# Introduction to Seismology

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## *What is Seismology?*

- *Seismology* (from the Greek words *Seismos* meaning *earthquake* and *Logos* meaning *science*) is the science of earthquakes, being a branch of a more general science of Geophysics, which refers to the Earth structure.
- Its objective is the study and elaboration of theories concerning the generation of an earthquake and the propagation of seismic waves. At the same time Seismology is involved with record and interpretation of recorded seismograms.

## *Who are Seismologists?*

- The *seismologists*, as Earth scientists, are specialized in geophysics and they are devoted to analyze the genesis and propagation of seismic waves in geological materials.
- Some of them study the relation between faults, stress and seismicity, others interpret the mechanisms of rupture from seismic wave data, others integrate geoscientific information in order to define zones of seismicity, and finally others collaborate with engineers trying to minimize the damage caused to construction.

From Gioncu and Mazzolani "Earthquake Engineering for Structural Design"

## *Seismology and Engineering Seismology*

• Seismology is the branch of Geophysics concerned with the study of the generation, propagation and recording of elastic waves in the earth, and the sources that produce them.

• Engineering Seismology is concerned with the solution of engineering problems connected with the Earthquakes. Seismology is very important because:

- Study of earthquakes gives us important clues about the earth's interior
- Understanding earthquakes allows us to minimize the damage and loss of life

## *Engineering Seismology and Earthquake Engineering*

- *Engineering Seismology, developed to solve the problems of the Earthquake* hazard, is a branch of *Seismology, having the purpose to use the seismological* knowledge for the seismic design of buildings, by proposing the seismic actions function of the source and site characteristics.
- *Earthquake Engineering, with the task to solve the problems of construction* vulnerability, is a branch of more general field, the *Structural Engineering Science,* having the purpose to develop specific methodologies for analyzing the effects of seismic actions on constructions, very different from that used in case of other actions like dead, live, wind, snow, etc., loads.

From Gioncu and Mazzolani "Earthquake Engineering for Structural Design"

## *What is an Earthquake?*

- An earthquake is the vibration of Earth produced by the rapid release of accumulated energy in elastically strained rocks. It is the earth's natural means of releasing stress.
  - Energy released radiates in all directions from its source, the focus;
  - Energy propagates in the form of seismic waves;
  - Sensitive instruments around the world record the event.

## *Types of Earthquakes*

•**Tectonic Earthquakes** : occur when rocks in the earth's crust break due to geological forces created by movement of tectonic plates.

• **Volcanic Earthquakes:** occur in conjunction with volcanic activity.

• **Collapse Earthquakes** :are small earthquakes due to collapse of underground mines,

• **Explosion Earthquakes:** result from the explosion of nuclear and chemical devices.

* About 90% of all earthquakes result from tectonic events, primarily movements on the faults

## *What causes an earthquake?*

**Movement of Tectonic Plates**

Earth is divided into sections called Tectonic plates that float on the fluid-like interior of the earth. Earthquakes are usually caused by sudden movement of earth's tectonic plates

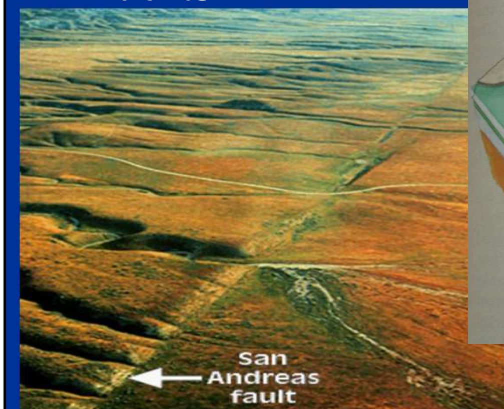
**Rupture of rocks along a fault**

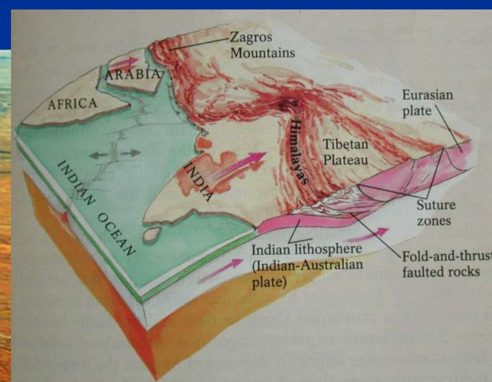
Faults are localized areas of weakness in the surface of the earth, sometimes the plate boundary itself. Rupture of rocks along a fault cause earthquakes.

## *Where do earthquakes occur?*

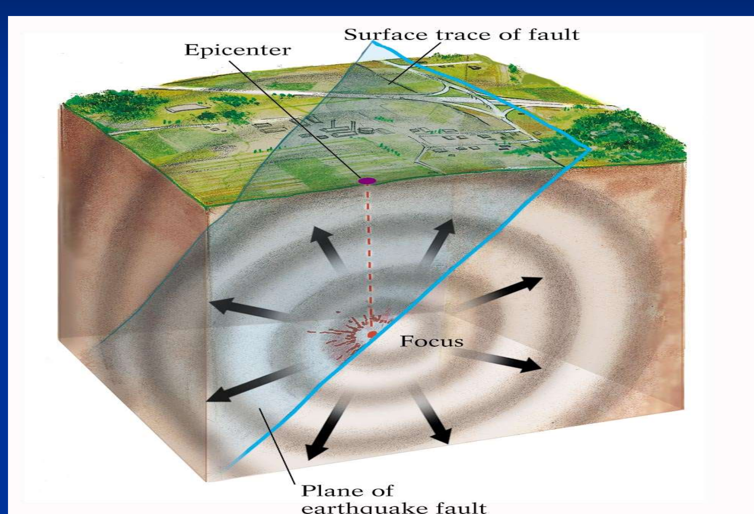
**plate boundaries**

**faults**



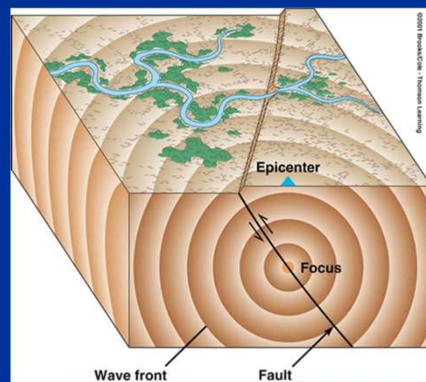




## *Release of Accumulated Energy*



## *The Focus and Epicenter of an Earthquake*

- The point within earth where faulting begins is the focus, or hypocenter
- The point directly above the focus on the surface is the epicenter



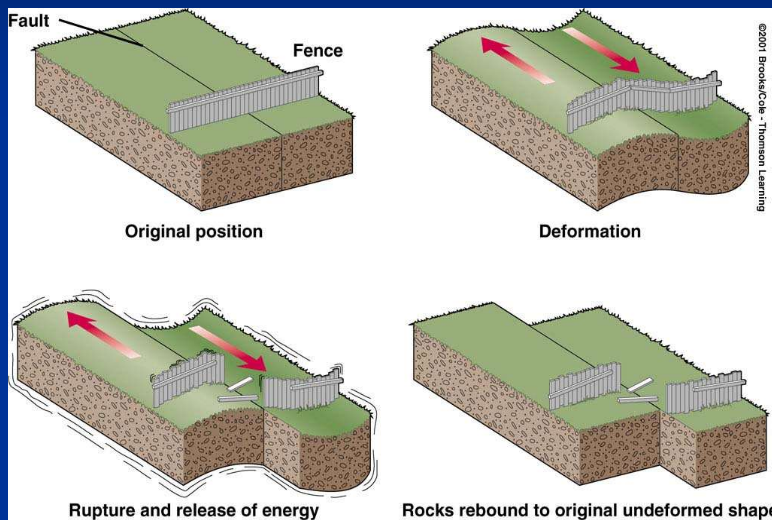

## *Elastic Rebound Theory*

• The gradual accumulation and release of stress and strain is referred to as the ‘’elastic rebound theory’’ of earthquakes.

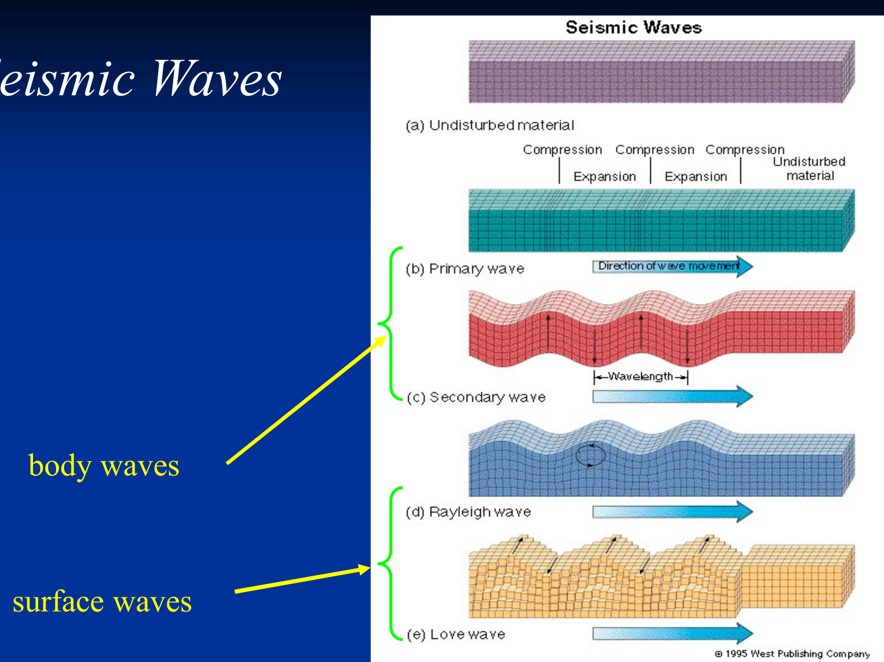
• Mechanism for earthquakes was first explained by H.F. Reid (Professor of Geology at Johns Hopkins University). He concluded that earthquakes must have involved an ‘’elastic rebound’’ of previously stored elastic stress.

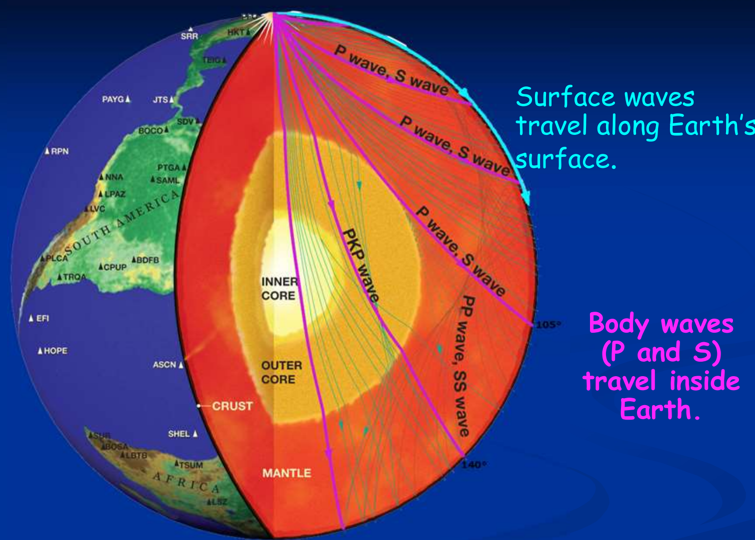
•Rocks bend under stress while storing elastic energy. When the strain in the rocks exceeds their strength, breaking will occur along the fault. Stored elastic energy is released as the earthquake. Rocks “snap back”, or rebound to their original condition.

## Elastic Rebound Theory



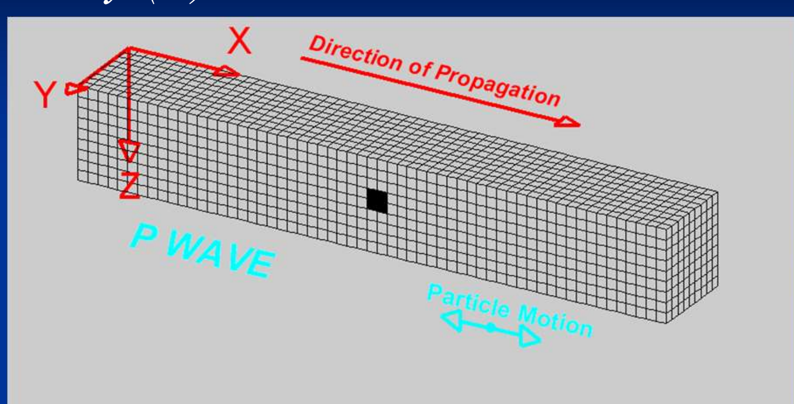

## Seismic Waves





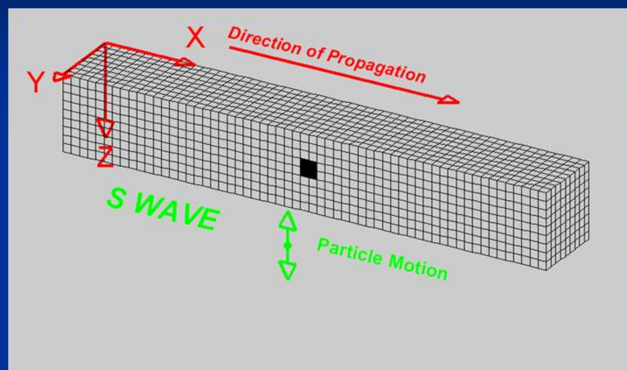

While P- and S- waves radiate outward in all directions, surface waves travel along the surface of the earth and decrease in amplitude with depth.

## *Primary (P) Waves Animations*



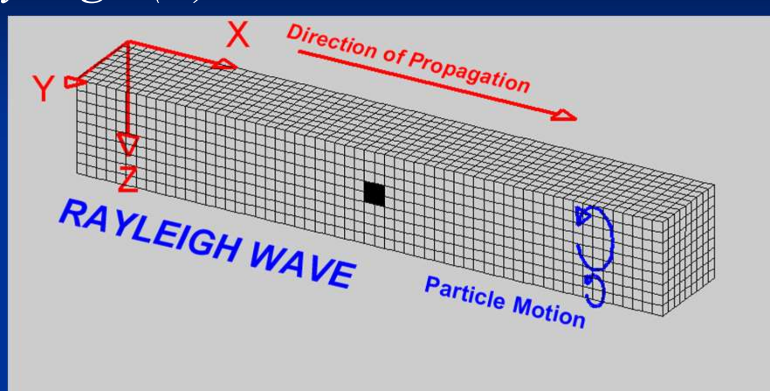

Deformation propagates. Particle motion consists of alternating compression and dilation. Particle motion is parallel to the direction of propagation (longitudinal). Material returns to its original shape after wave passes.

## *Secondary (S) Waves Animations*



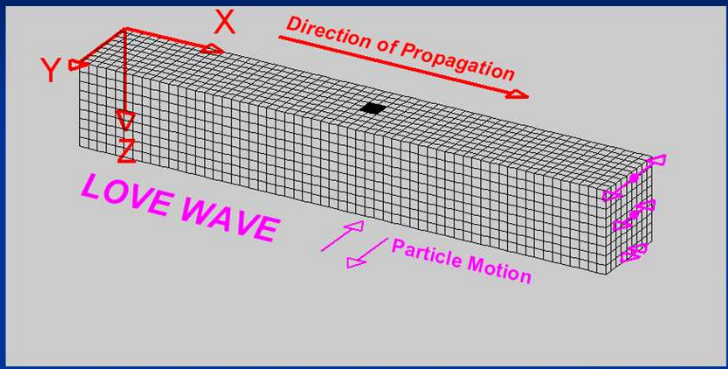

Deformation propagates.  Particle motion consists of alternating transverse motion.  Particle motion is perpendicular to the direction of propagation (transverse).  Transverse particle motion shown here is vertical but can be in any direction. .  Material returns to its original shape after wave passes.

## *Rayleigh (R) Waves Animations*




Deformation propagates.  Particle motion consists of elliptical motions (generally retrograde elliptical) in the vertical plane and parallel to the direction of propagation.  Amplitude decreases with depth.  Material returns to its original shape after wave passes.

## *Love (L) Waves Animations*




Deformation propagates. Particle motion consists of alternating transverse motions. Particle motion is horizontal and perpendicular to the direction of propagation (transverse). To aid in seeing that the particle motion is purely horizontal, focus on the Y axis (red line) as the wave propagates through it. Amplitude decreases with depth. Material returns to its original shape after wave passes.

## *Study of Earthquake waves*

- The study of earthquake waves, Seismology, dates back almost 2000 years to the Chinese Seismographs, instruments that record seismic waves. The first seismograph called Di-Dong-Di was invented by Cheng Heng (132 A.D.).

## Ancient Chinese Seismograph


## Ancient Chinese Seismograph

The ancient Chinese seismograph consist of a special vase that had eight sculpted dragons mounted around the vase in eight primary directions. Each dragon held in its mouth a metal ball. When the ground shook, some of the balls would fall from the mouths of the dragons into the waiting mouths of the sculpted frogs to show how the ground had moved.

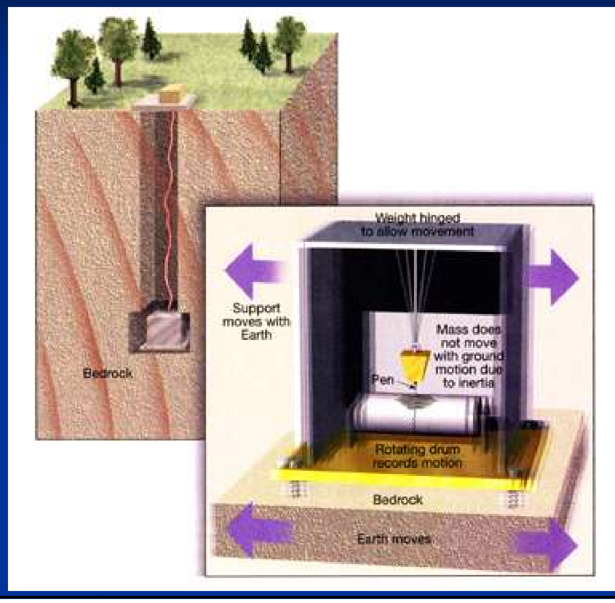
## Earthquake Waves & Seismographs

- The energy released during the earthquake travels as seismic waves
- Modern Seismograph can measure the intensity and duration of these waves in different directions.
- Seismogram is visual record of arrival time and magnitude of shaking associated with seismic wave, generated by a seismograph.

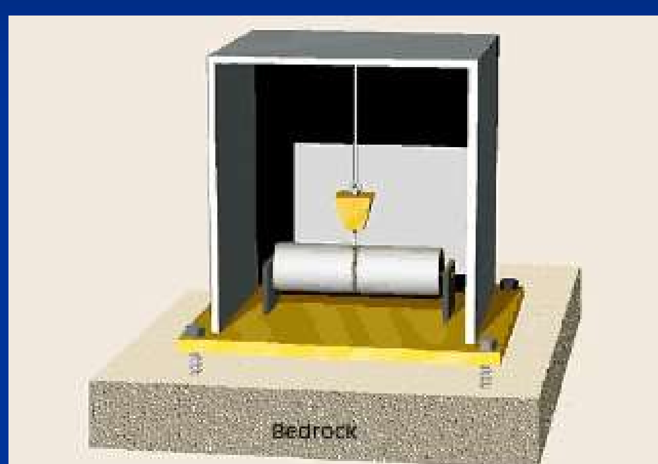
## Modern Seismographs

- Seismographs are instruments that record seismic waves
  - Records the movement of Earth in relation to a stationary mass on a rotating drum or magnetic tape
  - More than one type of seismograph is needed to record both vertical and horizontal ground motion
  - The time, location, and magnitude of an earthquake can be determined from the data recorded by seismograph stations.

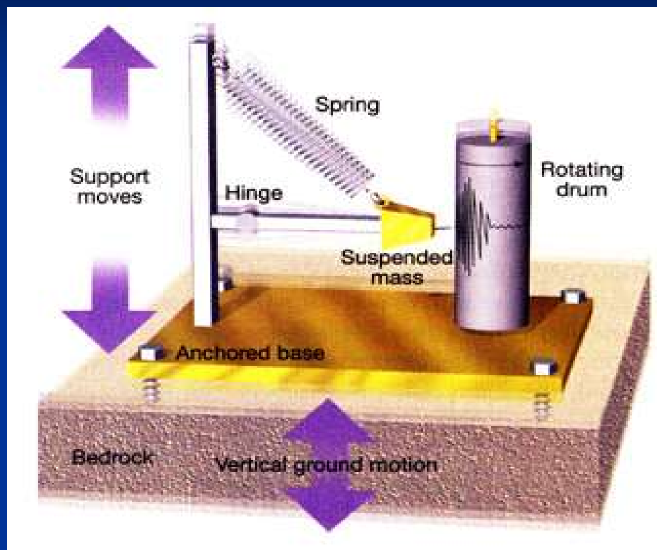
## Modern Seismograph (Horizontal)



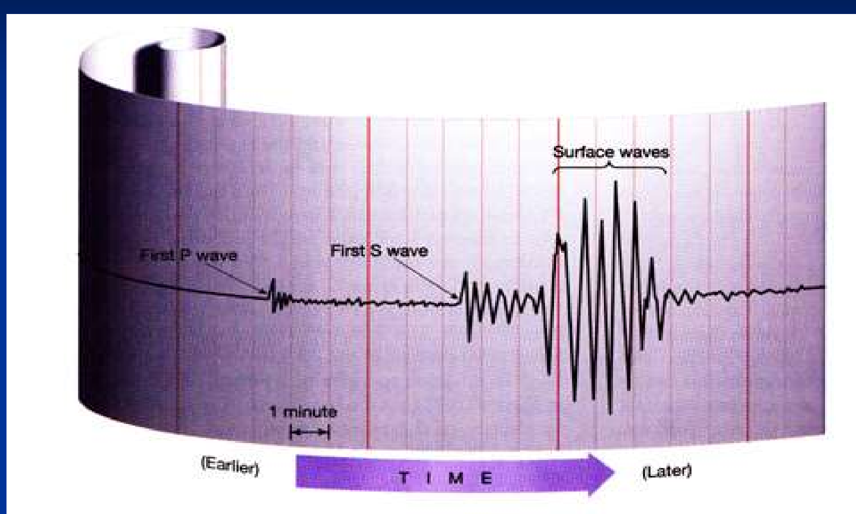

## Modern Seismograph (Horizontal)



## Modern Seismograph (Vertical)

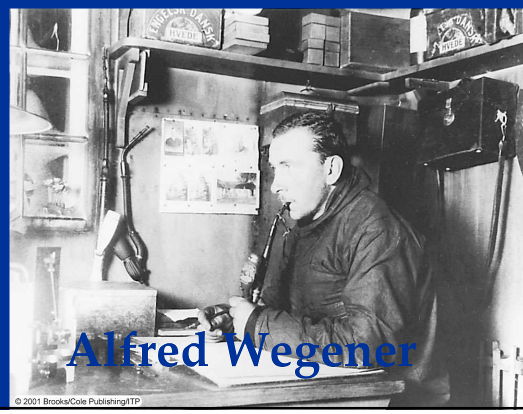



## Seismogram



## Continental Drift Theory

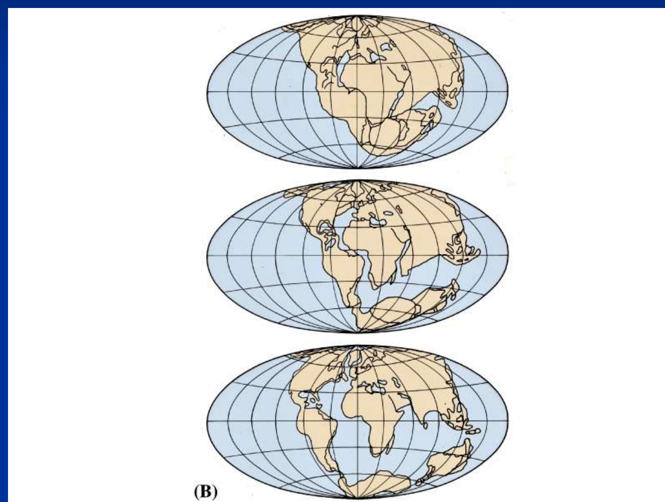
- Theory that continents and plates move on the surface of the Earth proposed by Alfred Wegener in 1912.



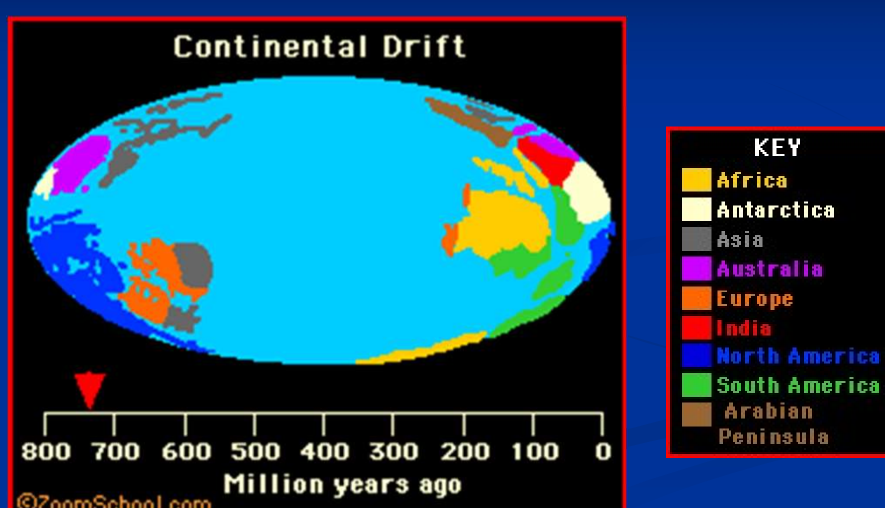

## Continental Drift Theory

- Alfred Wegener (German meteorologist and geophysicist) proposed the continental drift theory.
- He proposed that at one time all the continents were joined into one huge supercontinent "Pangaea" and at a later date the continents split apart, moving slowly to their present positions on the globe.
- The idea has not been widely accepted, but new evidence suggest that the principle is correct

## *Maps by Wegener (1912), showing continental drift*




## Continental Drift Theory

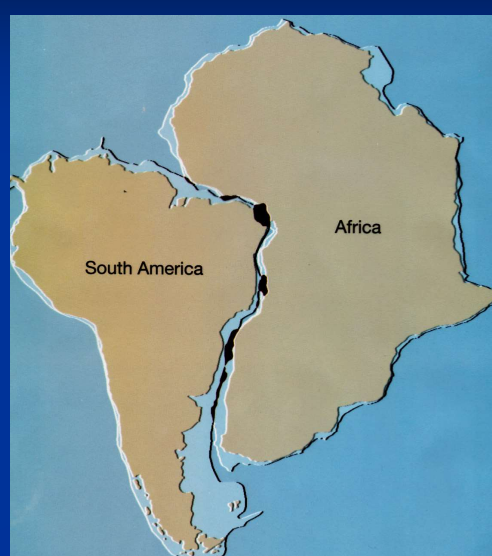


## *Evidence for continental drift*

- Matching coastlines
- Matching mountains
- Matching rock types and rock ages
- Matching glacier deposits
- Matching fossils

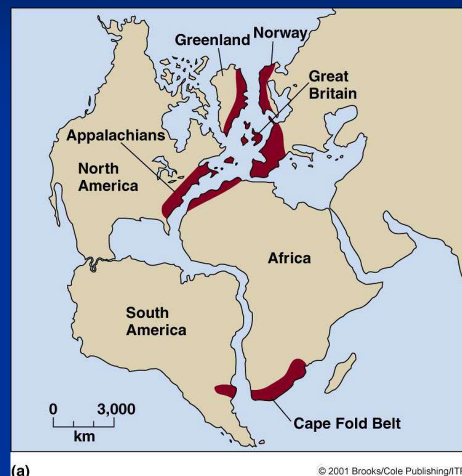
## *Evidence for continental drift*

Matching coastlines



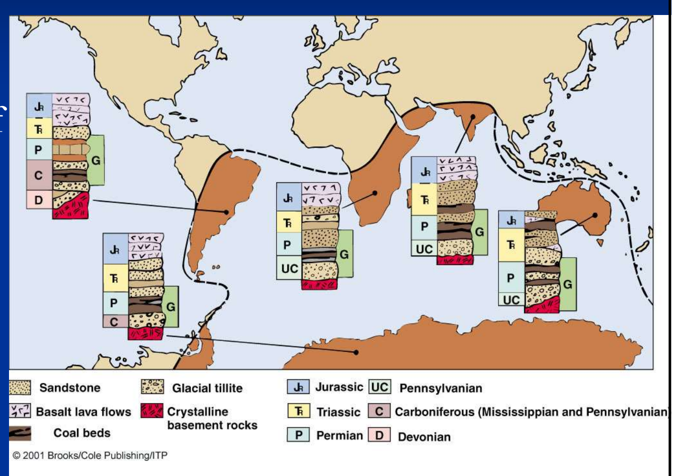
## Evidence for continental drift

Matching mountain ranges



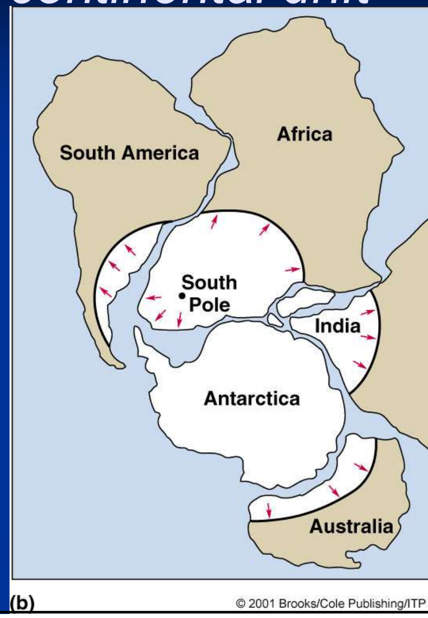

## Evidence for continental drift

Matching rock types and ages of rocks



## Evidence for continental drift

Matching glacier deposits 300 million years ago



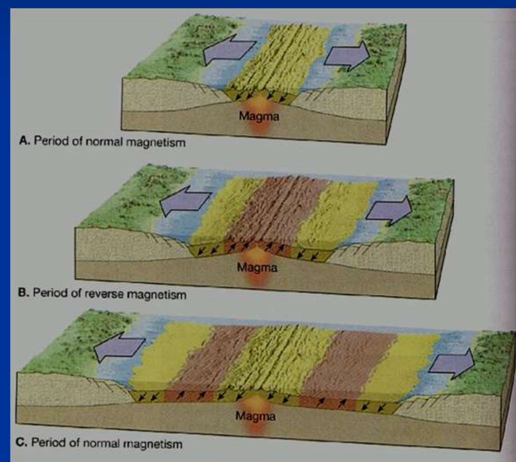

## Evidence for continental drift


Fossils of Mesosaurus (aquatic reptile) found on both sides of Atlantic

## Earth's magnetic field

Basic Data used in formulating plate tectonics:

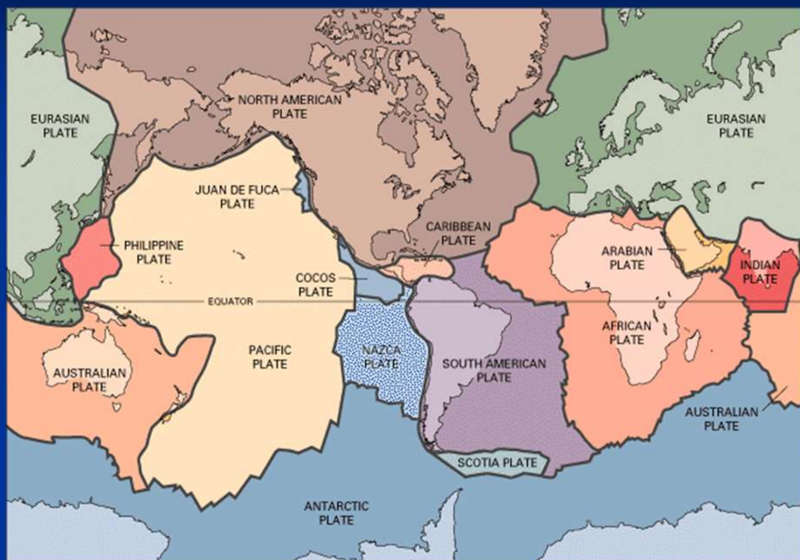
Magnetic stripes on the sea-floor. Magnetic field of Earth reverses on semi-regular basis. Minerals act like compass needles and point towards magnetic north. "Hot" rocks record the direction of the magnetic field as they cool.



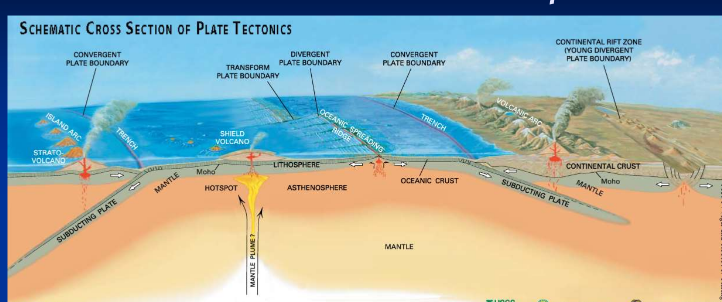

## *Theory of Plate tectonics*

- The theory of Plate tectonics was proposed in 1960s based on the continental drift theory.
- This is the Unifying theory that explains the formation and deformation of the Earth's surface.
- According to this theory, continents are carried along on huge plates (slabs) on the Earth's outermost layer (Lithosphere).
- Earth's outermost layer is divided into 15 major Tectonic Plates (~80 km deep). These plates move relative to each other a few centimeters per year.

## *Tectonic plates of Earth*




## *What are Tectonic plates?*



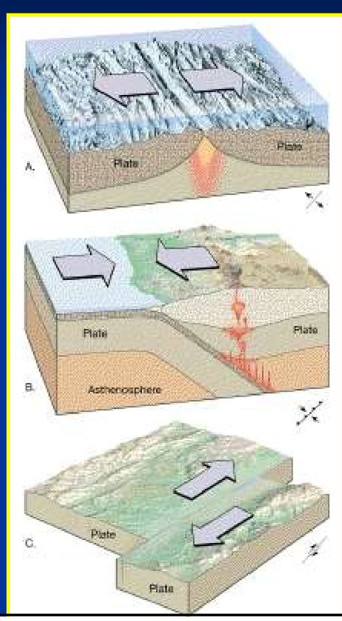

### Lithospheric plate

- The ~100-km-thick surface of the Earth;
- Contains crust <u>and</u> part of the upper mantle;
- It is rigid and brittle;
- Fractures to produce earthquakes.

## *Types of plate boundaries*

- Divergent plate boundaries: where plates move apart
- Convergent Plate boundaries: where plates come together
- Transform plate boundaries: where plates slide past each other

## *Types of plate boundaries*

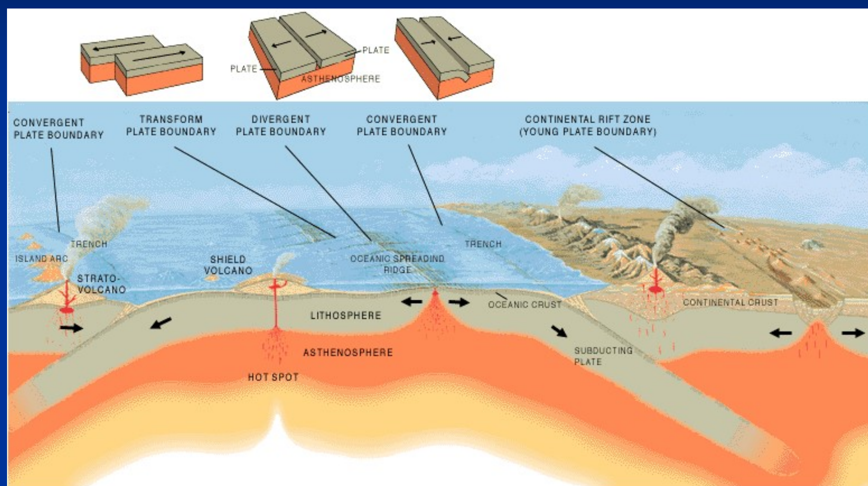



Divergent (Tension)

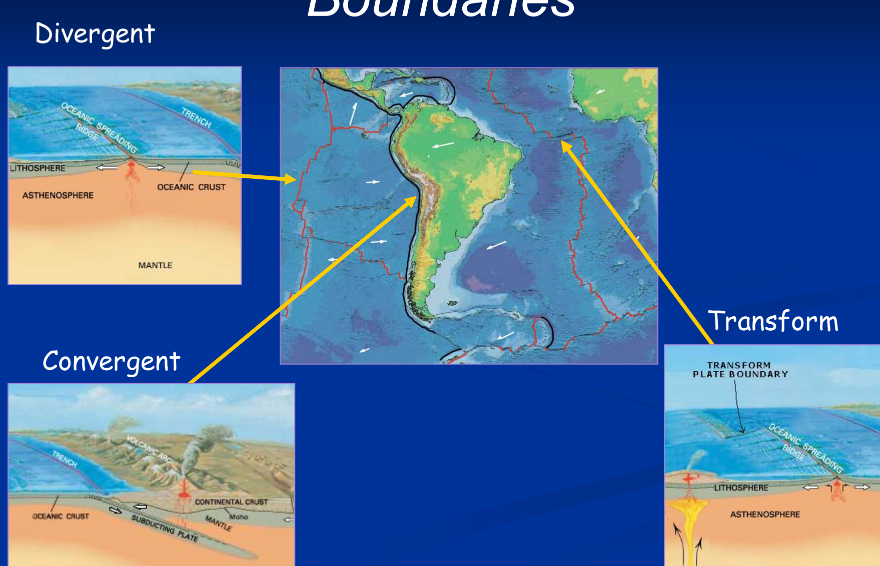
Convergent (Compression)

Transform (shearing)

## *Types of plate boundaries*

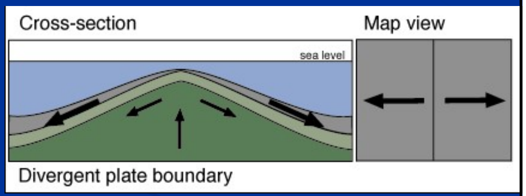



## Three Basic Types of Plate Boundaries

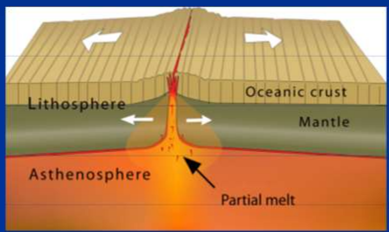


## Divergent Plate Boundaries

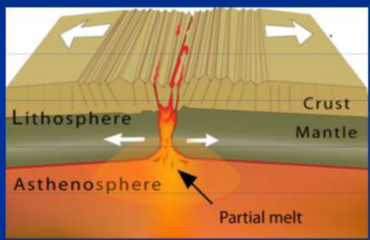
- Plates move away from each other (tension)
- New lithosphere is formed
- normal faults
- Causes volcanism
- not very explosive




## Divergent Plate Boundaries




Fast-spreading Ridge
Example:
- East Pacific Rise (moving apart at about 15 cm/year)



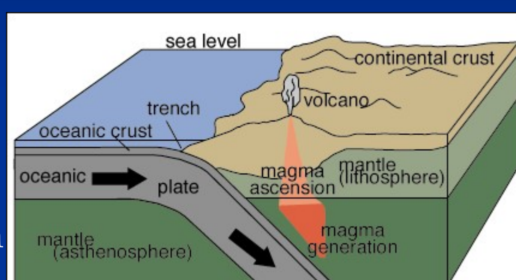

Slow-spreading Ridge
Examples:
- Atlantic mid-ocean ridge
- Basin and Range, USA
- African Rift Valley
- Northern Red Sea

## *Convergent Plate Boundary*

- Plates move toward each other (compression)
- lithosphere is consumed
- reverse/thrust faults
and folds
- Mountain building
- explosive volcanism

## *Ocean- Continent convergent margin*

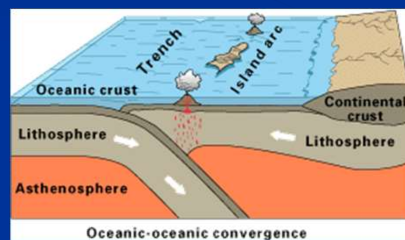
- Ocean-continent plates collide
- Ocean plate subducts below continent
- Forms a subduction zone
- Earthquakes and volcanoes




Magma is generated at subduction zones where dense oceanic plates are pushed under lighter continental plates.

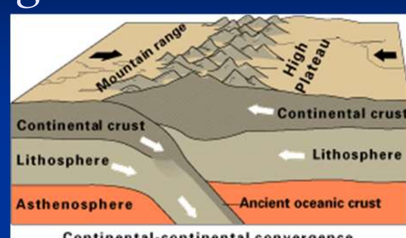
## *Ocean-ocean convergent margin*

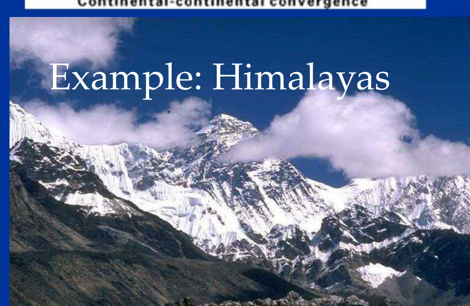
- 2 oceanic plates collide
- One plate dives (subducts) beneath other
- Forms subduction zone
- Earthquakes and volcanoes




## *Continent-continent convergent margin*

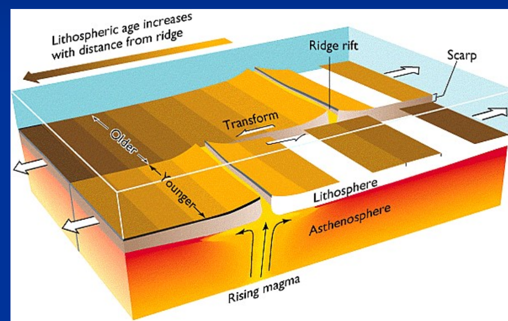
- 2 continental plates collide
- Neither plate wants to subduct
- Collision zone forms high mountains
- Earthquakes, no volcanoes



## *Transform plate margin*

- Two plates slide past each other
- strike slip faults.
- Lithosphere is neither consumed nor created.
- Earthquakes, no volcanoes
- Responsible for most of the earthquakes




Example: San Andreas CA
N Anatolian, Turkey

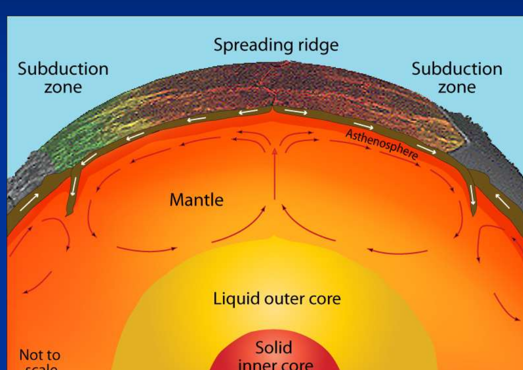
## *How fast are the plates moving?*

Plates move 1-10 centimeters per year (≈ rate of fingernail growth).

## *What drives plate movement?*

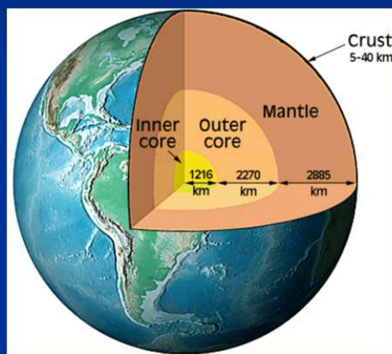
- Ultimately: heat transported from core and mantle to surface
- Heat transported by convection
- Core is ~5,000°C and surface is ~0°C
- Where mantle rises: rifting
- Where mantle dives: subduction zones

## *What drives plate movement?*




Convection is like a boiling pot. Heated soup rises to the surface, spreads and begins to cool, and then sinks back to the bottom of the pot where it is reheated and rises again.

## *Layers of the Earth*




- Crust:
  - Continental crust (25-40 km*)
  - Oceanic crust (~6 km)
- Mantle
  - Upper mantle (650 km)
  - Lower mantle (2235 km)
- Core
  - Outer core: liquid (2270 km)
  - Inner core: solid (1216 km)

* Values in brackets represent the approximate thickness of each layer

## *Layers of the Earth - Crust*

- outermost layer
- comprises the continents and ocean basins.
- has a variable thickness:
  - 35-70 km thick in the continents
  - 5-10 km thick in the ocean basins.
- composed mainly of alumino-Silicates

## *Layers of the Earth - Mantle*

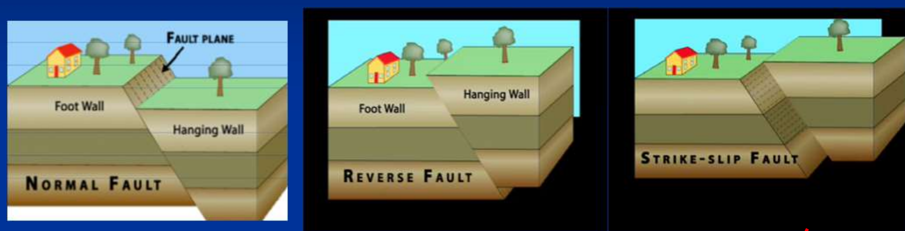
- composed mainly of ferro-magnesium silicates.
- It is about 2900 km thick, and is separated into the upper and lower mantle.
- This is where most of the internal heat of the Earth is located.
- heat is circulated and may drive plate tectonic processes.

## *Layers of the Earth - Core*

- separated into the liquid outer core and the solid inner core.
- The outer core is 2300 km thick and the inner core is 1200 km thick.
- The outer core is composed mainly of a nickel-iron alloy, while the inner core is almost entirely composed of iron.

## Types of Faults

Normal | Reverse | Strike slip




Basin & Range
African Rift

Himalayas
Rocky Mountains

San Andreas, Calif.
N. Anatolian, Turkey

## *Earthquake Depth*

Earthquakes usually occur at some depth below the ground

Surface. The depth can also be calculated from seismograph records

Earthquake foci are described as:

- Shallow: less than 70 km depth
- Intermediate: 70 - 300 km depth
- Deep: 300 - 700 km depth

90% of earthquake foci are less than 100 km deep

Large earthquakes are mostly at < 60 km depth

No earthquakes occur deeper than 700 km

## *Foreshocks and aftershocks*

- Adjustments that follow a major earthquake often generate smaller earthquakes called aftershocks

- Small earthquakes, called foreshocks, often precede a major earthquake by days or, in some cases, by as much as several years

## Measures of Earthquake (Earthquake Magnitude and Intensity)

## *Magnitude and Intensity*

- Both Magnitude and Intensity are ways to describe the size of a seismic event
- The magnitude is the measure of energy set free by earthquake at the focal point in the form of elastic waves
  - There is one magnitude per seismic event
  - There are different magnitude scales

## *Magnitude and Intensity (cont'd)*

- The intensity is a measure of the damage caused by the earthquake. It is based on subjective feelings and observations of local damages.
  - There are many intensity scales per seismic event
  - Depends on magnitude, focal depth, epicentral distance, soil type at the site, local effects (topography), frequency content, duration, (quality of the construction at the site), …..
  - There are different intensity scales

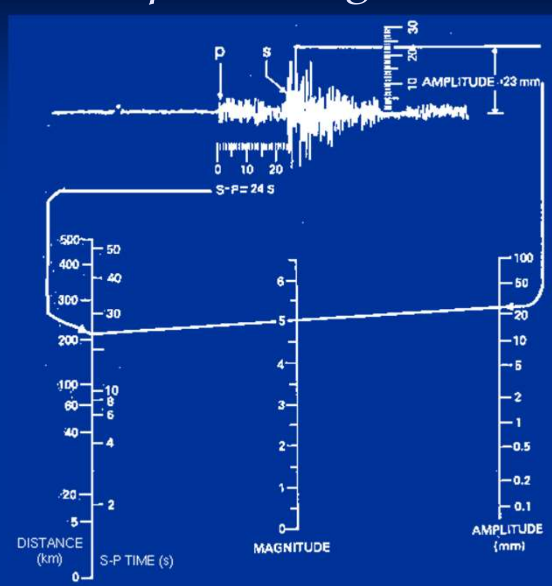
## *The Richter Magnitude Scale*

•The Richter Magnitude scale was developed in 1935 by Charles F. Richter.

•The magnitude of an earthquake is determined from the logarithm of the amplitude of waves recorded by seismographs.

• On the Richter Scale, magnitude is expressed in whole numbers and decimal fractions. For example, a magnitude of 5.3 might be computed for a moderate earthquake, and a strong earthquake might be rated as magnitude 6.3, which corresponds to the release of about 32 times more energy than the 5.3 magnitude one.

## *Earthquake Magnitude*



## *Different Magnitude Scales*

- *Local (or Richter) magnitude ($M_L$): measures the maximum seismic wave amplitude A (in* microns) recorded on standard Wood – Anderson seismographs located at a distance of 100 km from the earthquake epicenter.

$$M_L = \log_{10} A + 3\log_{10}[8\Delta t]-2.92$$

where A is the maximum wave amplitude in μm

Δt is the time interval between P and S waves arrival

## *Different Magnitude Scales*

- *Body wave magnitude ($m_b$): measures the amplitude of P - waves with a period of about 1.0* second, i.e. less than 10 - km wavelengths. This scale is suitable for deep earthquakes that have few surface waves. Moreover, *$m_b$ can measure distant events, e.g. epicentral distances not less* than 600 km.

$$m_b = log_{10}V_P - 0.01log_{10}\Delta + 5.1$$

where *Vp* is the velocity of P wave in μm/s

Δ is the angle (in degrees) between the epicenter and the station

## Different Magnitude Scales

- *Surface wave magnitude ($M_S$): is a measure of the amplitudes of LR - waves with a period of 20* seconds, i.e. wavelength of about 60 km, which are common for very distant earthquakes, e.g. where the epicenter is located at more than 2,000 km. *$M_S$ is used for large earthquakes. However,* it cannot be used to characterize deep or relatively small, regional earthquakes.

$$M_S = log_{10}V_S - 1.66log_{10}\Delta + 2.5$$

where *Vs* is the velocity of surface wave in μm/s
Δ is the angle (in degrees) between the epicenter and the station

## Different Magnitude Scales

- *Moment magnitude ($M_w$): accounts for the mechanism of shear that takes place at earthquake* sources. It is not related to any wavelength. As a result, *$M_w$ can be used to measure the whole* spectrum of ground motions. Moment magnitude is defined as a function of the seismic moment $M_0$ .

$M_0 = \mu A d$

Where $\mu$ (dyne/cm$^2$) is the shear strength of rocks
$A$ (cm$^2$) is fault area
$d$ (cm) is the slip distance

## *Different Magnitude Scales*

**Table 1.4** Properties of major magnitude scales.

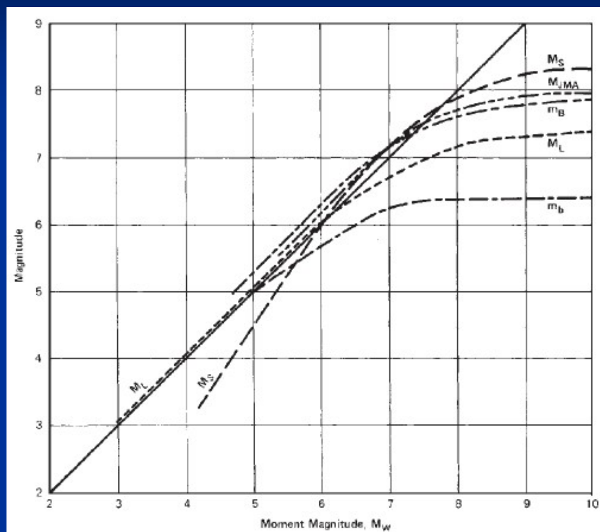
| Scale type | Author | Earthquake size | Earthquake depth | Epicentre distance (km) | Reference parameter | Applicability | Saturation |
|---|---|---|---|---|---|---|---|
| $M_L$ | Richter (1935) | Small | Shallow | <600 | Wave amplitude | Regional (California) | ✓ |
| $m_b$ | Gutenberg and Richter (1956) | Small-to-medium | Deep | >1,000 | Wave amplitude (P-waves) | Worldwide | ✓ |
| $M_S$ | Richter and Gutenberg (1936) | Large | Shallow | >2,000 | Wave amplitude (LR-waves) | Worldwide | ✓ |
| $M_w$ | Kanamori (1977) | All | All | All | Seismic moment | Worldwide | n.a. |

*Key*: n.a. = not applicable; ✓ = saturation occurs.

## *Different Magnitude Scales*

- Where
  - $M_L$ = local richter magnitude
  - $m_b$ = body wave magnitude
  - $M_s$ = surface wave magnitude
  - $M_w$ = moment magnitude

## *Relationship between different Magnitude scales*




## *Magnitude Scale & Intensity Scale*

•The Magnitude Scale is not used to express the damage.

• An earthquake in a densely populated area which results in considerable damages to man made structures and many deaths.

• whereas an earthquake of the same magnitude as a shock in a remote area that does nothing more than frighten the wildlife.

## *Magnitude Scale & Intensity Scale*

Intensity – magnitude relationships are essential for the use of historical earthquakes for which no instrumental records exist. Several simple methods to convert intensity into magnitude have been proposed*; most of which exhibit large scatter because of the inevitable bias present in* the definition of intensity. Gutenberg and Richter (1956) proposed a linear relationship between local magnitude $M_L$ *and epicentral intensity* $I_0$ *for Southern California,* given by:

$$M_L = 0.67I_0 + 1.00$$

in which the intensity $I_0$ *is expressed in the MM scale. The above equation shows, for example, that* the epicentral intensity $I_0$ *of VI corresponds to* $M_L = 5.02$*, indicating that the earthquake is likely to* cause significant damage.

## Earthquake ***Intensity*** is what you feel.

**What Controls the Level of Shaking?**

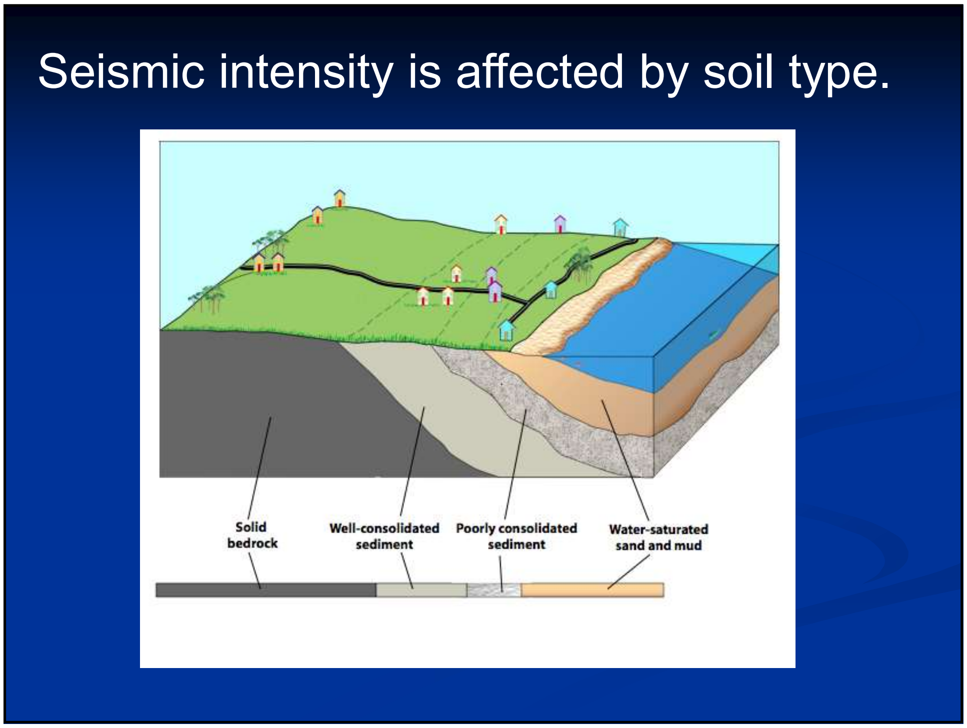
**Magnitude —** Amount of energy released

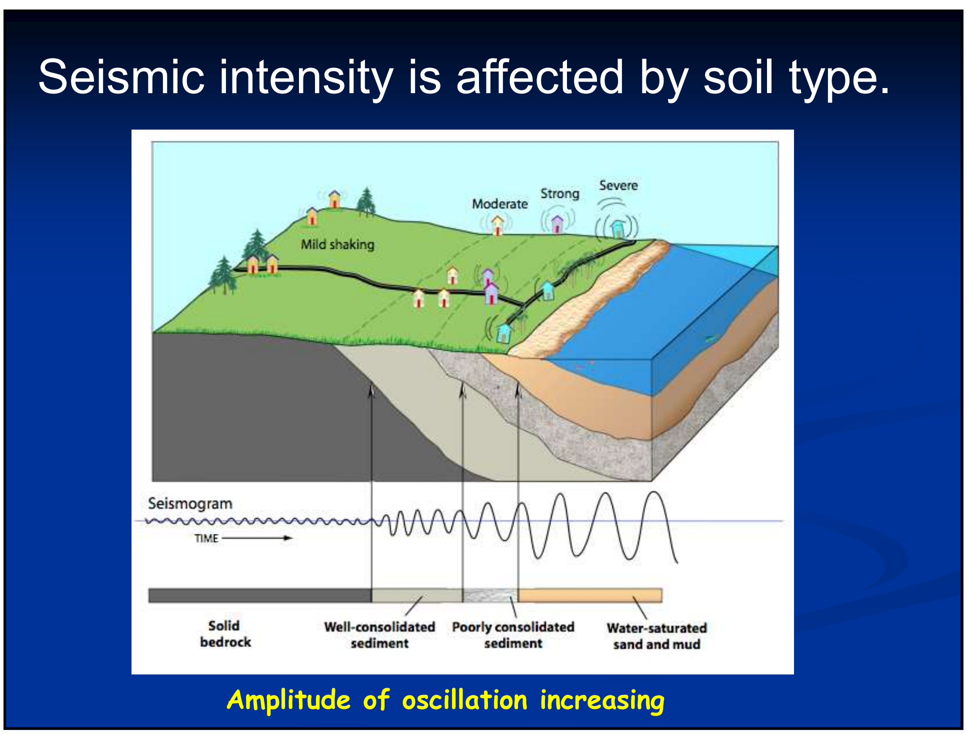
**Distance —** Shaking decays with distance

**Geology —** Local soils amplify the shaking

**Building style** — Construction, not height

**Duration** of shaking

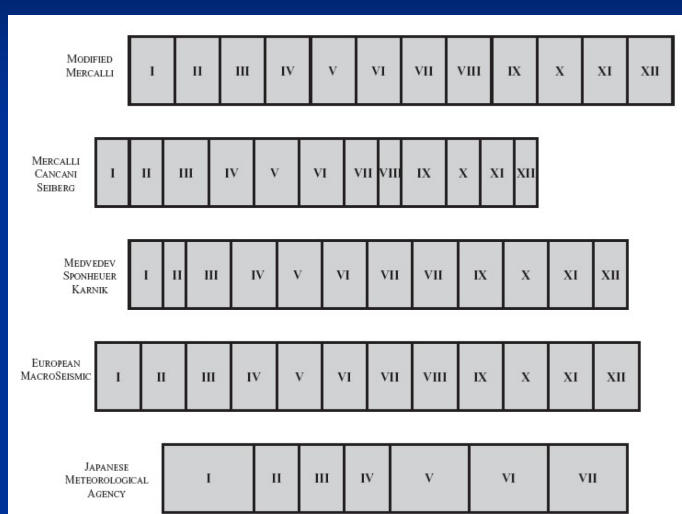

Seismic intensity is affected by soil type.
Solid bedrock
Well-consolidated sediment
Poorly consolidated sediment
Water-saturated sand and mud


Seismic intensity is affected by soil type.
Mild shaking
Moderate
Strong
Severe
Seismogram
TIME
Solid bedrock
Well-consolidated sediment
Poorly consolidated sediment
Water-saturated sand and mud
Amplitude of oscillation increasing

# Different Intensity Scales

- Mercalli-Cancani-Seiberg (MCS) 1931
  - Southern Europe – 12 scales
- Modified –Mercalli (MM)1983
  - California and several countries – 12 scales
- Medvedev-Sponheur-Karnik (MSK)1964
  - Central and eastern Europe – 12 scales
- European Macroseismic Scale (EMS)1998
  - Europe – 12 scales
- Japanese Metrological agency (JMA) 1949
  - Japan – 7 scales
- Rossi-Forel (RF) 1883
  - Italy – 10 sclaes

# Comparison between seismic scales



## *Modified Mercalli Scale (MM)*

• The intensity scale consists of a series of certain key responses such as people awakening, movement of furniture, damage to chimneys, & finally total destruction.

• Numerous intensity scales have been developed over the last several hundred years to evaluate the effects of earthquakes, one example is the Modified Mercalli (MM) Intensity Scale.

• This scale, composed of 12 increasing levels of intensity that range from imperceptible shaking to catastrophic destruction, is designated by Roman numerals.

• It does not have a mathematical basis; instead it is an arbitrary ranking based on observed effects.

## Modified Mercalli Intensity Scale

The following is an abbreviated description of the 12 levels of Modified Mercalli intensity (MMI).

**I.**

Not felt except by a very few under especially favorable conditions.

**II.**

Felt only by a few persons at rest, especially on upper floors of buildings. Delicately suspended objects may swing.

**III.**

Felt quite noticeably by persons indoors, especially on upper floors of buildings. Many people do not recognize it as an earthquake. Standing motor cars may rock slightly. Vibration similar to the passing of a truck.

**IV.**

Felt indoors by many, outdoors by few during the day. At night, some awakened. Dishes, windows, doors disturbed; walls make cracking sound. Sensation like heavy truck striking building. Standing motor cars rocked noticeably.

**V.**

Felt by nearly everyone; many awakened. Some dishes, windows broken. Unstable objects overturned. Pendulum clocks may stop.

**VI.**

Felt by all, many frightened. Some heavy furniture moved; a few instances of fallen plaster. Slight Damage.

**VII.**

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; some chimneys broken.

**VIII.**

Slight Damage in specially designed structures; considerable damage in ordinary substantial buildings with partial collapse. Great Damage in poorly built structures. Fall of chimneys, factory stacks, columns, monuments, walls. Heavy furniture overturned.

**IX.**

Considerable Damage in specially designed structures; well-designed frame structures thrown out of plumb. Great Damage in substantial buildings, with partial collapse. Buildings shifted off foundations.

**X.**

Some well-built wooden structures destroyed; most masonry and frame structures destroyed with foundations. Rails bent.

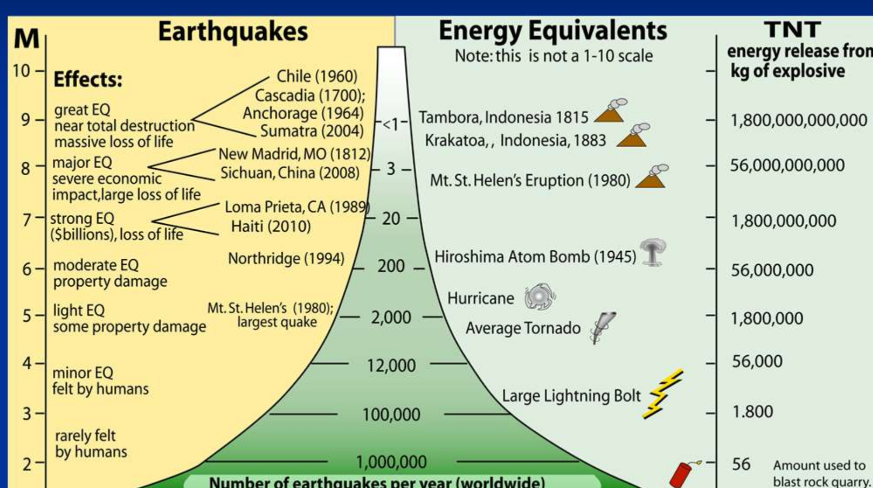
**XI.**

Few, if any (masonry) structures remain standing. Bridges destroyed. Rails bent greatly.

**XII.**

Total Damage. Lines of sight and level are distorted. Objects thrown into the air.

## *Magnitudes and Energy of Earthquakes*




Annual Numbers of EQs

## Predicting Earthquakes

**Strange Animal Behavior**

stress in the rocks causes tiny hairline fractures to form, the cracking of the rocks evidently emits high pitched sounds and minute vibrations imperceptible to humans but noticeable by many animals.

**Foreshocks**

unusual increase in the frequency of small earthquakes before the main shock

**Changes in water level**

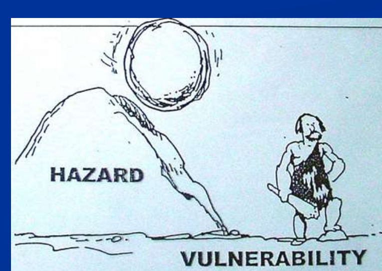
porosity increases or decreases with changes in strain

**Seismic Gaps**

based of the chronological distribution of major earthquakes

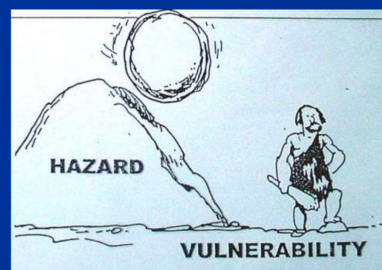
## *Seismic Hazard, Vulnerability and Risk*

- *Seismic Hazard is any physical phenomenon (e.g. ground shaking, ground failure) associated with an earthquake that may produce adverse effects on human activities.*
  - *(EERI 1984)*



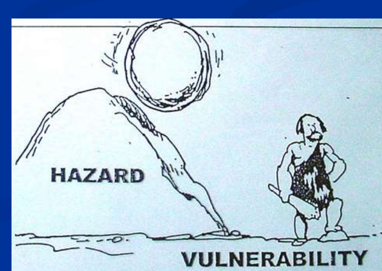
## Seismic Hazard, Vulnerability and Risk

- *Vulnerability is the amount of damage, induced by a given degree of hazard, and* expressed as a fraction of the *Value of the damaged item under consideration*
  - *(EERI 1984)*




## Seismic Hazard, Vulnerability and Risk

- *Seismic Risk is the probability that social or economic consequences of earthquakes will equal or exceed specified values at a site, at several sites, or in an area, during a specified exposure time*

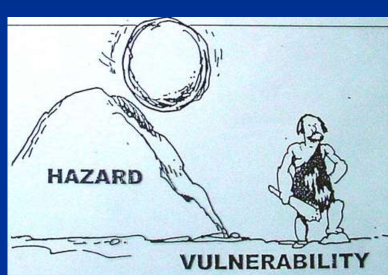


## *Seismic Hazard, Vulnerability and Risk*

- It follows that seismic risk is an outcome of seismic hazard as described by relationships of the form
- *Risk = Hazard × Vulnerability × Value*
  - Risk - probability of disaster occurrence
  - Hazard - potential threat to humans and their welfare
  - Vulnerability - exposure and susceptibility to loss of life or dignity
  - Value – value of the damaged item

From Dorwick 2009 “Earthquake Resistant Design and Risk Reduction”

## Disaster Prevention, Mitigation & Preparedness

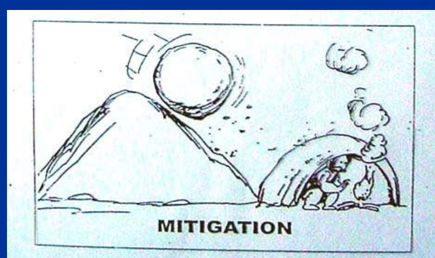




Disaster = f(hazard, vulnerability)

# Disaster Prevention, Mitigation & Preparedness

- Prevention requires the elimination of risk while mitigation is the reduction of risk.
- Disaster Preparedness : Forecast and take precautionary measures in advance of an imminent threat.

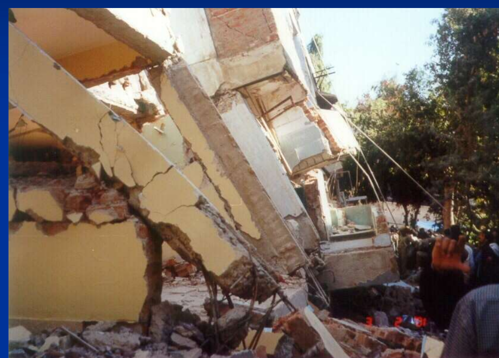




While Hazards Are Inevitable, Each Hazard Need Not Convert Into A Disaster… As What Comes In Between Is The Culture of Safety And Prevention

Let us Work Together to Build a Culture of Prevention !

## Earthquake Do Not Kill People



**Improperly Designed Structures Do!**

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That is all for today