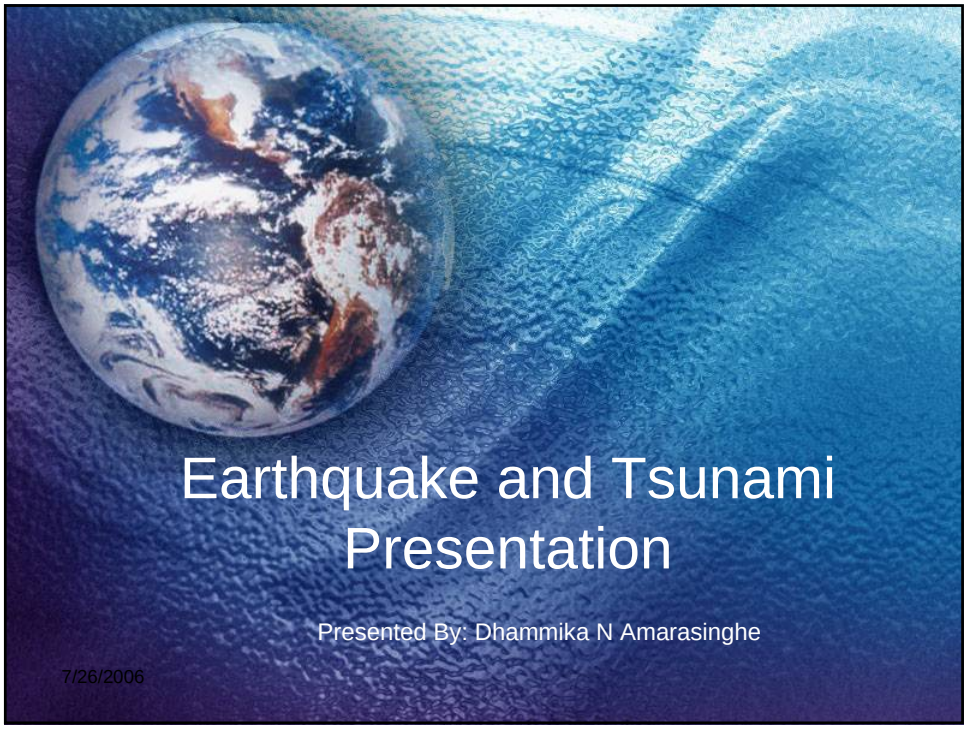
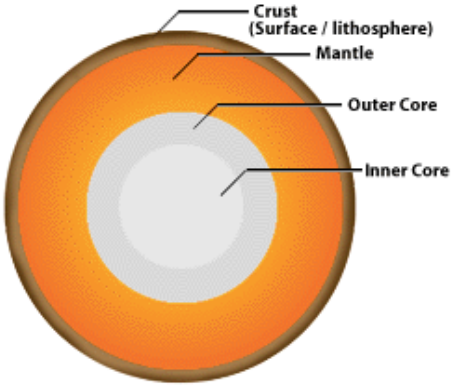


Interior of the Earth

Let's first take a look at the earth. The earth is made up of 4 main layers

1. Inner core
2. Outer core
3. Mantle
4. Crust (Surface/ Lithosphere)



Layers of the Earth

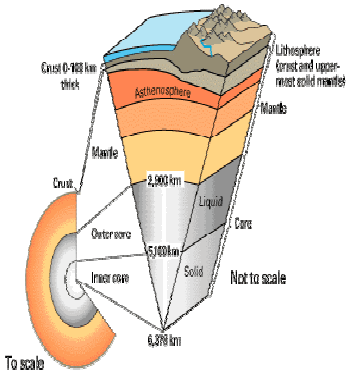
…Interior of the Earth

•The core is composed mostly of iron (Fe) and is so hot that the outer core is molten, with about 10% sulfur (S). The inner core is under such extreme pressure that it remains solid.

•Mantle is made up of solids, liquids and gases.

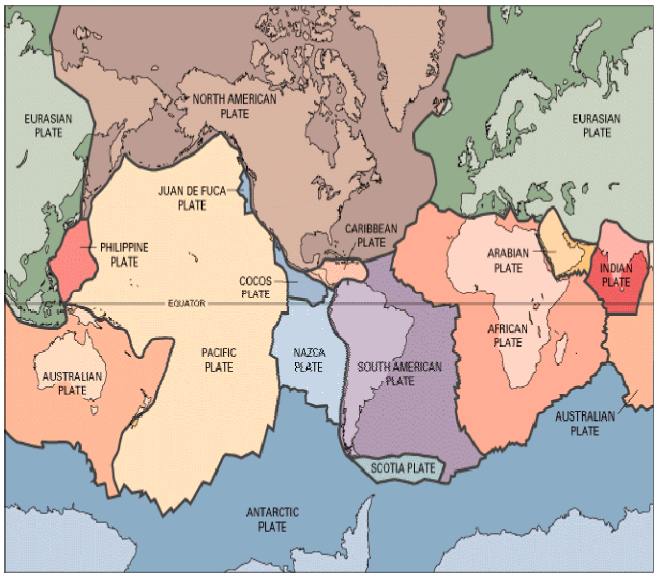
•The crust is where we live, on the surface of the earth.

•The lithosphere is made up of the crust and the upper most layer of the mantle, and is divided up into 7 large and many small Tectonic (moving) plates.



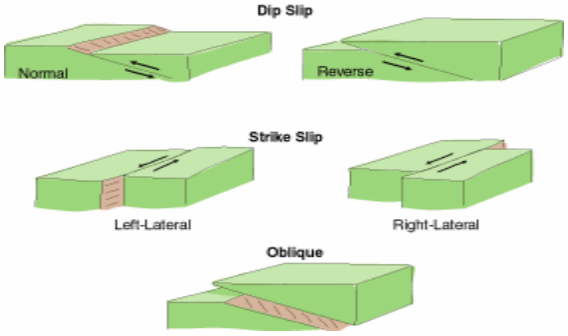
Major Tectonic Plates Of The World

1. Eurasian Plate
2. Pacific Plate
3. Australian Plate
4. North American Plate
5. South American Plate
6. Antarctic Plate
7. African Plate



Facts about Faults

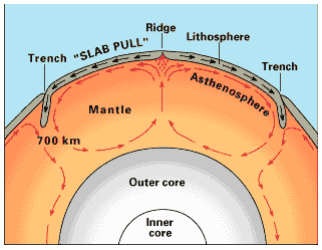
•Faults may range in length from a few millimeters to thousands of kilometers.
•The fault surface can be horizontal or vertical or some arbitrary angle in between.
•Faults which move along the direction of the dip plane are **dip-slip faults** and described as either normal or reverse, depending on their motion.
•Faults which move horizontally are known as **strike-slip faults** and are classified as either right-lateral or left-lateral.
•Faults which show both dip-slip and strike-slip motion are known as **oblique-slip faults**.
•Usually **Tsunamis** are **created by** faults which show **dip-slip and oblique motion.**



Understanding plate tectonics. Why does the plates move?

- The Lithosphere is more firm/ rigid compared to the soft Mantel.
- The hot Inner core consists of hot soft rock compared that with cooler rigid rock that of the lithosphere. Hence the inner core drives convection current to the surface.
- This process can be described by a simple test as shown in the diagram below.

Pour 500 ml of water into a beaker and place it on a hot plate. Place six ice cubes in the middle of the beaker. Allow the convection cell to develop and spread the ice cubes in a manner similar to a divergent plate boundary. Ice is less dense than liquid water and corresponds to the rigid lithospheric plates floating over the fluid (glass-like) mantle. The hot plate corresponds to the Earth's internal sources of heat such as radioactive decay, pressure, and friction.

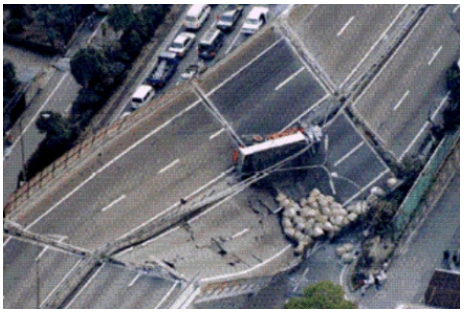


Other possible reasons for the movement of the plates

- Rotation of the Earth
- The orbit the Earth takes around the sun.
- Gravitational effects of the moon or sun affecting the Earth.
- Heat receiving from the sun.
- Magnetic field from other celestial bodies.

How Earthquakes Occur

As the plates of the lithosphere shift, weak spots develop. The place where the crust is weakened is called a "fault". When this shifting has built up over long periods of time, the crust of the earth weakens hence causing an earthquake.



General Facts about Earthquakes

- Earthquakes can not be predicted. However based on scientific data, probabilities can be calculated for potential future earthquakes.
- Earthquakes are equally as likely to occur at any time of the day or month or year.
- There is no connection between the weather and earthquakes

Measurement of Earthquakes

There are many different ways to measure different aspects of an earthquake.

Magnitude

- It is a measure of the size of the earthquake source and is the same number no matter where you are or what the shaking feels like such as the Richter scale.

Intensity

- Is a measure of the shaking and damage caused by the earthquake, and this value changes from location to location.

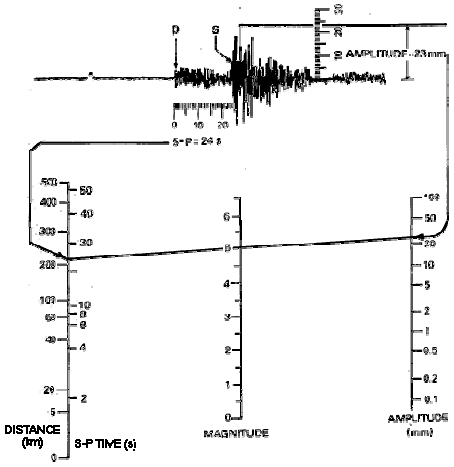
Magnitude scale

Great; M > =8
Major; 7 < =M < 7.9
Strong; 6 < = M < 6.9
Moderate: 5 < =M < 5.9
Light: 4 < =M < 4.9
Minor: 3 < =M < 3.9
Micro: M < 3

Current earthquakes around the world:
http://earthquake.usgs.gov/recenteqsww/Quakes/quakes_all.html

Richter Scale

One of **Dr. Charles F. Richter**'s most valuable contributions was to recognize that the **seismic waves** radiated by all earthquakes can provide good estimates of their magnitudes.



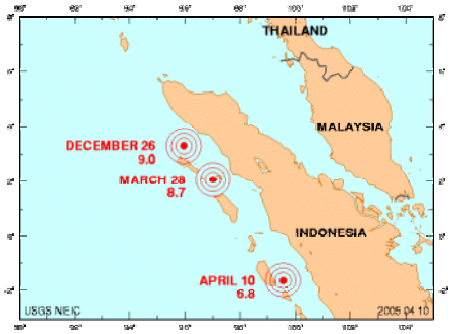
The scales in the diagram above form a **nomogram** that allows you to do the mathematical computation quickly by eye. The equation for Richter Magnitude is:

$$ML = \log_{10} A(mm) + (\text{Distance correction factor})$$

- Here *A* is the amplitude, in millimeters,
- *Distance correction factor is* the distance of the seismometer from the earthquake and is estimated by the S-P time difference.

Recently Recorded Great Earthquakes in the Indian Ocean

- Magnitude 6.8 KEP. MENTAWAI REGION, INDONESIA Sunday, April 10, 2005
- Magnitude 8.7 - NORTHERN SUMATRA, INDONESIA 2005 March 28
- Magnitude 9.0 - NORTHERN SUMATRA, INDONESIA, Sunday, December 26, 2004



Reasons why the March 28th earthquake did not create a tsunami
- Fault slip was strike-slip in nature.
- ripple propagation was North-South compared to East-West propagation by the 26th December earthquake

Largest earthquakes by magnitude

Pos.	Date	Location	Magnitude
1	May 22, 1960	Chile	9.5
2	March 28, 1964	Prince William Sound, Alaska, United States	9.2
3	December 26, 2004	Off west coast northern Sumatra, Indonesia	9.1-9.3*
4	March 9, 1957	Andreanof Islands, Alaska, United States	9.1
5	November 4, 1952	Kamchatka, Russia	9.0
6	January 26, 1700	Cascadia subduction zone from Northern California to Vancouver Island	~9
7	January 31, 1906	Colombia-Ecuador	8.8
8	February 4, 1965	Rat Island, Alaska, United States	8.7
9	November 1, 1755	Lisbon, Portugal	~8.7
10	March 28, 2005	Sumatra, Indonesia	8.5-8.7*
11	December 16, 1920	Ningxia-Gansu, China	8.6
11	August 15, 1950	Assam-Tibet	8.6

* Scientists have not yet agreed on an official magnitude.

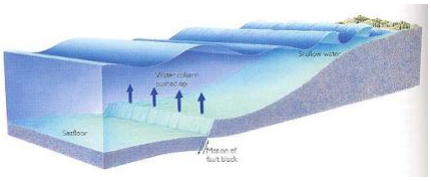
Deadliest earthquakes on record

Pos.	Date	Location	Fatalities	Magnitude	Comments
1	January 23, 1556	Shaanxi, China	830,000	~8	
2	December 26, 2004	Off west coast northern Sumatra, Indonesia	283,100	9.1-9.3	Deaths from earthquake and tsunami.
3	July 27, 1976	Tangshan, China	255,000 (official)	7.5	Estimated death toll as high as 655,000.
4	August 9, 1138	Aleppo, Syria	230,000		
5	December 22, 856+	Damghan, Iran	200,000		
5	December 16, 1920	Ningxia-Gansu, China	200,000	8.6	Major fractures, landslides.
5	May 22, 1927	Tsinghai, China	200,000	7.9	Large fractures.
8	March 23, 893+	Ardabil, Iran	150,000		
9	September 1, 1923	Kanto, Japan	143,000	7.9	Great Tokyo fire.
10	October 5, 1948	Ashgabat, Turkmenistan, USSR	110,000	7.3	

Tsunami

What is a tsunami?

- Tsunami is a Japanese word with the English translation, "harbor wave." Represented by two characters, the top character, "tsu," means harbor, while the bottom character, "nami," means "wave."
- A tsunami can be generated by submarine volcanic eruptions, by displacement of submarine sediments, by coastal landslides into a bay or harbor, by meteor impact, or by **vertical** displacement of the earth's crust along a zone of fracture which underlies or borders the ocean floor.
- The vertical displacement of the earth's crust is by far the most frequent cause of tsunamis and for all practical purposes the primary cause of tsunamis capable of propagation across an ocean basin.



Overview of tsunamis in the past

- **January 20, 1606/1607**:
  along the coast of the Bristol Channel (main article) thousands of people were drowned, houses and villages swept away, farmland was inundated and flocks were destroyed by a flood that might have been a tsunami.
- **November 1, 1755 - Lisbon, Portugal**
  One of the worst tsunami disasters engulfed whole villages along Sanriku, Japan, in 1896. A wave more than seven stories tall (about 20 m) drowned some 26,000 people.
- **1929**: An undersea landslide off the Grand Banks of Newfoundland, Canada triggered a giant wave that killed 27 people in Newfoundland.
- **1946**: An earthquake in the Aleutian Islands sent a tsunami to Hawaii, killing 159 people (five died in Alaska).
- **1958**: A very localized tsunami in Lituya Bay, Alaska was the highest ever recorded: more than 500 m (1500 ft) above sea level. It did not extend much beyond the outlet of the fjord in which it occurred but did kill two people in a fishing vessel.
- **1976**: August 16 (midnight) a tsunami killed more than 5000 people in the Moro Gulf region (Cotabato city) of the Philippines.
- **1983**: 104 people in western Japan were killed by a tsunami spawned from a nearby earthquake.
- **July 17, 1998**: A Papua New Guinea tsunami killed roughly 2200 people. A 7.1 magnitude earthquake 15 miles offshore was followed within 10 minutes by a tsunami about 12 m tall. While the magnitude of the quake was not large enough to create these waves directly, it is believed the earthquake generated an undersea landslide, which in turn caused the tsunami. The villages of Arop and Warapu were destroyed.

Tsunami warning system

There are two types of tsunami warning Systems

- Regional warning systems
- International tsunami warning systems

Regional warning systems

- Use seismic data about nearby earthquakes to determine if there is a possible local threat of a tsunami.
- Capable of issuing warnings to the general public (via public address systems and sirens) in less than 15 minutes.
- False alarms can occur with this systems.

International warning systems

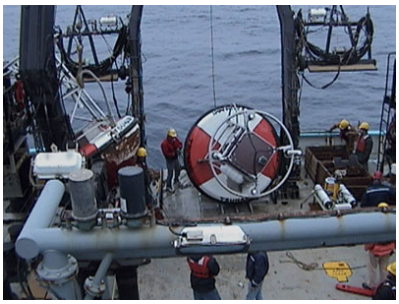
- Also uses seismic data as its starting point, but then takes into account oceanographic data when calculating possible threats.
- Tide gauges in the area of the earthquake are checked to establish if a tsunami wave has formed.
- The centre then forecasts the future of the tsunami, issuing warnings to at-risk areas
- There are never false alarms

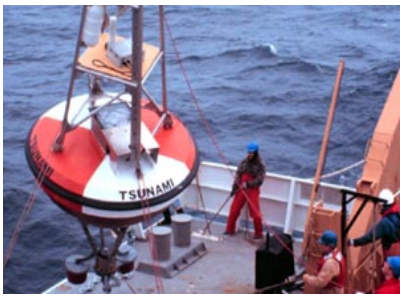
Centers that monitor Tsunamis around the World

- National Oceanic and Atmospheric Administration (NOAA).
- Pacific Tsunami Warning Center (PTWC)
- West Coast & Alaska Tsunami Warning Center
- Yuzhno-Sakhalinsk Tsunami Warning Center (Y S T W C)
- At present there are no tsunami detection system for the Indian Ocean and Atlantic Ocean.

Deep-ocean Assessment and Reporting of Tsunamis (DART)

(DART) Project is an ongoing effort to maintain and improve the capability for the early detection and real-time reporting of tsunamis in the open ocean. Developed by NOAA's Pacific Marine Environmental Laboratory (PMEL) and operated by NOAA's National Data Buoy Center (NDBC), DART is essential to fulfilling NOAA's national responsibility for tsunami hazard mitigation and warnings

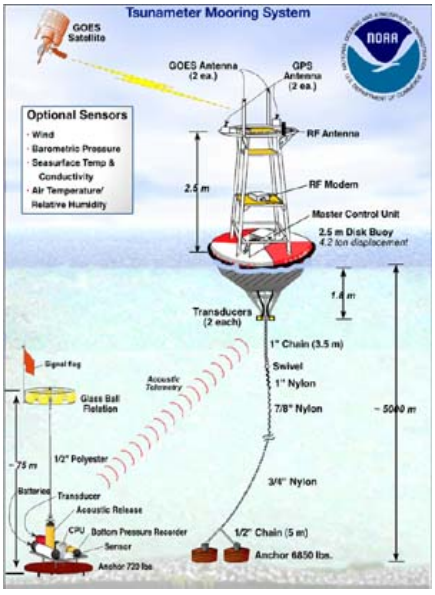




Deep-ocean Assessment and Reporting of Tsunamis (DART)

System Overview

DART systems consist of
• An anchored seafloor bottom pressure recorder (BPR) and a companion moored surface buoy for real-time communications.
•An acoustic link transmits data from the BPR on the seafloor to the surface buoy. The data are then relayed via a GOES satellite link to ground stations which demodulate the signals for immediate dissemination to NOAA's (National Oceanic and Atmospheric Administration) tsunami Warning Centers.



The End