Geology: scientific study of Earth’s materials and processes

- Materials:

- Processes:

Major External Processes

Driven by energy from the sun and from gravity. Also create hazards and resources.

- Hydrologic cycle
- Weathering and erosion
- Deposition and Soil Formation
- Glaciers, Rivers and Streams
- Mass Movement (landslides, rock falls)
- Land-Sea Interactions/Coastal Erosion

Major Internal Processes

Driven by energy (heat) in the Earth’s interior

1) Convection and Plate Tectonics

3) Rock Deformation

4) Crystallization

5) Metamorphism
Geology: scientific study of Earth’s materials and processes
– Materials:
– Processes:
Geologic Processes create: ?

Let’s think about Plate Tectonics:
Definition
“Boundaries = geologic activity”
Hazards and resources association

Plate Tectonics
• Outer layers of Earth made up of ~ 12 major individual rigid plates (lithospheric/tectonic plates)
• These plates move in response to convection in the mantle
• Most geologic activity occurs near plate boundaries (3 types of boundaries)
• “Geologic activity” = ?

Transform Boundary
example: San Andreas Fault
Divergent Boundaries
Sea Floor Spreading on Oceanic Ridges
Typically shallow focus and small earthquakes

Convergent Boundaries
Subduction at deep sea trenches, shallow to deep focus earthquakes

Geologic Hazards
Result from a combination of internal and external processes. Examples include?

1. Earthquakes
2. Tsunamis
3. Mass Movement
4. Volcanoes
5. Coastal Erosion / Flooding / Rising Sea Level
6. Fluvial Systems / Flooding (Later in the Course)
Earthquakes
Over 1,061,000 fatalities from earthquakes in the last 10 years.
What are the hazards / outcomes?

**Ground Shaking**: landslides, liquefaction, land subsidence, buildings, roads, bridges collapse

**Fire**: broken gas and power lines

**Flooding**: tsunamis and/or “co-seismic subsidence”

**Ground Displacement**: damages structures lying across fault

Major dangers are from human-made structures rather than the earthquake itself.


Types of Earthquake Waves

![Diagram of earthquake waves](image)

- **Love Wave**: named after A.E.H. Love, a British Mathematician in 1911
- **Rayleigh Wave**: named after Lord Rayleigh, a British Physicist in 1885

![Diagram of body waves and surface waves](image)
Richter Magnitude measures the amount of ground shaking and the total amount of energy released by an earthquake at its source.

How is the Richter number determined?

Amount of damage controlled by what?

1) Strength
2) Relative Proximity
3) Foundation
4) Building Type

Foundation
Turkey 8/17/1999
Type of construction / Building codes
>17,000 fatalities, 7.6 magnitude, 37 sec shaking, 500,000 homeless

Mud and brick buildings in Bam Iran did not comply with earthquake standards

Earthquake: Central CA, SLO County
Southeastern Iran, Bam
Date: 12/22/03 12/26/03
Magnitude: 6.5 6.6
Depth: 7.6 km 10 km
Tectonic Setting: Transform Convergent
Population: 239,000 100,000
Casualties: 2 >43,000
Injuries: 40 ~30,000
Damages: 40 buildings collapsed; small fires; buildings destroyed

Reducing Earthquake Hazards?
- Locate active faults
- Map high risk areas
- Better land-use planning
- Better building codes
- Better prediction both on land and in the worlds oceans.
- Improved global seismic sea wave warning system
Tsunamis

- Seismic Sea Waves
  - Triggers
  - Speed, height, period, wavelength
  - Trough often arrives first

Historical Tsunami Events and Resulting Fatalities

<table>
<thead>
<tr>
<th>Year</th>
<th>Event Description</th>
<th>Fatalities</th>
</tr>
</thead>
<tbody>
<tr>
<td>225,000</td>
<td>Indian Ocean earthquake with tsunami 12/26/ 2004</td>
<td>225,000+</td>
</tr>
<tr>
<td>100,000</td>
<td>Lisbon earthquake, tsunami, earthquake and fire, Portugal and Morocco</td>
<td>100,000</td>
</tr>
<tr>
<td>100,000</td>
<td>Japan, 1700</td>
<td>100,000</td>
</tr>
<tr>
<td>70,000</td>
<td>Messina, Italy, earthquake and tsunami, 1908</td>
<td>70,000</td>
</tr>
<tr>
<td>40,000</td>
<td>South China Sea, 1792, including deaths in Taiwan</td>
<td>40,000</td>
</tr>
<tr>
<td>36,000</td>
<td>Krakatoa volcano explosion, 1883</td>
<td>36,000</td>
</tr>
<tr>
<td>27,000</td>
<td>Japan, 1826</td>
<td>27,000</td>
</tr>
<tr>
<td>25,674</td>
<td>Chile, 1868</td>
<td>25,674</td>
</tr>
<tr>
<td>22,070</td>
<td>Sanriku, Japan, 1896</td>
<td>22,070</td>
</tr>
<tr>
<td>15,850</td>
<td>Japan, 3/11/11 (~3,287 missing)</td>
<td>15,850</td>
</tr>
<tr>
<td>15,030</td>
<td>Southwest Kanto, Japan, 1702</td>
<td>15,030</td>
</tr>
<tr>
<td>11,486</td>
<td>Banda Aceh, Indonesia, 2004</td>
<td>11,486</td>
</tr>
<tr>
<td>5,233</td>
<td>Nankai Trough, Japan, 1703</td>
<td>5,233</td>
</tr>
<tr>
<td>5,000</td>
<td>Kanto-Kumamoto, Japan, 1895</td>
<td>5,000</td>
</tr>
<tr>
<td>3,000</td>
<td>Papua New Guinea, 1998</td>
<td>3,000</td>
</tr>
<tr>
<td>3,000</td>
<td>Sumatra, Indonesia, 1933</td>
<td>3,000</td>
</tr>
<tr>
<td>2,000</td>
<td>Chilean Earthquake, deaths in Chile, U.S. (Hawaii), Philippines and Japan 1960</td>
<td>2,000</td>
</tr>
<tr>
<td>122</td>
<td>Good Friday Earthquake, Alaska and Hawaii, U.S., 1964</td>
<td>122</td>
</tr>
<tr>
<td>605</td>
<td>Argentina Island earthquake, deaths in Hawaii and Alaska, U.S., 1966</td>
<td>605</td>
</tr>
</tbody>
</table>

Japan Earthquake Tsunami
Seacliff State Beach, Apts, CA
3/11/11
Capitola
California
March 11, 2011

Santa Cruz Yacht Harbor, California
Reducing Tsunami Hazards?

- Warning system in all major oceans
- Better Land Use Planning
- Local gov’t evacuation routes and procedures
- Education about warning signs
  - Ground-shaking in coastal areas
  - Unusual disturbance of ocean, drop in SL
  - Move to high ground (several hours-days)
  - First wave generally not largest

Mass Movement

Main Causes: Water, Seismic Activity, Volcanoes, Humans

- Slumps / Slides
- Mudflows, Earthflows
- Rock Falls
- Lahars (volcanic)
- Debris Flows
- Avalanche

http://daveslandslideblog.blogspot.com/2008/08/la-conchita-landslide-verdict.html
Southern Italy Landslide 2/16/10

La Conchita 1995

La Conchita 1/10/05
Mass Movement
Triggered by human activities

- Irrigation
- Water leakage: septic tanks other utilities
- Surface water diversion
- Road construction
- Mining operations
- Logging
- Fires
- Excavation of slope

SOLUTIONS?

Mass Movement
Santa Cruz Mountains especially susceptible

- Topography
  - Geology (Dip Slopes)
- Rocks:
  - soft
  - fractured, folded, faulted
- Rainfall, El Niño winters
- Earthquakes
- Wildfires

Volcanoes

- Volcanoes: landforms created when magma escapes from Earth’s interior through vents or fissures @ Earth’s surface and becomes lava. Lava cools and solidifies around vents forming volcanic rock.

- Globally, ~50 volcanoes erupt each year.

- Located at both convergent and divergent plate boundaries (not transform) and interior plate hot spots.
**Volcanism**

**Hazards**
- Volcanic materials bury and destroy habitats and property; toxic gases (acid rain)
- Ash clouds can block sun and lower global temperature
- *Lahars* (volcanic mudflows formed from sudden ice melting)
- Tsunamis

**Benefits**
- Release of gases and water vapor forming atmosphere and hydrosphere
- Addition of fertile soils
- Addition of “real estate” (Hawaii, Pacific Islands, Iceland)
- Geothermal energy
- Info about Earth’s interior

---

**Reducing Volcanic Hazards?**
- Map high risk areas
- Volcanic zoning (no development in volcanically prone areas)
- Better prediction (monitor volcano’s surface, temperature, gas release, seismic activity)
- Effective evacuation plans
- Successful case histories: Mount PinatuboPhilippines, Mount St Helens, Oregon

---

**Coastal Erosion / Flooding / Rising Sea Level**
- Storms
- Waves
- Coastal slides
- Human activities
Sea Level Measurements from San Francisco 1900 - 1999

Vertical cross-section of New Orleans, showing maximum levee height of 23 feet (7 m).
Human impacts on coastal erosion: Santa Cruz Harbor example

April 9th 2005

Coastal Armoring; seawalls, rip-rap, and more

Coastal Armoring; seawalls, rip rap and more
Reducing Coastal Erosion Hazards

• How will sea level rise impact coastal erosion?
• Establish better land-use planning
• Monitor erosion rates
• Map high risk areas
• Limit coastal armor and damming of rivers
• Evaluate and monitor coastal engineering projects

Better land use planning

Geologic Processes create: Hazards and Resources

- **Hazards** (dangerous events and conditions)
  - **Resources** (the materials we use to get the things we want: fuel our cars, power our homes, computers, construct homes, buildings, roads etc.)

- Links between internal and external geologic processes:
  - Internal processes create new crust, cause hazards, concentrate minerals.
  - External processes carve up crust creating landforms and environments which are subjected to hazards (flooding, landslides), concentrate minerals.