First year of Geomatics Department

Engineering Geology 2018

Lecture 8

EARTHQUAKES

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OBJECTIVES

- Relate earthquake activity to plate tectonics
- Define earthquake, and identify the focus and epicenter of an earthquake.
- Describe the types of waves emitted during an earthquake.
- Distinguish between earthquake intensity and magnitude.
- Review some current methods of earthquake prediction.

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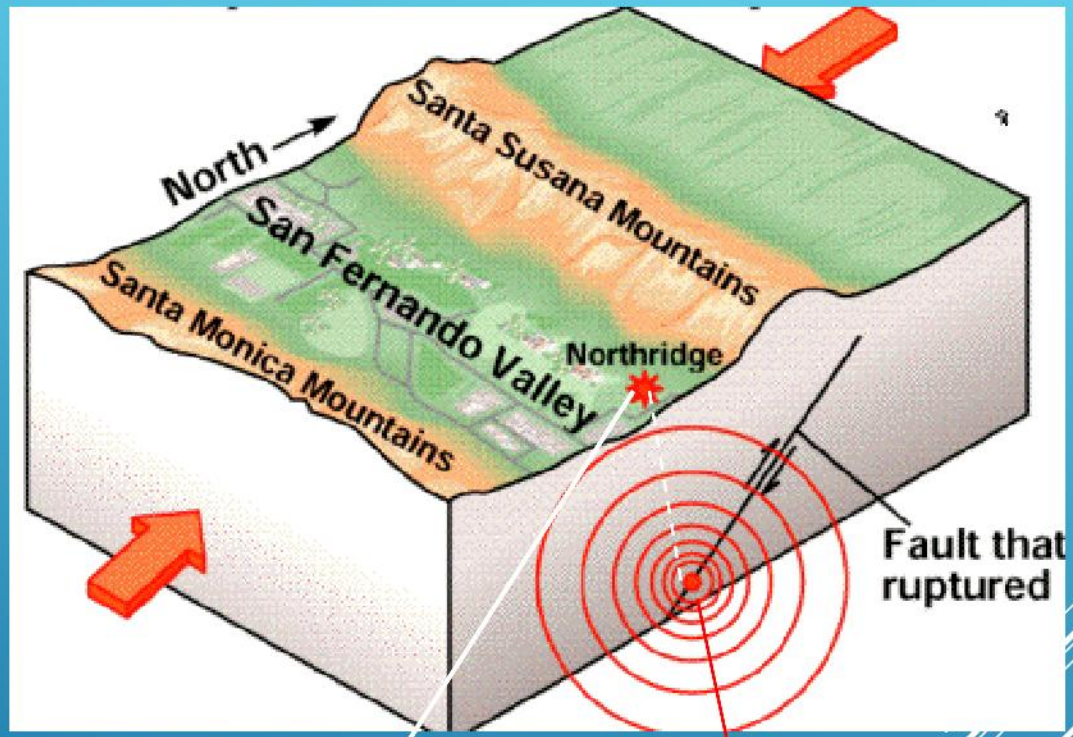
WHY DO EARTHQUAKES OCCUR?

- *Fractures, faults*
- Energy released and propagates in all directions as seismic waves causing earthquakes

Where do earthquakes occur:

1) Most earthquakes occur along the edge of the **oceanic** and **continental plate**

2) Along **faults:** normal, reverse, transform



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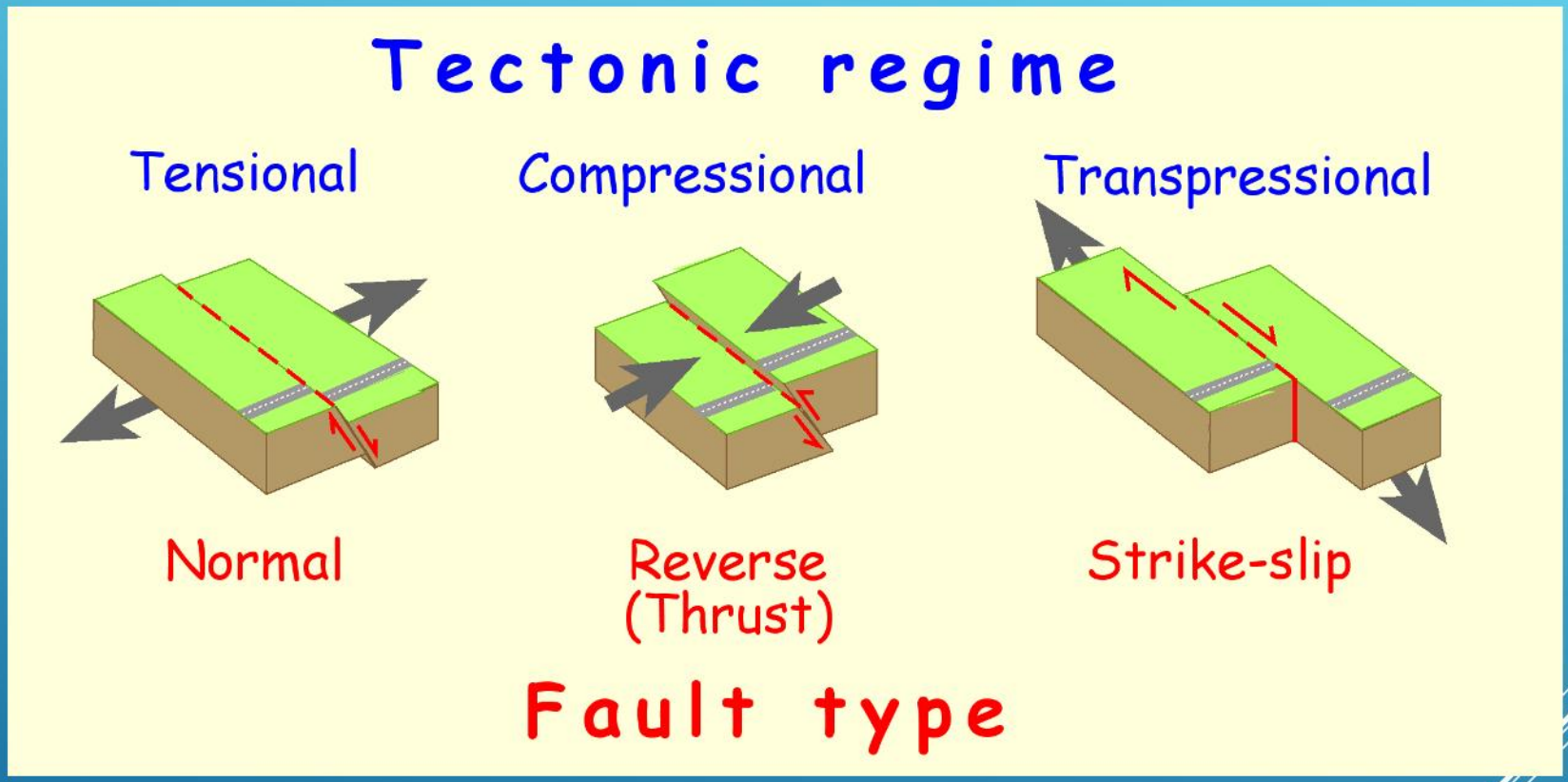
STYLES OF FAULTING



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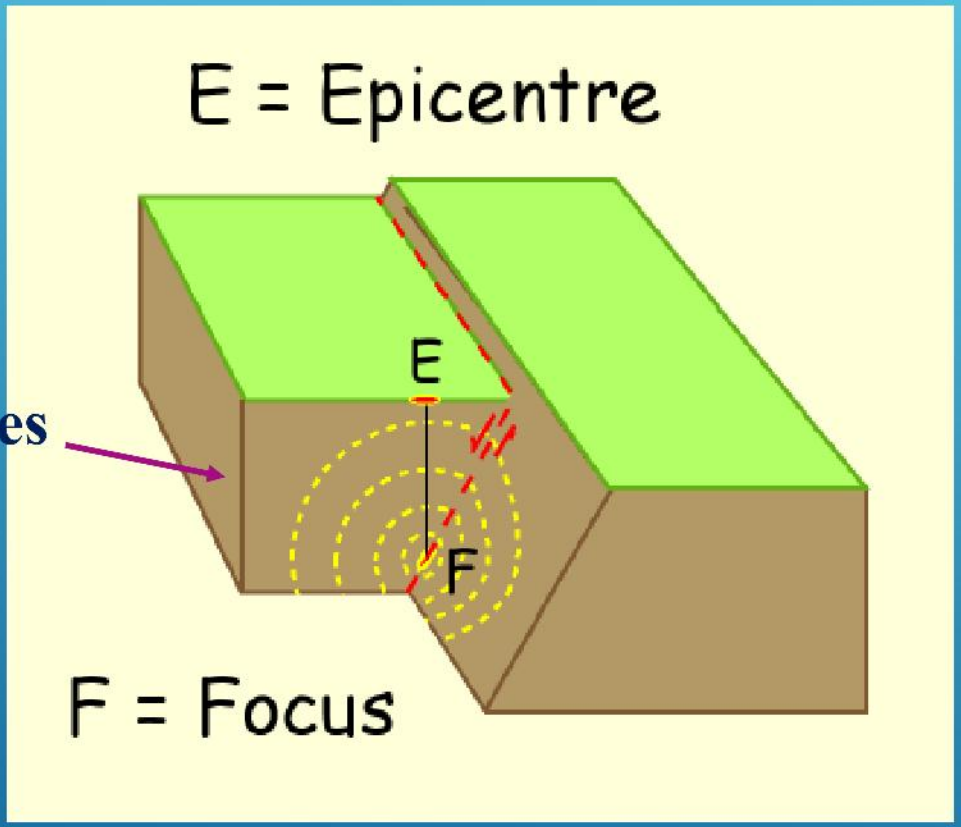
CAUSES: FAULT MOVEMENT RELEASES ENERGY AS SEISMIC WAVES RADIATING FROM RUPTURE



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DEFINITIONS

- Earthquake = Vibration of the Earth produced by the rapid release of energy
- Seismic waves = Energy moving outward from the focus of an earthquake
- Focus= location of initial slip on the fault; where the earthquake origins
- Epicenter= spot on Earth's surface directly above the focus

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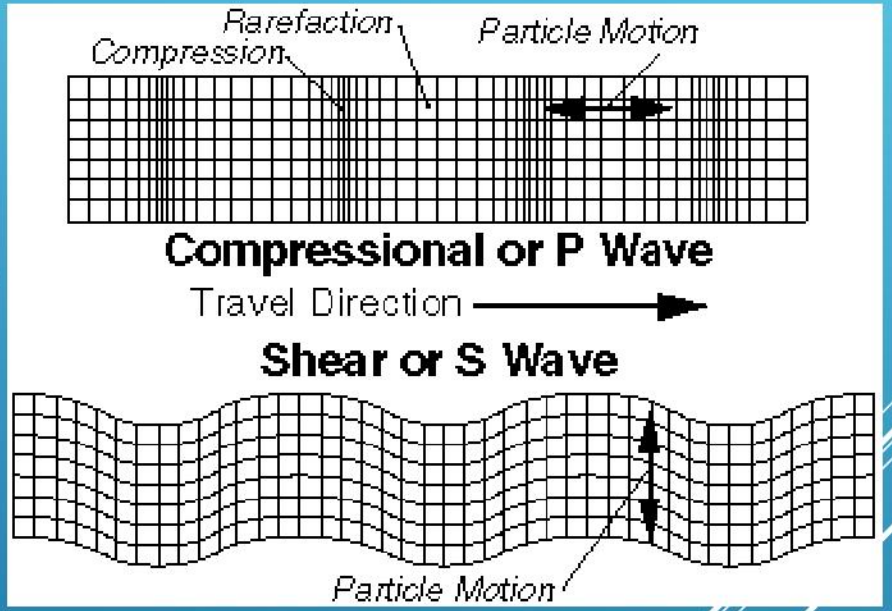
SEISMIC WAVES: FORMS

- P-waves:
  - called compressional, or push-pull waves
  - Propagate parallel to the direction in which the wave is moving
  - Move through solids, liquids
- S-waves:
  - Called shear waves
  - Propagate the movement perpendicular to the direction in which the wave is moving
- Surface waves (Long waves).
  - Complex motion
  - Up-and-down and side-to-side
  - Slowest
  - Most damage to structures, buildings



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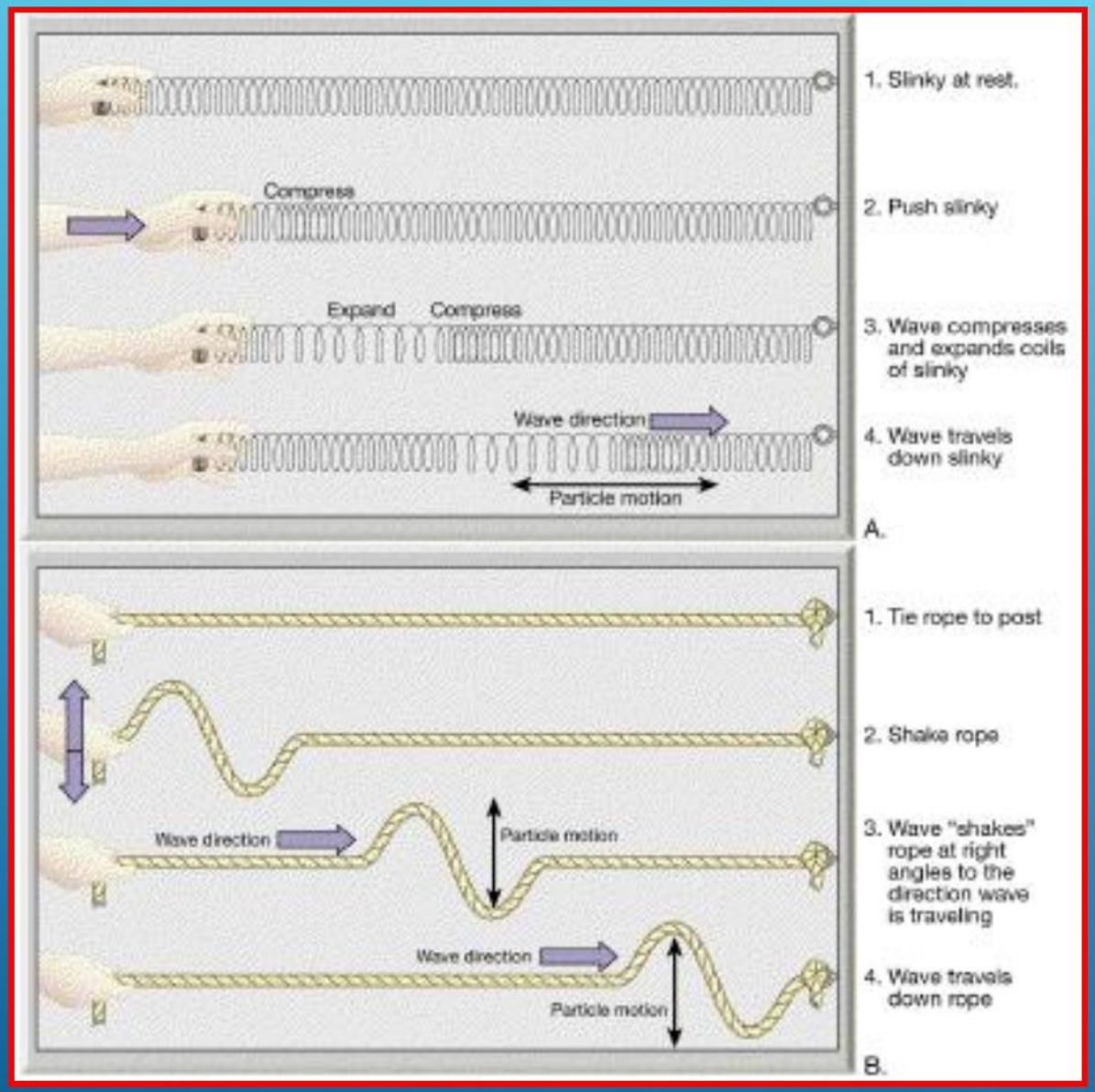
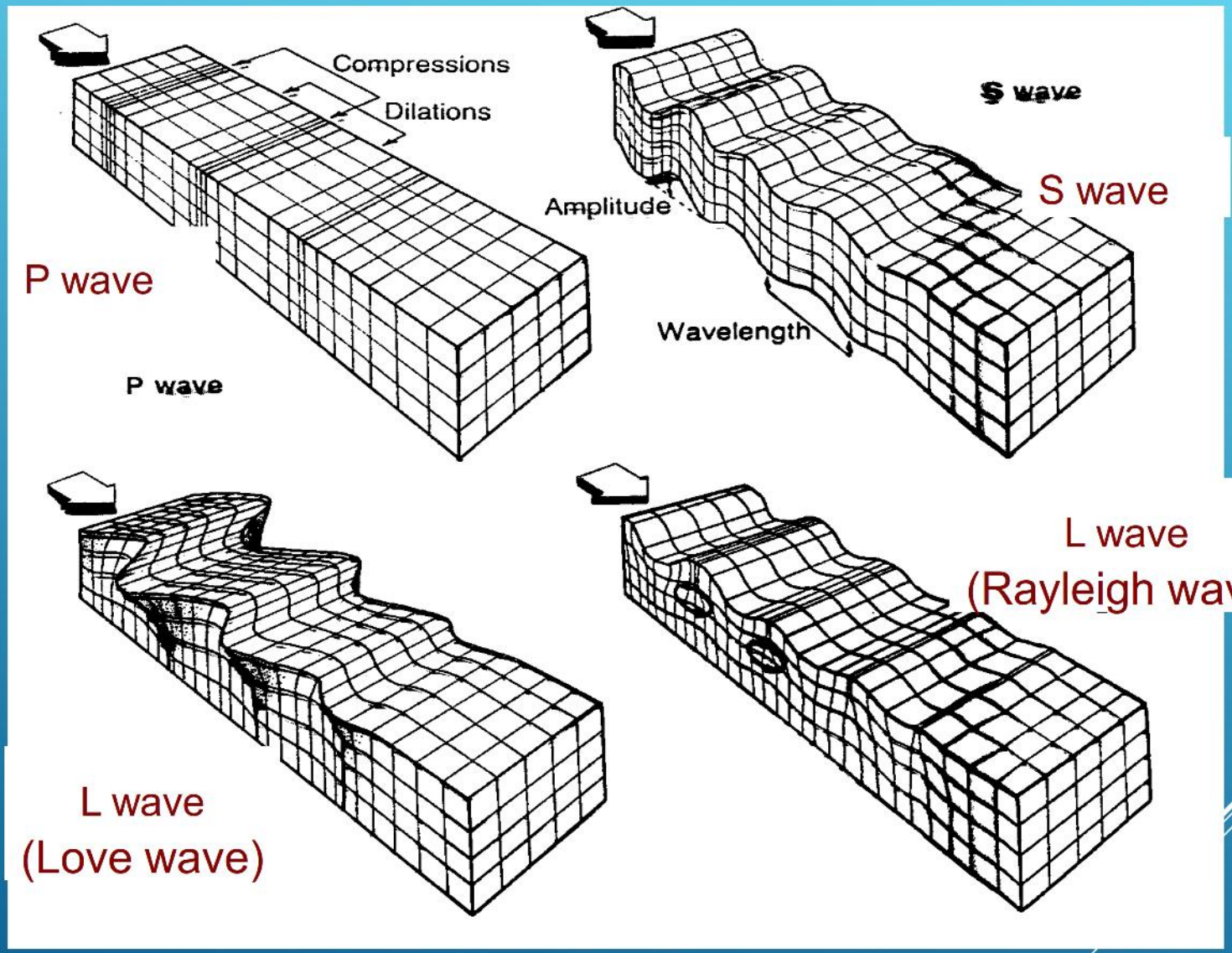


Primary or "P" Wave

Secondary or "S" Wave

SEISMIC WAVE FORMS



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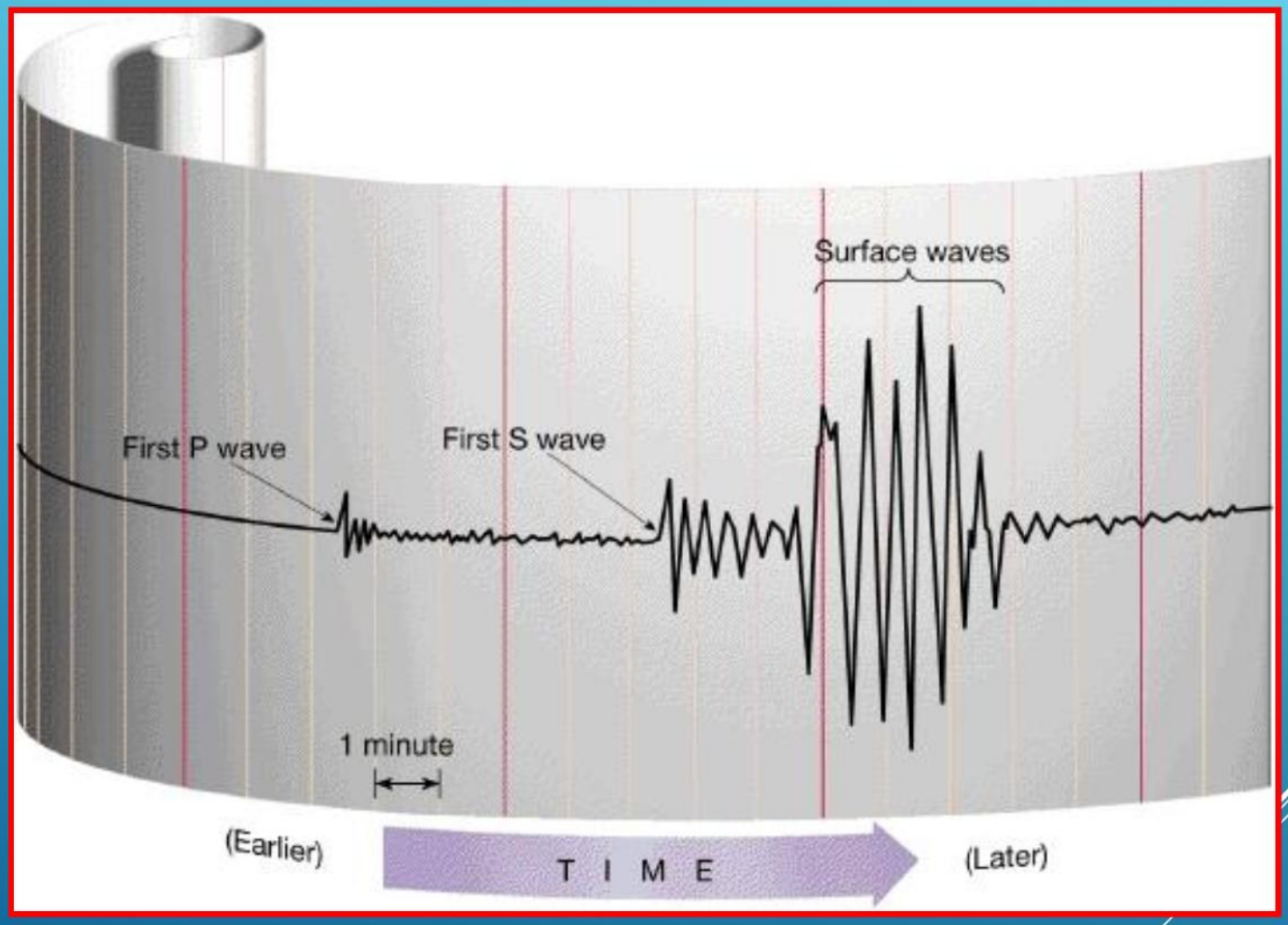
Seismogram Printout



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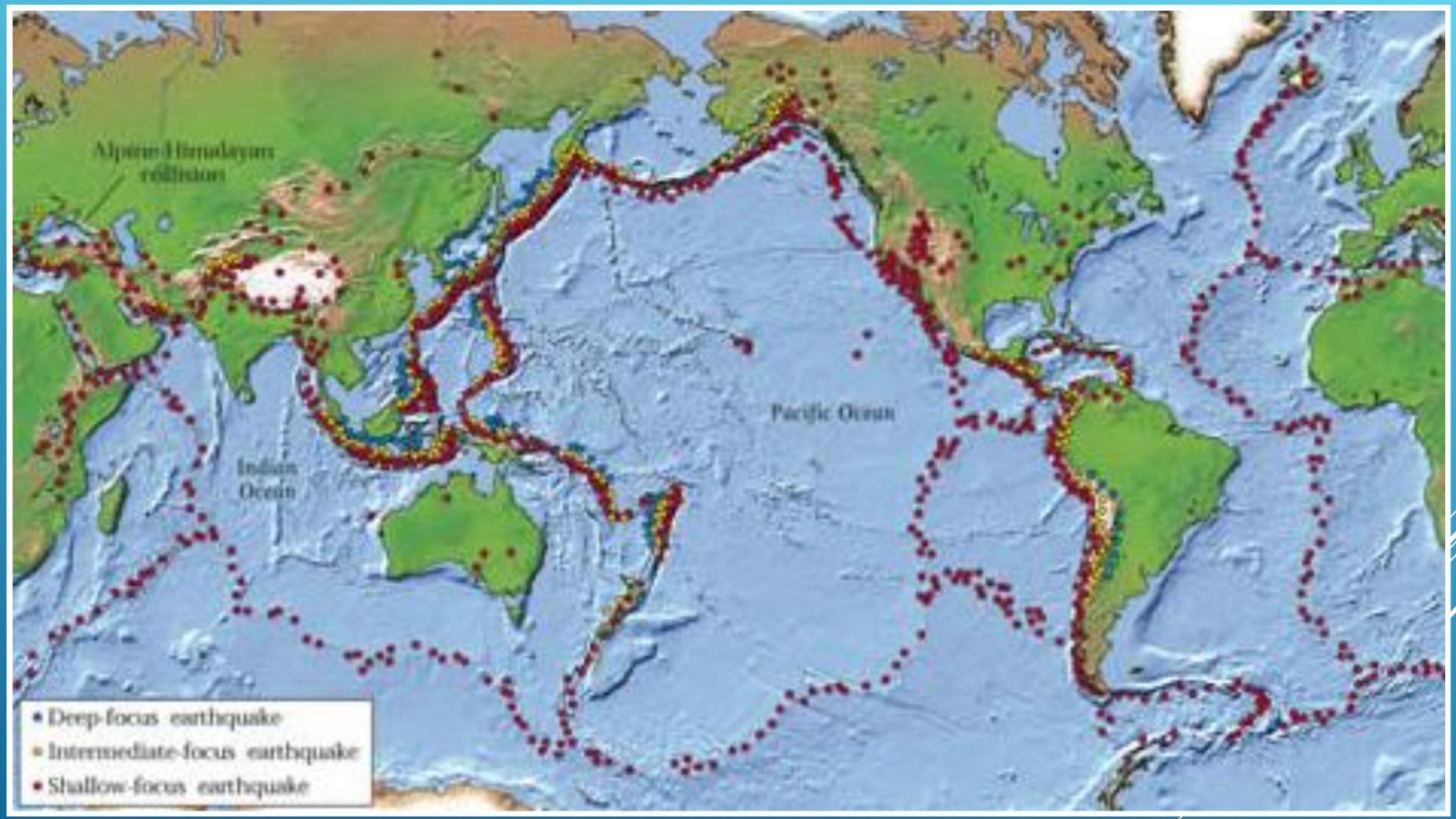
Global Seismicity



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EARTHQUAKE SIZE: TWO WAYS TO MEASURE

Determining the magnitude of an earthquake

Magnitude -- measure of energy released during earthquake.

There are several different ways to measure magnitude.

Most common magnitude measure is **Richter Magnitude**, named for the renowned seismologist, Charles Richter.

Richter Magnitude

- Measure amplitude of largest S wave on seismograph record.
- Take into account distance between seismograph & epicenter.

Richter Scale

- Logarithmic numerical (NOT a physical) scale
- Increasing one whole unit on Richter Scale represents 10 times greater magnitude.
- Going up one whole unit on Richter Scale represents about a 30 times greater release of energy

Intensity

- Intensity refers to the amount of damage done in an earthquake
- Mercalli Scale is used to express damage

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EARTHQUAKE SIZE: TWO WAYS TO MEASURE

1) **Magnitude**: Richter Scale
   - Measures the energy released by fault movement
   - related to the maximum amplitude of the S wave measured from the seismogram
   - Logarithmic-scale; **quantitative** measure
   - For each whole number there is a 31.5 times increase in energy
     - e.g. an increase from 5 to 7 on the Richter scale = an increase in energy of 992 times!!

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EARTHQUAKE MAGNITUDE:
SCALES BASED ON SEISMOGRAMS

- M_L=local (e.g. Richter scale) - based on amplitude of waves with 1s period within 600 km of epicenter.
- M_b=body-wave (similar to above)
- M_s=surface wave (wave periods of 20s measured anywhere on globe
- M_o=seismic moment
- M_w= moment magnitude

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THE RICHTER SCALE

Steps:

1. Measure the interval (in seconds) between the arrival of the first P and S waves.
2. Measure the amplitude of the largest S waves.
3. Use monogram to estimate distance from earthquake (S-P interval) and magnitude (join points on S-P interval scale and S amplitude scale).
4. Use seismograms from at least three geographic locations to locate epicenter by triangulation.

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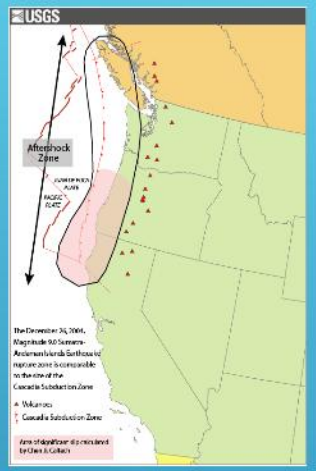
Richter Scale… Measure of Earthquake Size



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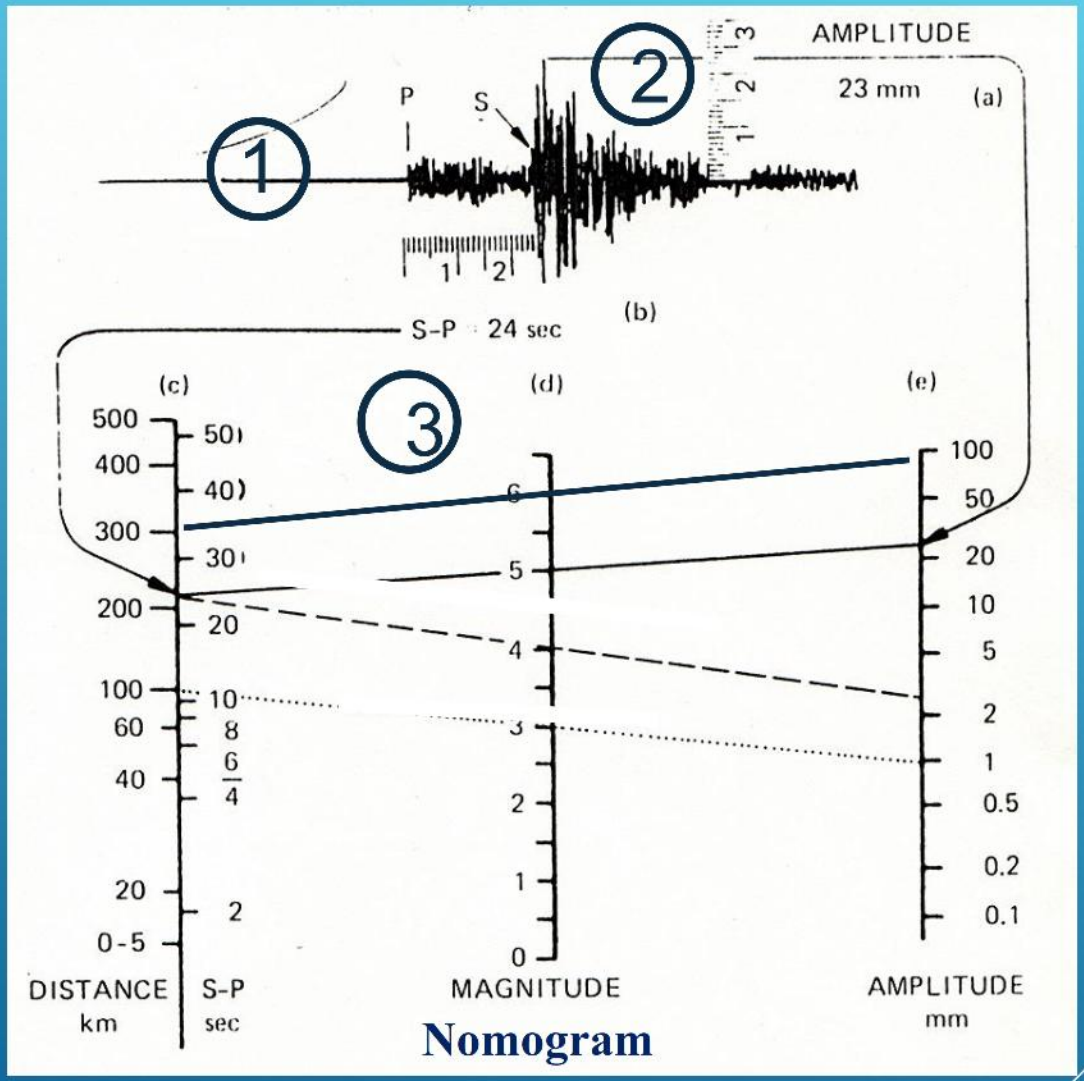
THE RICHTER SCALE MONOGRAM



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SEISMIC WAVES: PROPERTIES

- **Velocity**: function of the physical properties of the rock the wave is traveling through
  - Velocity *increases* with rock density
  - Velocity *changes* when passing from one material to another (increases/decreases)
  - Liquids: S-waves do not get transmitted through liquid; P-waves slow down

- Why is this important?

–If we know the velocity of the wave, we can infer the type of rock it traveled through- that's how we map the interior of the Earth!!!

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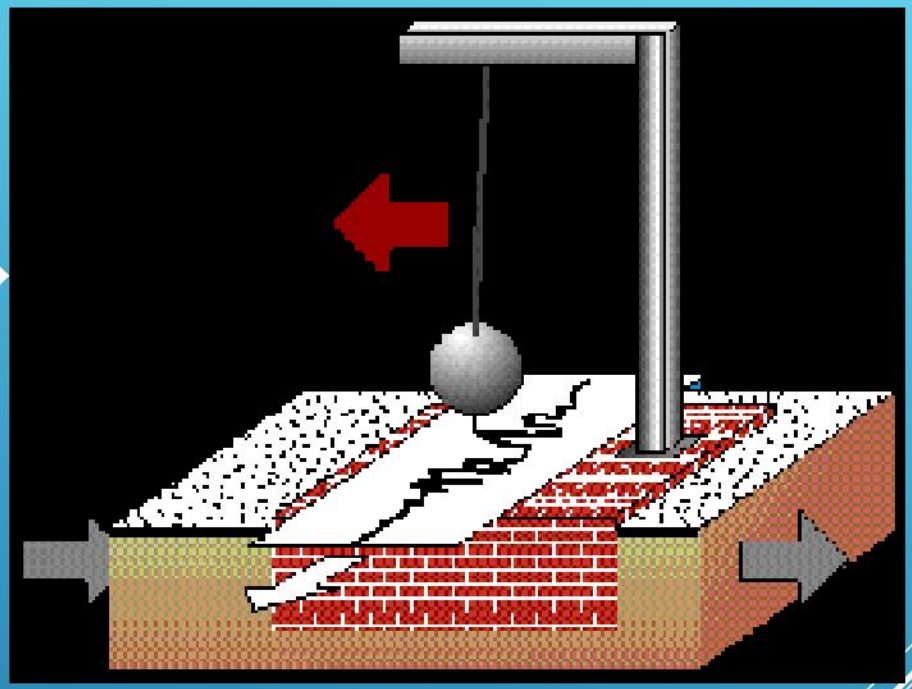
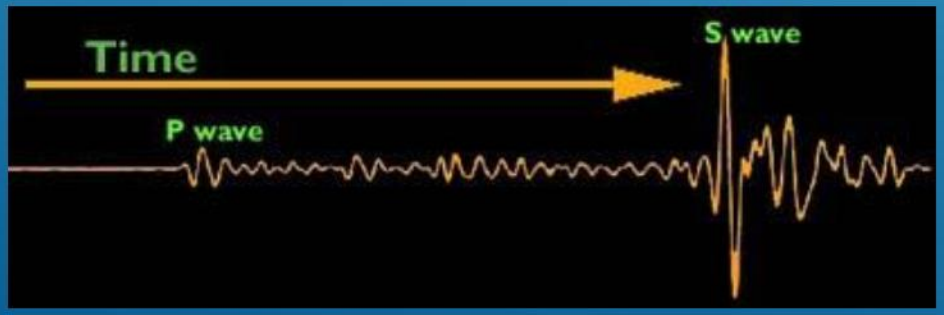
MEASURING EARTHQUAKES

- Seismometers: instruments that detect seismic waves
- Seismographs



Record intensity, height and amplitude of seismic waves



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2) **Intensity:** Mercalli Scale:

- *What did you feel?*
- Assigns an intensity or rating to measure an earthquake at a particular location **(qualitative)**
- I (not felt) to XII (buildings nearly destroyed)
- Measures the destructive effect
- Intensity is a function of:
  - Energy released by fault
  - Geology of the location
  - Surface substrate: can magnify shock waves e.g. Mexico City (1985) and San Francisco (1989)

Frequency of Occurrence of Earthquakes

Descriptor	Magnitude	Average Annually
Great	8 and higher	1 [1]
Major	7 - 7.9	17 [2]
Strong	6 - 6.9	134 [2]
Moderate	5 - 5.9	1319 [2]
Light	4 - 4.9	13,000 (estimated)
Minor	3 - 3.9	130,000 (estimated)
Very Minor	2 - 2.9	1,300,000 (estimated)

[1] Based on observations since 1900.
[2] Based on observations since 1990.

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LARGEST EARTHQUAKE IN THE WORLD

More than 2,000 killed, 3,000 injured, 2,000,000 homeless, and $550 million damage in southern Chile
tsunami caused 61 deaths
$75 million damage in Hawaii;
138 deaths and $50 million damage in Japan;
32 dead and missing in the Philippines;
and $500,000 damage to the west coast of
the United States.

Chile : 1960 May 22
19:11:14 UTC
Magnitude 9.5

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EARTHQUAKE DAMAGE

- Ground Failure - constructions collapse
- Fires - from broken gas and electrical lines
- Landslides - EQ's triggered; occur in hilly/mountainous areas.
- Liquefaction - water-saturated, unconsolidated materials flow
- Tsunami (seismic sea waves; "tidal" waves) - can grow up to 65 m

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EARTHQUAKES AND THE SAN ANDREAS FAULT

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SHORT-TERM PREDICTIONS

Precursor phenomena (<1 year to days)

1. **Foreshocks:** usually increase in magnitude
2. **Ground deformation**
3. **Fluctuations in water well levels**
4. **Changes in local radio wave characteristics**
5. **Anomalous animal behavior???**

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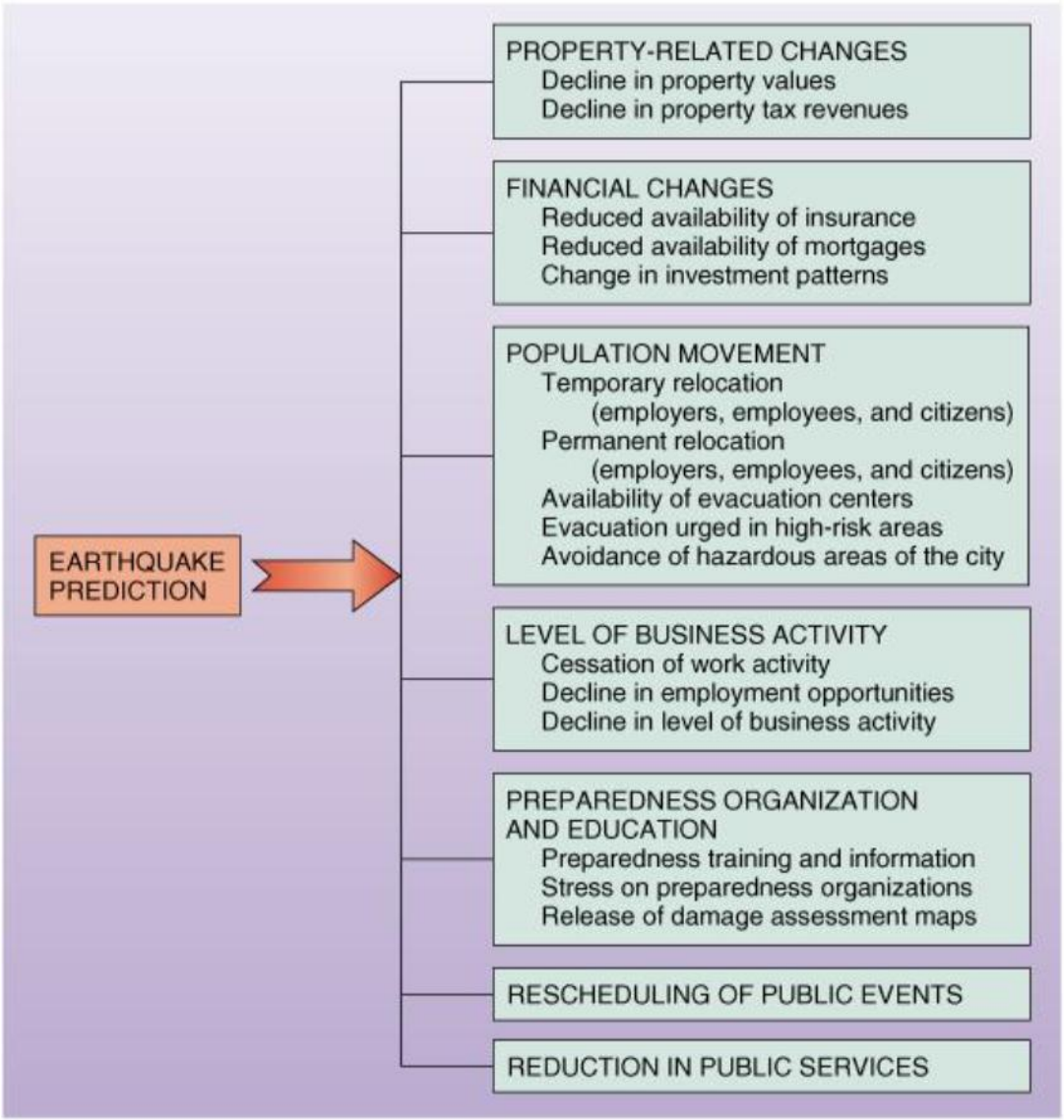
Impacts of Earthquake Prediction



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THANKS

Please visit the following links:

https://en.wikipedia.org/wiki/Earthquake

https://www.britannica.com/science/earthquake-geology

https://www.youtube.com/watch?v=T0AEtX-uPLA

https://www.youtube.com/watch?v=FIgksa3x11w

https://www.youtube.com/watch?v=uA_OLKfQpYA

https://www.youtube.com/watch?v=NaNw9LHq9dc

https://www.youtube.com/watch?v=HL3KGK5eqaw

https://www.youtube.com/watch?v=zFKI1iPmetY

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