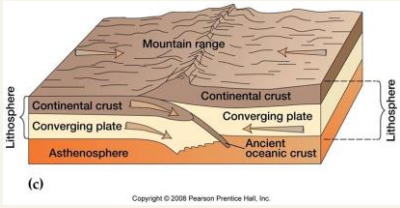
Convergent Plate Boundary

- Subduction trenches in deep ocean
- Destructive boundary: Rock is destroyed via subduction
- Island arcs – e.g., Aleutian Islands and Mariana Islands



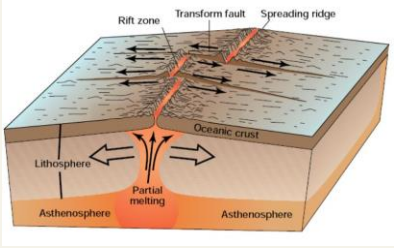
Convergent Plate Boundary

- No subduction
- Conservative boundary: Rock is neither created nor destroyed, but lifted 'up' into mountain ranges.
- Folded Mountains: e.g., Himalayas



Transform Plate Boundary

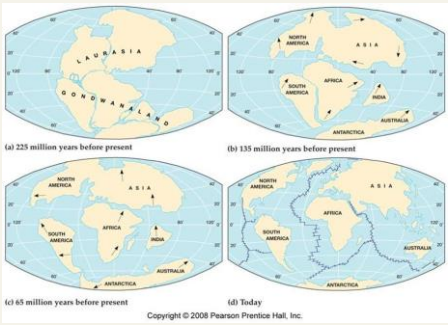
- Transform faults: Horizontal slippage (no subduction, no seafloor spreading)



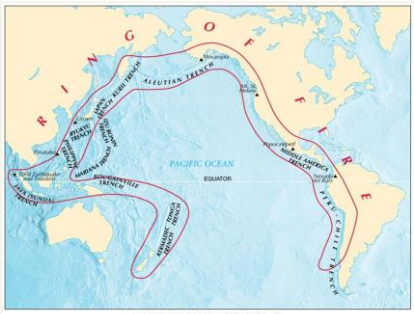
Transform Plate Boundary

- California and San Andreas Fault system (e.g. of transform plate boundaries)

The Rearrangement

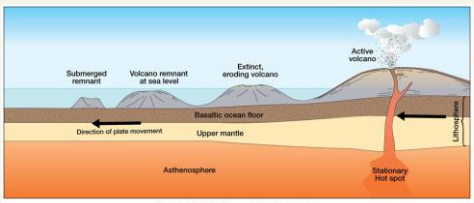


The Pacific Ring of Fire

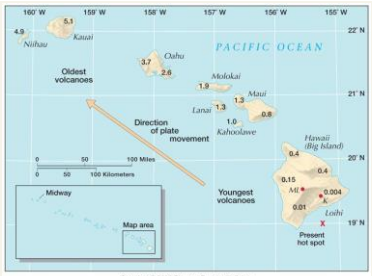


Mantle Plumes

- Island assembly line; as the plate moves underneath, the volcanoes have to move too, and so become extinct.

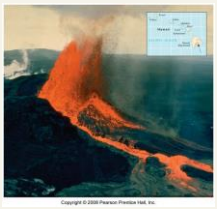


Hawaiian Islands

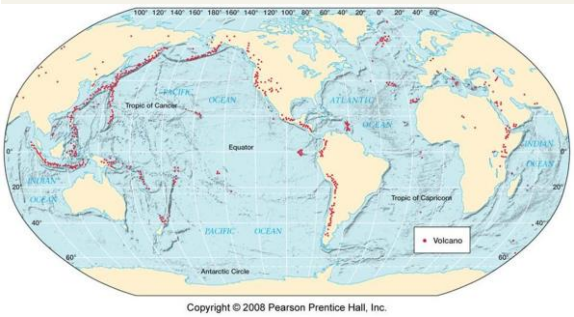


Volcanism

- This is the general term for **everything** relating to the origin and movement of molten rock.
  - **Extrusive volcanism** is when magma is *expelled* onto the Earth's surface while still molten.
  - **Intrusive volcanism** is when magma solidifies in the *shallow* crust near the surface.
  - **Plutonic activity** is when magma solidifies *deep* inside the Earth, far below the surface.



Volcano Distribution

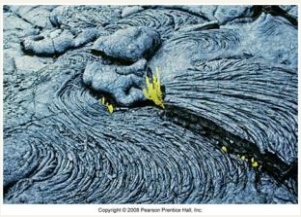


Volcanic Activity

- Shield volcanoes are more *sedate* and produce runny lava, while composite cone volcanoes tend to be *explosive*, and produce pyroclasts and more sticky lava.
- Volcanoes are temporary geological features.
- Role in mineral cycles (P, K, Mg, Ca, S). They provide important minerals for plant growth. That's what draws people to their base. E.g. Pompei, Italy.

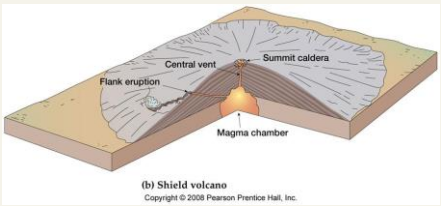
Volcanic Activity

- Creates landforms
  - Lava flows, sometimes resembles sedimentary layers
  - Volcanic peaks
  - Calderas
  - Volcanic necks



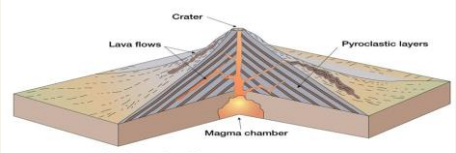
Shield Volcanoes

- Dome-shaped (broad base, gentle slopes), and can grow to great heights, although not steep.
- Hawaiian Islands (Mauna Loa and Kilauea)



Composite Volcanoes

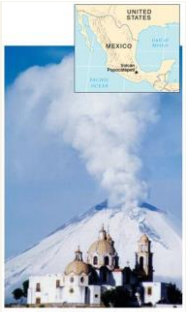
- Cone-shaped, steep slopes
  - Also called stratovolcanoes
  - Mt. Fuji; Mt. Kilimanjaro; Mt. Rainier; Mt. Shasta; Mt. Vesuvius



(d) Composite volcano

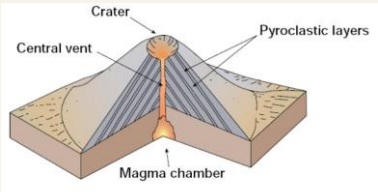
Volcanic Peaks

- Volcán Popocatépetl, Mexico



Cinder Cones

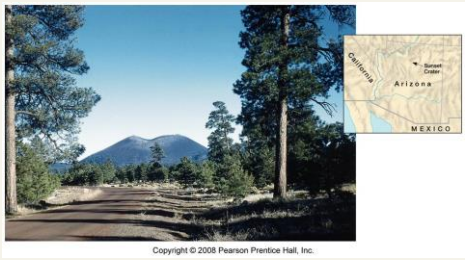
- Youthful volcanoes
- Highly erodible slopes (loose pyroclasts)
- Found in association with other volcanoes



(a) Cinder cone

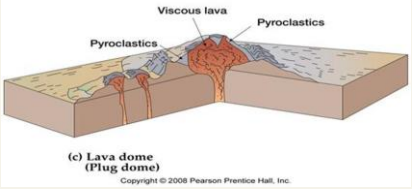
Cinder Cone

- Sunset Crater, AZ



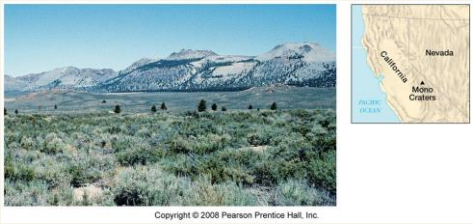
Lava domes (plug domes)

- They have masses of very viscous lava that are too thick to flow very far
- Solitary volcanoes: Mono Craters, CA
- Inside craters of composite volcanoes: Mt. St. Helens

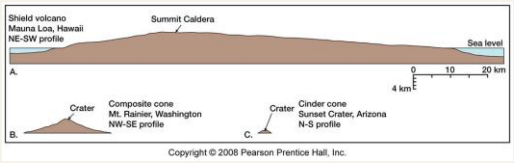


Lava (Plug) Dome

- Crater Mountain, Mono Craters, CA



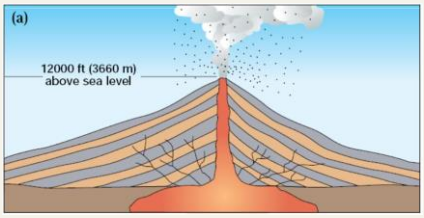
Types of volcanoes / cones



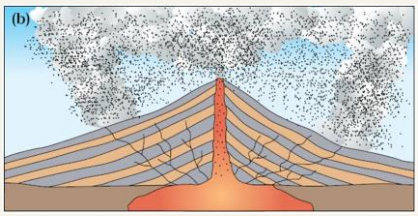
Calderas

- Massive crater
- Lava dome (plug)
- Volcano "blows its top"

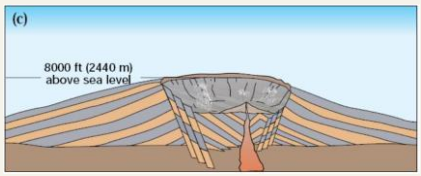
Calderas



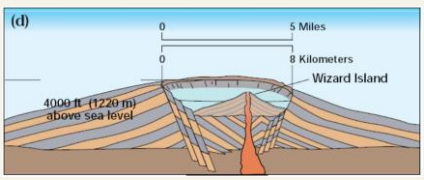
Calderas



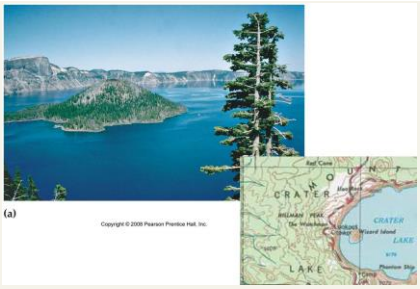
Calderas



Calderas

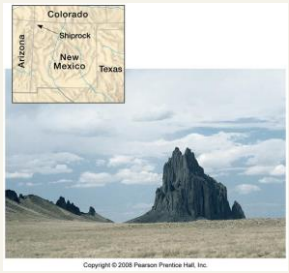


Crater Lake, OR



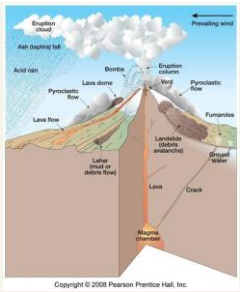
Shiprock, NM

- Volcanic Necks are exposed solidified magma that was part of a throat / pipe of an old volcano.



Volcanic Hazards

- Volcanic gases
- Lava flows
- Eruption column and clouds; rock "bombs" and thick ash
- Pyroclastic flows; high speed (over 100 mph) avalanche of searing hot gases, ash and rock fragments
- Volcanic mudflows (Lahars); caused when loose volcanic material is carried by heavy rain, glacier / snow melt.



Examples of Pyroclastic Flows

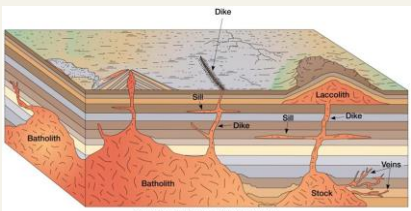
- Eruption of Mount St. Augustine, Alaska.
- A pyroclastic flow is moving down the slope to the left.

Examples of Pyroclastic Flows

- Unzen volcano in Japan showing path of pyroclastic flows.

Igneous Features

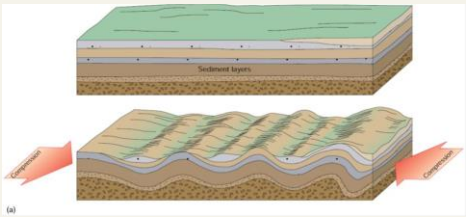
- Batholiths
- Stocks
- Laccoliths
- Dikes
- Sills
- Veins



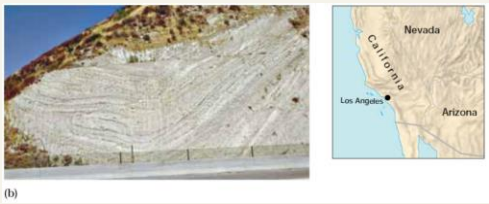
Diastrophism

- Means the deformation of Earth's Crust.
  - Separated into 2 kinds: folding and faulting.
  - Very noticeable in sedimentary rocks.
- Involves Earth Movements
  - Tectonic Forces, e.g.
    - Compression, Tension, Shear

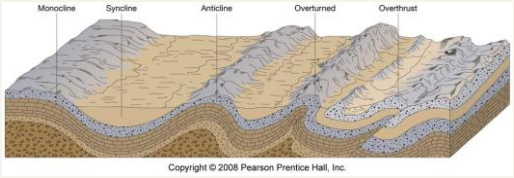
Folding



Folding

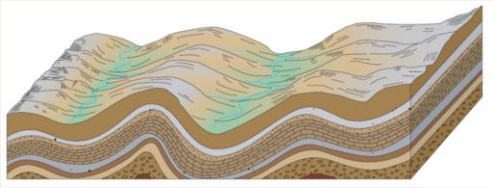


Basic Types of Folds



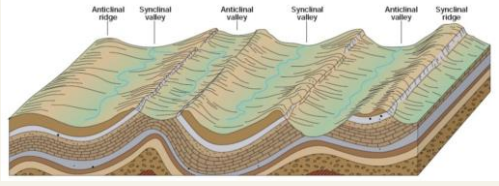
Basic Types of Folds

- Formation of Anticlinal Valleys and Synclinal Ridges



Basic Types of Folds

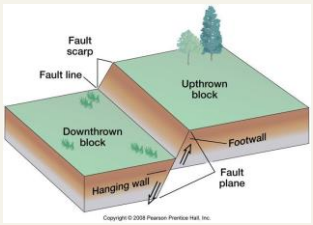
- Formation of Anticlinal Valleys and Synclinal Ridges



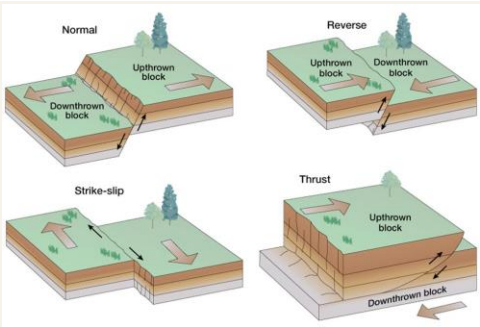
Appalachian topography

Faulting

- This is when rock / earth's crust is broken and displaced at the same time.
- Movement can be vertical, horizontal, or both.



Types of Faults



Strike-slip fault

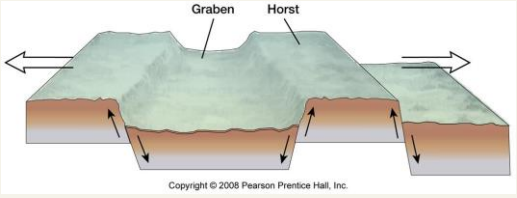
- Calaveras Fault, Hollister, CA.

Landforms Associated with Normal Faulting

- Tilted Fault-Block Mountains

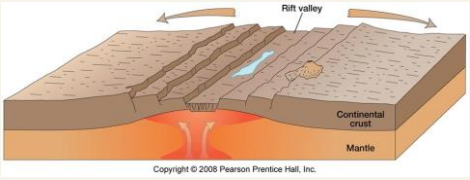
Horst and Graben

- Extensional faulting

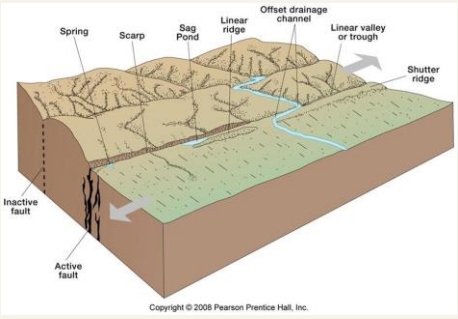


Horst and Graben

- Rift Valley (e.g. in East Africa - 2000 miles long!)
  - Extensional faulting ("extended grabens")

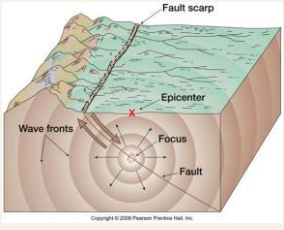


Landforms Associated with Strike-Slip Faulting



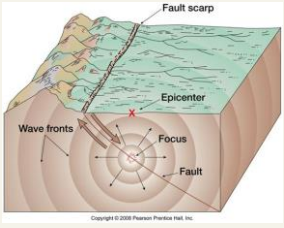
Earthquakes

- An earthquake is a vibration in the earth caused by shock waves produced from a sudden displacement along a fault line.
- Focus is where the earthquake *originates*.



Earthquakes

- Epicenter is where it is *felt strongest directly above the ground.*
- Earthquake waves move like ripples in a pond.
  - P waves – these are fastest / primary waves.
  - S waves – these are the slower / secondary waves that follow.



Earthquake Magnitude

- Amount of *energy released* during an earthquake.
- Richter Scale (1935) uses logarithmic scale, where 32 times more energy is released in the next higher scale. So the difference in energy released btw small and large earthquakes is very great.
  - M3 or less (small)
  - M7 or greater (enormous)

Earthquake Magnitude

- Famous earthquakes and their magnitudes
  - Chile (1960), 9.5
  - Alaska (1964), 9.2
  - Sumatra (2004), 9.0
  - San Francisco, CA (1906), 7.7
  - Loma Prieta, CA (1989), 7.0
  - Northridge, CA (1994), 6.8

Earthquake Frequency

TABLE 14-2 Worldwide Earthquake Frequency

Magnitude	Number per Year
<3.4	800,000
3.5–4.2	30,000
4.3–4.8	4800
4.9–5.4	1400
5.5–6.1	500
6.2–6.9	100
7.0–7.3	15
7.4–7.9	4
>8.0	1 every 5–10 years

Mercalli Intensity Scale

TABLE 14-3 Modified Mercalli Intensity Scale

I. Not felt except by very few people under especially favorable circumstances

II. Felt only by a few persons at rest, especially on upper floors of buildings

III. Felt quite noticeably indoors, especially on upper floors of buildings, but many people do not recognize it as an earthquake

IV. During the day felt indoors by many, outdoors by few; sensation like heavy truck striking building

V. Felt by nearly everyone, many awakened; disturbances of trees, poles, and other tall objects sometimes noticed

VI. Felt by all; many frightened and run outdoors; some heavy furniture moved; few instances of fallen plaster or damaged chimneys; damage slight

VII. Everybody runs outdoors; damage negligible in buildings of good design and construction; slight to moderate in well-built ordinary structures; considerable damage in poorly built or badly designed structures

VIII. Damage slight in specially designed structures; considerable in ordinary substantial buildings, with partial collapse; great in poorly built structures; fall of chimneys, factory stacks, columns, monuments, and other vertical features

IX. Damage considerable in specially designed structures; buildings shifted off foundations; ground cracked conspicuously

X. Some well-built wooden structures destroyed; most masonry and frame structures destroyed with foundations; ground badly cracked

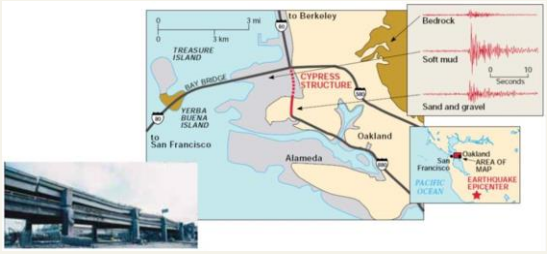
XI. Few, if any, masonry structures remain standing; bridges destroyed; broad fissures in ground

XII. Damage total; waves seen on ground surfaces; objects thrown upward into the air

Earthquake Hazards

- Building damage due to shaking
- Liquefaction
- Landslides
- *Seiches* (great waves similar to, but not as large as Tsunamis)
- *Tsunami*

Earthquake Hazards



Formation of a Tsunami