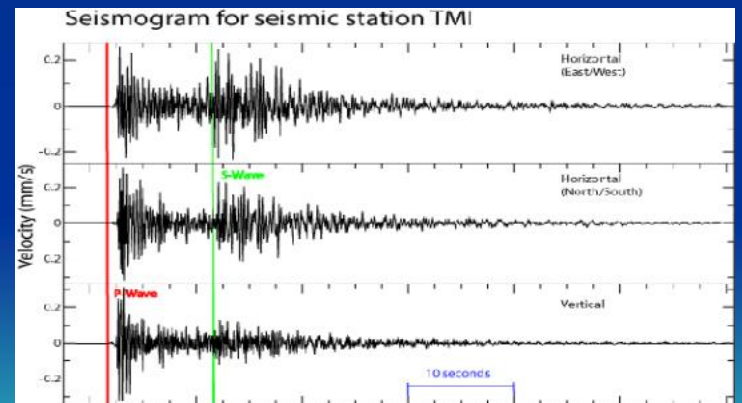
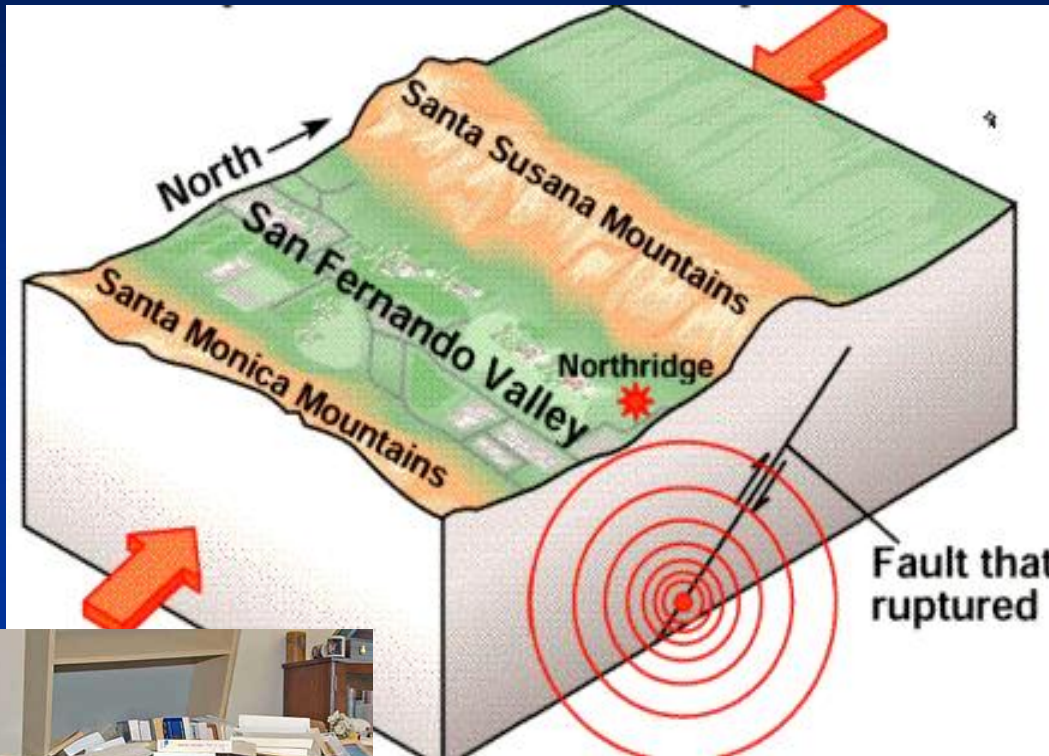


Earthquake!

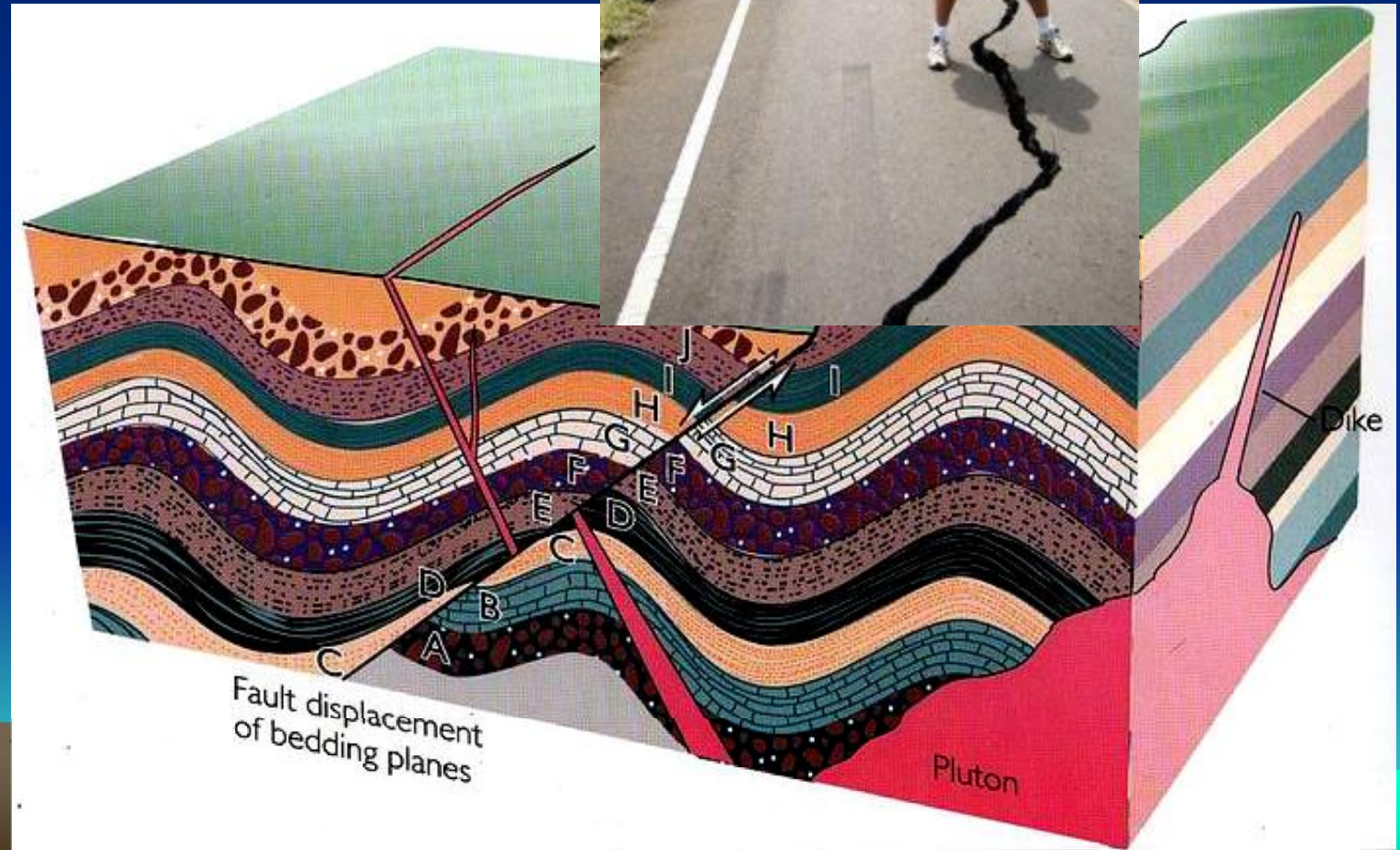
Principles and Consequences



General Geology - GEOL 100

Ray Rector - Instructor

Earthquakes Occur Along Active Fault Zones



EARTHQUAKE TOPICS

What are Earthquakes?

Where and How do Earthquake Form?

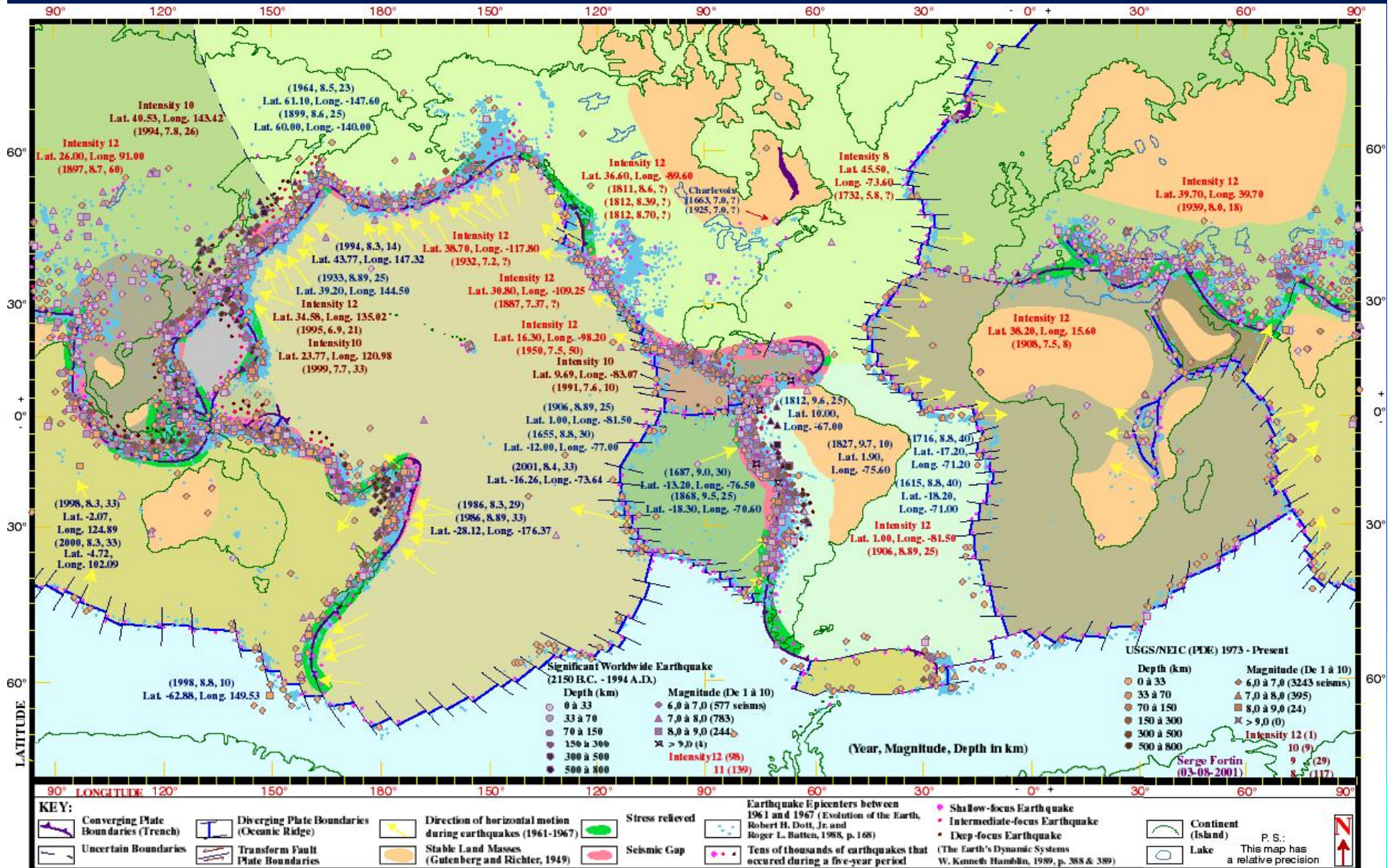
How are Earthquakes Measured?

What are the Effects of Earthquakes?

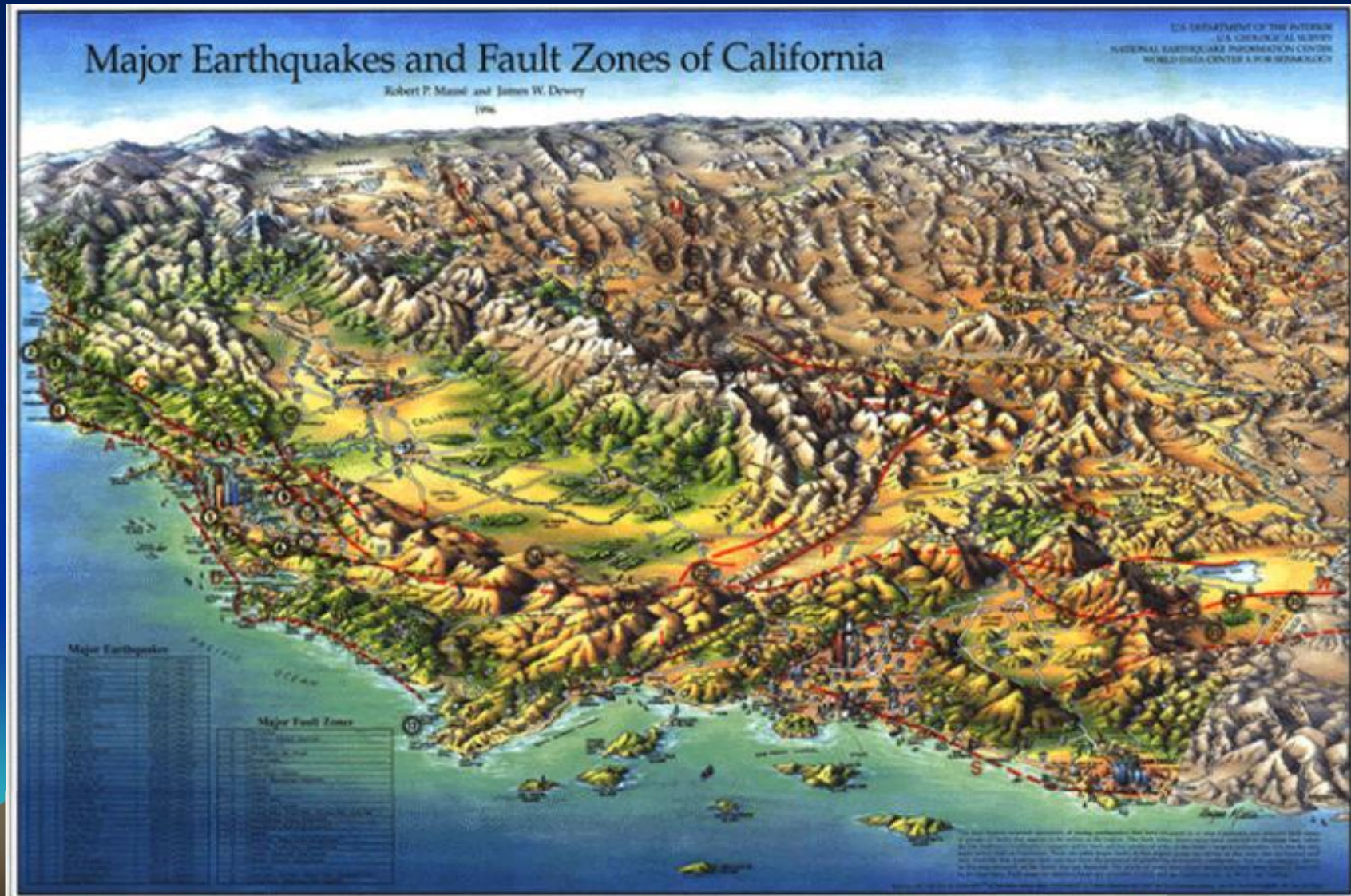
Can we Predict Earthquakes?

How can we Prepare for an Earthquake?

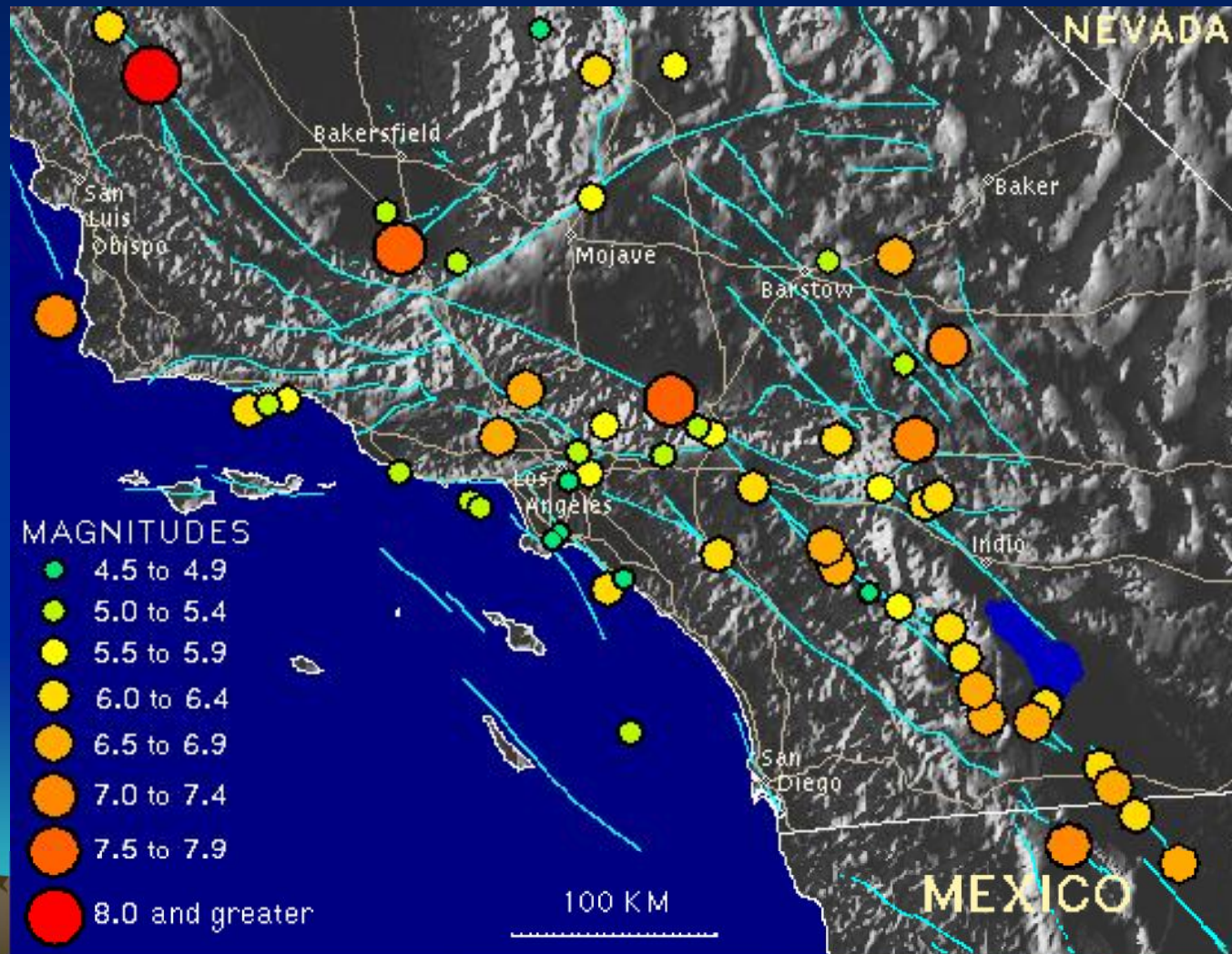
Major Earthquakes and Fault Zones of the World



Major Earthquakes and Fault Zones of Southern California

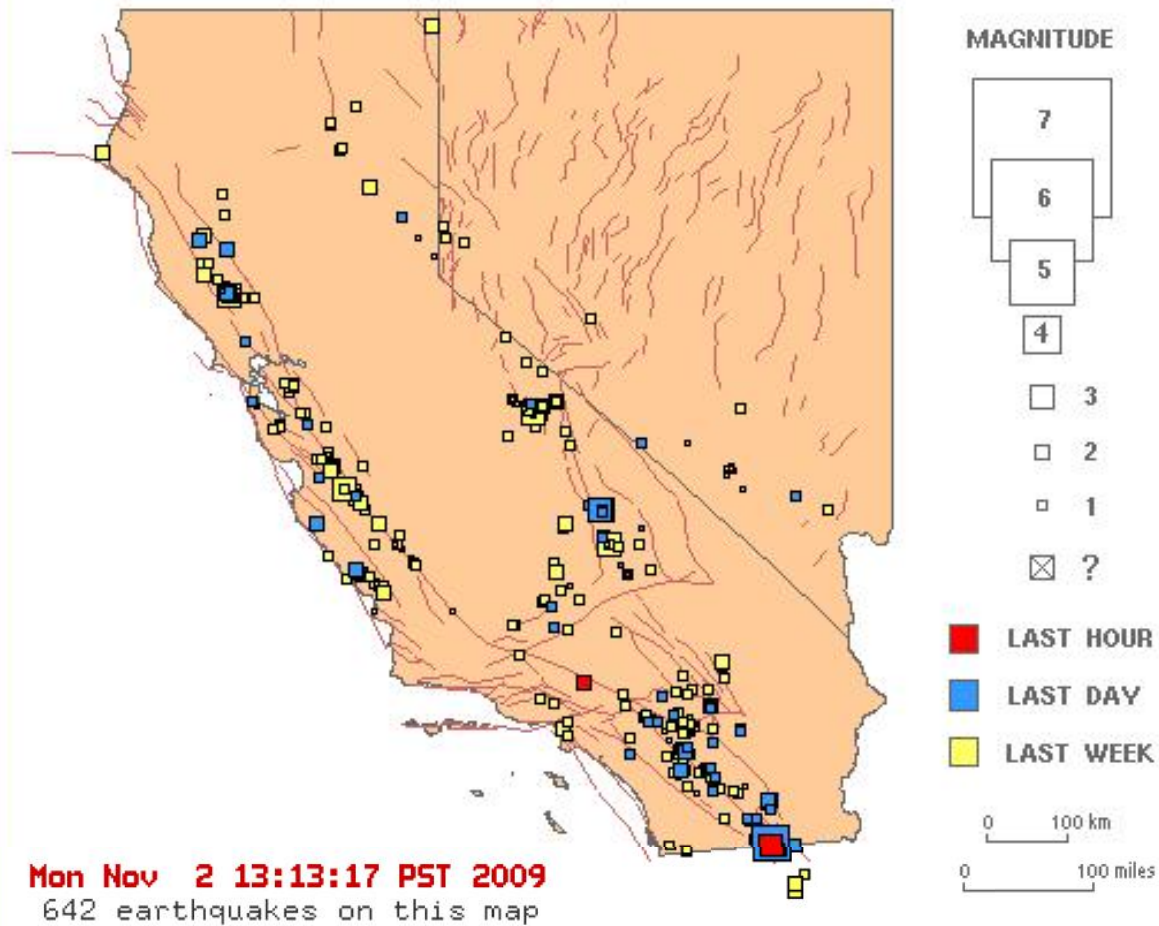


Major Earthquakes and Fault Zones of Southern California

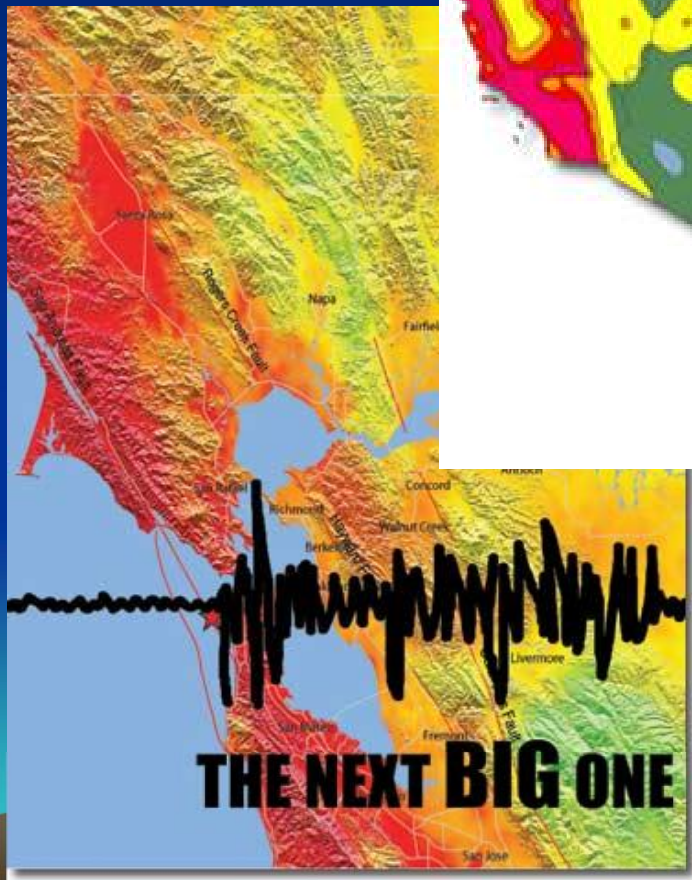
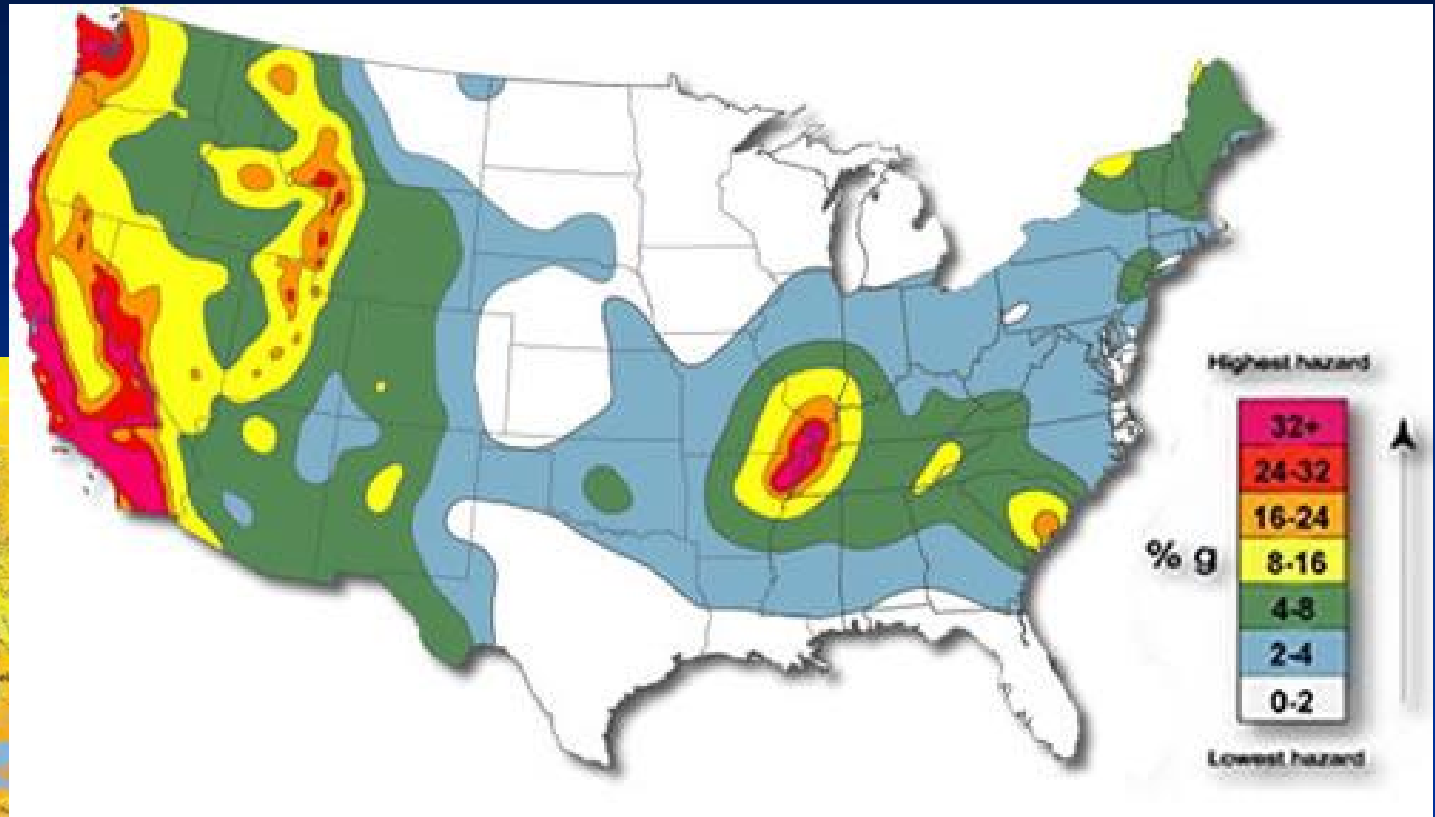


Most Recent Earthquakes in California

Index Map of Recent Earthquakes in California-Nevada
USGS·UCB·Caltech·UCSD·UNR



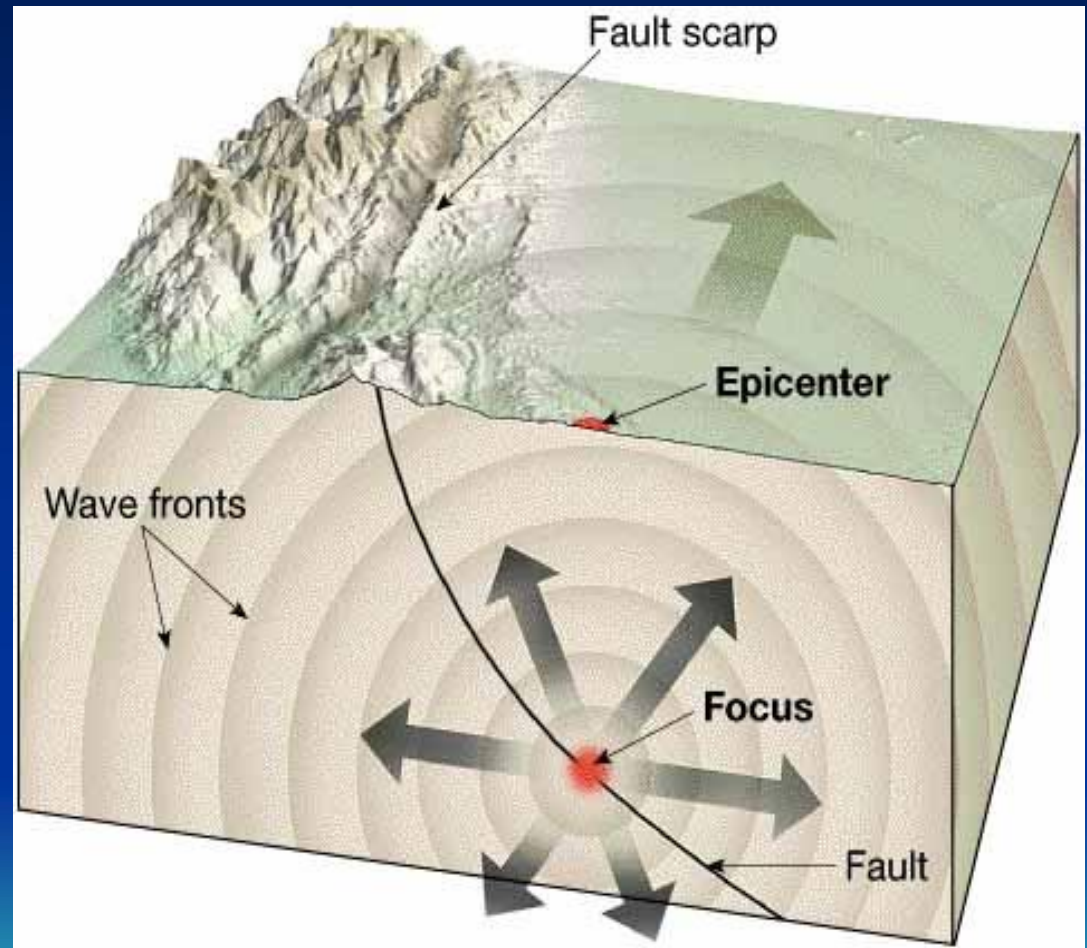
Earthquake Probability in USA



?

Anatomy of an Earthquake

- 1) Fault rupture
- 2) Fault scarp
- 3) Focus
- 4) Epicenter
- 5) Seismic Waves



What Causes an Earthquake?

1) Pre-load Period

- No Stress
- No Deformation

2) Bending Period

- Slow Stress Loading
- Elastic Deformation

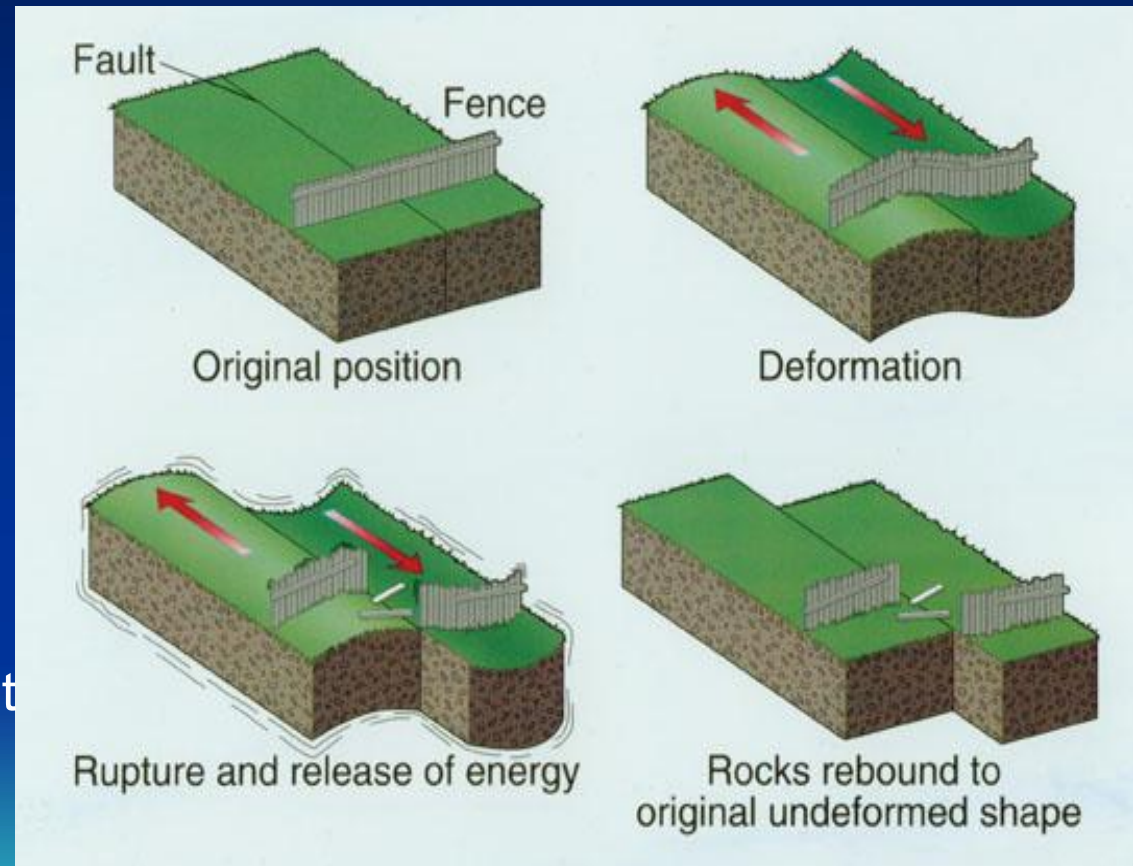
3) Rupture Period

- Instant Stress Release
- Brittle Deformation/Offset

4) Rebound Period

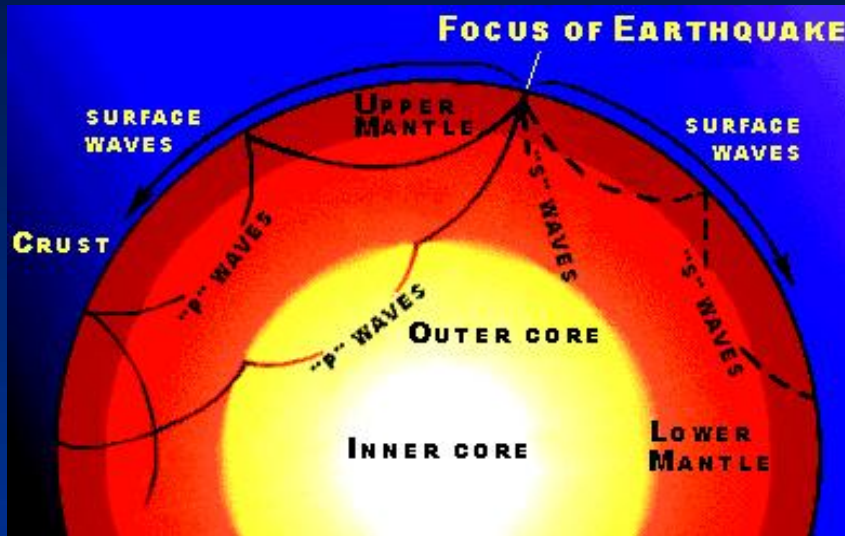
- Removal of Bending
- Stress Relieved

Reid's Elastic Rebound Theory



Four Stages

Types of Seismic Waves

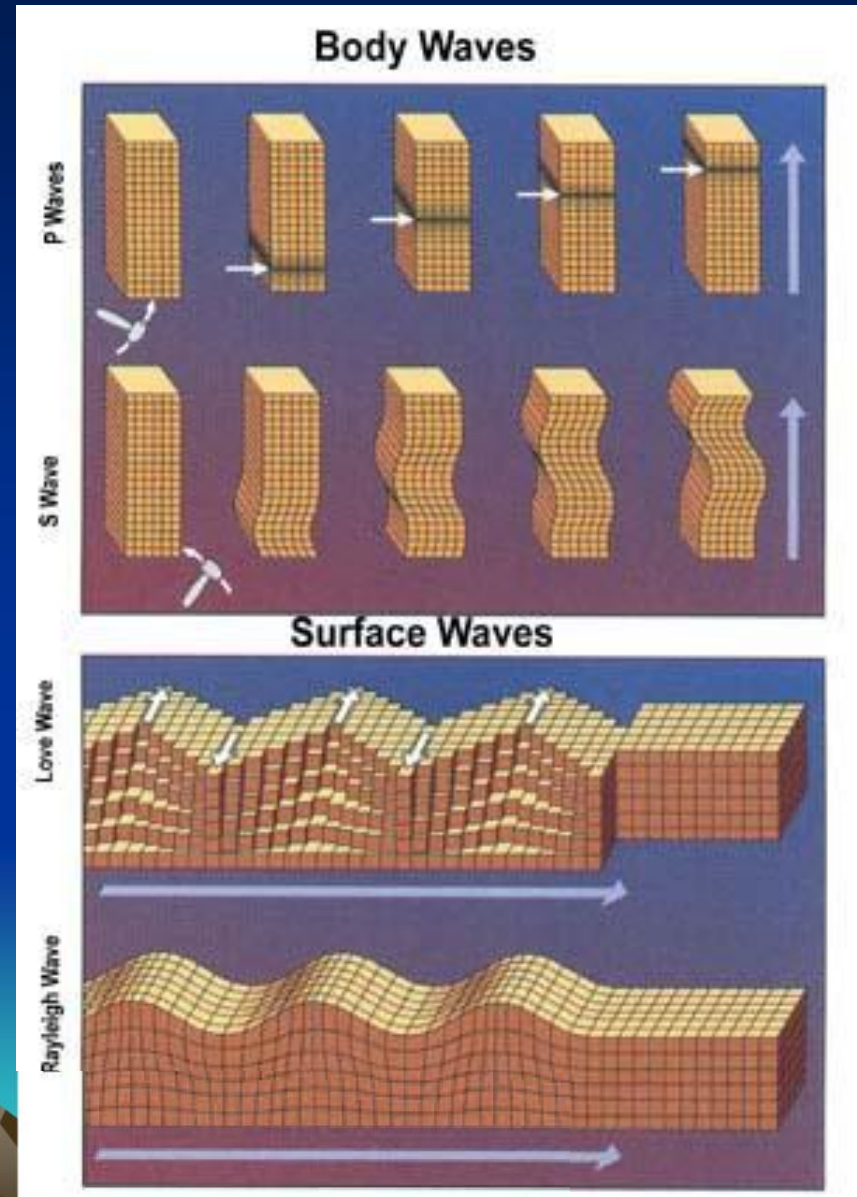


Body Waves

- 1) P-waves
- 2) S-waves

Surface Waves

- 1) Love-waves
- 2) Raleigh-waves



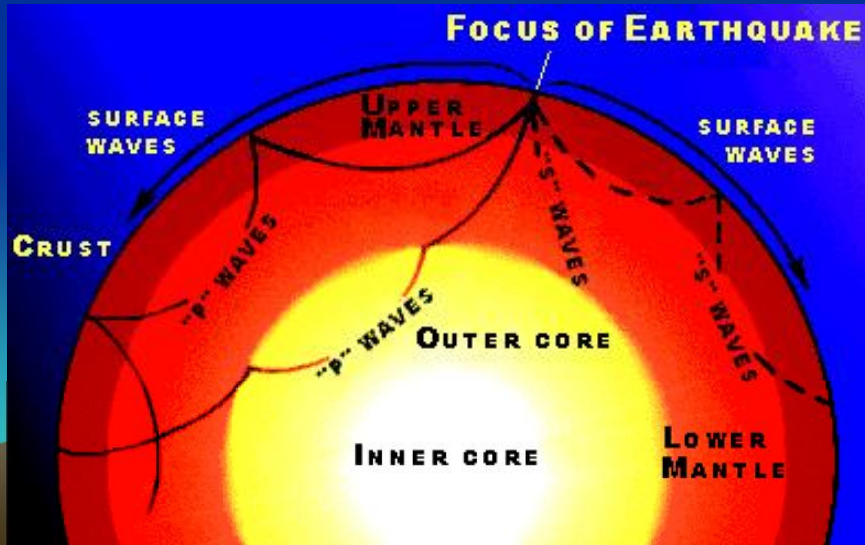
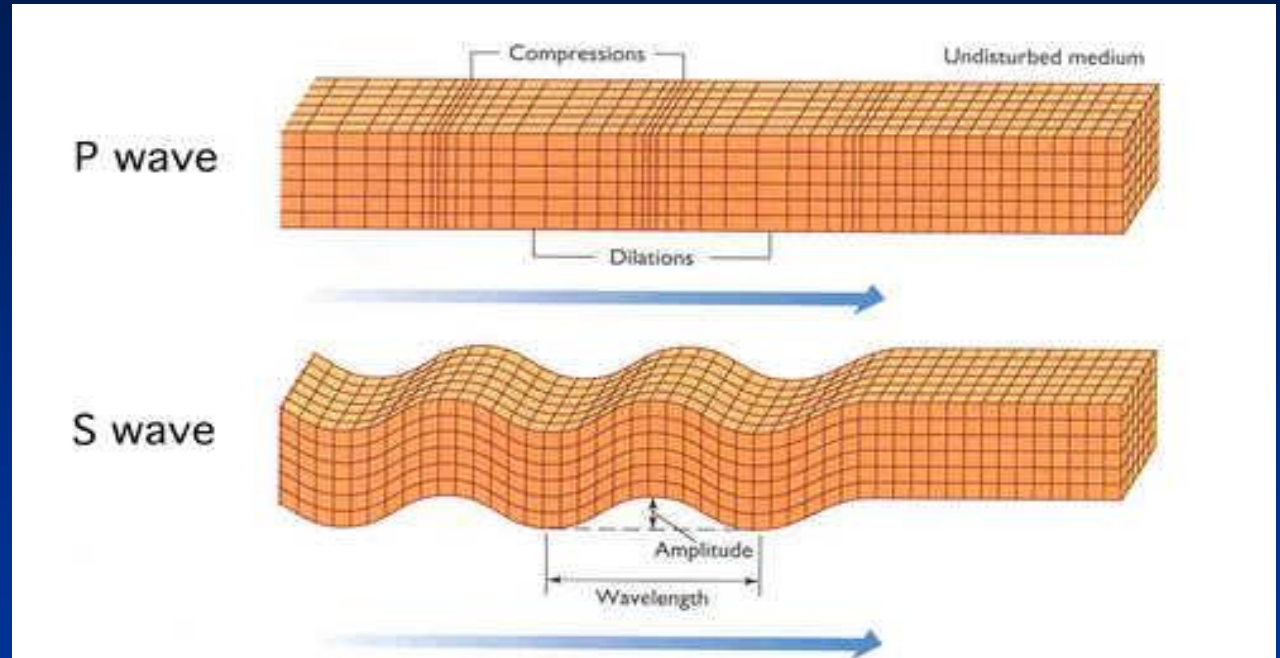
Two Types of Body Waves

1) P-waves

- Compressional
- Fast

2) S-waves

- Shear
- Slow

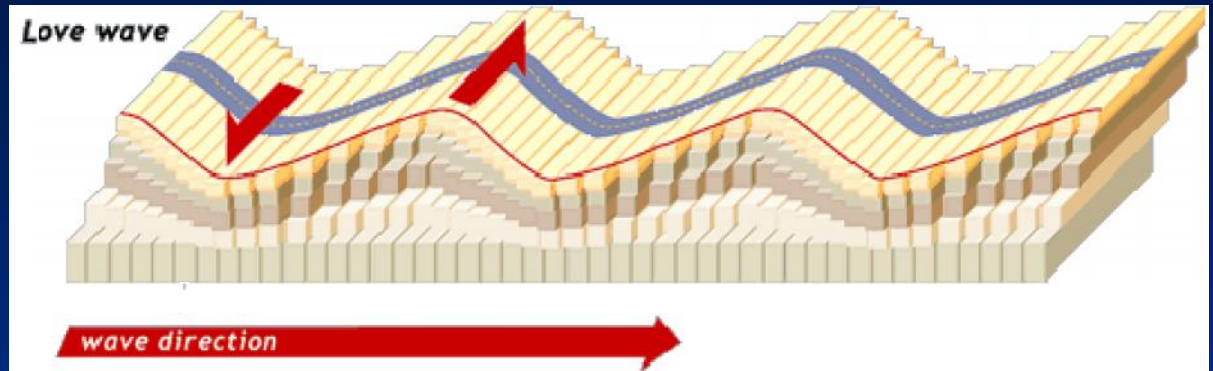


P-waves are twice as fast as S-waves

Two Types of Surface Waves

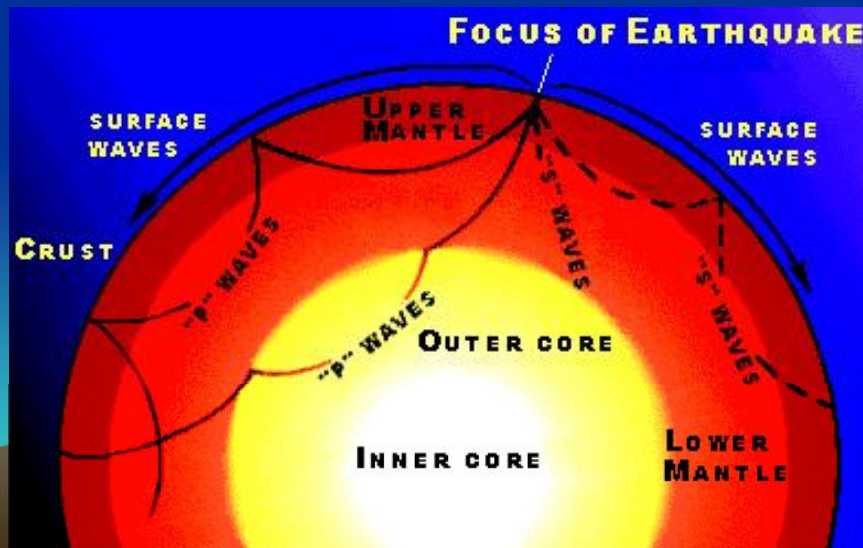
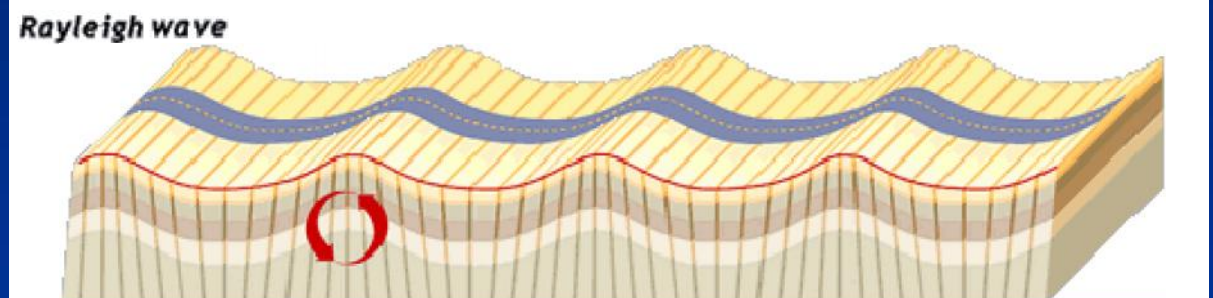
1) Love-waves

- Side-to-side Shear Motion



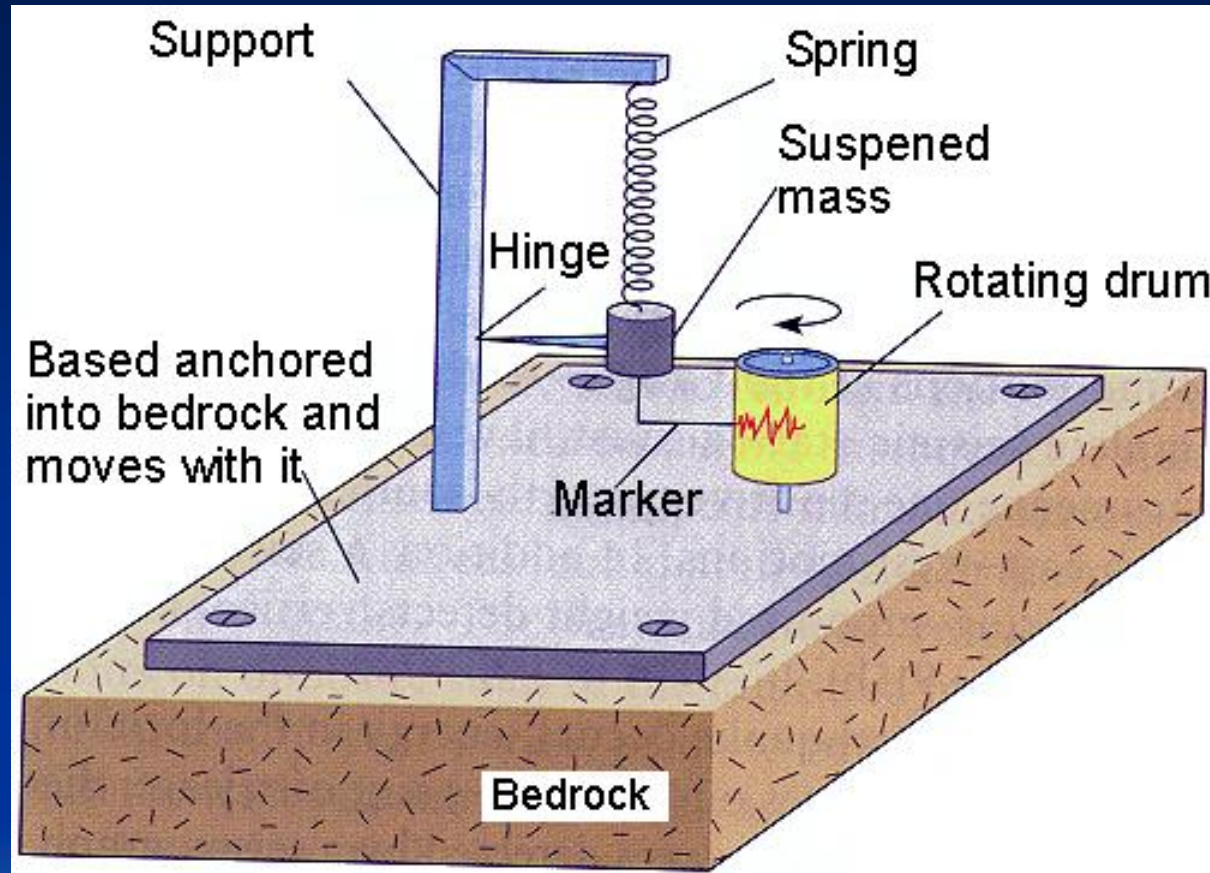
2) Raleigh-waves

- Orbital Rolling Motion



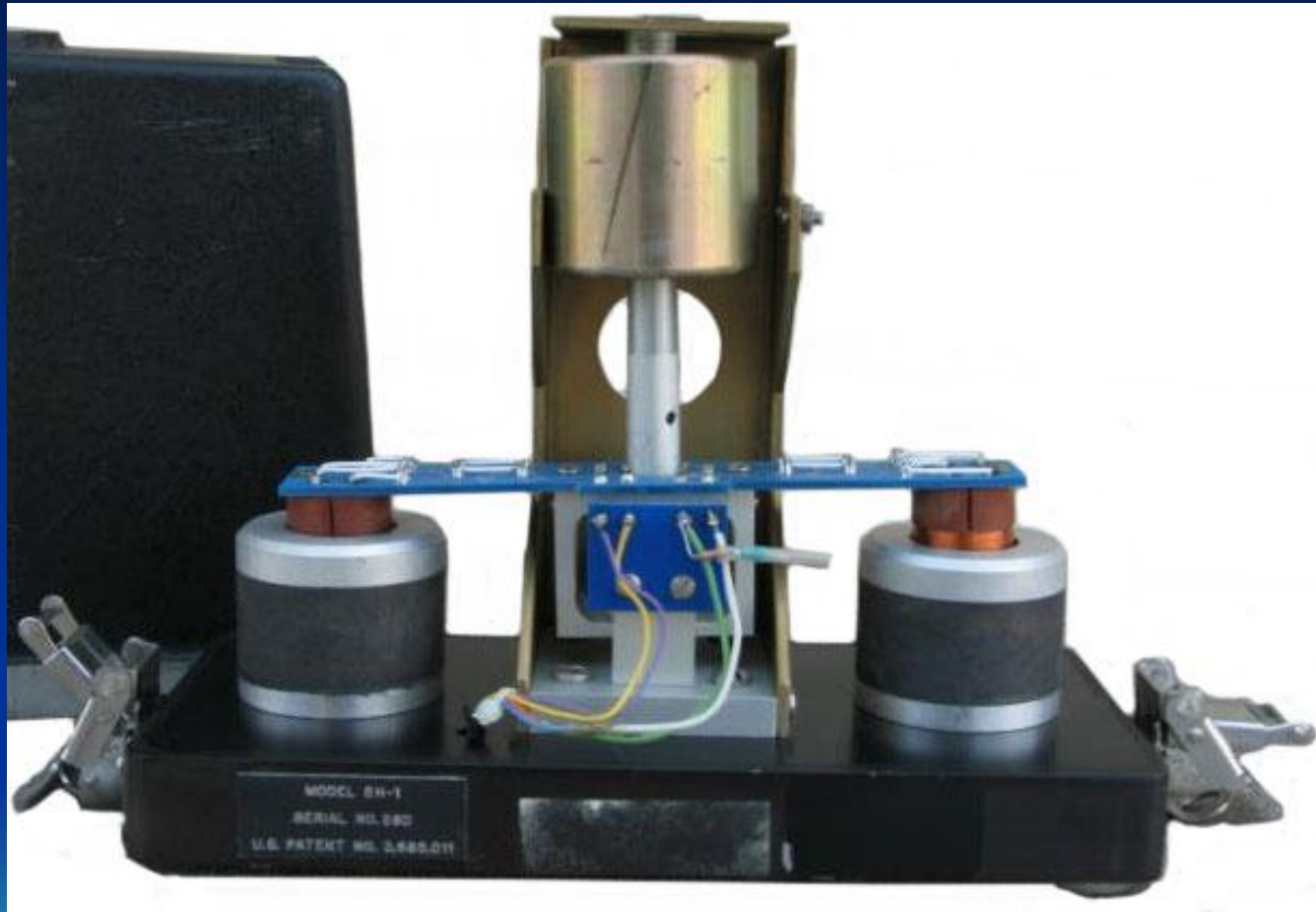
Surface waves are very destructive to building, dams, and bridges

Recording Seismic Activity



A Simplistic Seismometer

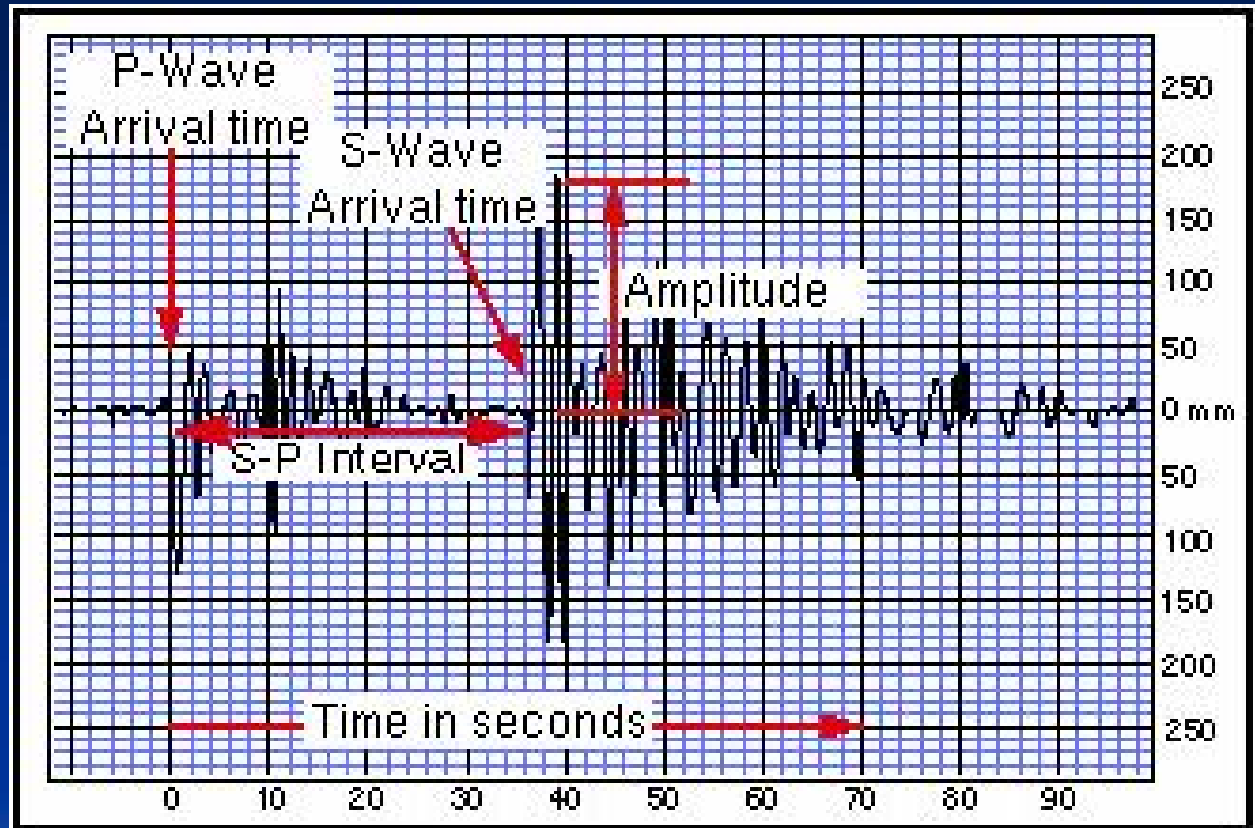
Recording Seismic Activity



A Real Seismometer

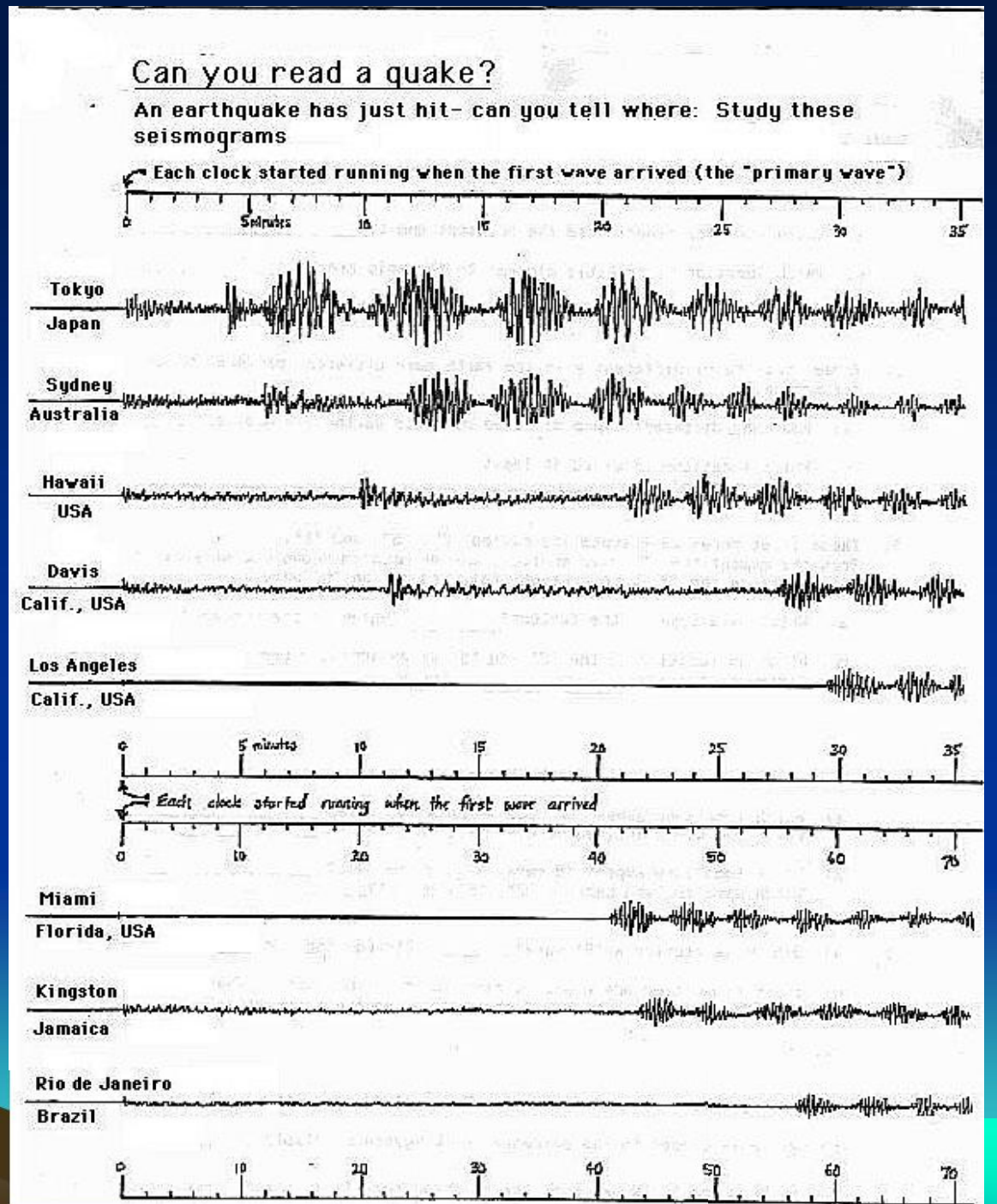
Fundamentals of a Seismogram

- 1) P-wave Arrival time
- 2) S-wave Arrival time
- 3) S-P Interval
- 4) Amplitude



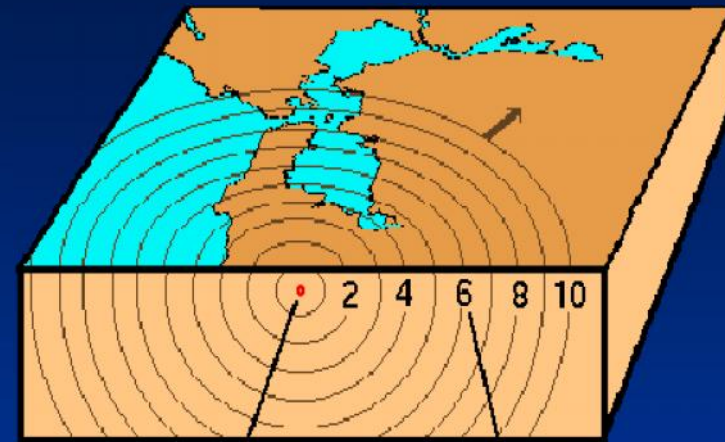
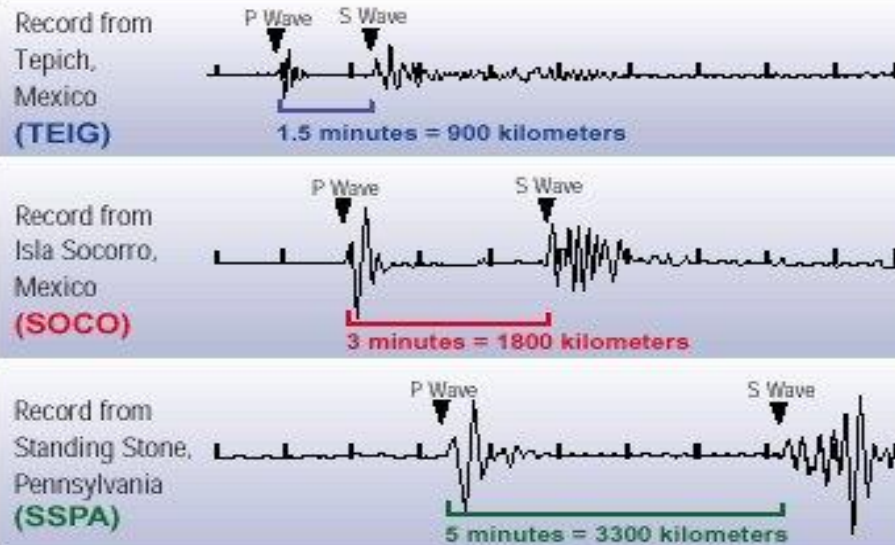
Reading a Seismogram

- 1) P-wave Arrival time
- 2) S-wave Arrival time
- 3) S-P Interval
- 4) Amplitude



Determining Distance to Epicenter

STEP 1: Measure

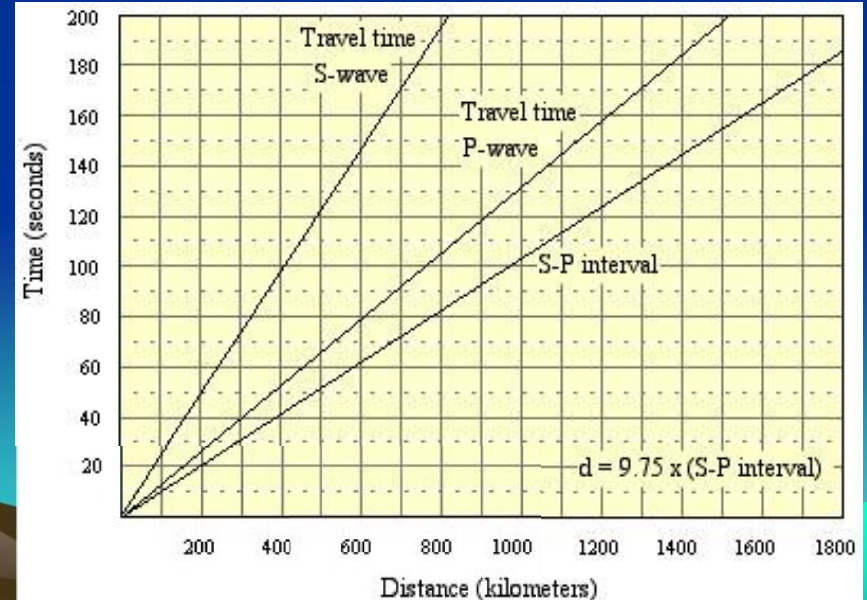


EARTHQUAKE HYPOCENTER

TIME OF EXPANDING WAVEFRONT IN SECONDS

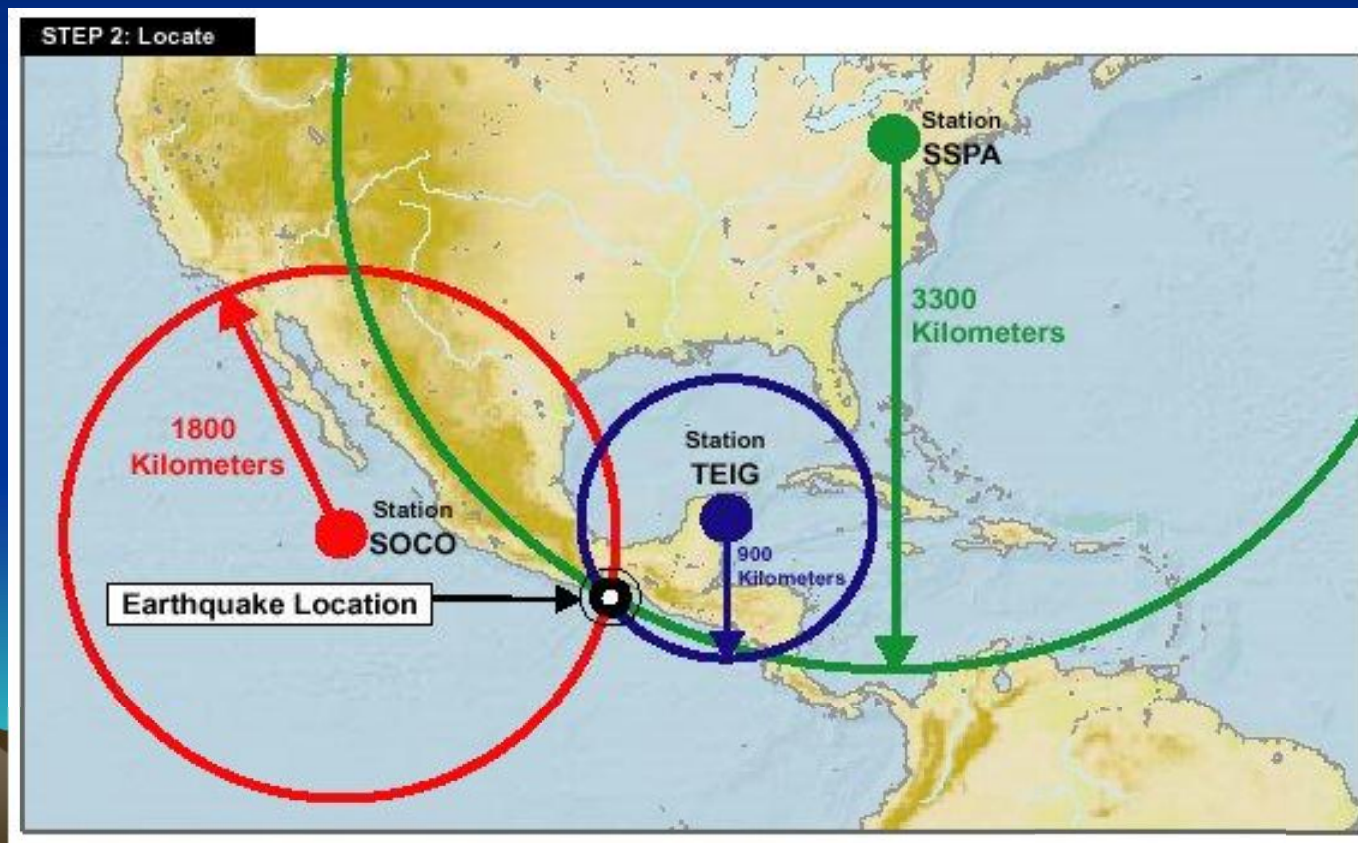
1) Measure S-P Interval for each station

2) Convert S-P Interval time into ground distance from epicenter using conversion chart



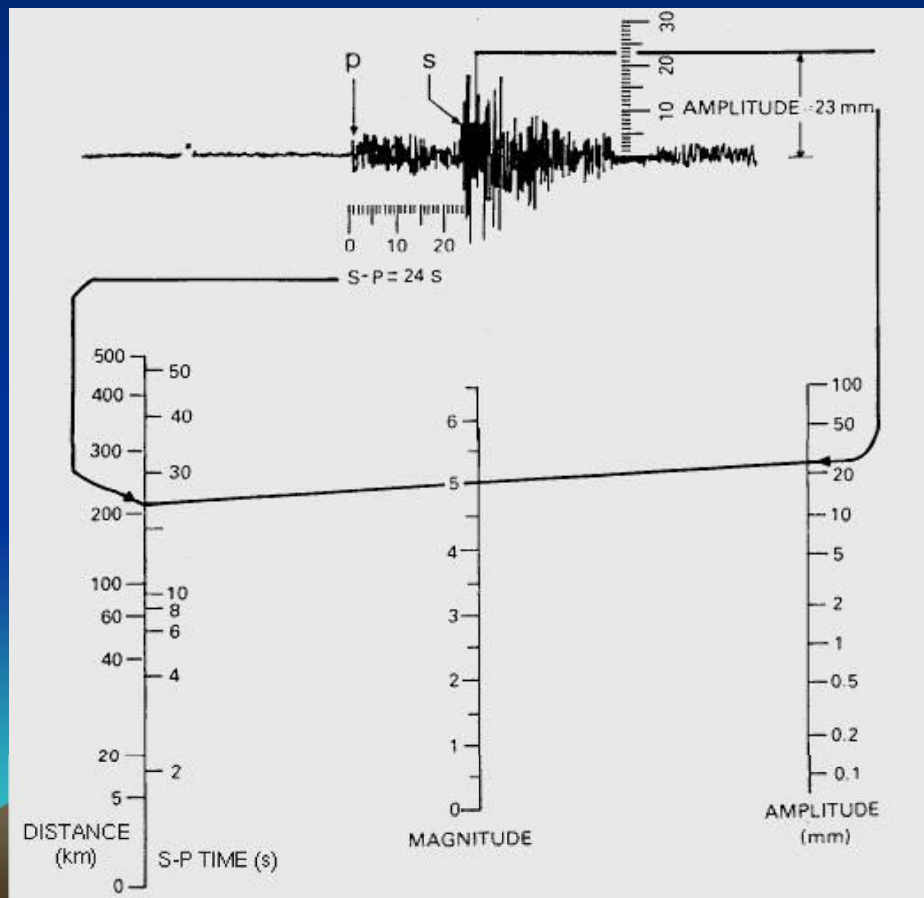
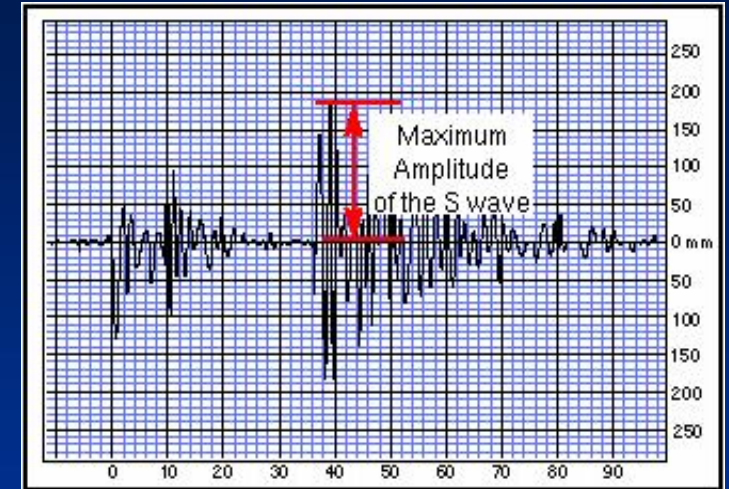
Determining Earthquake Epicenter

- 1) Need at least three seismograph stations
- 2) Find distance from station to epicenter for each station
- 3) Plot distance circles for each station
- 4) Epicenter located where all three circles intersect



Determining Earthquake Magnitude

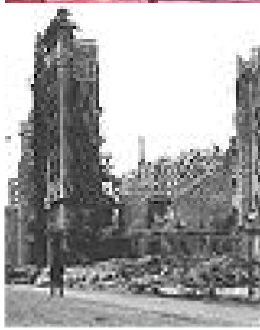
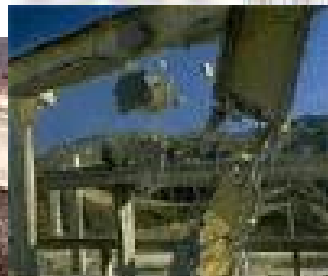
- 1) Measure amplitude of largest S-wave
- 2) Plot line from distance to amplitude
- 3) Magnitude is read from center scale



Earthquake Epicenter and Magnitude Internet Exercise

Welcome to

Earthquake



[Virtual Earthquake Internet Exercises](#)

Ground Shaking

Modified Mercalli Intensity Scale

- I Not felt
- II Felt only by persons at rest
- III–IV Felt by persons indoors only
- V–VI Felt by all; some damage to plaster, chimneys
- VII People run outdoors, damage to poorly built structures
- VIII Well-built structures slightly damaged; poorly built structures suffer major damage
- IX Buildings shifted off foundations
- X Some well-built structures destroyed
- XI Few masonry structures remain standing; bridges destroyed
- XII Damage total; waves seen on ground; objects thrown into air

Banda Aceh, Indonesia Video

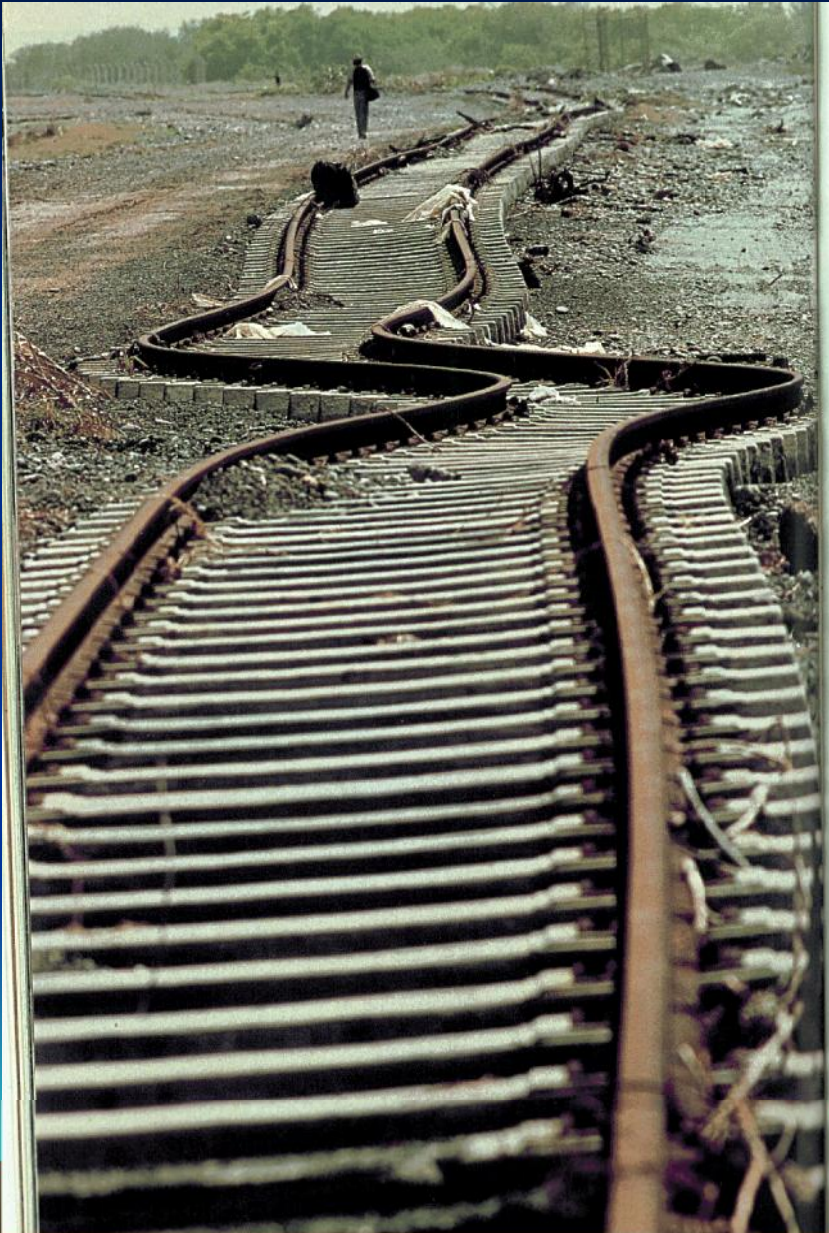


Earthquake and Tsunami Footage

Ground Rupturing Effects and Hazards



Surface Displacement Along Active Faults



Hogbacks could be limbs of a fold - anticline axis to left & syncline axis to right

Hogbacks show dip to the right

Note: Rule of V's shows beds dipping to the right

Motion if this is a strike-slip fault

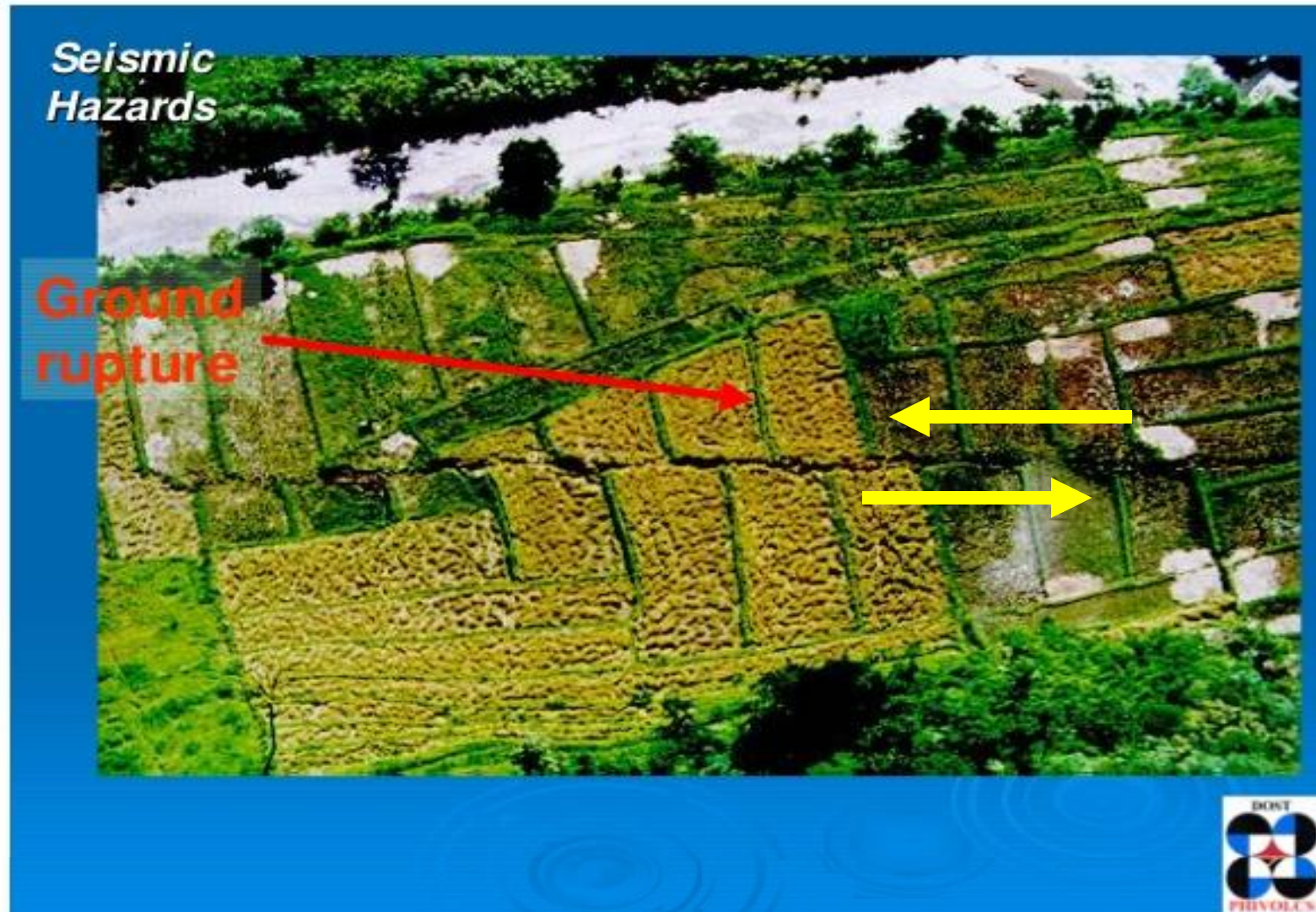
Geologic History
1.) Sedimentation
2.) Lithification
3.) Folding
4.) Uplift/Erosion
5.) Faulting
(4&5 could be reversed)

Non-resistant beds

Resistant beds



Surface Displacement Along Active Faults



Houses Collapse Due to Ground Shaking



Poorly-constructed homes are easily damaged in big quakes

Building Collapse Due to Ground Shaking



Weak foundation supports are easily damaged in big quakes

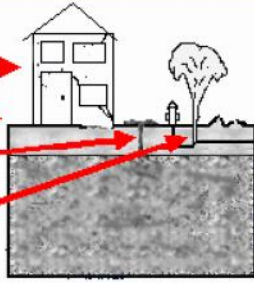
Bridge Collapse Due to Ground Shaking



Poorly-constructed bridges are easily damaged in big quakes

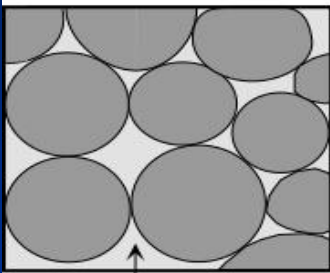
Liquifaction!

Building damage
Roads and sidewalks
Sand boils
Pipeline breaks

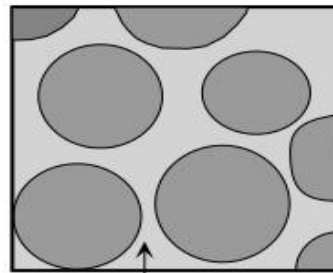


Water-Saturated Sediment

Liquefaction



Water fills in the pore space between grains. Friction between grains holds sediment together.



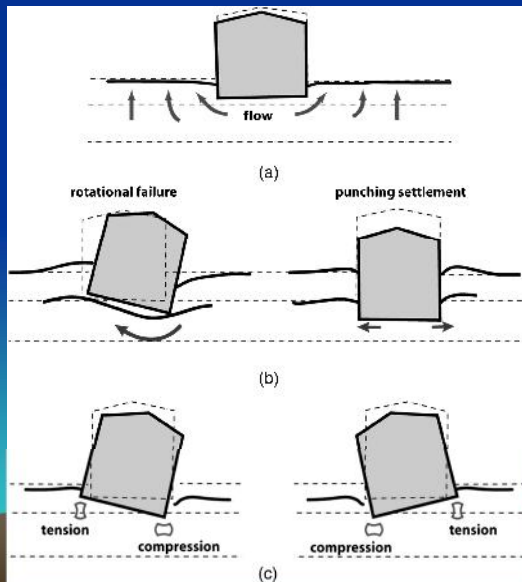
Water completely surrounds all grains and eliminates all grain to grain contact. Sediment flows like a fluid.



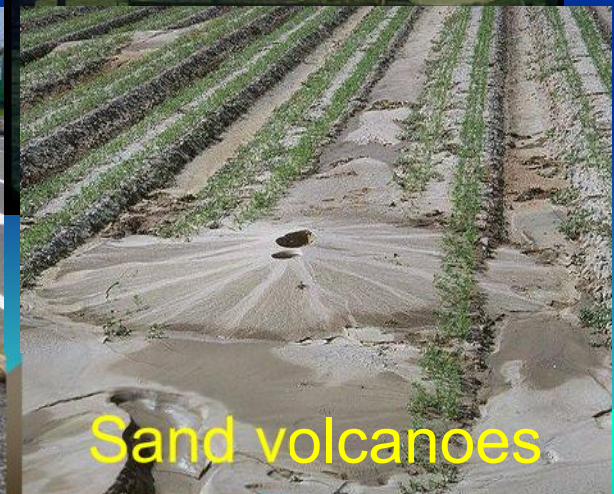
Roadway Failure



Sinking Building



Exhumed pipes



Sand volcanoes

Liquifaction!



Liquefaction during the 1964 Niigata M7.6 earthquake, Honshu, Japan caused major foundation failure in these apartment blocks.

Image from WikiCommons.

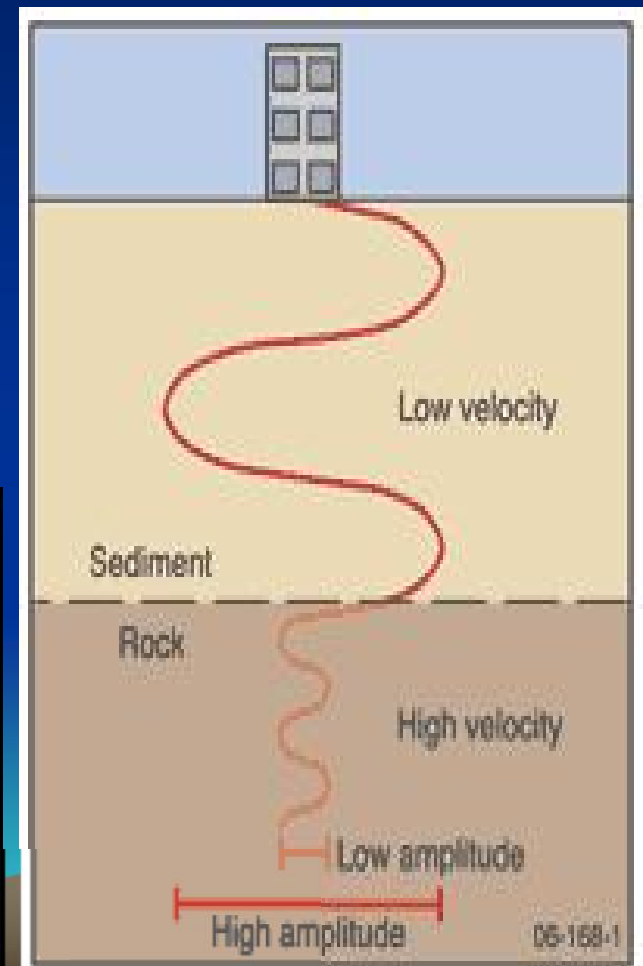
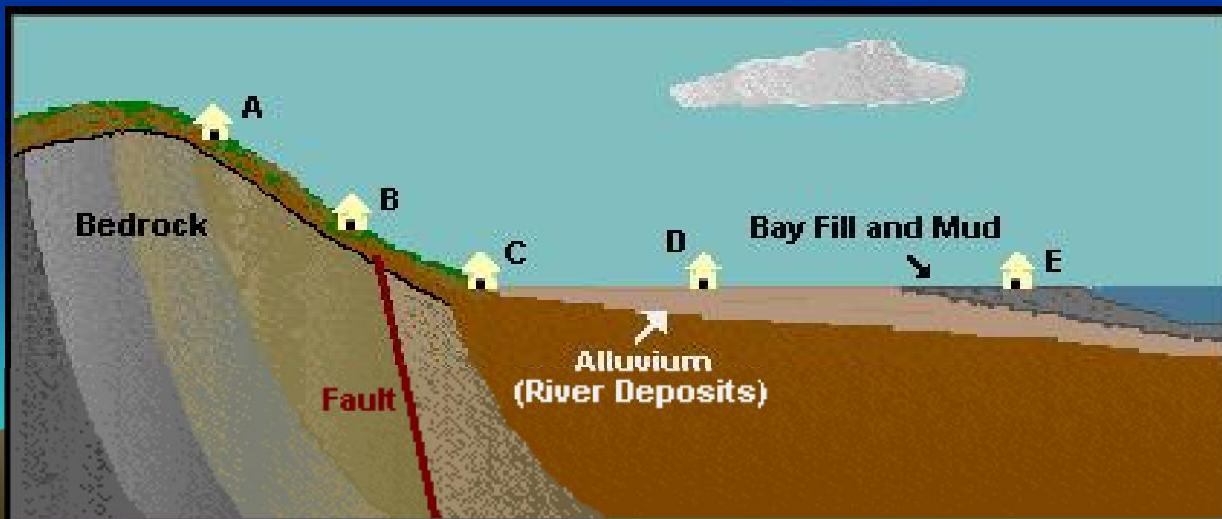
Earth Shaking: Ground Effects

Different types of ground materials behave differently to seismic waves: the softer the ground material, the greater the shaking.

Solid rock is favorable over sediment

Dry sediment favorable over saturated

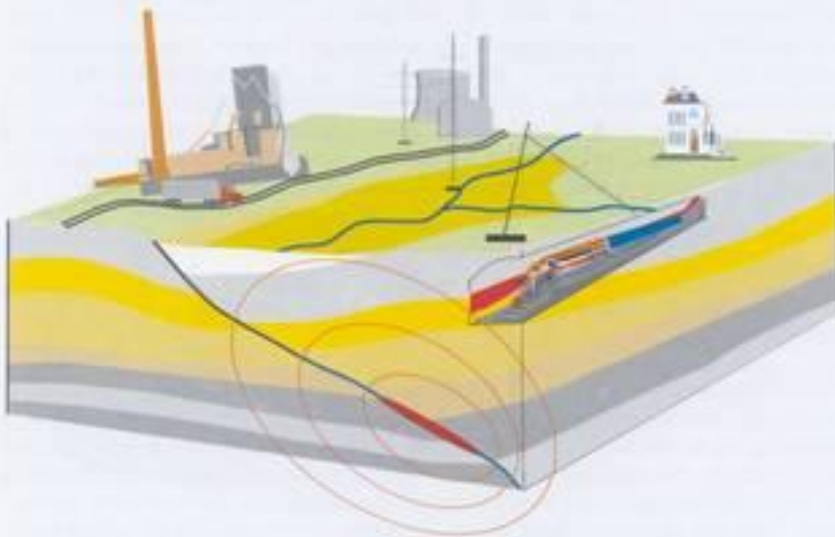
Different types of building material and structural designs give different failure results for a given level of shaking.



Substrate Type versus Shaking Intensity

Structures

general damage analysis
estimation of risk
repair and retrofiting
earthquake resistant design



Soil dynamics

increase of damage due to
site effects

Lifelines

water
electricity
gas
communication
traffic

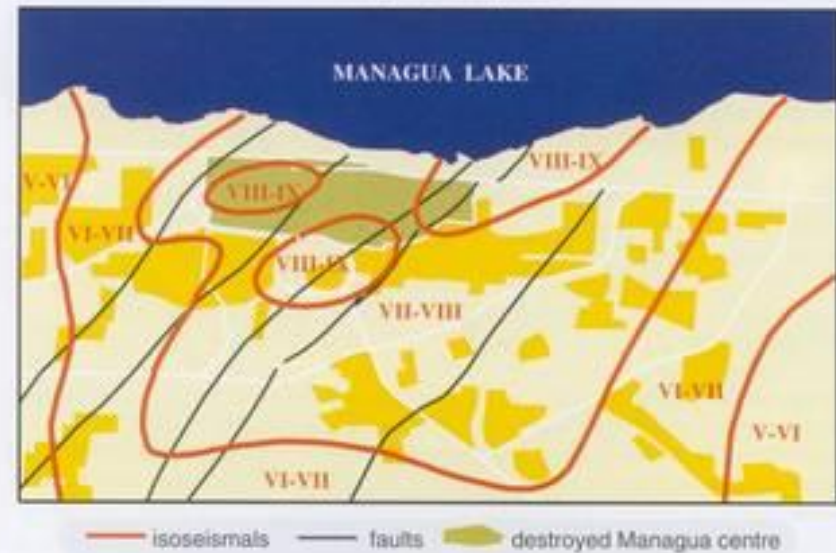
Regional planning

intensity maps
probabilistic hazard maps
land development plans

Microzonation

engineering geology
soil dynamics
interactions

Map of seismic intensities of the December 12, 1972
Managua earthquake



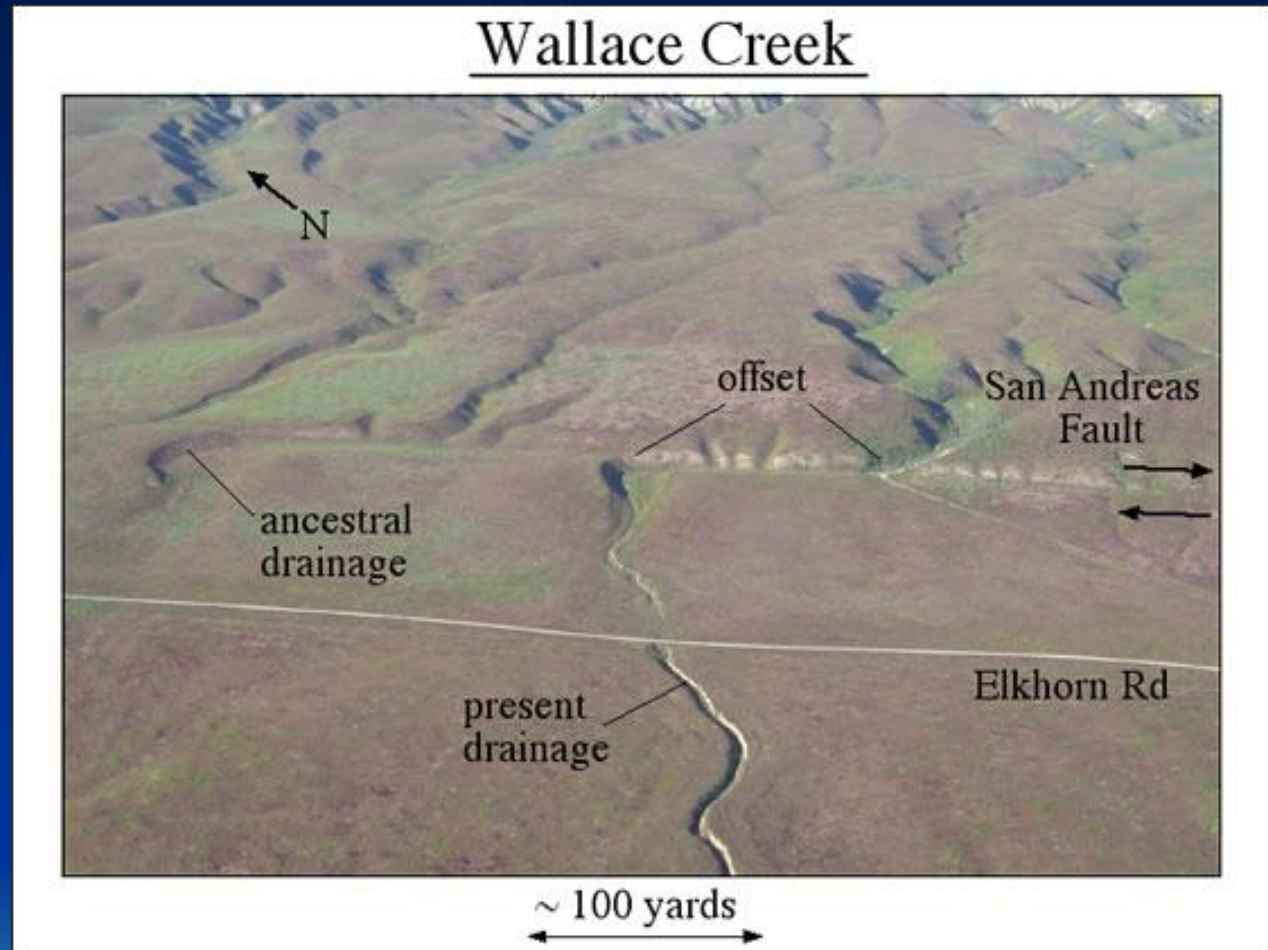
Building codes

structural parameters
revision of building codes

Simple structures

damage analysis
retrofitting
advice for new construction

Using Aerial Photos to Interpret Fault Movement



Surface Displacement
Along San Andreas Fault

Earthquakes on the Net

Earthquake Research Exercises

Part I. Active Faults and Recent Earthquakes in California and Nevada

<http://quake.wr.usgs.gov/recenteqs/latest.htm>

Part II. Create and Analyze Your Own Earthquake –
Virtual Earthquake Computer Program

<http://www.sciencecourseware.com/eec/Earthquake/>

Part III. Earthquake Preparedness Information

