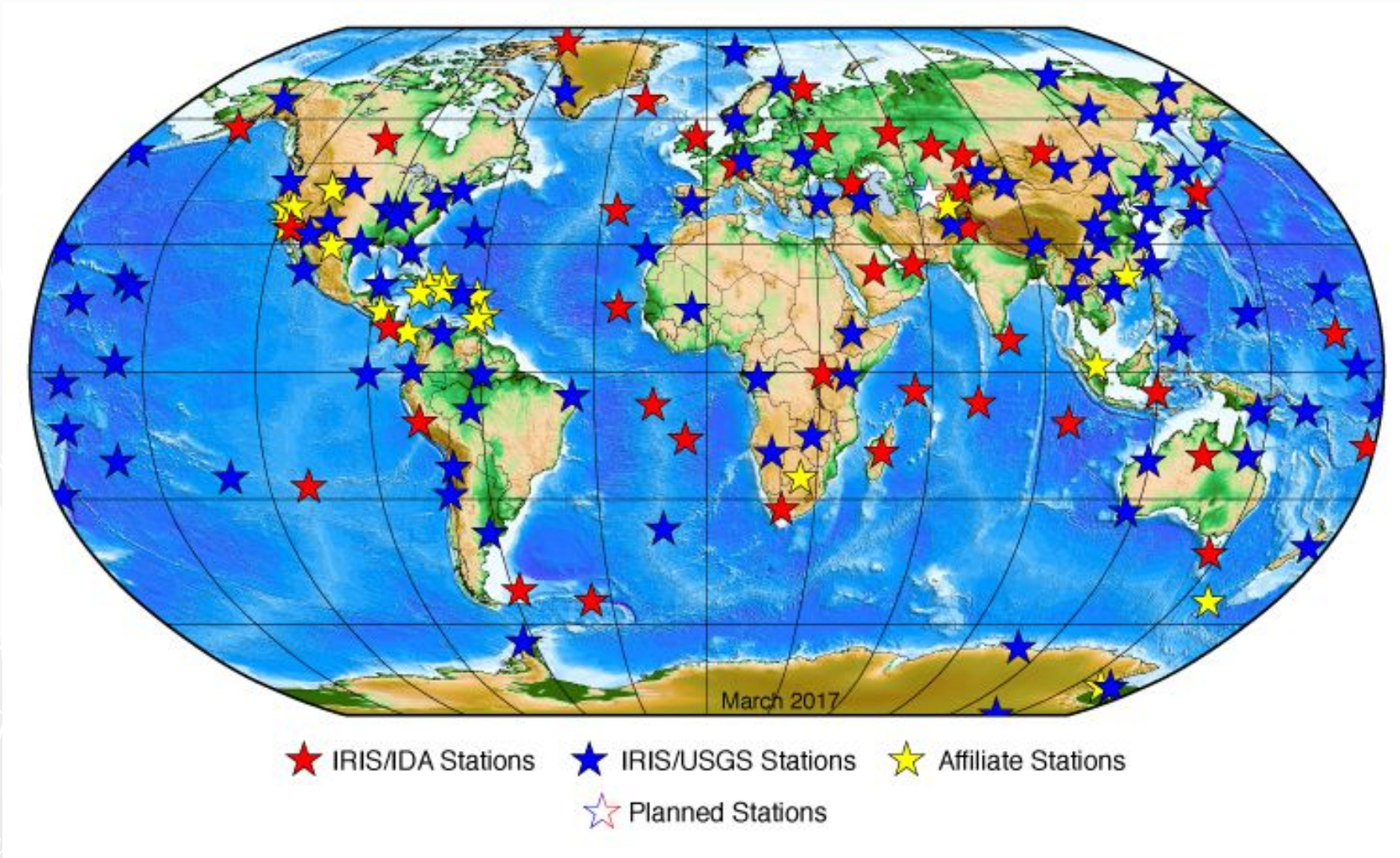
EWCE 203

Geology and Geomorphology

Global Seismographic Network

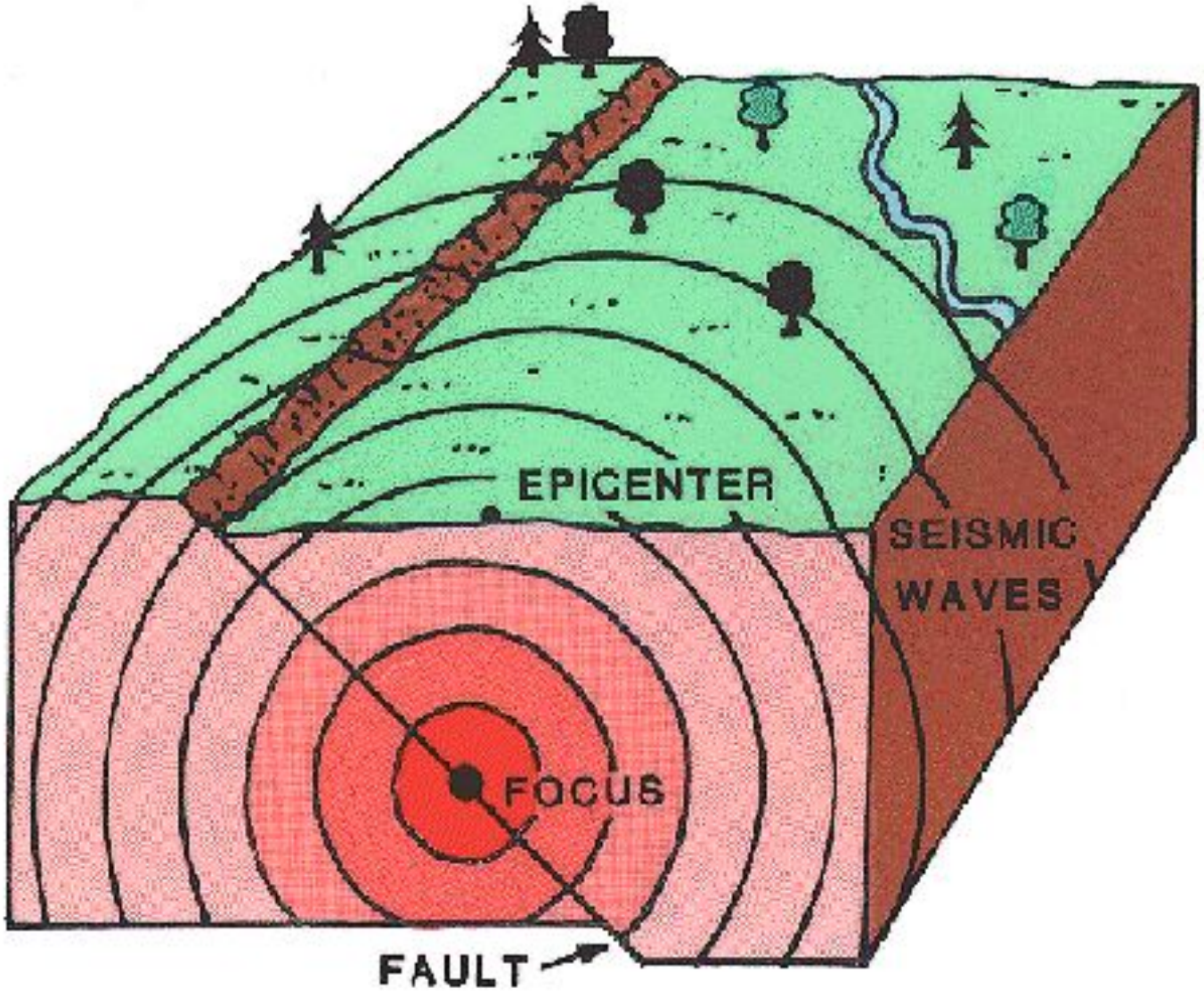


Earthquake Focus:

In seismology, the term '**focus' designates the source** of a **given set of the EQ waves**.

What is the source of the EQ waves?

- **Waves** that constitute an EQ, that are **generated by the rupture of Earth's materials.**
- When recorded, their **pattern indicates** that they are **originated within a limited region.**
- Most of the sources have the dimensions of about **50 km in length and breadth of about 5 to 500 km.**



Focus of an EQ, is at some depth below the earth's surface. Normally 75 to 500 km.

Shallow, intermediate, and deep foci:

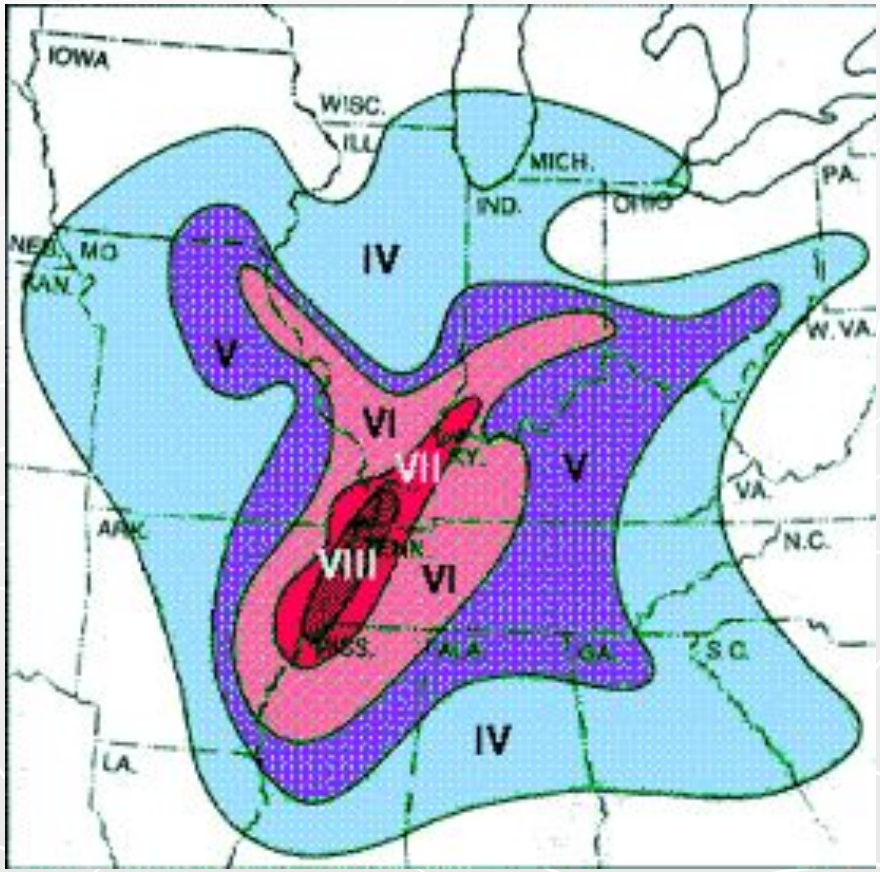
- **Shallow:** Most parts of the world experience at least occasional shallow earthquakes, originate within **60 km** (40 miles) of the Earth's outer surface.

- **Intermediate:** Of the total energy released in earthquakes, 12 percent comes from intermediate earthquakes with a focal depth ranging from **about 60 to 300 km**.

- **Deep:** About 3 percent of total energy comes from deeper earthquakes. The greatest focal depths, of about 700 km (430 miles), are approached.

EQ Intensity

Definition: The **intensity** is a number (Roman numeral) **describing the severity** of an **earthquake** in terms of **its effects** on the **earth's surface and on humans and their structures.**



Iso-seismal map

EQ Intensity:

- Way of specifying the size of EQ.
- Earlier days, a missionary in remote region would keep a record of an EQ as **weak**, **strong** and **very strong**.
- **In 1883, Intensity scale is developed**.
- USGS uses **Modified Mercalli Intensity scale** (MMI)

What is Intensity of an EQ? Describe the Modified Intensity Scale of EQ.

Modified Mercalli Intensity scale.

Rossi-Forel Intensity Scale:

- In 1883, an intensity scale as developed by M. S. de **Rossi of Italy** and **F. A. Forel** of Switzerland.
- Widely used for about half a century.
- EQ effects were classified in term of 10 degree of intensity.

Write down the limitations of Rossi-Forel Intensity scale of EQ.

Limitations of Rossi-Forel Intensity Scale:

- Has definite limitations. Here, the definition of the degree of intensity are:
  - -General awaking of those asleep.
  - -General ringing of bells
  - -Oscillation of chandeliers.
  - -Stopping of clocks.
  - -Some shattered persons leave their dwellings

- But an EQ, that produced those effects in Italy and Switzerland might **not even awake** the baby in Japan, but it might have general **stampede in Boston**.

Mercalli Intensity Scale:

- In 1902, L. Mercalli of Italy set up a new scale and later on modified in 1931 by Wood and Frank which are used by USGS.
- **It has 12 degree of Intensity** and takes into account the various types of constructions.

I – Not felt except by a very few.

II – Felt by only a few persons at rest, suspended object may swing.

III – Felt by quite noticeably indoors.

IV – During the day, felt indoors by many, outdoors by a few.

V – Felt by nearly everyone, many awakened.

VI – Felt by all,many frightened and run outdoors.

VII – Everybody runs outdoors, damage negligible in buildings.

VIII – Damage slightly in specially designed structure, fall of chimneys.

IX – Damage considerable, ground cracks conspicuously.

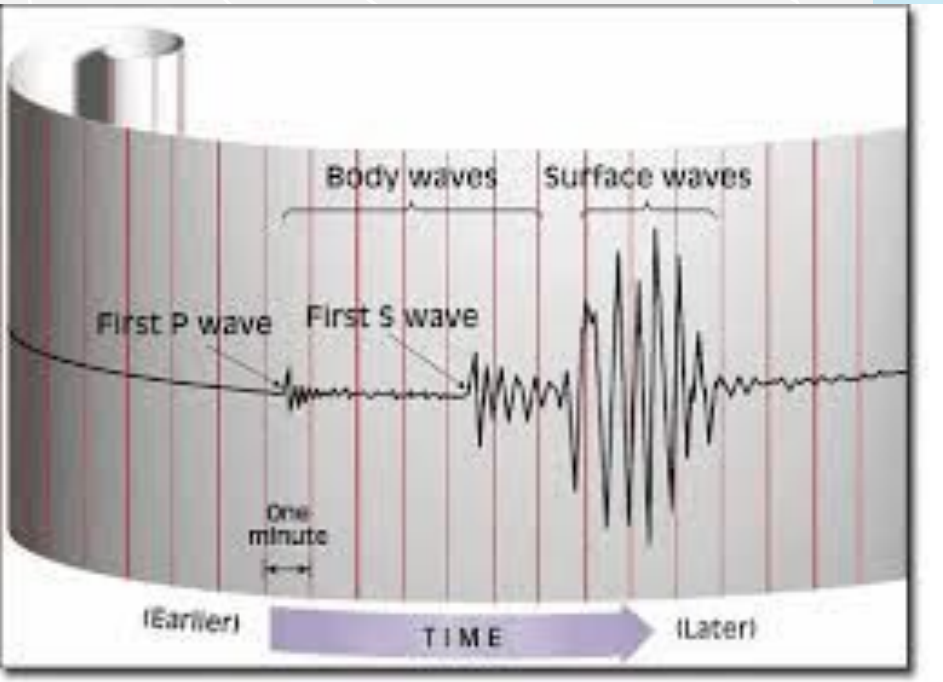
X – Masonry and framed structure destroyed.

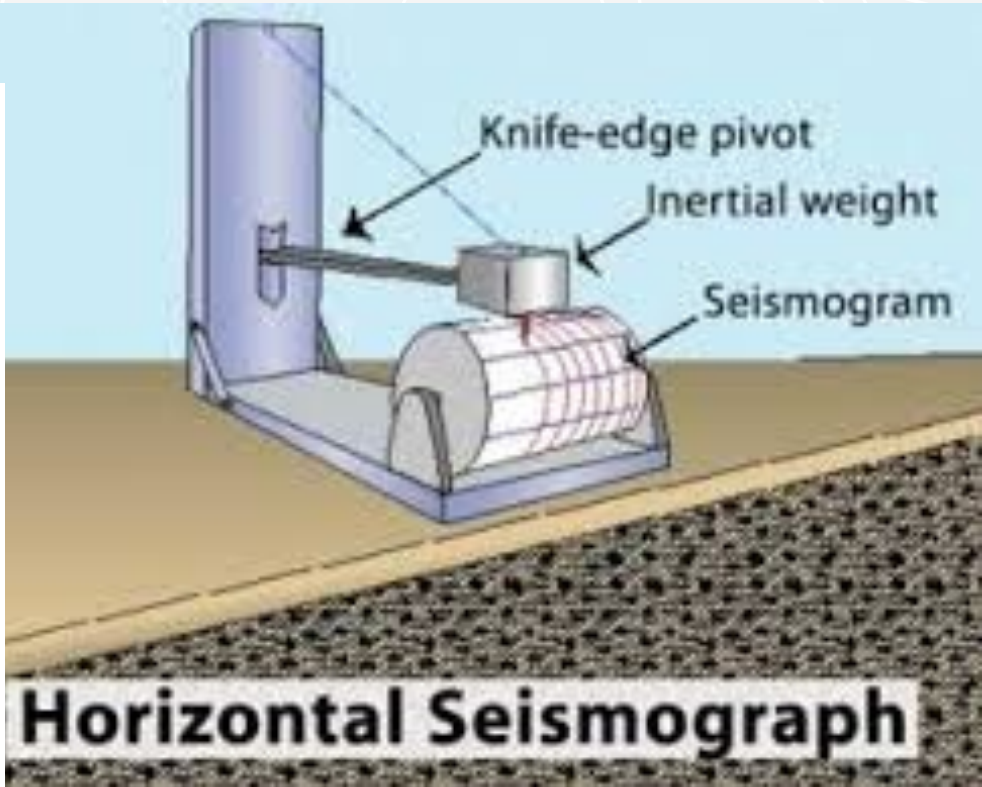
XI – Bridges destroyed, underground pipelines completely out of service.

XII – Damage total

Magnitude

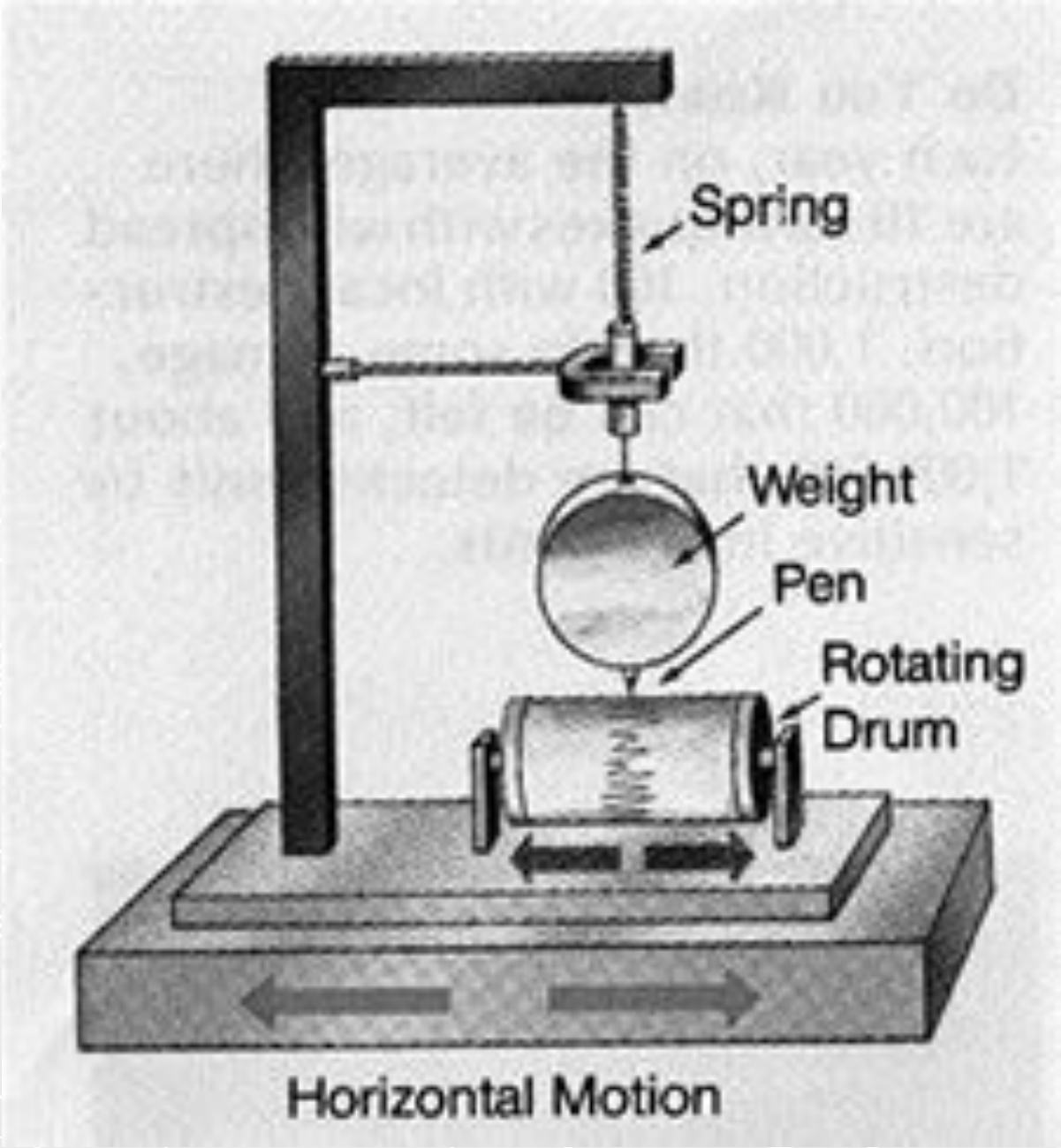
- Magnitude is **a number** that **characterizes the relative size of an earthquake.**
- Magnitude is **based on measurement of the maximum motion recorded by a seismograph**.





Seismograph

- A seismograph, or seismometer, is an **instrument used to detect and record earthquakes.**
- It consists of a **mass attached to a fixed base**.
- During an earthquake, **the base moves and the mass does not**.
- Motion of the base with respect to the mass is commonly transformed into an electrical voltage.
- **Electrical voltage is recorded on paper**, magnetic tape, or another recording medium.
- **Record is proportional to the motion of the seismometer mass relative to the earth**, but it can be mathematically converted to a record of the absolute motion of the ground.



Horizontal Motion

Type of Magnitude Scale

Several scales have been defined, but the most commonly used are:

- **Local magnitude (M_L)**, commonly referred to as "Richter magnitude",
- **Surface-wave magnitude (M_S)**,
- **Body-wave magnitude (M_b)**, and
- **Moment magnitude (M_w)**.

Type of Magnitude (cont..)

- Scales M_L , M_s , M_b have **limited range and applicability** and do not satisfactorily measure the size of the largest earthquakes.

- **Moment magnitude (M_w)** scale, **based on the concept of seismic moment**, is uniformly applicable to all sizes of earthquakes but is more difficult to compute than the other types.

- All magnitude scales should **yield approximately the same value for any given earthquake.**

Magnitude versus Intensity

- Magnitude and Intensity measure different characteristics of earthquakes.

- **Magnitude measures** the **energy released at the source** of the earthquake. Magnitude is **determined** from measurements on seismographs. **Same** for particular EQ.

- **Intensity measures** the **strength of shaking** produced by the earthquake **at a certain location**. Intensity is **determined** from effects on **people**, **human structures**, and the **natural environment**. **Varies** from location to location.

Richter Scale

- Whenever a major earthquake is in the news, you'll **probably hear** about its **Richter scale rating**.

- **Most common standard of measurement** for an earthquake is the Richter scale, **developed in 1935 by Charles F. Richter** of the California Institute of Technology.

- Richter scale is used to **rate the magnitude of an earthquake** - the amount of energy it released. This is **calculated** using information gathered by a seismograph.

Richter Scale (cont..)

- **Richter scale is logarithmic**, meaning that **whole-number jumps indicate a tenfold increase.**

- In this case, the **increase is in wave amplitude**. That is, the wave **amplitude in a level 6 earthquake is 10 times greater than in a level 5** earthquake, and the **amplitude increases** 100 times between a level 7 earthquake and a level 9 earthquake.

- Amount of **energy released increases 31.7 times** between whole number values.

EQ Magnitude and Energy:

What is Magnitude of an EQ? How **Magnitude is related to the energy** released during EQ.

Magnitude:

- **A scale devised in 1935, based on the instrumental records of EQs**.
- **Computation based on the amount of motion of certain waves**
- **Ascribed to each EQ a number** called the EQ's Magnitude.
- An index if the quake's **energy at its source**.
- Magnitude calculation for any given EQ is **corrected for distance from the epicenter** so that seismic stations all over the world calculate the same Magnitude for the same EQ.

Modification of Magnitude of EQ

- Refined in 1956 by B. Gutenberg and CF Richter.
- Refined in 1967 by an International Committee of Magnitude.

What is Richter Scale Magnitude of EQ? How it is being determined?

- Measured as **logarithm basis**.
- **M varies logarithmically** with the wave amplitude of the quake recorded on seismograph.
- **Each higher whole number** on the scale, represents an increase of **10 time in the measured wave** amplitude of an EQ.
- Amplitude of wave of a **M=8.0 EQ,** is not the twice as large as one of **M=4.0** but **10,000 as large**.

How the amount of energy released during an EQ can be estimated by use of Richter Scale Magnitude?

Estimation of Energy by Richter Scale magnitude:

- An **increase of one unit of the magnitude** scale of represent a **31.7 fold increase** **in energy released**.

- An EQ of M=6.0 releases **31.7 time** as much energy as one of M=5.0 and over **900 time** as much as one of M=4.0.

- Example: A **M=8.0 EQ releases almost one million times more energy** than on of M=4.0 on the Richter Scale.

How can you compare the energy released during an EQ with atomic energy?

Magnitude and Energy:

- An EQ of **M=5.0** releases approximately same amount of energy as did the **first atomic bomb when tested** in 16 July 1945 (generated the destructive power of **15,000 to 20,000 tons** of TNT).
- An EQ of **M=6.0** releases amount of energy by a **megaton nuclear device**.
- But **energy releases** by nuclear devices is **highly concentrated** but **widely dispersed in EQ**.



Explosion from a 14-kiloton nuclear test at the Nevada Test Site, in 1951

In Hiroshima, of a resident civilian **population of 250,000** it was estimated that **45,000 died on the first day** and a further **19,000** during the subsequent four months. (Another figure is 78,500 fatalities, with 5 to 15% of the short-term ones being from radiation.)

In Nagasaki, out of a population of **174,000**, on the **first day 22,000** died and another **17,000 within four months**. Unrecorded deaths of military personnel and foreign workers may have added considerably to these figures.

About 15 square kilometers (**over 50%) of the two cities was destroyed.**

Major Determinants in EQ Damages:

- Location of EQ Epicenter with respect to population density, can damage more in lower magnitude.
- Local soil/rock condition
- Different types of construction.

Earthquake Magnitude Scale

Magnitude	**Earthquake Effects**	**Estimated Number Each Year**
2.5 or less (Minor)	Usually not felt, but can be recorded by seismograph.	900,000
2.5 to 5.4 (Light EQ)	**Often felt**, but only causes minor damage.	30,000
5.5 to 6.0 (**Moderate EQ**)	**Slight damage** to buildings and other structures.	500
6.1 to 6.9 (Strong EQ)	May cause a **lot of damage** in very populated areas.	100
7.0 to 7.9 (**Major EQ**)	Major earthquake. **Serious damage.**	20
	Great earthquake. Can	

Earthquake Magnitude Classes

Earthquakes are classified in categories ranging from minor to great, depending on their magnitude.

Class	Magnitude
Great	8 or more
Major	7 - 7.9
Strong	6 - 6.9
Moderate	5 - 5.9
Light	4 - 4.9
Minor	3 -3.9

Causes of EQ: (myths)

- Mysterious shaking of the earth were caused by the **restless of a monster** that was supposed to be supporting the globe.
- Japan- **Great Spider**, later a **giant catfish**
- South America – A **Whale**
- North America – Giant **Tortoise**
- Mongolia – Immense **Frog**
- Subcontinent – **Giant Cow**

Elastic Rebound Theory:

- Known as **H F Reid's** (John Hopkins University) Elastic Rebound Theory.

- Rocks in the Earth's Crust in the vicinity of Fault**, store elastic energy** at a **uniform rate** over **a period of time.**

- Region started forming from an **unstrained condition to strained condition over 100s years** and **progressively** more or more **wrapped**.

- When the **relative movement** on either side of fault become great, the **strength** of the rock **exceeded** and **rupture** occurs.

Elastic Rebound Theory: (cont..)

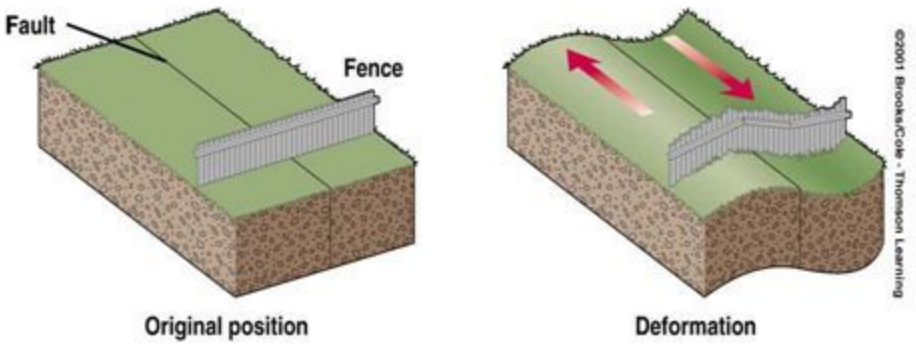
- **Blocks snap back** towards an unstrained position, driven by the stored elastic energy.
- **Elastic rebound** is the result of faulting and the **associated loss of confinement**.
- **Snapping back of ruptured rocks,** to un-deformed shape**, is called elastic rebound** and was contributed as a **mechanism associated with the generation of EQ.**
- Such EQ is called intraplate EQ.

Elastic rebound

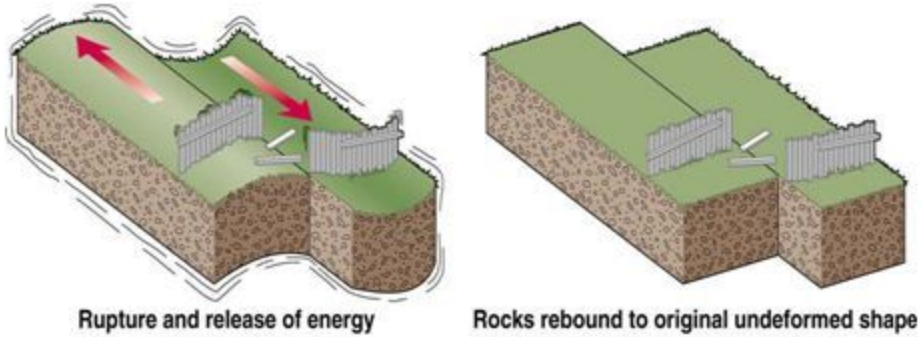
- In an seismic period, the earth's plates move relative to each other except at most plate boundaries where the are Locked.
- Thus if a road is built across the fault as in the Figure Time-1, it is perpendicular to the fault plane E, where the fault is locked.
- The plate motions (large arrows) cause the rocks in the region of the locked fault to accrue elastic deformation, Figure Time-2.
- Deformation builds at the rate of a few cm/yr, over a time period of many years.
- When the accumulated strain is great enough to overcome the strength of the rocks, an earthquake occurs.
- During the earthquake, the portions of the rocks around the fault that were locked, and had not been moved; 'spring back', relieving the displacement in a few seconds that the plate moved over the entire inter-seismic period (D1 and D2 of Fogure Time-3).
- Time period between Time 1 to Time 2 could be months to hundred of years, while the change time from Time 2 to Time 3 is seconds.

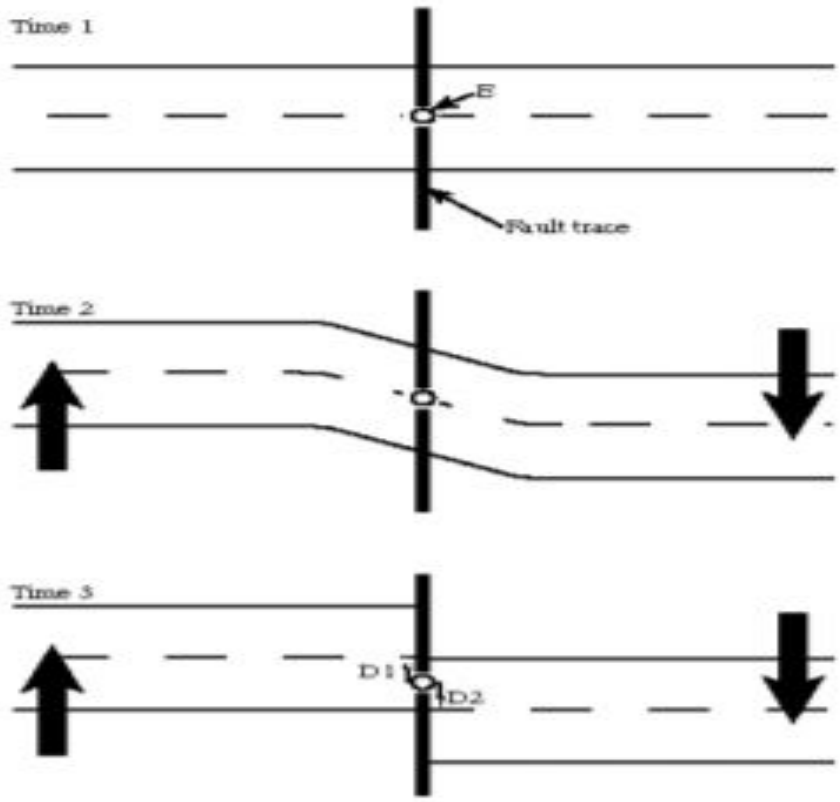
EARTHQUAKES

- **Elastic Limit**: the ability of rocks to bend to a certain point.



- **Elastic Rebound**: Rocks become strained, break, and snap back-rebound back to shape.





Elastic rebound

Thank You