YORK CASTLE HIGH SCHOOL
GEOGRAPHY DEPARTMENT
EARTHQUAKE HAND-OUT

WHAT IS AN EARTHQUAKE?

- An earthquake is a trembling or shaking of the ground caused by the sudden release of energy stored in the rocks.
- Shaking and vibration at the surface of the earth resulting from underground movement along a fault plane

Great forces acting deep in the earth may put a stress on the rock, which may bend or change in shape (strain). A rock can deform only so far before it breaks. 'When a rock breaks, waves of energy are released and sent out through the earth. These are ***seismic waves*** (the waves of energy produced by an earthquake.) It is the seismic waves that cause the ground to tremble and shake during an earthquake.

The sudden release of energy when rock breaks may cause one huge mass of rock to slide past another mass of rock into a different relative position. The break between the two rock masses is a fault.

Most earthquakes occur on plate edges, especially where a plate is forced under another, eg California. Smaller events occur more frequently - in fact, most earthquakes cause little or no damage. A very large earthquake can be followed by a series of smaller aftershocks weeks after the event.

Earthquakes can also cause tsunamis, which are giant ocean-waves that can cross an ocean and may cause extensive damage in coastal regions. In areas where there are steep slopes, vibrations may cause landslides.

The study of seismic waves is called seismology. Instruments called seismometers or seismographs are used to record the strength of seismic waves. They produce printed records called seismographs or seismograms.

CAUSES OF EARTHQUAKES

Most earthquakes occur at the edges of tectonic plates. The tectonic plates are in motion, shifting position and jostling each other The adjacent plates may collide, pull apart or slide past each other The movement of these crustal blocks releases enormous amounts of energy sending series of vibrations (earthquake waves) travelling in all directions.

1. ***Plate movements - earthquakes at convergent plate boundaries***

The area where the oceanic plate is descending is called a subduction zone. The lighter plate grinds its way over the denser plate, causing vibrations and sometimes sharp jolts, the shock of which causes earthquakes.

2 Earthquakes at divergent plate boundaries

As divergent plates move away from each other they create fault lines, which are lines of weakness or fractures in the earths crust. Sometimes there is a sudden slippage of fractured rocks on either side of the fault. The sudden release of energy produces an earthquake.

3 Earthquakes at transform plate boundaries

A transform boundary, or transform-fault boundary, is where two plates slide past each other in parallel but opposite directions. The line separating the plates is called a fault.

4. ***Volcanic earthquakes***

The passage of magma and the eruption of the volcano cases the crust to vibrate generating earthquakes.

Most earthquakes occur along the edges of the Earth's plates, as they slide past each other.

Some earthquakes are caused by human activities, such as:

(1) the extraction of minerals and fossil fuel from the Earth's crust,
(2) the removal or injection of fluids into the crust,
(3) reservoir-induced seismicity. A rare few earthquakes have been associated with the build-up of large masses of water behind dams
(4) and collapse of large buildings.
(5) and with the injection or extraction of fluids into the Earth's crust. Such earthquakes occur because the strength of the Earth's crust can be modified by fluid pressure.
(6) Earthquakes have also been known to be caused by the removal of natural gas from subsurface deposits.
(7) The detonation of powerful explosives, such as nuclear explosions, can cause low-magnitude ground shaking.

Earthquakes related terms:

(1) **epicentre** - The epicenter is the point on the earth's surface vertically above the hypocenter (or focus), point in the crust where a seismic rupture begins.
(2) **Focus/hypocenter** - The hypocenter is the point within the earth where an earthquake rupture starts.
(3) **Intensity** - The intensity is a number describing the severity of an earthquake in terms of its effects on the earth's surface and on humans and their structures. Several scales exist, but the ones most commonly are the Modified Mercalli scale and the Rossi-Forel scale.
(4) **Magnitude** - (a) The magnitude of an earthquake is an estimate of the energy released by it. Magnitude is based on measurement of the maximum motion recorded by a seismograph.

Commonly, earthquakes are recorded with magnitudes from 0 to 8, although occasionally large ones (M=9) and very small ones (M= -1 or -2) are also recorded. Nearby earthquakes with magnitudes as small as 2 to 3 are frequently felt.

A number of earthquake **magnitude scales** exist, including local or Richter magnitude and moment magnitude.

(5) **Aftershock** - (a) One of many earthquakes that often occur during the days to months after some larger earthquake (mainshock) has occurred.

(6) **Foreshock** - A small tremor that commonly precedes a larger earthquake or main shock by seconds to weeks that originates in or near the rupture zone of the larger earthquake

(7) **Mainshock** - The largest in a series of earthquakes occurring closely in time and space. The mainshock may be preceded by foreshocks or followed by aftershocks.

Where do earthquakes occur?

No part of the Earth's surface is safe from earthquakes. But some areas experience them more frequently than others.

Earthquakes are most common at plate boundaries, where different tectonic plates meet. The largest events usually happen where two plates are colliding - this is where large amounts of stress can build up rapidly.

About 80 percent of all recorded earthquakes occur at the circum-Pacific seismic belt, commonly known as the Ring of Fire due to the prevalence of seismic and volcanic activity. The belt extends:

- extends northward through Fiji, Papua New Guinea, the Philippines, and Japan along the eastern coast of Russia
- east to the southern edge of Alaska
- south along the western coast of Canada, North America and South America
- within the West Indies, affecting the Greater and Lesser Antilles;
- from the Mediterranean Sea to east Africa, affecting Turkey, Iran and Italy.

(See map at back)

Measuring earthquakes

The severity of an earthquake can be measured in terms of magnitude and intensity. For that seismologists use two fundamentally different but equally important types of scales.

The **original force or energy** of an earthquake is measured on a **magnitude scale**. **The Richter scale** is a well known example of a magnitude scale.

The magnitude of most earthquakes is measured on the Richter scale, invented by Charles F. Richter in 1934.

Here's a table describing the magnitudes of earthquakes, their effects, and the estimated number of those earthquakes that occur each year.

Magnitude	Earthquake Effects	Estimated Number Each Year
2.5 or less	Usually not felt, but can be recorded by seismograph.	900,000
2.5 to 5.4	Often felt, but only causes minor damage.	30,000
5.5 to 6.0	Slight damage to buildings and other structures.	500
6.1 to 6.9	May cause a lot of damage in very populated areas.	100
7.0 to 7.9	Major earthquake. Serious damage.	20
8.0 or greater	Great earthquake. Can totally destroy communities near the epicenter.	One every 5 to 10 years

The second type of scale measures the intensity of shaking occurring at any given point on the Earth's surface. These scales are referred to as intensity scales. The **Mercalli intensity scale**, which **measures the effects of the seismic waves**, is an example of a commonly used intensity scale.

The non-specialized media will often refer to the magnitudes of earthquakes as being reported on the Richter scale. However, the magnitudes reported nowadays are actually on the moment magnitude scale.

Invented by Giuseppe Mercalli in 1902, this scale uses the observations of the people who experienced the earthquake to estimate its intensity.

The Mercalli scale isn't considered as scientific as the Richter scale.

LOCATING AND MEASURING EARTQUAKES

Earthquake instruments measure the amount of ground shaking and can be used to find the location, depth and size of an earthquake.

Modified Mercalli Scale

I.	Not felt.
II.	Felt by persons at rest, on upper floors, or favorably placed.
III.	Felt indoors. Vibration like passing of light trucks.
IV.	Vibration like passing of heavy trucks.
V.	Felt outdoors. Small unstable objects displaced or upset.
VI.	Felt by all. Furniture moved. Weak plaster/masonry cracks.
VII.	Difficult to stand. Damage to masonry and chimneys.
VIII.	Partial collapse of masonry. Frame houses moved.
IX.	Masonry seriously damaged or destroyed.
X.	Many buildings and bridges destroyed.
XI.	Rails bent greatly. Pipelines severely damaged.
XII.	Damage nearly total.

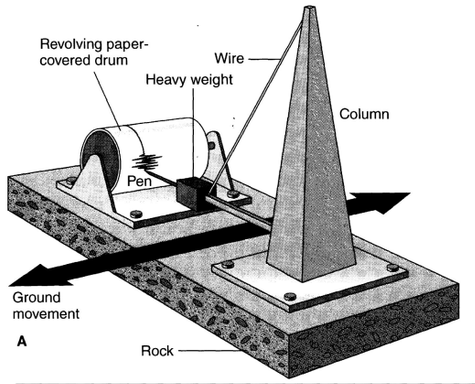
The instrument used to detect seismic waves is a seismometer. A seismograph is a recording device that produces a permanent record of motion detected by a seismometer. The paper record of earthquake waves is called a seismogram.

A network of seismograph stations is maintained all over the earth to record and study earthquakes.

TYPES OF SEISMOGRAPHS

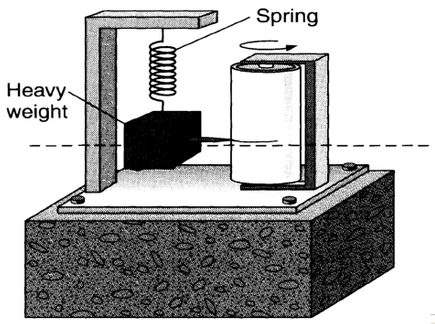
HORIZONTAL SEISMOGRAPH

A seismograph for horizontal motion. Modern seismographs record earth motion on moving strips of paper. The mass is suspended by a wire from the column and swings like a pendulum when the ground moves horizontally. A pen attached to the mass records the motion on a moving strip of paper.



SEISMOGRAPH FOR DETECTING VERTICAL MOVEMENT

A simple seismograph for detecting vertical rock motion. The pen records the ground motion on the seismogram as the spring stretches and compresses with up and down movement of the spring. Frame and recording drum move with the ground. Inertia of the weight keeps it and the needle relatively motionless.



SEISMIC WAVE OR EARTHQUAKE WAVES

The point within the earth where seismic waves originate is called the focus (or hypocenter) of the earthquakes. This is the center of the earthquake, the point of initial breakage and movement on a fault. Rupture begins at the focus and then spreads rapidly along the fault plane. The point on the earth's surface directly above the focus is the epicenter.

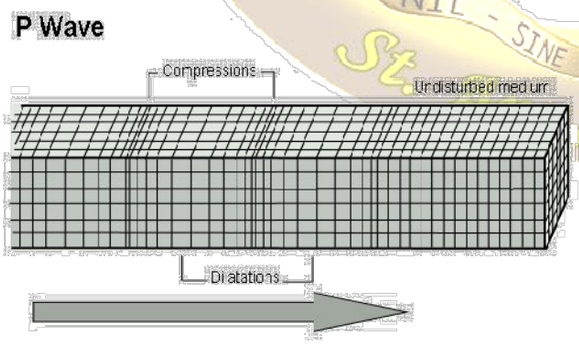
Two types of seismic waves are generated during earthquakes.

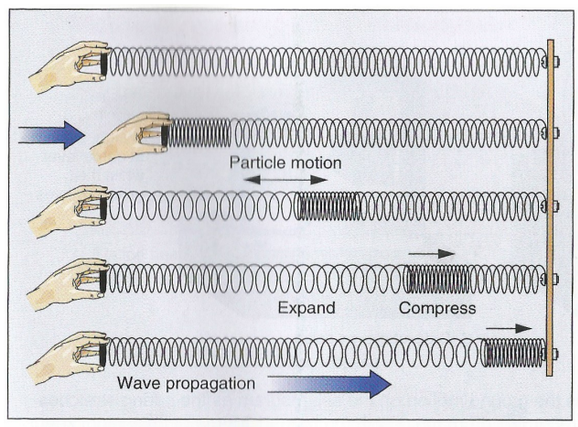
(1) **Body waves** are seismic waves that travel through the earth's interior, spreading outward from the focus in all directions, like sound waves moving through air.
(2) **Surface waves** are seismic waves that travel on the earth's surface away from the epicenter, like water waves spreading out from a pebble thrown into a pond. Rock movement associated with seismic surface waves dies out with depth into the earth, just as water movement in ocean waves dies out with depth.

Body Waves

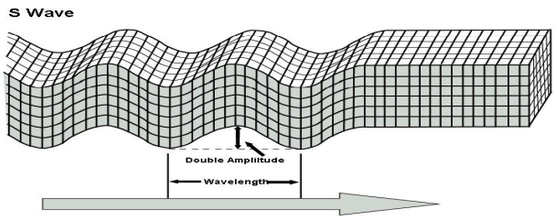
There are two kinds of body waves.

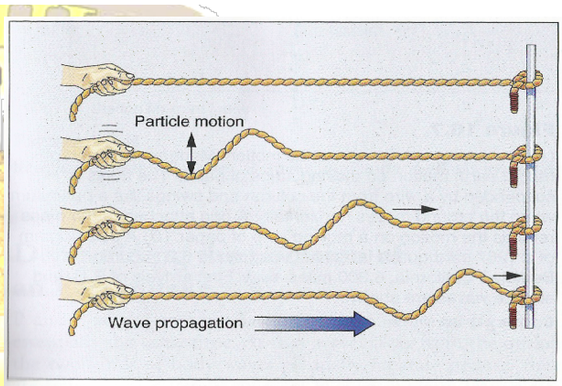
(1) **P wave is a compressional** (or longitudinal) wave in which rock vibrates back and forth parallel to the direction of wave spread. Because it is a very fast wave, traveling through near surface rocks at speeds of 4 to 7 kilometers per second (9,000 to more than 15,000 miles per hour), a P wave is the first (or primary) wave to arrive at a recording station following an earthquake.





(2) The second kind of body wave is called an **S wave (secondary)** and is a slower, transverse wave that travels through near surface rocks at 2 to 5 kilometers per second. An S wave is propagated by a shearing motion much like that in a stretched, shaken rope. The rock vibrates perpendicular to the direction of wave propagation (grows), that is, crosswise to the direction the waves are moving.





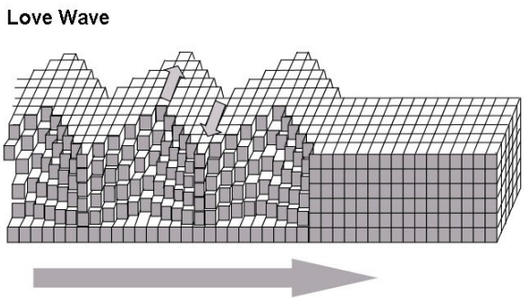
Both P-waves and S-waves pass easily through solid rock.

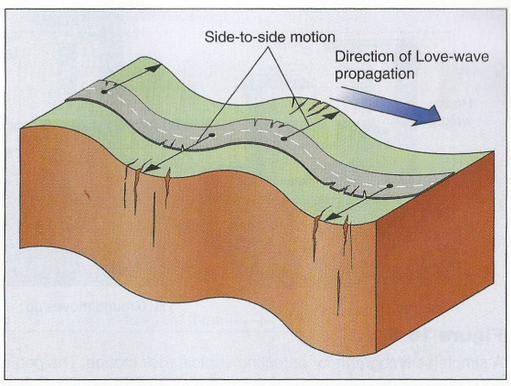
A P-wave can also pass through a fluid (gas or liquid), but an S-wave cannot.

Surface Waves

Surface waves are the slowest waves set off by earthquakes. In general, surface waves cause more property damage than body waves because surface waves produce more ground movement and travel more slowly, so they take longer to pass. The two most important kinds of surface waves are:

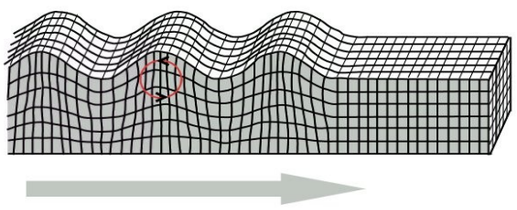
(1) **Love waves** - Love waves are most like S waves that have no vertical displacement. The ground moves side to side in a horizontal plane that is perpendicular to the direction the wave is traveling . Like S waves, Love waves do not travel through liquids and would not be felt on a body of water. Because of the horizontal movement, Love waves tend to knock buildings off their foundations

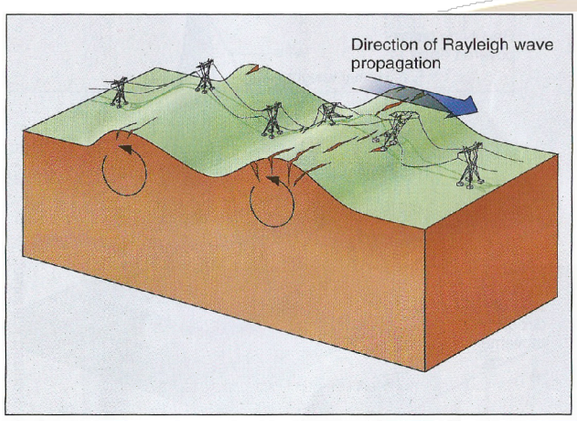




(2) **Rayleigh waves** - Rayleigh waves behave like rolling ocean waves. Rayleigh waves cause the ground to move in an elliptical path as the wave passes. Rayleigh waves tend to be incredibly destructive to buildings because they produce more ground movement and take longer to pass.

Rayleigh Wave





	Social impacts	Economic impacts	Environmental impacts
Short-term impacts	People may be killed or injured. Homes may be destroyed. Transport and communication links may be disrupted. Water pipes may burst and water supplies may be contaminated.	Shops and business may be destroyed. Looting may take place. The damage to transport and communication links can make trade difficult.	The built landscape may be destroyed. Fires can spread due to gas pipe explosions. Fires can damage areas of woodland. Landslides may occur. Tsunamis may cause flooding in coastal areas.
Long-term impacts	Disease may spread. People may have to be rehoused, sometimes in refugee camps.	The cost of rebuilding a settlement is high. Investment in the area may be focused only on repairing the damage caused by the earthquake. Income could be lost.	Important natural and human landmarks may be lost.

TSUNAMIS

The sudden movement of the sea-floor upward or downward caused by submarine earthquakes can generate very large sea waves. Geologist called the large sea waves tsunamis. They are often caused by large earthquakes that disturb the sea-floor. They are also caused by submarine landslides and volcanic explosions.

When a large part of the of the sea-floor suddenly rises or falls during a quake all the water over the moving area is lifted or dropped for an instant. As the water returns to sea-level long, low waves spread out rapidly over the ocean.

Tsunami generated waves are not like ordinary sea waves. A large sea wave have a wave length of about 400m(1300ft) and moves at speed of about 90 km per hour (55 miles / hr) in the open ocean. When these waves break on shore their height is about 0.6 to 3m (2 to 10ft). A tsunami wave length is about 160 km (100mile) and moves at about 725km/ hr (450 mile /hr). When a tsunami wave break onshore its height is between 15 to 30 m (50 to 100ft).

Even though the speed of the tsunami shows down drastically as it moves through shallow waters, a tsunami can still hit as a large very fast wave. Because of its very long wave length the waters of the tsunami does not withdraw quickly as normal waves do. The water keeps on rising causing great flooding as the water withdraws.

Effects of tsunamis

1. loss of lives- villagers, tourists, fishermen
2. Destruction of entire villages, hotels and other buildings
3. Damage of fishing boats, coral reef and marina facilities
4. Flooding
5. Disruption o the economy
6. Destruction of crops and infrastructure
7. Intrusion of salt water into soil
8. Food and water shortage
9. Diseases caused by contaminated water and unburied bodies