Earthquakes and Faults

Great San Francisco Earthquake
- April 18, 1906, 5:12 AM
- Quake lasted about 60 seconds
- San Francisco was devastated by:
  - Ground shaking
  - Fires
- Most damaging earthquake in US history
- First quake studied in detail by geologist
- Lead to scientific understanding of quakes

San Francisco Burning

1906 San Francisco

Damage
- Dead- more than 3000
- Homeless- 225,000
- Buildings destroyed- 28,000
Louis Agassiz after the 1906 San Francisco earthquake

Surface Rupture, Olema, CA

Fault Offset 2.5 m (8 ft)

Surface Rupture, Olema, CA
1906 Rupture-430 km long

Key Observations
- Earthquake was linked to a major fault
- A huge area was displaced horizontally
- Displacement was sudden

Elastic Rebound Theory
- Crust is like a spring
- Deformation (strain) is stored as the fault-blocks move
- Eventually the fault fails
- Strain is released -> Quake
- Strain begins to accumulate again
- etc...
Earthquake Cycle

- Earthquakes are recurrent
  - Small quakes are frequent
  - Large quakes are rare
- Cycle may be 100s of years for large quakes
- Strain builds up until an earthquake releases it
- Size of quake depends on amount of strain stored

Terminology

- Focus- origin of rupture
- Epicenter- point at the surface above the focus
- Fault scarp- vertical offset at the surface

Number of Quakes per year in Southern California

Terminology

Focus of an Earthquake

Scarp, Alaska 1964
Seismic Waves
- Body waves
  - P-wave (Primary Waves)
  - S wave (Secondary Waves)
- Surface waves - most damaging
  - Love waves
  - Rayleigh waves

Primary waves
P-waves
- Pressure waves
- Like sound
- Particles move in same direction as wave propagation
- Fastest

Secondary Waves
S-waves
- Shear Waves
- Particles move perpendicular to wave direction
- Slower than P-waves
- Cannot pass through liquids
Surface Waves-like sea waves

Seismic Record

Focal mechanism

Effects of earthquakes
- Ground motion
- Fire
- Landslides
- Liquifaction
- Permanent displacement of land surface
- After shocks
- Tsunamis-

Turkey

Quake Triggered Landslide
El Salvador

Anatolian Earthquake- Turkey 1999
Denali Fault, Alaska

Slides Triggered by Denali fault Quake 2003

Hector Mine Quake 1999 M=7.0 Fault Map
Vertical Displacement Field

Hector Mine Quake interferogram from Synthetic Aperture Radar data. Each fringe is 28 mm of vertical displacement.

Hector Mine fault
Landers fault

D.T. Sandwell, EOS 11/11/93
Earthquakes prediction

Scientific techniques being explored
- Patterns of earthquakes in space & time
- Microseisms
- Surface tilts & changes of elevation (Strain accumulation)

San Francisco Bay

San Francisco

Bay

San Andreas Fault
San Andreas Fault Risk 1988-2018

New Madrid Seismic Zone
Brown –74-2000
Green- before 74