VOLCANOES : NATURAL DISASTERS

WHAT IS VOLCANIC ERUPTION ?

It is the sudden occurrence of a violent discharge of steam and volcanic material like volcanic bombs, lapilli, ash and lava are expelled violently in the land air and water surfaces

What is a volcano - A mountain built from magmatic eruptions.

The earth has three main layers: the crust, the mantle and the core.

- The crust is made up of solid rock and is found below the oceans as well as across the continents. It varies in thickness – the crust is more than 60km thick under mountain chains like the Alps and Himalayas, but just 5km under the oceans.

- The mantle is a thick layer of molten rock (called magma), and the core is made up of an outer liquid layer and a solid centre.
- Temperatures inside the earth are very high – over 5000°C in the core. This means that the planet on which we live is like a huge fiery ball of hot molten rock, surrounded by a few kilometers of relatively cool, hard rock – the crust. Because heat rises, the magma in the earth's mantle has to find a way to rise upwards though the crust above it, rather like the way that hot air rises.

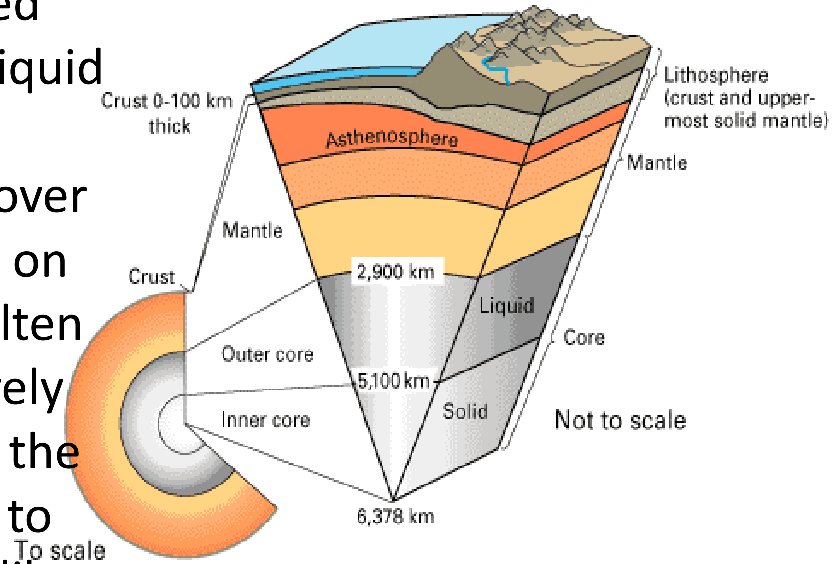


Plate tectonics

- Plate tectonics is a discovery that revolutionized the field of geology!
- Plate tectonics is the theory that pieces of the earth’s lithosphere, called plates, move about slowly on top of the asthenosphere
- Plate tectonics explain earthquakes and volcanoes
- Earth's tectonic plates are made of –
  The crust and uppermost mantle.

Wegener’s Continental Drift

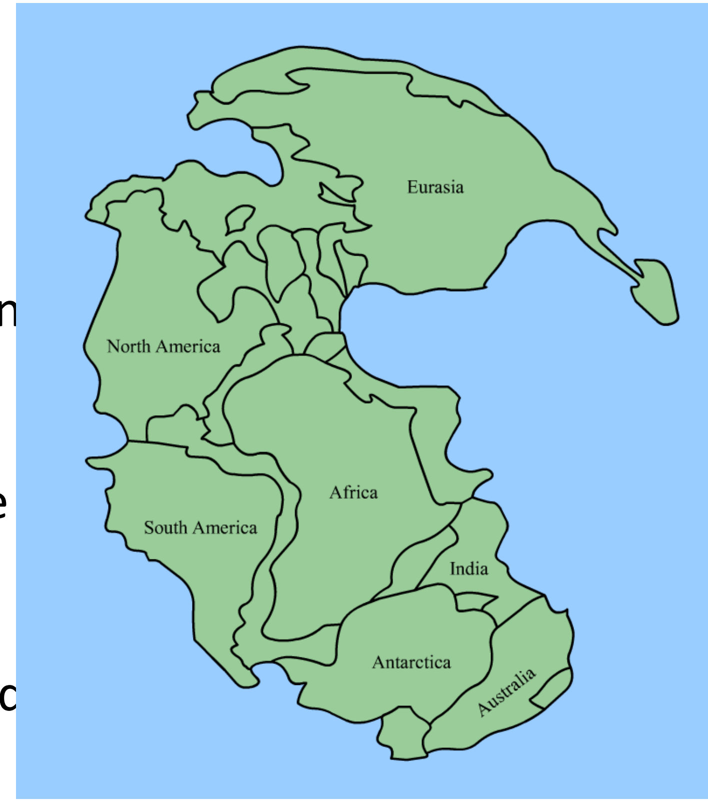
• When looked at in geological time scale, continen very mobile.

• Theory of continental drift proposes that continents were originally all connected, but broke up and are still drifting apart, so will continue to change position.

– Pangaea—the massive supercontinent that Alfred Wegener postulated to have existed about 250 million years ago.

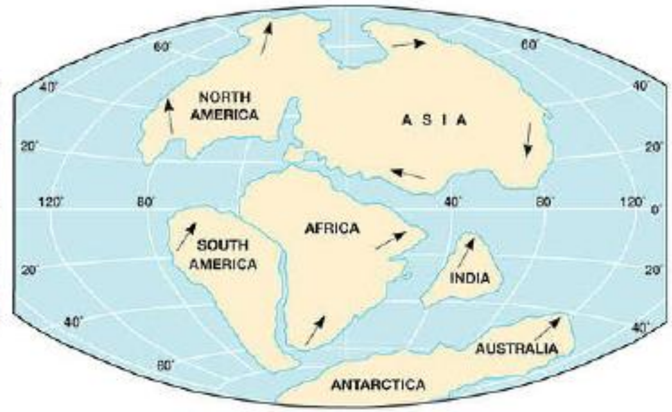
• Evidence includes remarkable number of close affinities of geologic features on both sides of Atlantic Ocean.

• Continental margins of subequatorial portions of Africa and South America fit together.

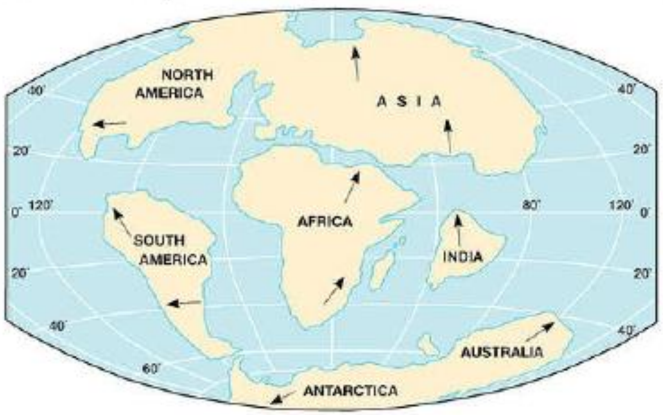


These plates lie above the hot, liquid mantle. There are 7 major plates and 10 minor plates. Each plate contains some continental crust (land) and some oceanic crust (sea-bed).

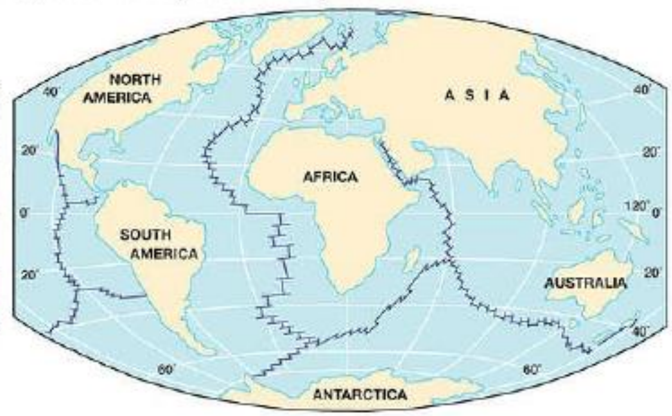
(a) 225 million years before present



(b) 135 million years before present



(c) 65 million years before present



(d) Today

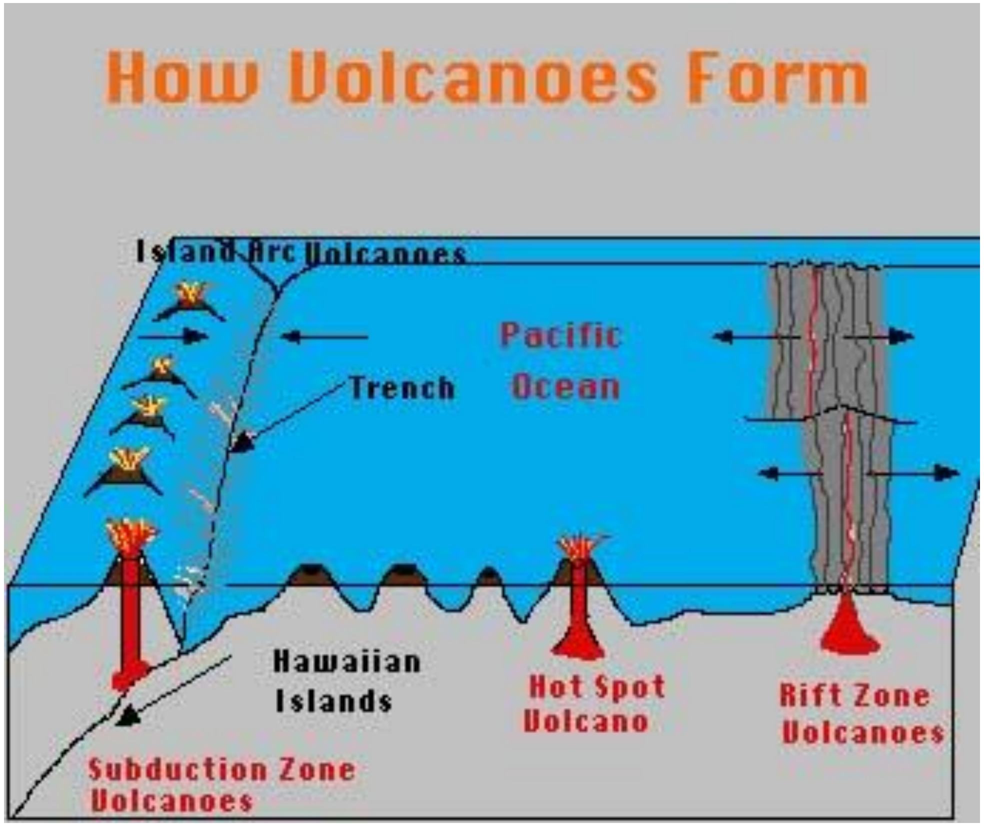
Only for your information

Plate Tectonics & volcanic activity

Where are volcanoes found?

Most volcanoes and earthquakes are found along plate boundaries.

- along mid-ocean ridges/rifts (divergent boundaries)
- at subduction boundaries
- over hot spots



The diagram above shows the three ways that volcanoes form.

Types of Boundaries

- Divergent ← →
  - Plates move apart / Rifting. Rifting causes seafloor spreading.
  - the movement of two oceanic plates away from each other (at a divergent plate boundary), which results in the formation of new oceanic crust (from magma that comes from within the Earth's mantle) along a mid-ocean ridge.

Land features include:

- Mid-Ocean Ridges
  - Ex. - Mid-Atlantic Ridge
- Rift Valleys
  - Ex. - African Rift Valley
- Earthquakes

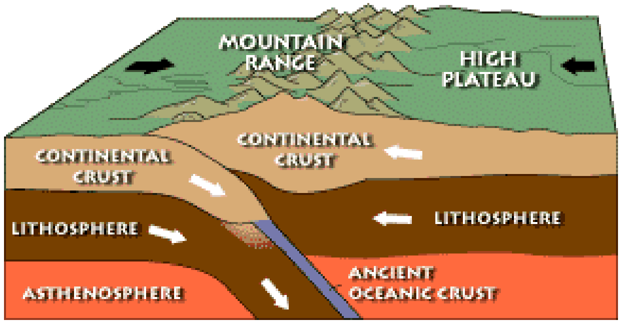
- Convergent →←
  - Plates come together (Colliding / Sub-duction)

There are 3 types – continental-continental, oceanic-continental, oceanic-oceanic.

- Transform ⇄
  - Plates slide horizontally past each other –(Sliding)

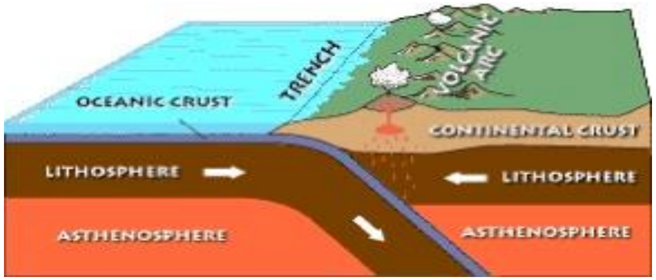
Continental-Continental Convergent

- ❑ When two continents collide.
- ❑ A collision place : where folded and thrust faulted mountains form.
- ❑ Forms mountains and deforms crust (folding and faulting).
- ❑ Metamorphism also a result
- ❑ Example: Himalayas and ancient Appalachians



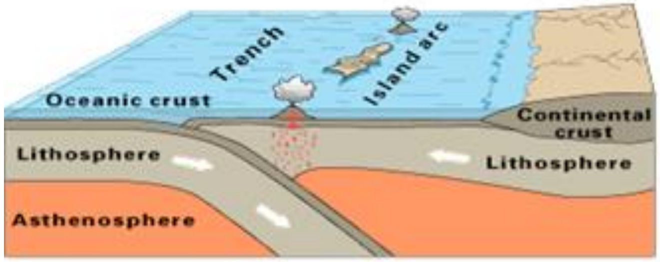
Oceanic-Continental Convergent

- More dense oceanic crust SUBDUCTS under less dense continental crust.
- Called Subduction Zones.
- Forms volcanoes and mountains from melting of overlying continental crust. Also earthquakes.
- Examples: Cascade Mountains in Washington and Andes Mountains in South America.

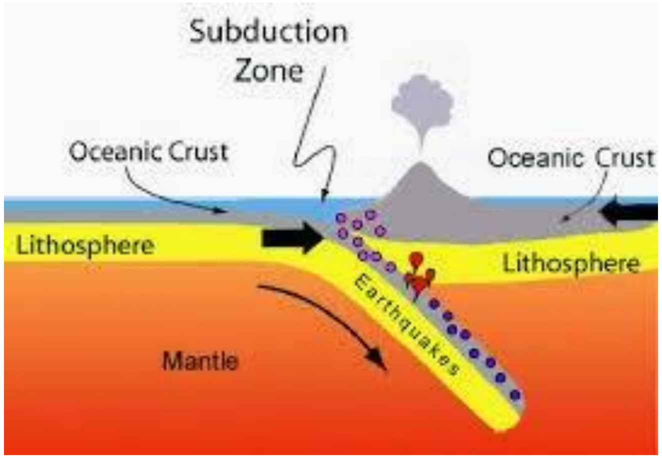


Oceanic-oceanic Convergent

- When older, more dense oceanic crust subducts under younger oceanic crust.
- Results in deep trenches (Marianas Trench) and Island Arcs of Volcanoes (Ex. Japan). Also earthquakes.
- The more dense plate slides under the more dense plate creating a subduction zone called a trench



Oceanic-oceanic convergence



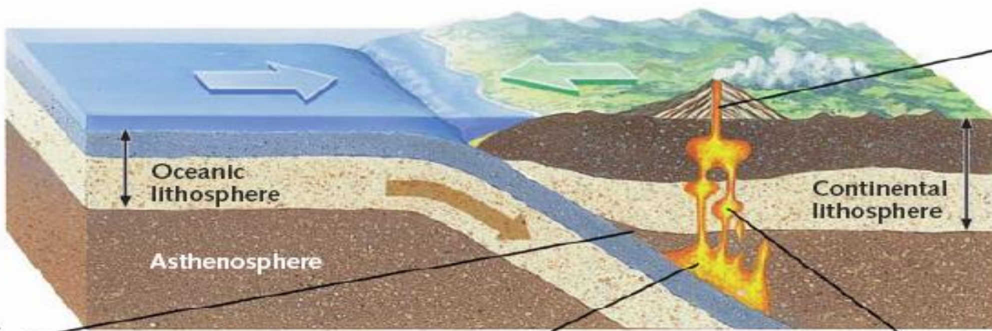
Subduction zone: When a Continental plate overrides Oceanic plate, the Oceanic Plate gets driven down and a Subduction zone forms.

- ❑ Subduction Zone volcanoes form at the boundaries of two plates, one overriding the other.
- ❑ Subduction zone volcanoes are the most violent and destructive of the volcanic types. e.g., Mt. St. Helens, Mt. Pinatubo, Krakatoa, and Mt. Vesuvius

- ❑ Oceanic-Continental & Oceanic-Oceanic… Volcanoes always form on the overriding (top) plate
- ❑ On continental plate at oceanic-continental convergence, ex. Cascade Mountains (Pacific coast of N. America.
- ❑ On the overriding oceanic plate at oceanic-oceanic convergence, ex. Mariana Islands in Pacific
- ❑ The seafloor certainly does disappear at subduction zones along the Ring of Fire. Here, the seafloor (and all the oceanic crust beneath it) plunges down under the continents into Earth's mantle, to be recycled.

Volcanic Activity at a Subduction Boundary

BETWEEN AN OCEANIC PLATE AND A CONTINENTAL PLATE



1 Water in the subducted rock is released into the asthenosphere.

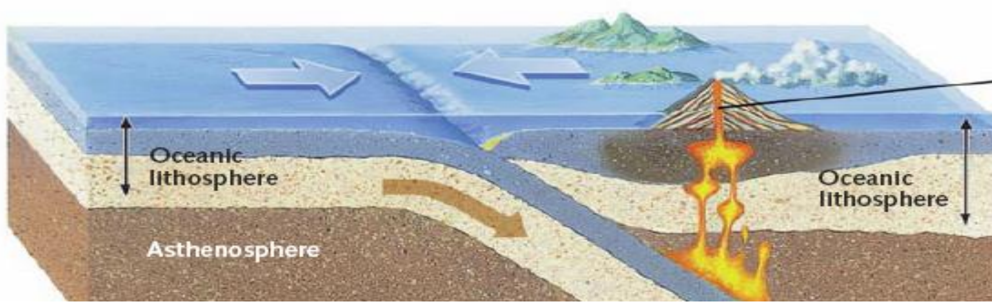
2 The water lowers melting temperatures of materials in the asthenosphere, leading to the formation of magma.

3 The magma is less dense than its surroundings, so it rises.

4 Some of the magma reaches Earth's surface, and volcanoes form on the overriding continental plate.

BETWEEN OCEANIC PLATES

The process by which magma forms at an oceanic-oceanic subduction boundary is similar to the process at an oceanic-continental boundary. Notice that the difference between the two processes occurs at step 4.

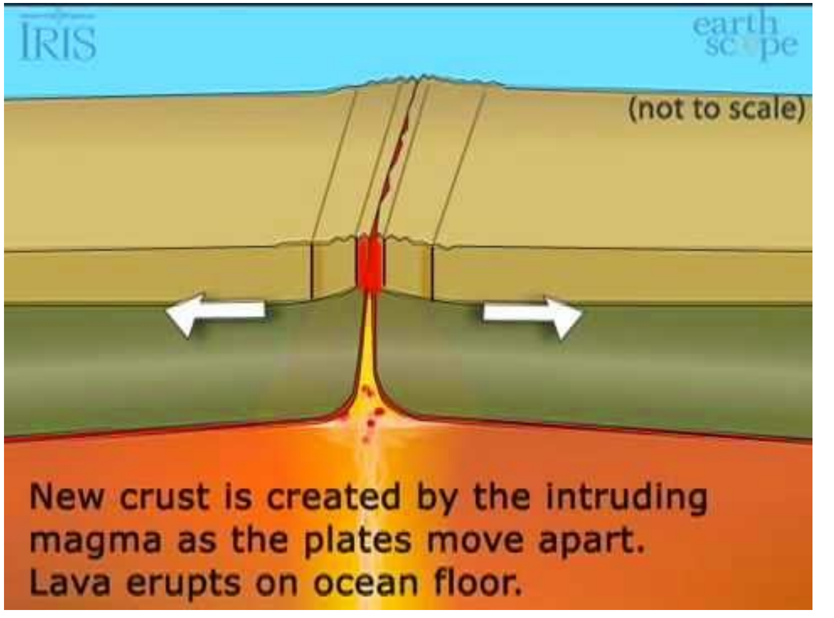


4 Magma that reaches Earth's surface is underwater. Thus, an arc of volcanic islands forms on the overriding oceanic plate.

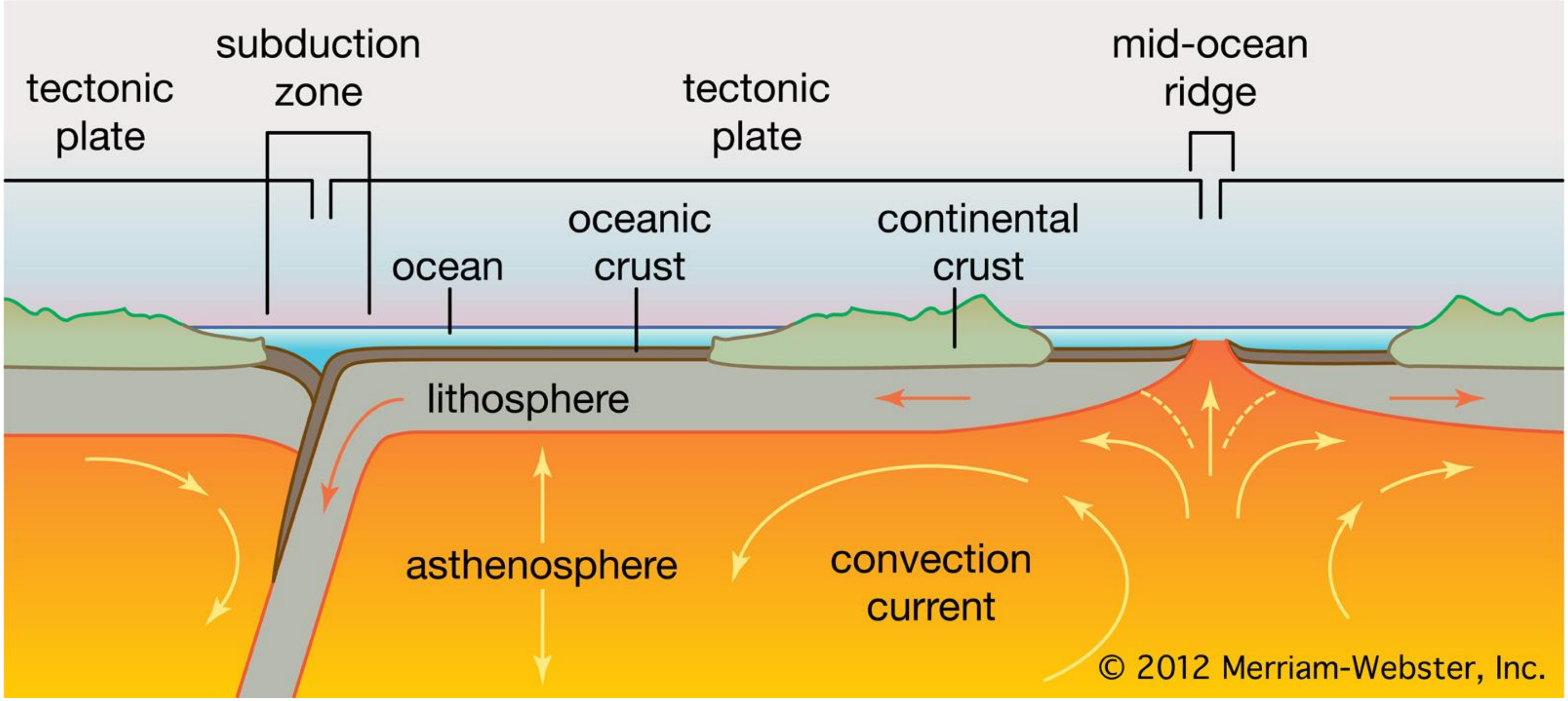
Only for your information

Divergent Boundaries

- ❑ Two plates move away from each other.
- ❑ Results in volcanoes, rift valleys, mid-ocean ridges.
- ❑ Youngest rock at spreading ridge.
- ❑ Normally Basalt is erupted to make new oceanic crust.
- ❑ Examples are East African Rift and Mid-Atlantic Ridge



- Mid-ocean rift volcanoes form where two oceanic plates are spreading apart (diverging).
- There are more rift zone volcanoes than any other type. along mid-ocean ridges.
- Mid-ocean ridges occur along divergent plate boundaries where new ocean floor is created as the Earth’s tectonic plates spread apart. As the plates separate, molten rock rises to the seafloor, producing enormous volcanic eruptions of basalt.
- The magma is less dense than the materials around it, so it rises through the rift to the surface.
- As this hot magma cools in the ocean water, it would expand and push the plates either side of it --- north America to the west and Africa-Eurasia to the east.
- This way, the Atlantic ocean getting wider
- These mid-ocean or rift zone volcanoes are the world's longest continuous mountain chain. This mountain chain encircles the entire Earth. It is more than 40,000 miles long.



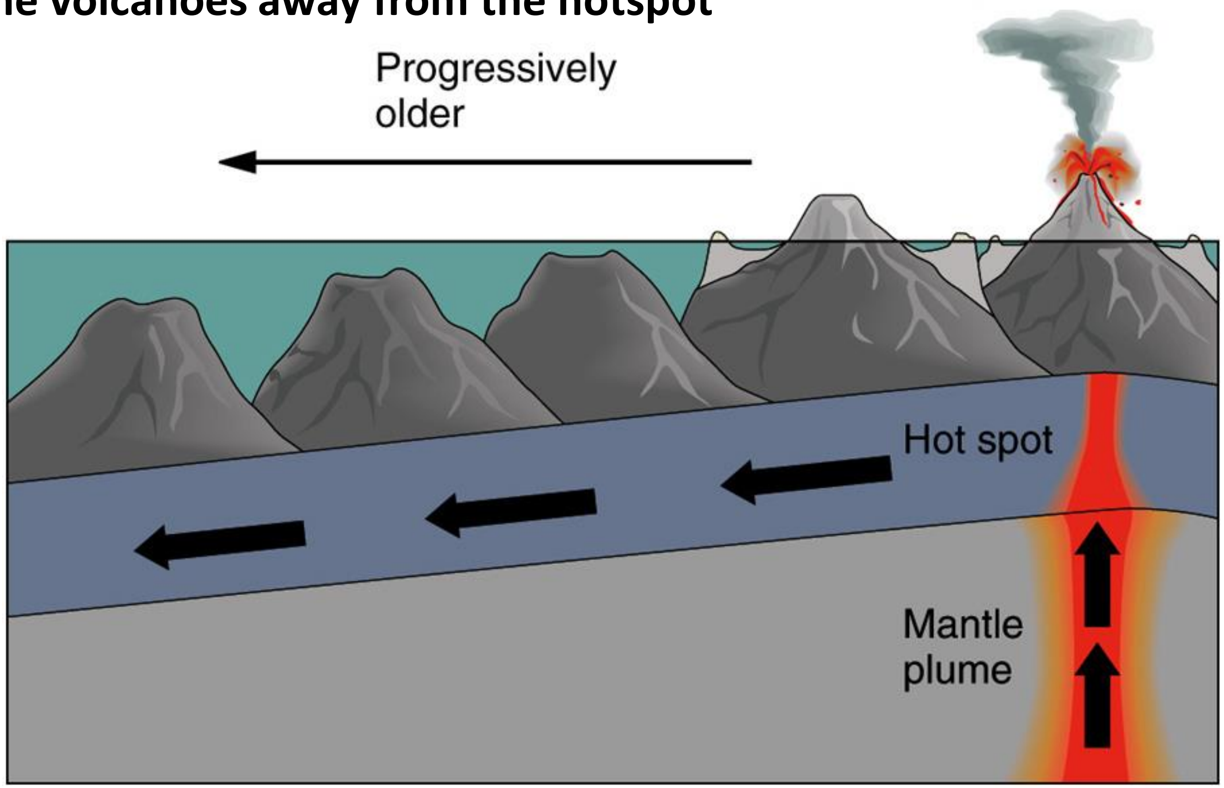
- Here is the thing: for all the seafloor and oceanic crust that disappears during subduction into the mantle, an equal amount of new seafloor and oceanic crust is made somewhere else to replace it. The new seafloor is made far away from the Ring of Fire, in the middle of the Pacific Ocean. !
- The same process happens in the middle of the Atlantic ocean, where the ridge is called the 'mid-Atlantic ridge'. the seafloor is destroyed at subduction zones, but it is simultaneously being created at mid-ocean ridges.

3. AT A HOTSPOT

- Over hot spots - an area of volcanic activity that results from a plume of hot solid material that has risen from deep within Earth's mantle. Hot spots are usually found under oceanic crust, but can be located under continental crust. Hot spots are found in the ocean, and on continents.
- There are a number of volcanoes that sit in the middle of plates. These volcanoes have formed above a hot spot - a single plume of hot mantle rising from deep within the Earth. Hot material that arise in the deep mantle and punch through the mobile, convecting, shallow mantle to reach the surface
- An increase in temperature can cause materials to melt. Often the hot spot creates a chain of volcanoes, as a plate moves across a relatively stationary mantle plume.
- The best example of a hot spot volcanic chain is the Hawaiian Islands in the Pacific ocean. From the volcanic track left by the moving plate we can tell the direction of motion of the plate (to the NW) and the rate at which it moves (8.6 cm/year). Currently the hot spot lies beneath the Big Island of Hawaii.
- Hotspot under the Big Island (making it the youngest of the Hawaiian Island) appears to have been there for 70+ million years, but as the plate slowly moves, a new island will be created. Indeed, it is in the process of being created now.
- The submarine volcano Lo'ihi (meaning long one), lies off the southeast coast of Hawai'i. It is known as submarine volcano as the summit of Lo'ihi is below sea level.
- The islands and seamounts (submarine mountains) exhibit age progression, with the oldest Hawaiian island is Kauai (approx. 5 million years old) of the eight main island near the Aleutian Trench.

No need to mug up data

Plate carries the volcanoes away from the hotspot



- A volcano above a hotspot does not erupt forever. Attached to the tectonic plate below, the volcano moves and is eventually cut off from the hotspot (plate moves overhead relative to the fixed plume source).
- Without any source of heat, the volcano becomes extinct and cools. This cooling causes the rock of the volcano and the tectonic plate to become denser. Over time, the dense rock sinks and erodes.
- A new and active volcano develops over the hotspot creating a continuous cycle of volcanism, forming a volcanic arc that parallels plate motion.

- Mantle plumes appear to be largely unaffected by plate motions. While a plume that feeds hot spot volcanoes remains stationary relative to the mantle, the plate above it usually moves. The result is that a chain of progressively older volcanoes are created on the overlying plate.
- The largest active volcano on earth is Mauna Loa on Hawaii Big Island, with 33 well-documented eruptions in historic times since 1843.
- Other hotspots with time-progressive volcanic chains – e.g., include Réunion (believed to have been active for over 66 million years, produced the Deccan Traps about 66 million years ago), the Chagos-Laccadive Ridge (Lakshadweep is a part of this ridge), the Yellowstone etc.
- Some hotspots are not time-progressive volcanic trails, e.g., Iceland, the Galapagos etc.

Iceland is a volcanic hotspot, because

- Iceland formed by the coincidence of the spreading boundary of the North American tectonic plate and Eurasian tectonic plate
- and a hotspot or mantle plume (an upsurge of abnormally hot rock in the Earth´s mantle). As the plates moved apart, excessive eruptions of lava constructed volcanoes and filled rift valleys.

- Hotspot volcanoes do not grow very large, because, the lithosphere moves while the hotspot stays in one place.
- Hotspots are found within continents, but not as commonly as within oceans. They are not common because it takes a massive mantle plume to penetrate the thick continental crust.x

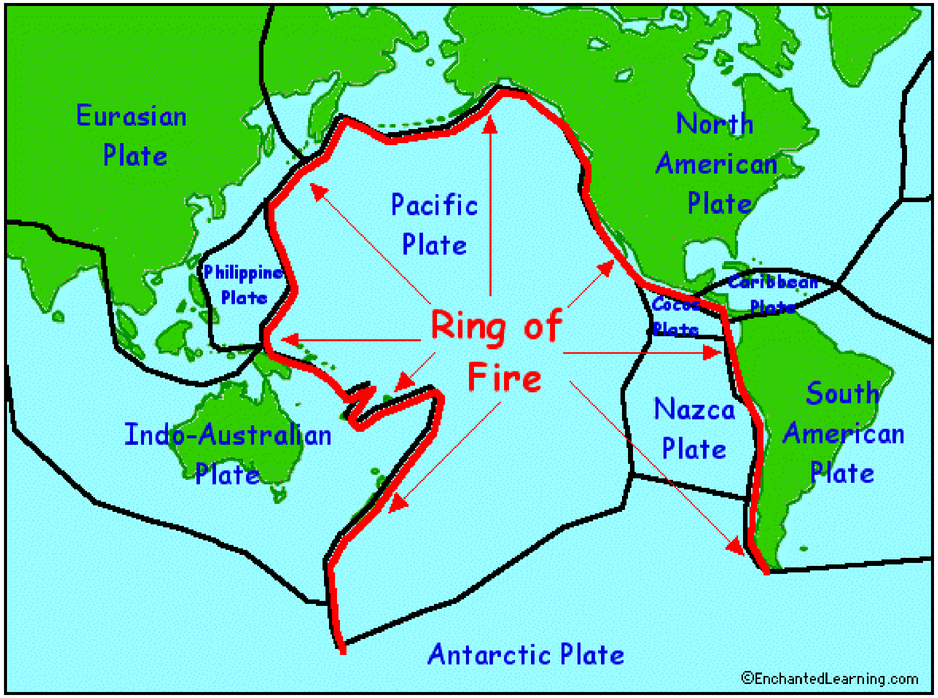
The Pacific 'Ring of Fire'

– Plate boundaries are found all around the Pacific basin—primarily subduction zones.

– Along these plate boundaries many volcanoes have formed giving this region the name the Pacific Ring of Fire

– More than half of all the world's volcanoes are found in the Pacific "Ring of Fire". This area forms a circle stretching down the eastern side of the Pacific Ocean, from Alaska in the north, through the Rocky Mountains of Canada and the USA, to the Andes mountains of South America. It loops back around the western side of the Pacific, up through New Zealand, Indonesia and Japan.

– e.g. include, Cotopaxi in Ecuador, which last erupted in 1928; Mt. St Helens in the USA, which erupted in 1980; and Krakatoa in Indonesia, erupted in 1883.



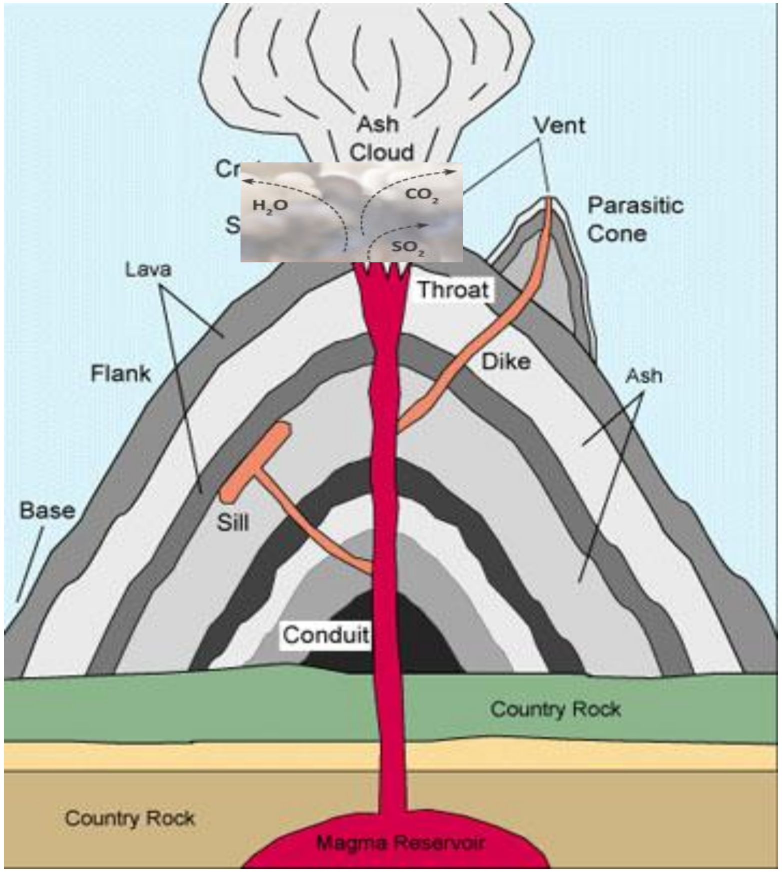
Eruption mechanisms - How a Volcano Erupts

- Volcanos can be either creators or destroyers. They can be mountains or hills, with a crater or vent where lava, molten rock, hot vapor, and gas erupt from within the earth.
- Volcanoes are driven by pressure and heat in the mantle, as well as tectonic activity that leads to volcanic eruptions.
- Beneath the Earth's crust, in the mantle region (solid body of rock), when rock from the mantle melts, moves to the surface through the crust, and releases pent-up gases, volcanoes erupt.
- Extremely high temperature and pressure cause the rock to melt and become liquid rock. Pressures increase considerably and temperatures can reach up to 1000 °C, which makes the rock viscous enough that it behaves like a liquid rock or magma.
- When it's beneath the surface, the molten rock is called magma. It experiences elastically on time scales of thousands of years or greater. This viscous, molten rock collects into vast chambers beneath the Earth's crust.
- Since this magma is less dense than the surrounding rock, it " floats" up to the surface, seeking out cracks and weaknesses in the mantle. When a large body of magma has formed, it rises through the denser rock layers toward Earth's surface. Magma that has reached the surface is called lava.
- When it finally reaches the surface, it explodes from the summit of a volcano, it erupts as lava, ash and volcanic rocks. With each eruption, rocks, lava and ash build up around the volcanic vent.

No need to mug up line by line, but for your understanding

Inside volcanoes, magma often has dissolved gases as a function of the very high pressures and chemistry of the magma. Much in the same way you open a carbonated drink – when you take the lid off, the bubbles burst out – when magma erupts as lava, the pressure is relieved and the gases exsolve. In explosive eruptions, this phenomena is so strong that it fragments the lava, violently ejecting it, along with anything caught along.

In the case of the convergent boundaries (oceanic-oceanic/oceanic-continental), subduction zones are often the result, where the heavier plate slips under the lighter plate – forming a deep trench. This subduction changes the dense mantle into buoyant magma, which rises through the crust to the Earth's surface. Over millions of years, this rising magma creates a series of active volcanoes known as a volcanic arc.



No need to mug up line by line, but for your understanding

Magma Chemistry and Styles of Eruption - Eruption products take 3 forms

– Chemistry of magma largely determines nature of eruption.

– Critical component appears to be relative amount of silica (SiO_2).

- Silica is the main ingredient in magma because, most rock forming-minerals are silicates
- Greater amounts of silica = High viscosity/resist flow (thick, gooey… syrupy)

  Type of eruption = explosive (because thick magma can clog a volcanic pipe, causing enormous pressure to build up. When the volcano finally explodes, lava and hot gasses are hurled outward.
- Lower amounts of silica = low viscosity/flow easily (thin, runny…. Like water)

  Type of eruption = gentle, flowing ("flood-like", "fountain-like").

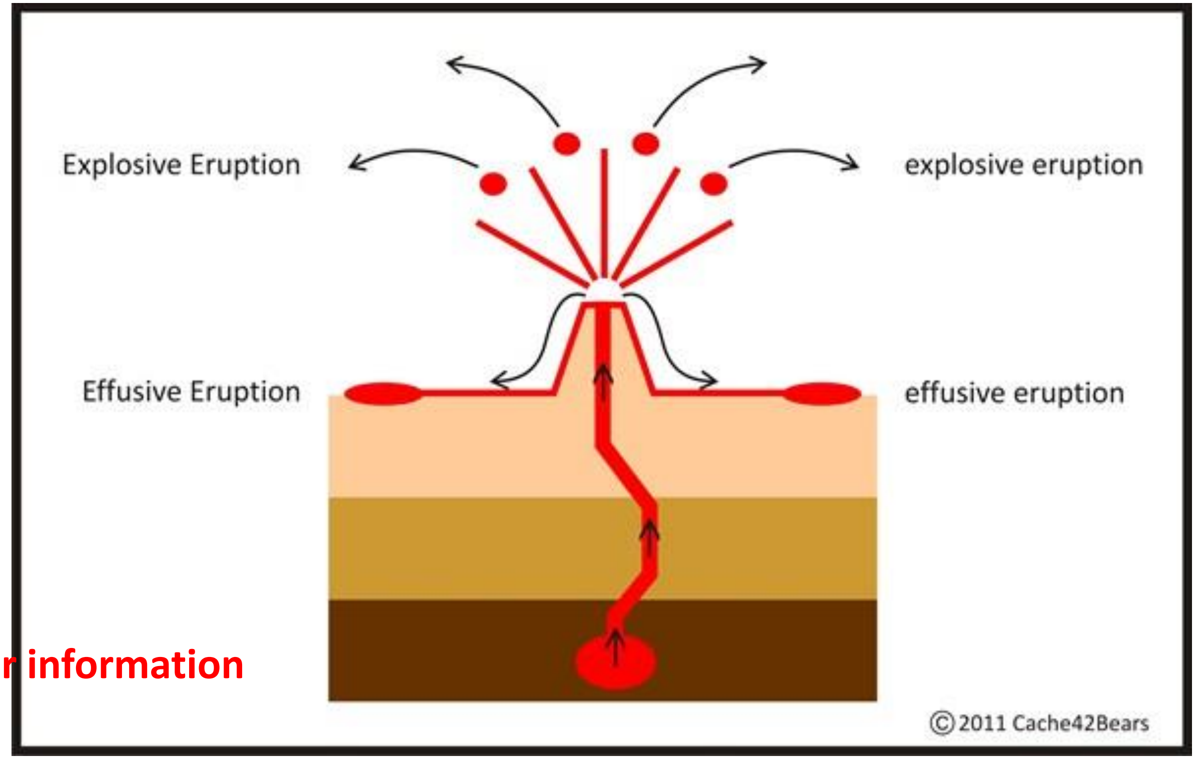
	Basic (Basaltic) magma	Andesitic Magma	**Acid (rhyolitic/silicic) magma**
Silica content	Least (about 50%)	Intermediate (about 60%)	Most (about 70%)
Gas content	Least	Intermediate	Most
Viscosity	Least viscous	Intermediate	Most viscous
Type of eruption	Rarely explosive	Sometimes explosive	Usually explosive
Melting temperature	Highest	Intermediate	Lowest
Location	Rifts, oceanic hot spots	Subduction boundaries	Continental hot spots
	- spread over a great distance **- Shield volcanoes, eg - Hawaii**	**Composite volcanoes**	**- eg - Yellowstone**

Q. What are the top 2 compositions of magma?

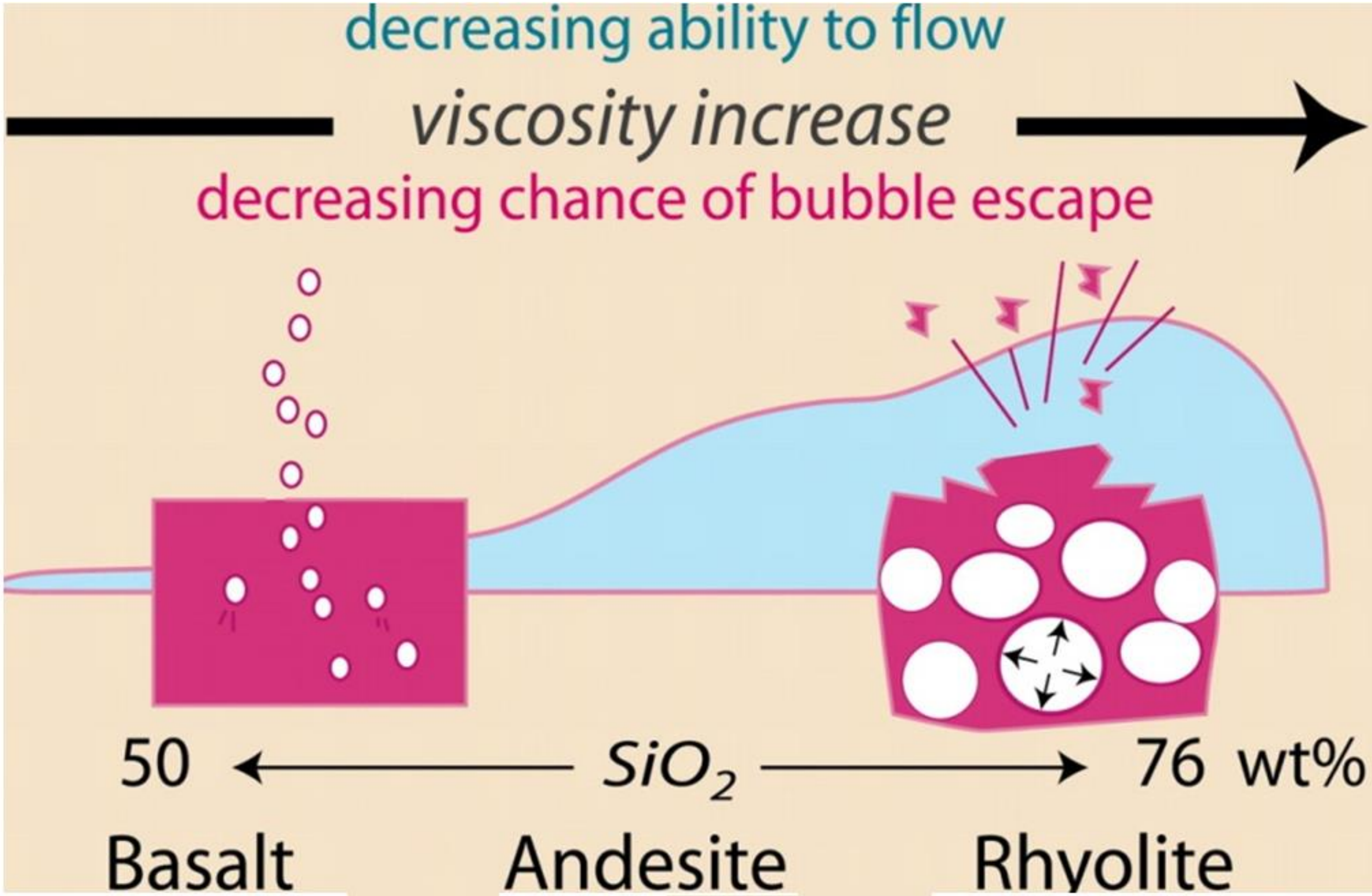
Oxygen, the most abundant element in magma, comprises a little less than half the total, followed by silicon at just over one-quarter. The remaining elements make up the other one-quarter. Magmas derived from crustal material are dominated by oxygen, silicon, aluminum, sodium, and potassium.

What is the composition of magma and how is it formed?

Magma is a molten and semi-molten rock mixture found under the surface of the Earth. This mixture is usually made up of four parts: a hot liquid base, called the melt; minerals crystallized by the melt; solid rocks incorporated into the melt from the surrounding confines; and dissolved gases



Only for your information



Long distance flow
(up to 100s km)

They mound near
vent, flow slowly

Rhyolitic lava rarely flows,
Plugs vent as a lava dome

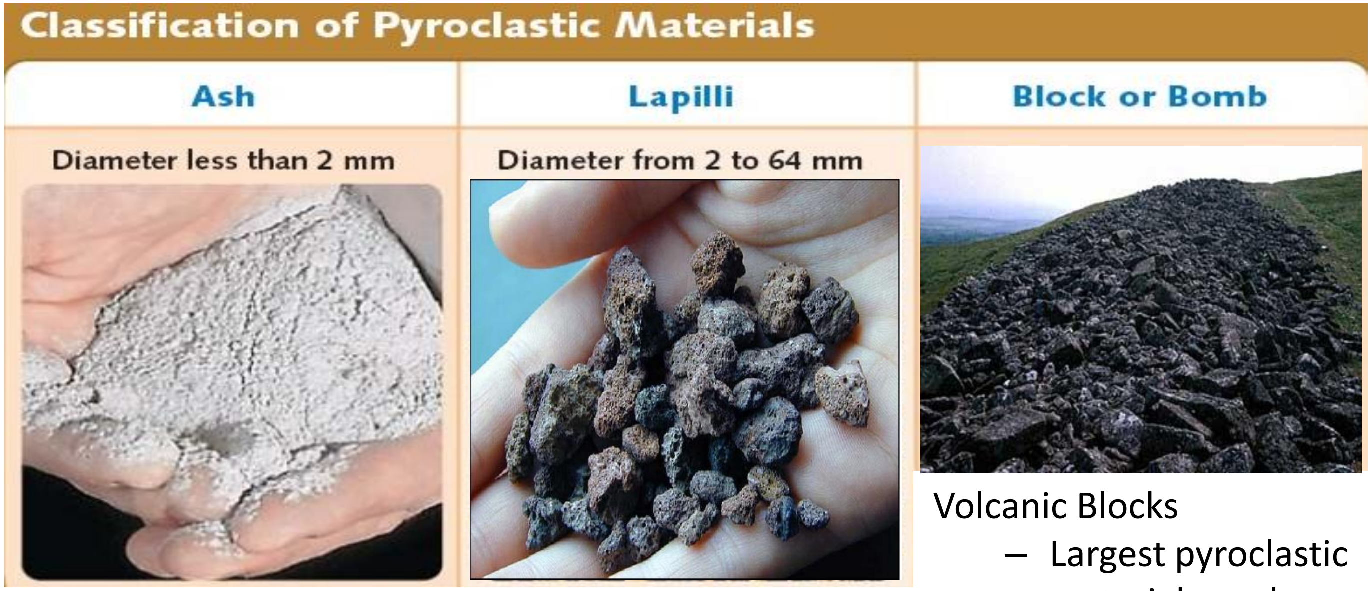
<u>Only for your understanding</u>

Volcanic Material

- Pyroclastic materials - rock fragments, dust, ash & gases that are ejected from a volcano.
- Volcanic gases – vapor and aerosols that exit a volcano
- What is a pyroclastic flow?
  - when pyroclastic materials combine with hot gases - dense, superheated cloud → travels rapidly downhill
  - Volcanic Mudflows (Lahars) —fast moving, and sometimes hot, slurry of mud and boulders; one of most common volcanic hazards.

Explosive eruptions usually involve magmas which contain trapped gases - when gases are released, solid pyroclastic material may be ejected

- Classified by size
- Smallest → ash
- Intermediate → lapilli
- Largest → blocks & bombs



Volcanic Blocks
- Largest pyroclastic material, can be as big as a house!

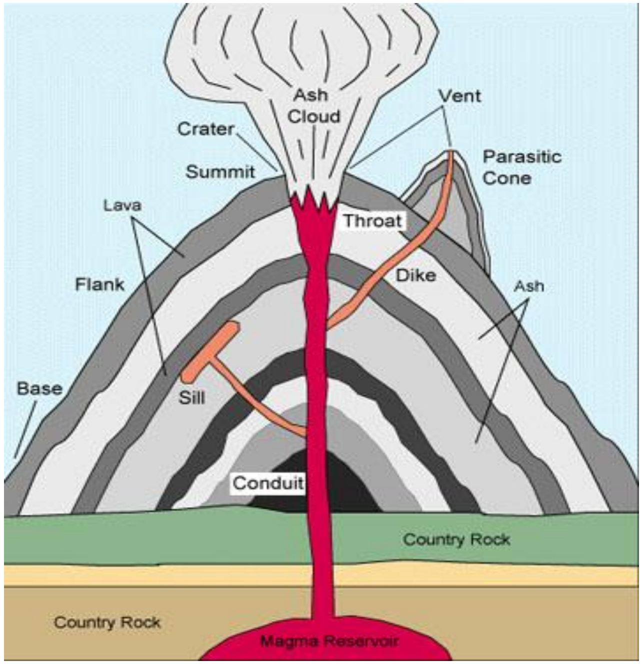
Only for your understanding

Volcanic Architecture

- Volcanoes have characteristic features:
- A magma chamber - is usually located far beneath the surface of the Earth
- Vents - opening in earth's surface where magma flows through
- Fissures - linear crack which lava flows out
- Craters - A crater is a funnel-shaped pit at the top of the volcanic vent. This is where the lava, ash and rock erupt out of a volcano. Craters are usually much smaller than calderas, only extending to a maximum of one kilometer in diameter.
- Calderas - A caldera is a depression created after a volcano releases - gigantic empty chamber underground. Without any structural support below, the land around the erupting volcanic vent (s) collapses inwardly into the empty magma chamber. Volcanic eruptions can create calderas as much as 100 kilometers wide. E.g., Yellowstone National Park is mostly a giant caldera.

It's a caldera.

a small lake at the center of the crater.



- Volcanoes erupt explosively (Mt. St. Helens) or quietly (effusive eruption, e.g., Hawai'i), depending on the characteristics of the magma.
- Effusive eruptions, meanwhile, are characterized by the outpouring of lava without significant explosive eruption.
- Magma varies in viscosity (thickness) based on temperature, water content and silica content

Volcanic Gas

1-10% of magma may be gas.

Water (H_2O)- most abundant gas

Carbon dioxide (CO_2)- second most abundant

Sulfur dioxide (SO_2)- rotten egg smell

Magma composition controls gas content.

Felsic (rholytic) magmas are gas-rich;

Shapes and sizes of volcano

- Volcanoes come in many shapes and sizes, ranging from common cinder cone volcanoes that build up from repeated eruptions and lava domes that pile up over volcanic vents to broad shield volcanoes and composite volcanoes.
- The nature of the eruption depends on the viscosity of the magma. Magma type governs volcano shape & size.
- When the lava flows easily, it can travel far and create wide shield volcanoes.
- When the lava is very thick, it creates a more familiar cone volcano shape (aka. a cinder cone volcano)

Types of volcanoes : size & shape

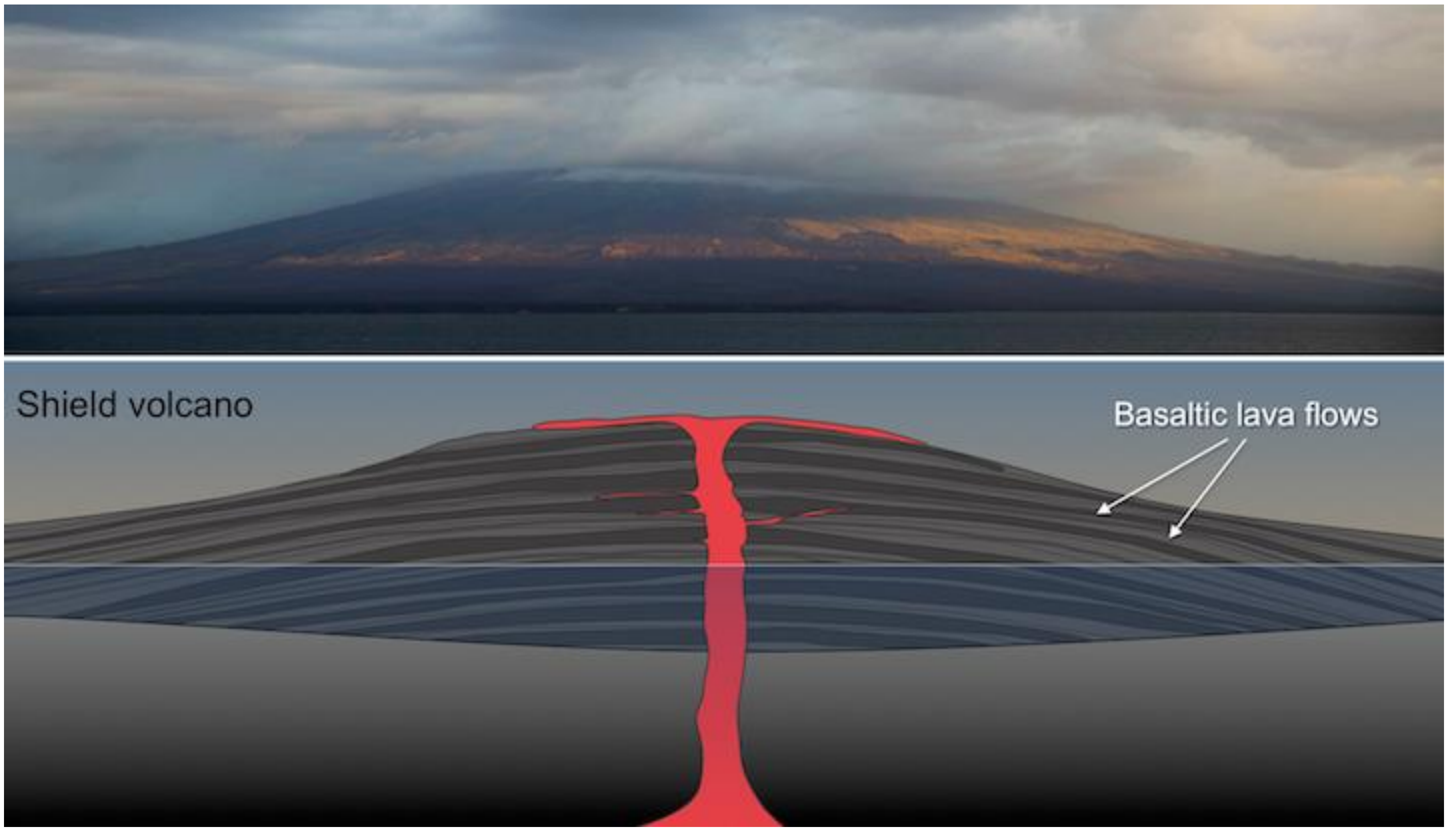
Volcanic Peaks often starts small, can grow into hill or mountain. Most have crater set at apex of cone.

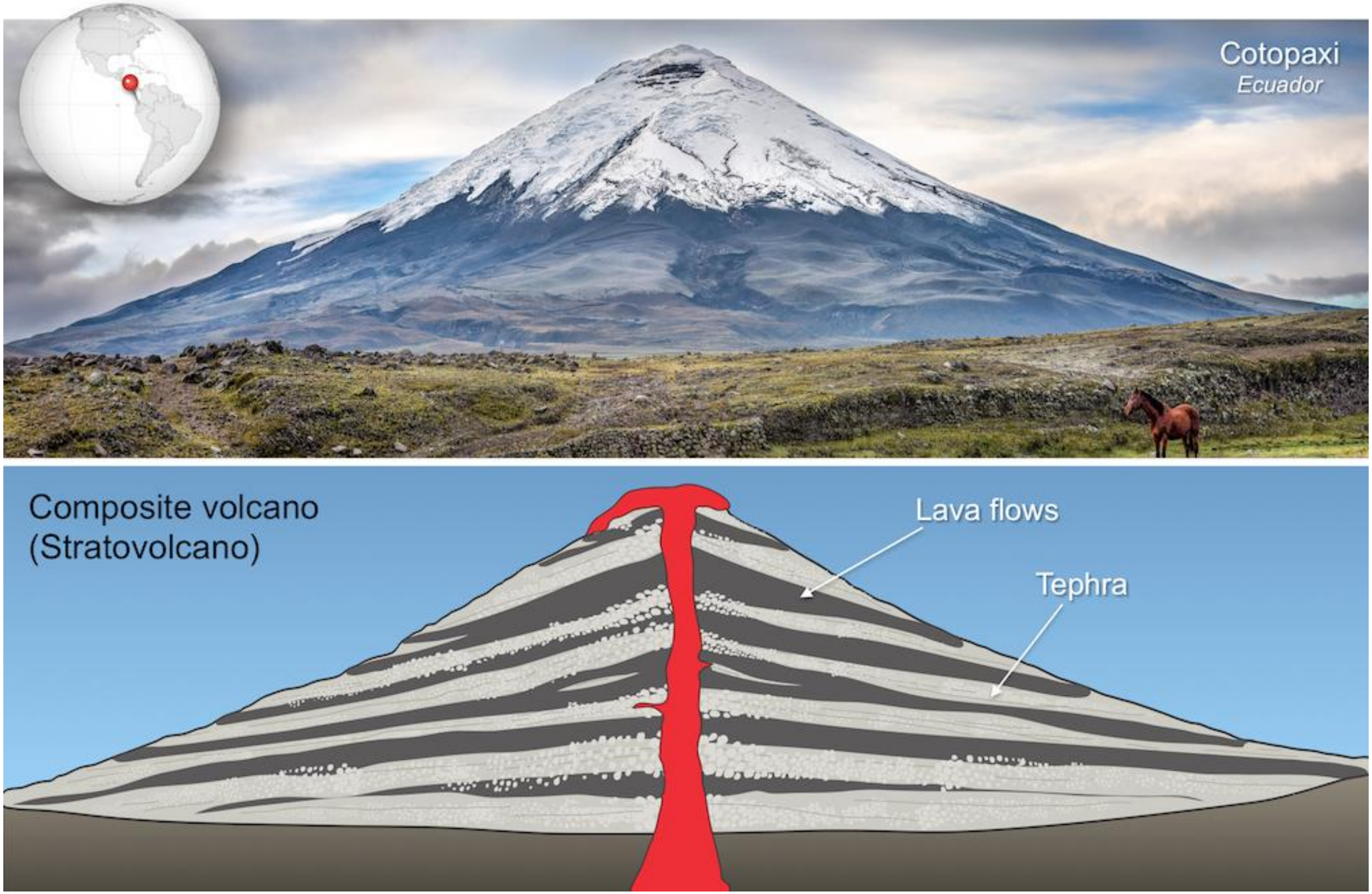
- Shield Volcanoes—never steep-sided, though can be very high (e.g., Hawaiian Islands).

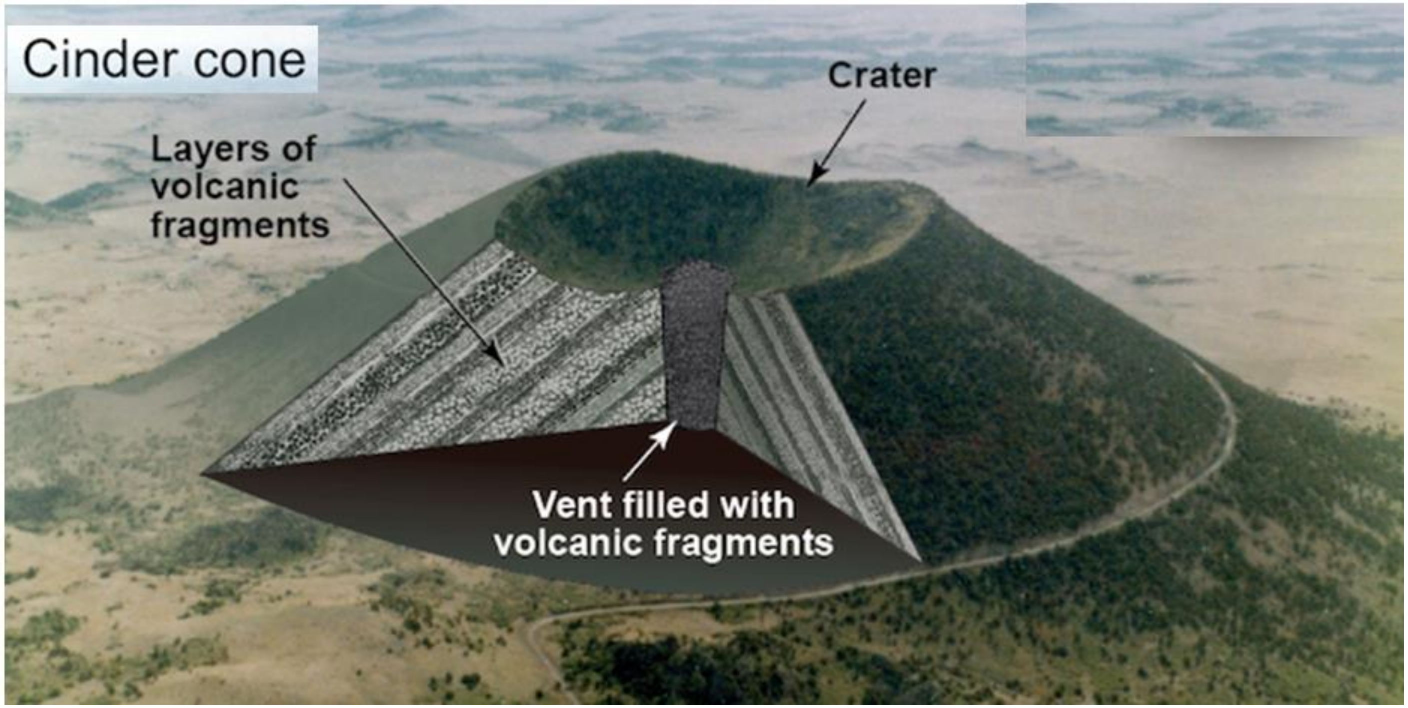
The eruption from a shield volcano is relatively nonviolent because the lavas are fairly fluid (less viscous). The slope of a shield volcano is less than 10°. quiet eruptions where lava slowly flows out.

- Composite Volcanoes—steep-sided, large, symmetrical cones (e.g., Mt. Fuji, Japan, Mt. St. Helen, Mt Vesuvius, Mt. Pinatubo). Composite volcanoes (aka Stratovolcanoes) are constructed of alternating layers of pyroclastics and rock solidified from lava flow with slopes between those of cinder cones and shield volcanoes.
- Cinder Cones—smallest of volcanic mountains (e.g., Sunset Crater in Arizona). Cinder cones are constructed of loose rock fragments ejected from a central vent. Most of the ejecta lands near the vent to form a cone with a slope of up to 30°. Highly erodible slopes (loose pyroclasts) and found in association with other volcanoes

1. shield volcanoes- largest
2. cinder cones- smallest
3. stratovolcanoes- intermediate


Shield volcano
Basaltic lava flows


Cotopaxi
Ecuador
Composite volcano
(Stratovolcano)
Lava flows
Tephra


Cinder cone
Crater
Layers of volcanic fragments
Vent filled with volcanic fragments

Volcanoes in history

- Dinosaurs went extinct about 65 million years ago during 5th Mass extinction at the end of Cretaceous Period. Some group of Scientists think that Deccan volcanic traps are more likely the culprit for the Cretaceous extinction. Gases erupted from the volcanoes blocked sunlight for years – plants died and death cascaded through out the food-chain. Long lasting cooling and lack of food led to the death of the dinosaurs.
- A.D. 79: One of the most famous volcanoes is Mount Vesuvius, which sits along the Bay of Naples in southern Italy. The A.D. 79 eruption, which buried Pompeii, made Vesuvius famous
- 1815: Eruption of Mount Tambora, in Indonesia - The volcano sent a cloud ejecta into the atmosphere leading to the “Year Without a Summer" of 1816 in Europe and North America. All vegetation on Sumbawa was destroyed. Later on, ash flows, tsunamis, and starvation led to the deaths of thousands of people. The world got colder, and the weather systems changed completely for three years. And so there was widespread crop failure and starvation all from Asia to the United States to Europe.”
- 1980: Mount St. Helens in Washington state.
- 1883: Another Indonesian volcano, Krakatoa.
- 1991: After 600 years of dormancy, Mount Pinatubo in the Philippines rumbled for days before erupting and killing many people. This dust cloud temporarily lowered the global temperature as we were talking about almost like in 1 degree and then Mount Pinatubo eruption was the 2nd largest in 20th century.

Predicting Volcanoes

- Predicting exactly when a volcano will erupt is next to impossible.
- Scientists can not stop a volcano from erupting but with constant monitoring they can warn and evacuate people and save lives.
- Today geologists are becoming much more accurate in making the public aware that a volcano is showing signs that it may erupt in the near future.
- Seismographs : In the months before Mt. St. Helens erupted geologists knew the mountain was getting restless. A magnitude 4.1 earthquake was recorded about 2 months before the large eruption. Many shallow earthquakes were recorded over the next seven weeks.
- Magma moving higher and higher inside the mountain was causing these earthquakes. As the magma rose it formed a large bulge. This bulge was growing daily and the geologists knew that an eruption was soon to be.
- What the authorities did was evacuate most of the people in and near the mountain. Some decided to stay.

- Geologists study a tilt meter. A tilt meter is used to measure the growth of the lavadome in the foreground. The tiltmeter will show a different angle as the dome grows. With careful study the geologists can tell if magma is on the rise and that an eruption may occur in the near future.
- Because of technological advances, we're able to more accurately predict when volcanic eruptions will occur in time for evacuations and safety measures, like when flights are canceled in anticipation of eruptions.

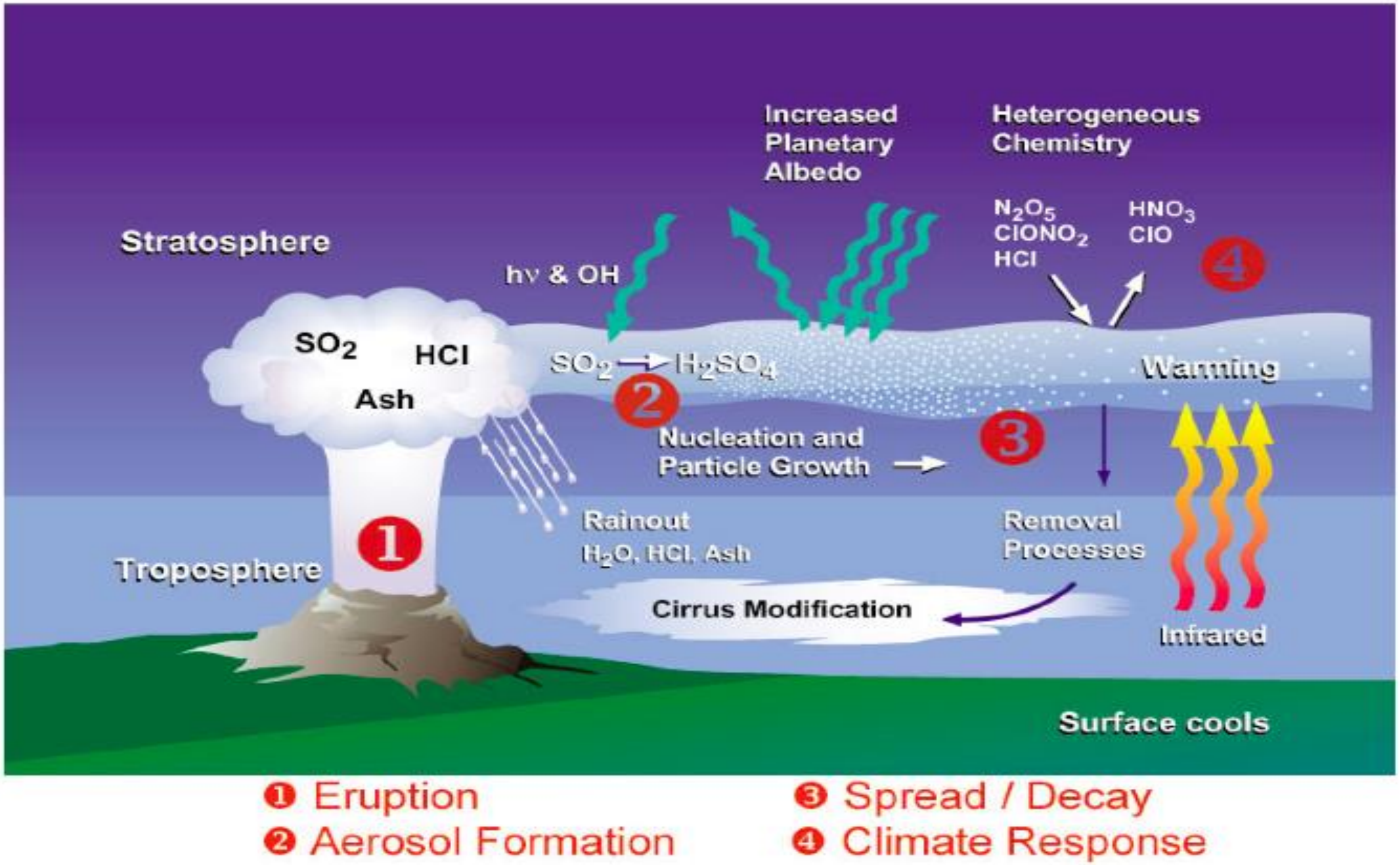
Only for your information

Effects of Volcanic eruptions

Volcanic eruptions can cause loss of life and livelihoods in exposed communities, damage critical infrastructure, displace populations, disrupt business and add stress to already fragile environments. Currently, an estimated 800 million people live within 100 km of a volcano that has the potential to erupt.

Volcanic eruptions are almost always preceded by 'unrest' including volcanic earthquakes and ground movements which can in themselves be hazardous. Volcanic earthquakes are typically small in magnitude (≤M5) and relatively shallow, but they may be felt and may cause structural damage.

- ❑ Volcanoes near the equator can cause global weather changes if their eruptions are powerful enough to release gases into the stratosphere.
- ❑ In the 1991 eruption of Pinatubo about many people died from roof collapse during the eruption.
- ❑ Volcanic ashes can often contain minerals that are beneficial to plants and is readily released on contact with water or body fluids. This can lead to both beneficial effects (such as the addition of agronomically-useful quantities of plant growth nutrients to pastoral systems); and harmful effects (such as fluorine toxicity to livestock).
- ❑ The prevalence of volcanic eruptions also has a profound impact on the local climate and geography in certain regions of the world – such as the Pacific Ring of Fire. Such regions are generally mountainous, have rich soil, and periodically experience the formation of new landmasses.
- ❑ Famines have occurred following some major eruptions due to destruction of food supplies due to ash fall.



Schematic of the events and processes beginning with a volcanic eruption and leading to the climate/atmospheric response.

- Destruction or damage to assets (e.g. buildings, bridges, electrical lines and power stations, potable water systems, sewer systems, agricultural land etc. can get covered with ash).
- The main effect on weather right near a volcano is that there is often a lot of rain, lightning, and
thunder during an eruption. This is because all the ash particles that are thrown up into the atmosphere are good at attracting water droplets.
- If the ash fall is really heavy it can make it impossible to breathe. Inhalation of fine ash may trigger asthma and other acute respiratory diseases, although these effects are inconsistent between different eruptions.

Volcanic gases and aerosols.

- Volcanic gases can directly cause fatalities, health impacts and damage to vegetation and property. The impact of volcanic gases on people depends on the concentrations present in the atmosphere and the duration of exposure.
- Although the main component of gases released during most eruptions is water vapour, there are many other gas species and aerosols released, including carbon dioxide, sulfur dioxide, hydrogen sulphide and halogens (hydrogen fluoride and chloride).
- Volcanic gases emitted by a volcano may combine with rainfall to produce acid rain, which damages sensitive vegetation and ecosystems.
- Fluorine- and chlorine-bearing gases can also be hazardous and may adhere to the surfaces of erupting volcanic ash which subsequently falls to the ground. If people and/or animals consume affected water, soil, vegetation or crops they can be affected by fluoride poisoning.

“Volcanism is a very important part in the evolution of life",

- Caused all the 5 extinctions – the last one results in the extinction of dinosaur era 65 million years ago after living on Earth for about 165 million years.
- And not just the dinosaurs; about 75% of all plants and animals went extinct.
- the eruption could have produced on the order of 30 billion pounds of sulfur dioxide and 9 billion pounds of hydrogen chloride for each cubic mile of lava.
- Tiny droplets of "sulfuric acid" formed high up in the air which blocked sunlight for several years and had a profound influence on life.
- Plants died and death cascaded through out the food chain. the droplets of sulfuric acid resulted in a long-lasting cooling, which was the most likely event that led to the death of the dinosaurs. The result was that the earth became very cold. Global annual mean surface air temperatures dropped by at least 26 degrees Celsius.

An active vs dormant volcano

- A volcano is active if it erupts lava, releases gas or shows seismic activity.
- It is dormant if it hasn't erupted for a long time but could again one day. Mt. St. Helens had been dormant for one hundred twenty-three years before it erupted in 1980
- An extinct volcano will never erupt again.

Active volcanoes— those that have erupted at least once in recorded history.

– U.S. has 10% of about 550 active volcanoes in world.

– Pacific Ring of Fire or Andesite Line has some 80% of world’s volcanoes.

- Mount Vesuvius is an active volcano in Italy, It is the only volcano on the European mainland to have erupted in the last 100 years. It is not currently erupting. It is dormant, not extinct

How was the Deccan plateau formed?

It was formed by volcanic activity that lasted millions of years, causing the deposition of lava. After the volcanoes became extinct, the layers of lava transformed into a region of highland known as the Deccan plateau. The solid rocks formed by the lava are called igneous rocks. Continuous weathering and erosion of these rocks formed the black soil.

Is Deccan plateau a hotspot?

The Deccan volcanic province (DVP) formed during India's northward migration as it passed over the Reunion hotspot (which is today the Reunion Island). About 66-68 million years ago (near the end of the Cretaceous,) present-day India was above the hot spot and great volumes of basaltic lava erupted to produce the Deccan Traps.

As the plate moved northeast over the hot spot more volcanic centers formed: the Maldives, the Mauritus Islands are among the prime examples.

Which is India's only active volcano?

Barren Island

Barren Island is an island located in the Andaman Sea. It is the only confirmed active volcano in the Indian subcontinent, and the only active volcano along a chain of volcanoes from Sumatra to Myanmar.

When was the last volcanic eruption in India?

The volcano on Barren Island erupted on August 24, 2005.

EARTHQUAKE

Earthquake

- ❑ Earthquake is one of the most destructive natural hazard. They may occur at any time of the year, day or night, with sudden impact and little warning.
- ❑ They can destroy buildings and infrastructure in seconds, killing or injuring the inhabitants. Earthquakes not only destroy the entire habitation but may de-stabilize the govt, economy and social structure of the country.
- ❑ But what is an earthquake? It is the sudden shaking of the earth crust. The impact of an earthquake is sudden and there is hardly any warning, making it impossible to predict.

- IT IS CAUSED DUE TO RELESE OF ENERGY WHICH GENERATES WAVES THAT TRAVELS IN ALL DIRECTIONS
- Caused by most commonly, by movement of the tectonic plates across a fault, other causes involves volcanic activity, meteorite impacts, undersea landslides, explosions of nuclear bombs

❑ OF COURSE, IT IS NOW KNOWN THAT AN EARTHQUAKE IS CAUSED BY A SLIP ON A FAULT. Fault means A FRACTURE BETWEEN TWO LARGE BLOCKS OF ROCK IN The Earth across which the two sides move relative to each other

❑SUCH FAULTS CAN EXTEND FROM A FEW CENTIMETERS TO THOUSANDS OF KILOMETERS.

Earthquakes can be of three types based on the focal depth:

- ♦ Deep:- 300 to 700 kms from the earth surface
- ♦ Medium:- 60 to 300 kms
- ♦ Shallow: less than 60 kms

The deep focus earthquakes are rarely destructive because by the time the waves reach the surface the impact reduces. Shallow focus earthquakes are more common and are extremely damaging because of their proximity to the surface.

No need to memorize line by line, for your understanding

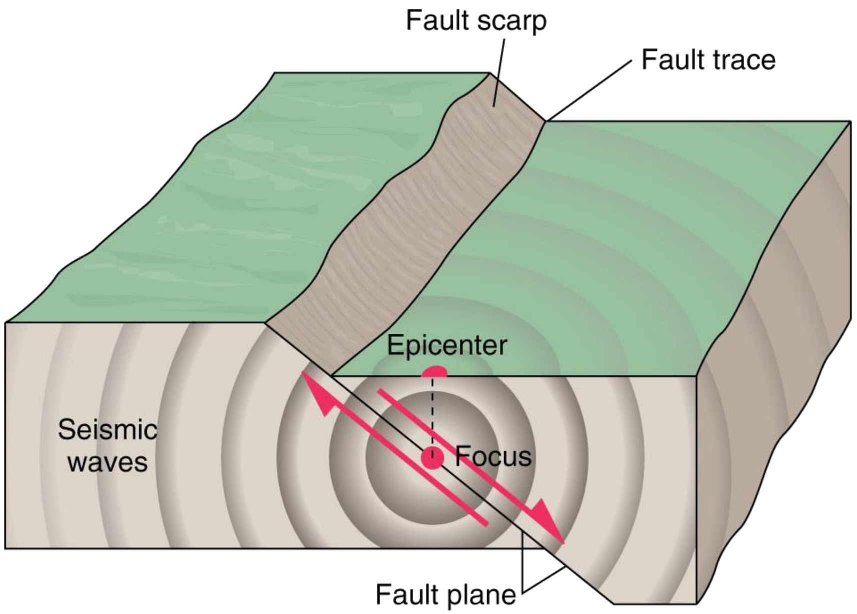
- The crust is not one piece but consists of portions called ‘plates’ which vary in size from a few hundred to thousands of kilometers under the sea to 65 kilometers under the continents.
- TWO BLOCKS OF ROCK MOVE RELATIVE TO EACH OTHER, EITHER SLOWLY, OVER GEOLOGIC TIMES; OR SUDDENLY, WHICH RESULTS IN AN EARTHQUAKE.
- The ‘theory of plate tectonics’ holds that the plates ride up on the more mobile mantle, and are driven by some yet unconfirmed mechanisms, perhaps thermal convection currents. When these plates contact each other, stress arises in the crust.
- The areas of stress at plate boundaries which release accumulated energy by slipping or rupturing are known as *'faults’*.
- SOME OF THE MOST "FAMOUS" FAULTS ACROSS THE WORLD INCLUDE THE CALIFORNIAN SAN ANDREAS FAULT
- THE FAULT LINES EXISTS NEAR PLATES BOUNDARIES, THEY ARE VERY LONG AND THEY RUN VERY DEEP.
- ROCKS NEAR A FAULT TEND TO MOVE IN A OPPOSITE DIRECTION THAT CREATES FRICTION. BUT IN SOME POINT OF TIME, THE MOVEMENT OVERCOME THE FRICTION
- AS A RESULT, THEY SLIDE PAST TO ONE ANOTHER. THIS CAUSES A RESEASE OF ENERGY from the focus in all directions AND THE ENERGY WAVES TRAVEL IN ALL DIRECTIONS

The point of rupture is called the *'focus'* and may be located near the surface or deep below it. The point on the surface directly above the focus is termed as the *'epicenter'* of the earthquake, WHERE THE STRONGEST SHOCKS AND GREATEST CRUSTAL VIBRATIONS ARE OFTEN FELT.

Definition of plates, fault, focus, epicenter - imp

Anatomy of an earthquake

1. focus
2. epicenter
3. slip
4. seismic waves



- There are two major regions of earthquake activity.
- One is the *circum-Pacific belt* which encircles the Pacific Ocean, and the other is the *Alpide belt* which slices through Europe and Asia.
- The circum-Pacific belt includes the West coasts of North America and South America, Japan, and the Phillipines.

Distribution pattern of Earthquakes in India

- India falls quite prominently on the 'Alpine - Himalayan Belt'. This belt is the line along which the Indian plate meets the Eurasian plate.
- This being a convergent plate, the Indian plate is thrusting underneath the Eurasian plate at a speed of 5 cm per year. The movement gives rise to tremendous stress which keeps accumulating in the rocks and is released from time to time in the form of earthquakes.

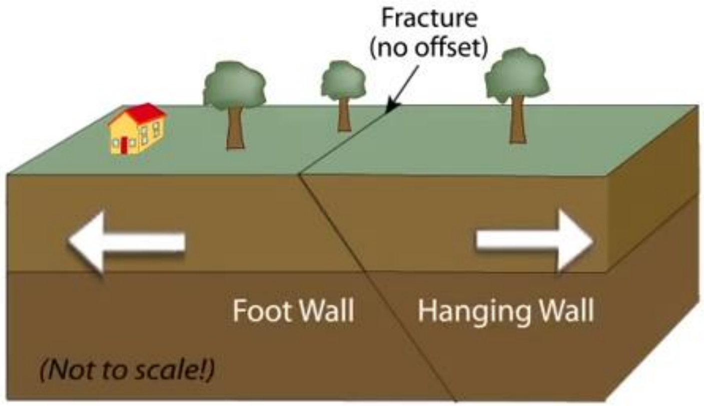
- Dip-slip Fault : A fault in which two fault blocks move past each other vertically.

DIP SLIP FAULTS ARE CLASSIFIED AS NORMAL OR REVERSE

- Normal Fault : A fault in which the hanging wall moves down in relation to the footwall.
- Reverse Fault : A fault in which the hanging wall moves up in relation to the footwall.
- Strike-slip Fault : A fault in which two fault blocks move past each other horizontally. Eg includes San Andreas Fault.

- GEOLOGISTS DEFINE FAULTS A DIP-SLIP FAULT IF THE HANGING WALL MOVES UP OR DOWN THE FAULT SURFACE PARALLEL TO THE DIP DIRECTION
- DIP-SLIP FAULTS ARE DOMINATED BY VERTICAL MOVEMENT
- NORMAL FAULT FORM WHEN THE HANGING WALL MOVES DOWN TO THE FOOT WALL.
- THE FOOT WALL BLOCK IS THE BLOCK WHICH WOULD BE UNDER THE FEET OF A PERSON STANDING IN A TUNNEL ON THE FAULT PLANE. THE HANGING WALL BLOCK WOULD THEN BE HANGING OVERHEAD.
- NORMAL FUALTS FORMED UNDER TENSION WHEN ROCKES MOVE APART OR DIVERGE
- REVERSE FAULTS FORMED WHEN THE HANGING WALL MOVES UP RELATIVE TO THE FOOT WALL
- REVERSES FAULT ARE FORMED UNDER COMPRESSION. WHERE DOMINANT FORCE IS COMPRESSIONAL, REVERSE FAULT OCCUR.
- \- WHEN THE HANGING-WALL BLOCK MOVES UP AND OVER THE FOOTWALL BLOCK – REVERSE SLIP ON A GENTLY INCLINED PLANE IS REFERRED TO AS THRUST FAULTING.

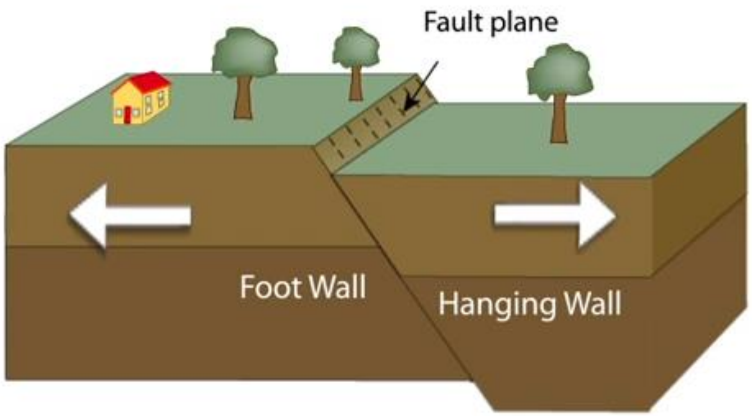
Dip-slip Fault Movement



Arrows show direction of forces

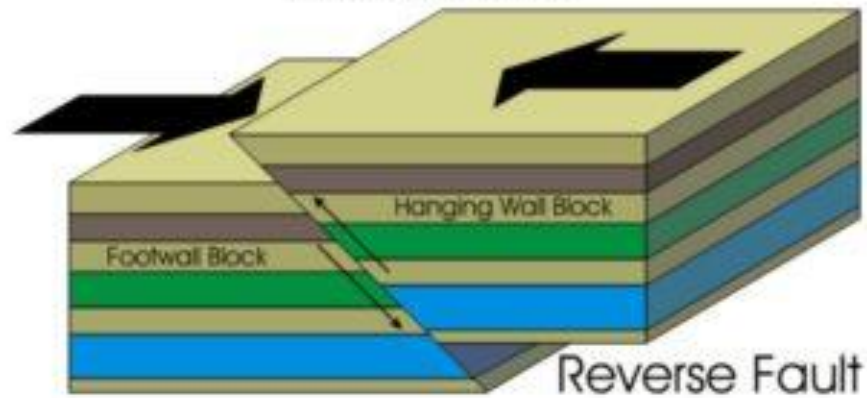
- Normal, or Dip-slip, faults are inclined fractures where the blocks have mostly shifted vertically.
- If the rock mass above an inclined fault moves down, the fault is termed normal fault
- if the rock above the fault moves up, the fault is termed a Reverse fault.

Normal Fault



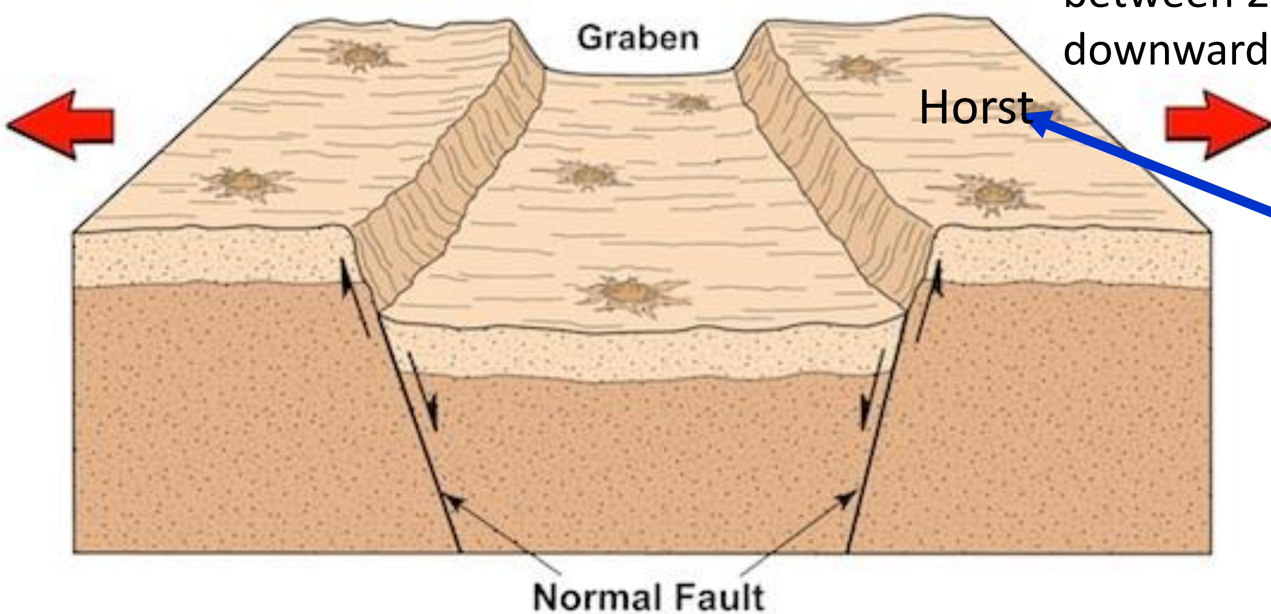
Fault: *Rock fracture between 2 blocks of rock across which there has been movement.*

Reverse fault



Commonly called rift valley

A graben is a piece of Earth's crust between 2 normal faults that is shifted downward



A block that has been relatively uplifted between two normal faults that dip away from each other is called a horst.

Horst and Graben created when the earth's crust is pulled apart.

<u>Horst and Graben</u>

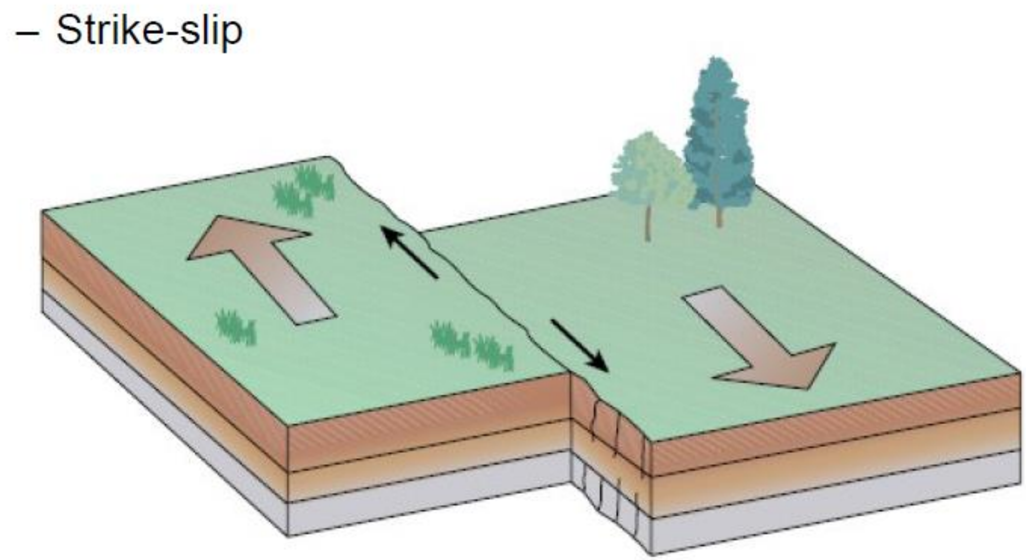
– Horst—an uplifted block of land between two parallel faults.

– Graben—a block of land bounded by parallel faults in which the block has been downthrown, producing a distinctive structural valley with a straight, steep-sided fault scarp on either side.

Rift Valleys—

A downfaulted graben structure extended for extraordinary distances as linear structural valleys enclosed between typically steep fault scarps.

STRIKES SLIP FAULTS (horizontal faults)



- Strike-slip fault - a fault on which the two blocks slide past one another. The San Andreas Fault is an example of a right lateral fault.

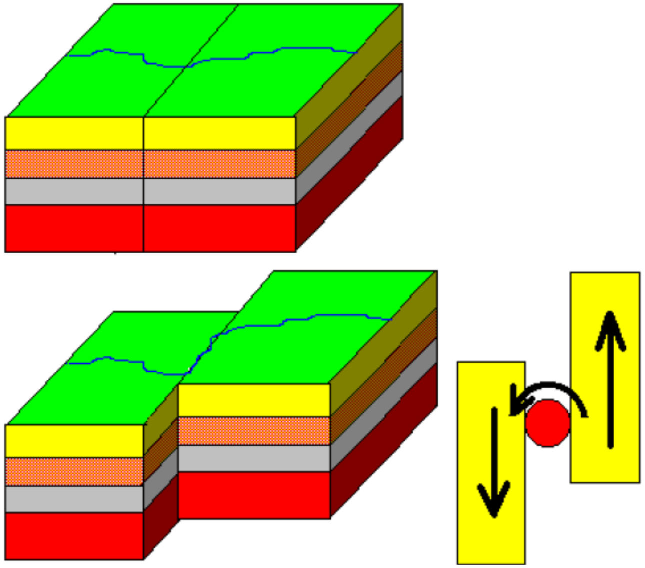
•Where the 2 plates - North American plate and pacific plate – meet, you find the San Andreas fault zone

•Dominated by horizontal movement

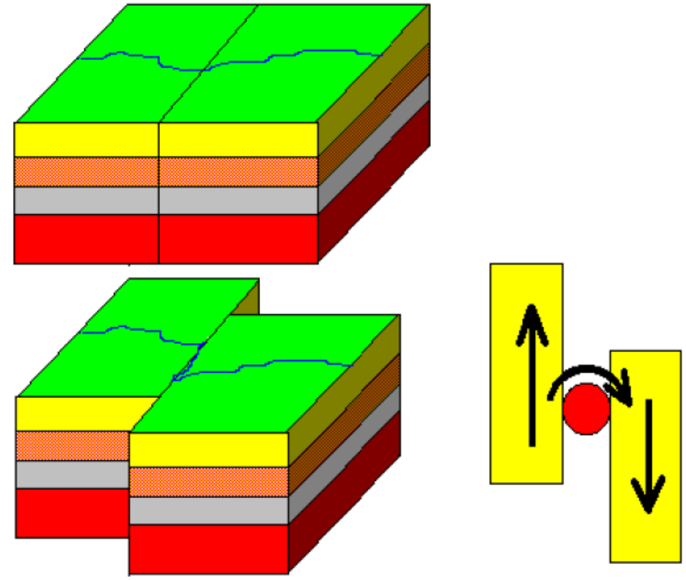
•When straddling a fault, if right-hand side moved towards you, it is a right-lateral fault When straddling a fault, if the left-hand side has moved towards you, it is a left-lateral fault

•Convention works in either direction

Strike-Slip Fault – Left Lateral



Strike-Slip Fault – Right Lateral



WE CAN CLASSIFY STRIKES LOOK FAULTS AS RIGHT OR LEFT LATERAL.

SEISMIC WAVES

- SEISMIC WAVES COME IN TWO CATEGORIES: THOSE THAT CAN PASS THROUGH ENTIRE EARTH (BODY WAVES) AND THOSE THAT MOVE NEAR SURFACE ONLY (SURFACE WAVES)
- BODY WAVES ARE GENERATED DUE TO THE RELEASE OF ENERGY AT THE FOCUS THAT IS THE EPICENTRE AND MOVES IN ALL DIRECTIONS TRAVELLING THROUGH THE BODY OF THE EARTH AND MOVES THE INTERIOR OF THE EARTH.

i. body waves – travels within the body of the Earth, of 2 types

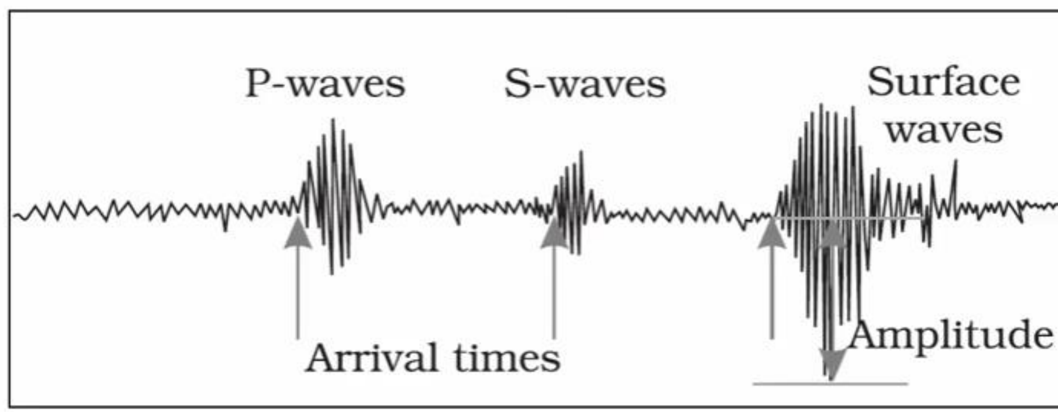
(1) P-waves : causes the ground to expand (to move back & forth)

(2) S-waves : shake the ground in a shearing or cross wise motion that is perpendicular to the direction of travel (up & down movement)

ii. surface waves

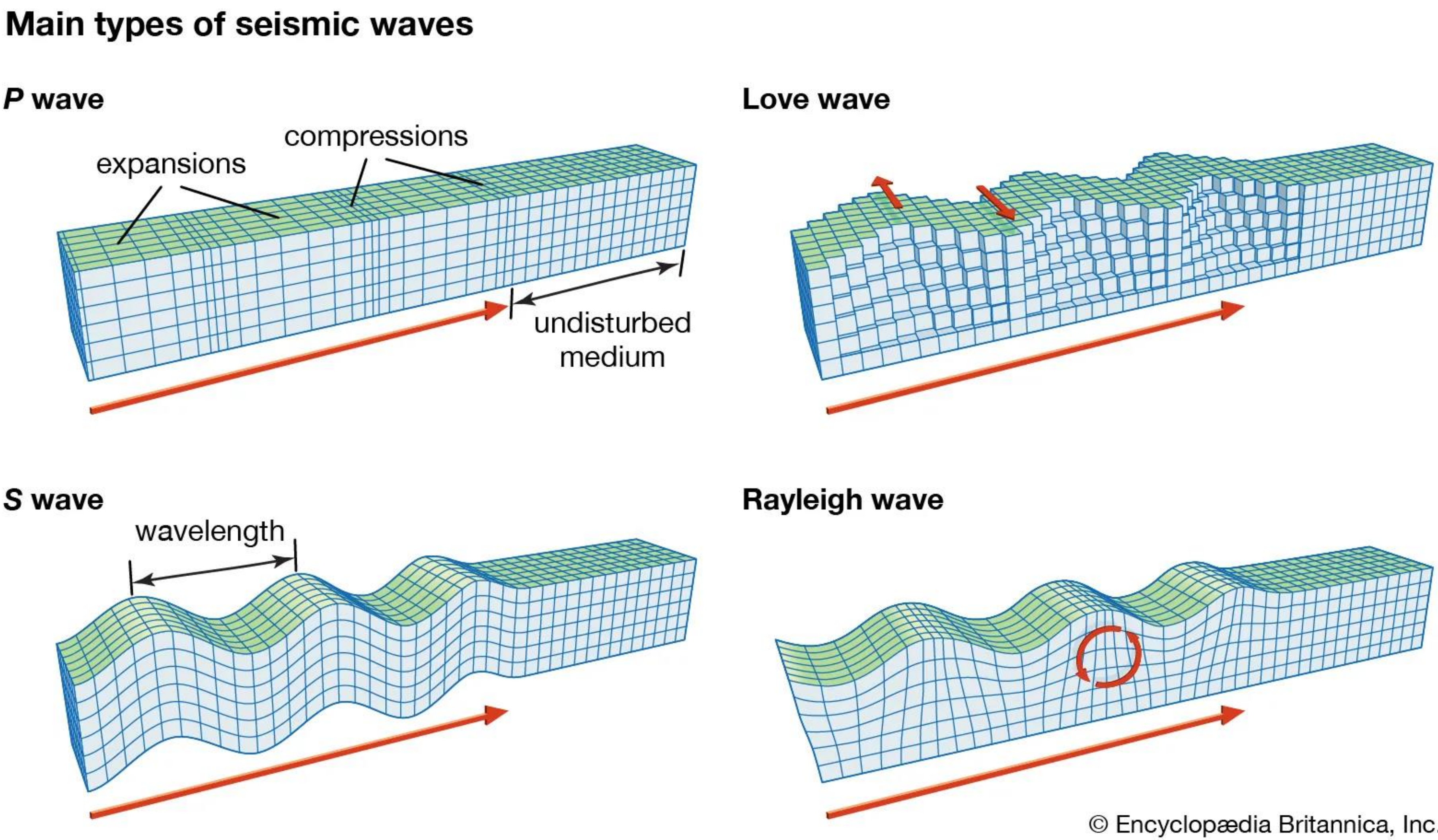
P (primary) waves

- Fastest of all waves
- Always first to reach a recording station (hence primary)
- Move as push-pull – alternating pulses of compression and extension
- Travel through solid, liquid or gas



- S-WAVES ARE CALLED SECONDARY WAVE BECAUSE ALWAYS IT ARRIVES AFTER P-WAVES AT SEISMIC RECORDING STATION. UNLIKE P WAVES S –WAVES CAN TRAVEL ONLY SOLID MATERIAL.
- THIS ARE THE SHAKE WAVES THAT MOVE THE GROUND UP & DOWN OR FROM SIDE TO SIDE
- THE S WAVE OR THE SECONDARY WAVE IS A TRANSVERSE WAVE THAT MEANS HAS AN S-SHAPED PATTERN AND AS A RESULT, PARTCLES MOVE PERPENDICULAR OR RIGHT ANGLES TO THE WAY THAT THE EARQUAKE WAVE IS TRAVELLING
- AFTER BOTH P & S WAVES MOVED THROUGH THE BODY OF EARTH , THEY ARE FOLLOWEED BY SURFACE WAVES WHICH TRAVEL ALONG THE EARTH'S SURFACE.

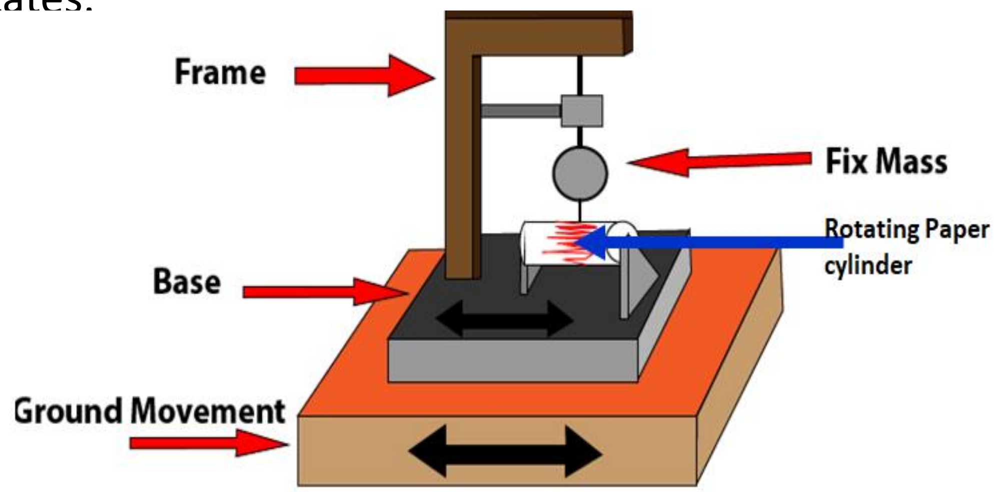
- A THIRD TYPE OF WAVES, SURFACE, DO NOT TRAVEL THROUGH EARTH LIKE P AND S WAVES DO, BUT ONLY TRAVEL ACROSS SURFACE, IMMEDIATELY AFTER S WAVES, SLOWEST OF ALL THESE 3 WAVES WOULD BE THE SURFACE WAVES.
- THERE ARE 2 TYPES OF SURFACE WAVES : LOVE WAVES AND RAYLEIGH WAVES
- LOVE WAVES HAS A HORIZONTAL MOTION THAT MOVES THE SURFACE FROM SIDE TO SIDE, PARPENDICULAR TO THE DIRECTION OF THE WAVE IS TRAVELLING.
- OF THE 2 SURFACE WAVES, LOVE WAVES MOVE FASTER
- RAYILEGH WAVES CAUSE THE GROUND TO SHAKE IN AN ELIPTICAL PATTERN. THIS MOTION IS SIMILAR TO THAT OBSERVED IN OCEAN WAVES (ROLLING MOTION).
- SINCE SURFACE WAVES ARRIVE LAST. THEY HAVE LONGER PERIODS THAN P & S WAVE DOES. THESE PERIOD TEND TO HAVE MAX ENERGY OF 5/10 OR EVEN 20 SECONDS. THOSE PERIODS TEND TO BE DAMAGING TO THE LARGE STRUCTURES.


Main types of seismic waves
P wave
expansions
compressions
undisturbed medium
Love wave
S wave
wavelength
Rayleigh wave
© Encyclopædia Britannica, Inc.

How are earthquake measured using a seismograph

Earthquakes are recorded using a seismograph. It is an instrument used to detect and record seismic waves.

- Frame is bolted to the Earth, as seismic waves pass through, the frame will move
- Frame moves by sinking and then rising with the ground
- A seismograph's heavy weight resists motion during a quake. But the rest of the seismograph is anchored to the ground and vibrates when seismic waves arrive
- The weight is free to swing back and forth, or to bounce up and down on a spring.
- A rotating paper cylinder is attached to the frame
- There is a pen attached to a heavy weight so that the pen draws a smooth line (in case, the ground does not move as the cylinder rotates.
- Thus, during an earthquake, Seismic wav cause the seismograph's drum to vibrate the paper cylinder moves back and forth beneath it.
- P-waves arrive first, secondary waves arr next. Surface waves arrive after the body waves and they are even bigger, amplitu the earthquake can then be recorded
- Time lag between the P-waves and S-waves increase with greater distance travelled

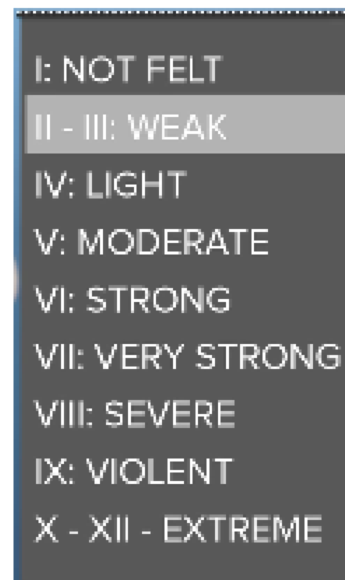


No need to memorize line by line, for your understanding

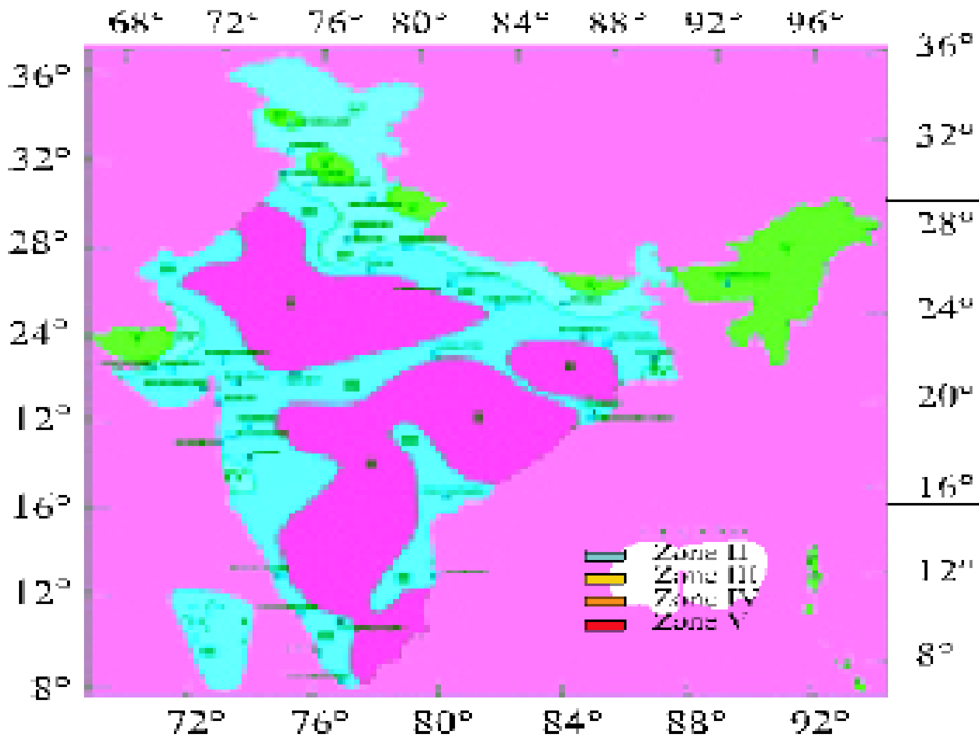
How are earthquakes measured : Earthquake Magnitudes

- The Richter Scale measures the magnitude of a tremor (how powerful it is) using an instrument called a seismometer
- The Richter magnitude of an earthquake can be easily determined from the S-P interval combined with the maximum motion recorded on the seismogram.
- The Richter Scale is measured on a scale from 1 to 10.
- It is a logarithmic scale which means that a size ‘6’ on the Richter Scale is 10 times more powerful than a size ’5’.
- Earthquakes of magnitude 10 or larger cannot happen. The magnitude of an earthquake is related to the length of the fault on which it occurs.

- Mercalli scale IS A MEASURE OF HOW IT FEELS IN AN EARTHQUAKE.
- This method is subjective - buildings are constructed to different standards in different parts of the world.
- Earthquake intensity is determined on a scale of Roman numerals between I and XII according to the convention called the modified Mercalli scale.



The seismic zoning map of India is divided into four zones namely Zone II, III, IV and V, with zone V shown in red colour in the following figure being most vulnerable to earthquakes. Much of India lies in zone III. New Delhi the capital city of India lie in zone IV where as big cities like Mumbai and Chennai are in zone III.



Zone	Magnitude
Zone V	Very High Risk Quakes of Magnitude 8 and greater
Zone IV	High Risk Quakes upto Magnitude 7.9
Zone III	Moderate Risk Quakes upto Magnitude 6.9
Zone II	Seismic Disturbances upto Magnitude 4.9

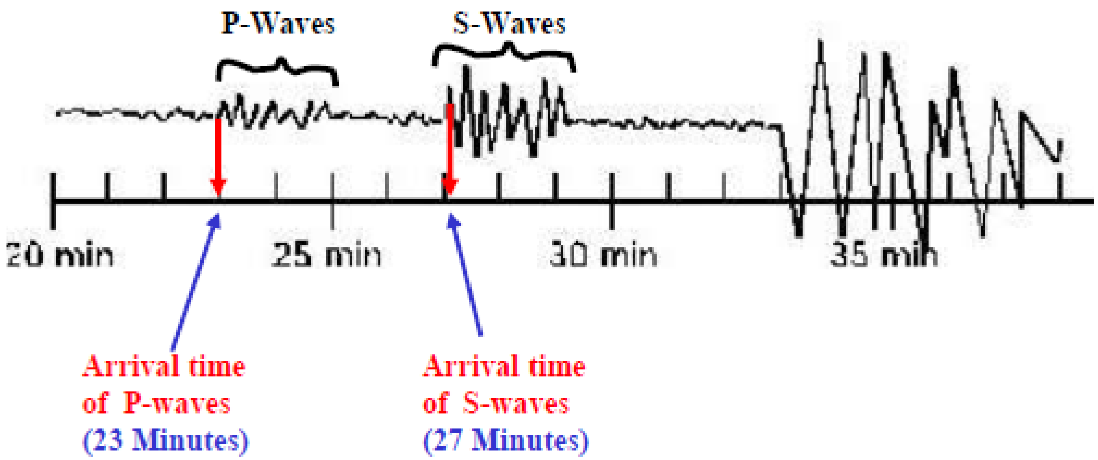
Source: IS 1893 (Part 1) : 2002 (BIS)

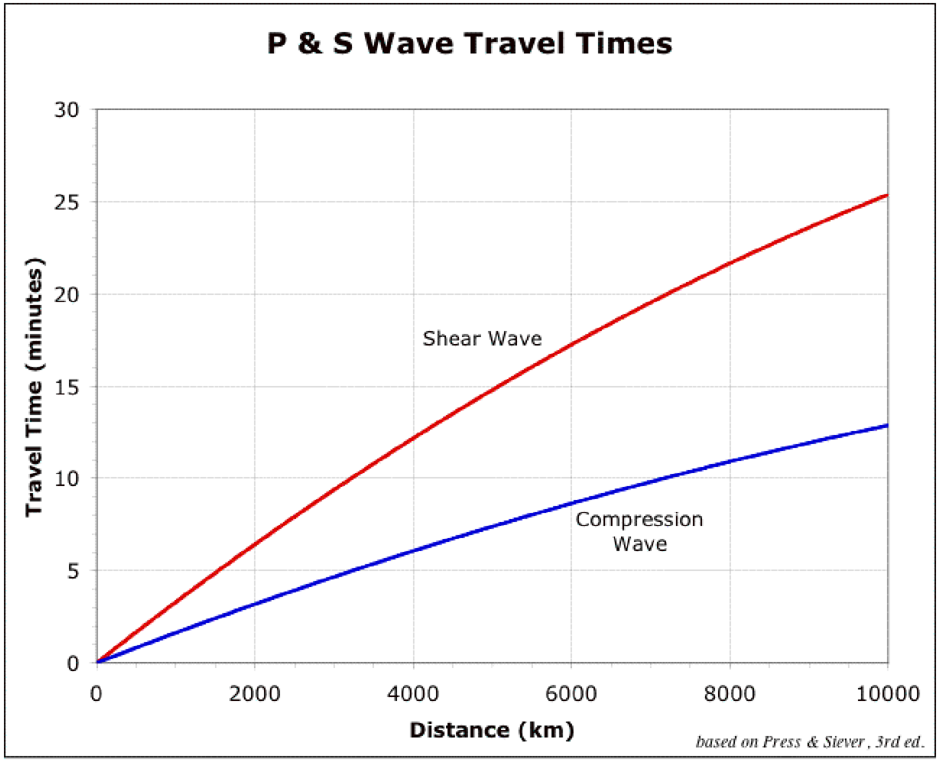
Only for your information

<u>Locating the Source of an Earthquake : Travel-time curve</u>

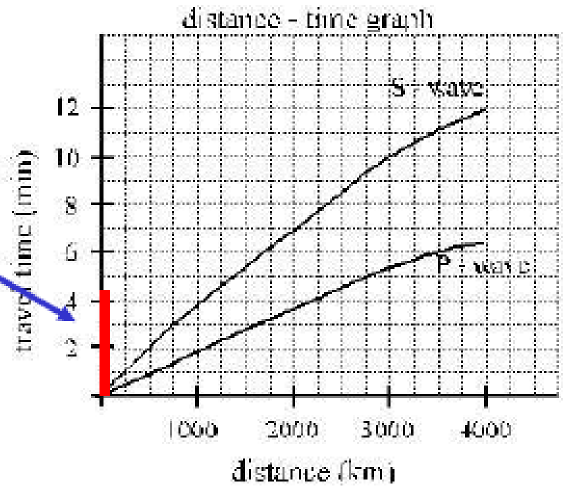
- Earthquakes are located using a record of the earth vibration called a *seismogram*.
- Because earthquake waves travel in at different velocities they arrive at distance seismic stations in a certain order: P-waves before S-waves before surfaces waves.
- The separation in time of the first arrival of the P- and S-waves correlates directly with the distance of the earthquake from the seismic station and the distance can be graphed on a *travel-time curve*.
- Several stations are necessary to pin-point the location of an earthquake. This is done by drawing a circle on the globe with the radius equal to the distance between the epicenter and the seismic station. Having done the same for three stations, the point of intersection of the three circles is the actual epicenter of the earthquake.

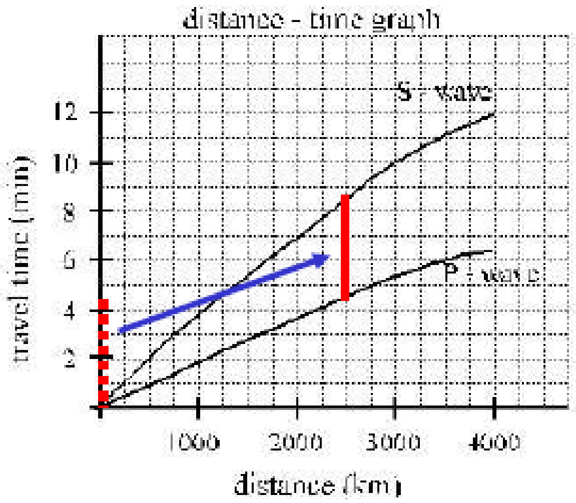
<u>No need to memorize line by line</u>

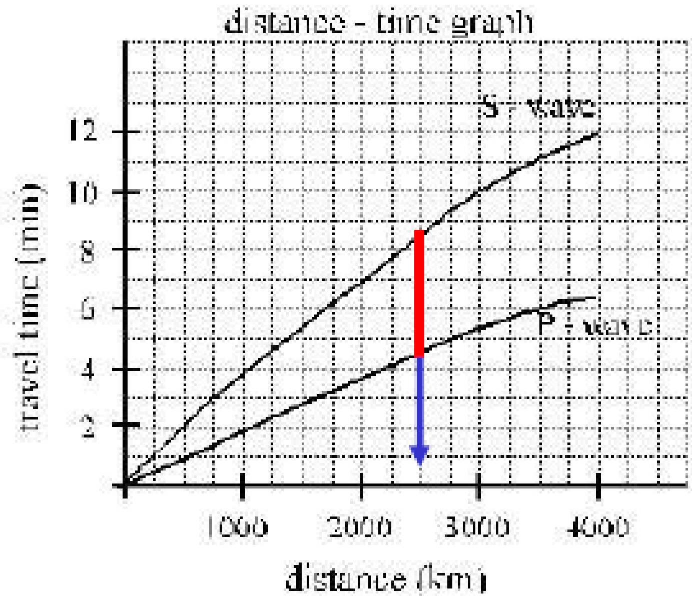

P-Waves
S-Waves
20 min
25 min
30 min
35 min
Arrival time of P-waves (23 Minutes)
Arrival time of S-waves (27 Minutes)


P & S Wave Travel Times
Travel Time (minutes)
30
25
20
15
10
5
0
0
2000
4000
6000
8000
10000
Distance (km)
Shear Wave
Compression Wave
based on Press & Siever, 3rd ed.

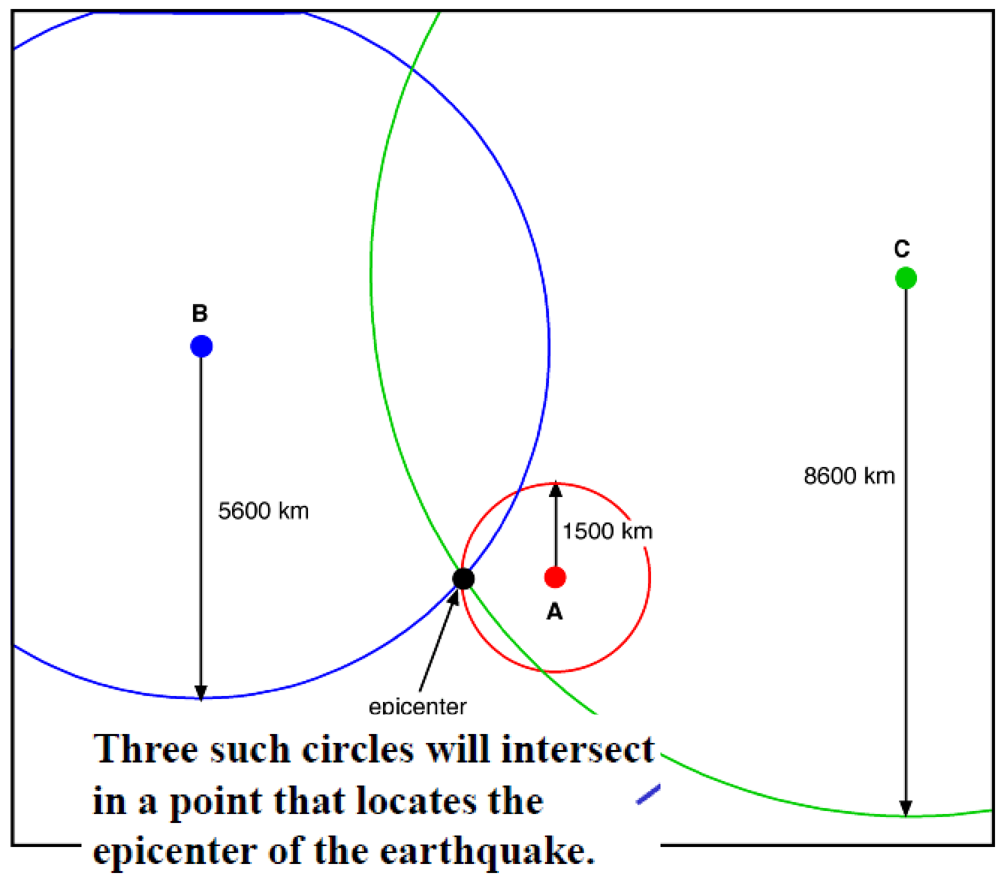
Next you plot 4 minutes on the travel-time graph.







triangulation: To determine the location of an earthquake the distance of the earthquake must be determined from at least three seismic recording stations. Circles with the appropriate radius are then drawn around each station. The intersection of three circles uniquely identifies the earthquake epicenter.



Earthquake-triggered landslides, Fires and tsunami

As well as being highly destructive in their own right, earthquakes can also trigger two other very destructive natural hazards.

- One of these is a landslide. This is a rapid movement of earth materials down a slope, the materials ranging from huge boulders to soil.
- Landslides can involve the movement of just a small amount of material or enough to bury whole towns in their path.
- They can have a number of causes, of which earthquakes are just one. The shock of an earthquake may be sufficient to start the slide.

Fire

- The fourth main earthquake hazard is fire. These fires can be started by broken gas lines and power lines, or tipped over wood or coal stoves.
- They can be a serious problem, especially if the water lines that feed the fire hydrants are broken, too.
- For example, after the Great San Francisco Earthquake in 1906, the city burned for three days. Most of the city was destroyed and 250,000 people were left homeless.

- Tsunami are ocean waves caused by movement of the ocean floor by an earthquake beneath the ocean.
- The water is moved as if it were being pushed by a giant paddle, producing powerful waves that spread out from the region of the earthquake across the ocean. Tsunami is seen only along the shore that they become noticeable or destructive. Tsunami are hardly detectable in the open ocean, having only a low wave height. In the open ocean they do no harm to ships.

How do earthquakes generate tsunamis?

- The second natural hazard that can be triggered by earthquakes is that of tsunami. Make a note that tsunami and the tidal waves are not the same.
- Tsunami is a Japanese word meaning bay or harbour wave, and is particularly apt as it is only along the shore that they become noticeable or destructive; Tsunamis are hardly detectable in the open ocean, having only a low wave height, 1 m or less, but when they reach shallow water at a coastline their wave height increases significantly, reaching over 10 m, with disastrous effects
- LARGE TSUNAMIS CAN APPROACH 30 METRE (160 FEET) IN HEIGHT AND CAN PUSH INLAND UPTO SEVERAL MILES
- By far, the most destructive tsunamis are generated from underwater volcanic eruption or an earthquakes with an epicenter or fault line near or on the ocean floor.
- We already have discussed how tectonic subduction occurs along tectonic plate boundaries by the collision of tectonic plates
- Or, the tectonic plate on the ocean floor may slips.
- Also, when these plates move past each other, they cause large earthquakes.
- The underwater earthquake tilt, offset, or displace large areas of the ocean floor from a few kilometers to as much as a 1,000 km or more.
- The sudden vertical displacements over such large areas, disturb the ocean's surface, displace water, and generate destructive tsunami waves. The waves can travel great distances from the source region.
- It should be noted that not all earthquakes generate tsunamis. Earthquakes with Magnitudes exceeding 7.5 usually produce destructive tsunamis.

No need to memorize line by line, but need to go through it

- This energy travels upto the surface, displacing the water and raising it above the normal sea level. But gravity pulls them back down which makes energy ripples upwards horizontally. Thus a tsunami the born moving 500 miles per hour.
- When it is far from the shore, it can barely be detectable and poses a little treat, since it moves through the entire depth of the water.
- By the time it reaches the shore, the wave's speed slows down but its height rises as much as 100 feet, because there is less water to move through, the still massive amount of energy is compressed.

No need to memorize line by line, but need to go through it

- The tsunami not only drown the people near the coast, but building, trees submerges miles after miles.
- If that were not enough the water dragging with it the newly created debris anything or anyone, unfortunate enough to be caught in its path.
- More than 80% of the world's tsunamis occur in the Pacific along its Ring of Fire subduction zones

Tsunamis in history

- **a.** The Great 1960 Chilean tsunami was generated by a magnitude 9.5 earthquake that had a rupture zone of over 1,000 km. Its waves were destructive not only in Chile, but also elsewhere in the Pacific
- **b**. The 2004 indian ocean tsunami was one of the deadliest natural disasters in history killing over 200,000 people throughout south Asia. Indian Ocean tsunami of 2004, tsunami that hit the coasts of several countries of South and South-East Asia in December 2004. The tsunami and its aftermath were responsible for immense destruction and loss on the rim of the Indian Ocean. Indian ocean tsunami released the energy equivalent of 23,000 Hiroshima type atomic bombs

- **c**. On 11th March 2011, a 9 magnitude offshore earthquake triggered a tsunami. That quake and massive flooding disabled the power supply and cooling of three Fukushima Daiichi reactors, causing a nuclear accident

Earthquakes in history

• **a**. The largest earthquake ever recorded was in Chileon May 22, 1960 on a fault that is almost 1,000 miles long. It measured 9.5 on the Richter Scale.

• **b**. The Lisbon Earthquake of 1755 - Morning of November 1, 1755: Lisbon experienced two major earthquakes in close succession, the first of which caused widespread fires and the second of which caused sea waves which swept many away. A few hours later, Lisbon was again shaken by an earthquake in Fez, Morocco (550 km away). 70,000 people killed and 90% of structures destroyed or damaged.

• **c**. *Latur earthquake* was one of the deadliest earthquakes Maharashtra has seen till date. The earthquake struck at about 3.56 am on September 30 1993 had a terrifying force of 6.4 on the Richter scale – powerful enough to put more than 30,000 people to sleep forever. It was India's worst earthquake since independence in 1947. In current seismicity maps, Latur district and much of the region around it in the Deccan Plateau are classified in Zone-I, denoting least susceptibility to earthquakes. Scientist said the Latur quake was caused by friction between two sides of the a fault --- known as Kurudwadi rift -- that runs hundreds of km from north of Pune to south-east of Sholapur.

• **d**. A 7.8 magnitude Nepal earthquake of 2015 that struck near the city of Kathmandu in Nepal on April 25, 2015. About 9,000 people were killed, many thousands more were injured, and more than 600,000 structures in Kathmandu and other nearby towns were either damaged or destroyed. The earthquake relieved compressional pressure between the Eurasian tectonic plate and the Indo-Australian Plate, which subducts the Eurasian Plate.

<u>Assessing risk</u>

- Evaluate and publicize the risk. Increase public awareness.
- Develop and enforce reasonable building codes.
- Have a relief plan thought out and practiced.
- Don't build sensitive structures (homes, hospitals, schools, waste receptacles) near active faults.

<u>Mitigation of Risk</u>

1) Improve building codes - improve resistance to ground motion.
- 2) Preparation - show figure
- 3) during earthquake:
- A) remain calm
- B) get into a protected area under beds or doorways
- C) stay way from buildings
- D) stop driving
- E) get off overpasses
- F) turn off gas

<u>Only for your information</u>

Possible risk reduction measures:

Community preparedness: Community preparedness is vital for mitigating earthquake impact. The most effective way to save you even in a slightest shaking is 'DROP, COVER and HOLD'.

Planning: The Bureau of Indian Standards has published building codes and guidelines for safe construction of buildings against earthquakes. Before the buildings are constructed the building plans have to be checked by the Municipality, according to the laid down **bylaws**. Many existing lifeline buildings such as hospitals, schools and fire stations may not be built with earthquake safety measures. Their earthquake safety needs to be upgraded by retrofitting techniques.

Public education is educating the public on causes and characteristics of an earthquake and preparedness measures. It can be created through sensitization and training programme for community, architects, engineers, builders, masons, teachers, government functionaries teachers and students.

Engineered structures: Buildings need to be designed and constructed as per the building by laws to withstand ground shaking. Architectural and engineering inputs need to be put together to improve building design and construction practices. The soil type needs to be analyzed before construction. Building structures on soft soil should be avoided. Buildings on soft soil are more likely to get damaged even if the magnitude of the earthquake is not stror n in Fi . Similar problems persist in the buildings constructed on the river banks which have alluvial soil.

Only for your information

What Should I Do Before, During, And After An Earthquake?

What to Do Before an Earthquake?

- Make sure you have a fire extinguisher, first aid kit, a battery-powered radio, a flashlight, and extra batteries at home.
- Learn first aid.
- Learn how to turn off the gas, water, and electricity.
- Make up a plan of where to meet your family after an earthquake.
- Don't leave heavy objects on shelves (they'll fall during a quake).
- Anchor heavy furniture, cupboards, and appliances to the walls or floor.

What to Do During an Earthquake?

- **Stay calm!** If you're indoors, stay inside. If you're outside, stay outside.
- If you're indoors, stand against a wall near the center of the building, stand in a doorway, or crawl under heavy furniture.
- If you're outdoors, stay in the open away from power lines or anything that might fall. Stay away from buildings (stuff might fall off the building or the building could fall on you).
- Don't use matches, candles, or any flame. Broken gas lines and fire don't mix.
- If you're in a car, stop the car and stay inside the car until the earthquake stops.
- Don't use elevators (they'll probably get stuck anyway).

What to Do After an Earthquake?

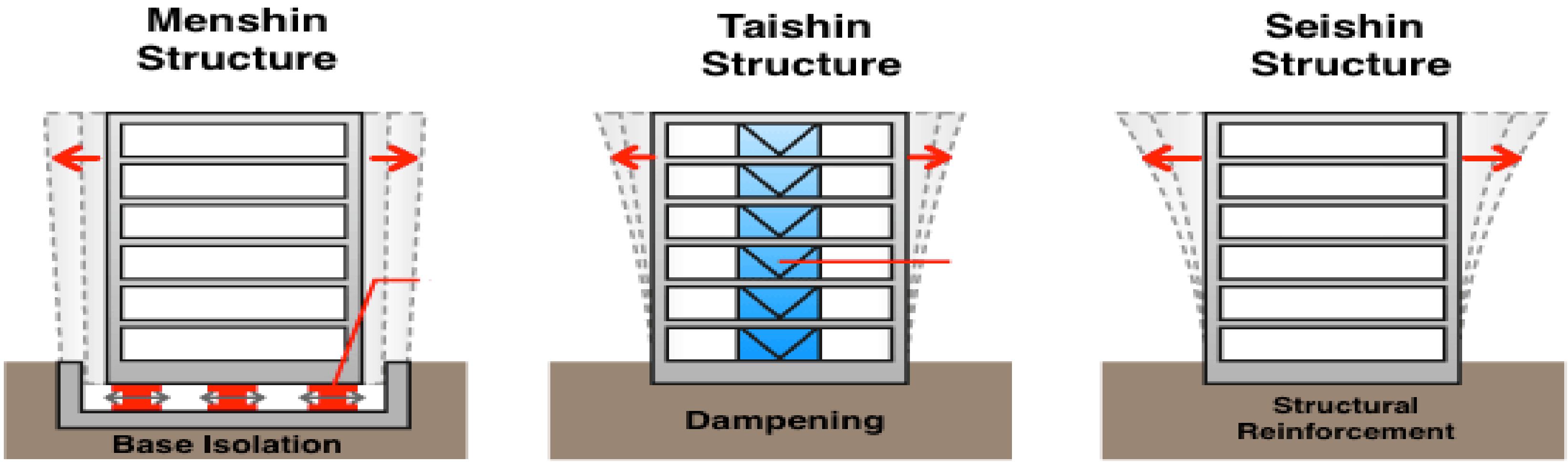
- Check yourself and others for injuries. Provide first aid for anyone who needs it.
- Check water, gas, and electric lines for damage. If any are damaged, shut off the valves. Check for the smell of gas. If you smell it, open all the windows and doors, leave immediately, and report it to the authorities (use someone else's phone).
- Turn on the radio. Don't use the phone unless it's an emergency.
- Be careful around broken glass and debris. Wear boots or sturdy shoes to keep from cutting your feet.

Only for your information

EARTHQUAKE-RESISTANT BUILDINGS

- Many cities vulnerable to earthquakes in the developed world have strict building codes for buildings, houses, bridges, tunnels and stadiums to prevent earthquake damage.
- To be earthquake-resistant, buildings have to be strengthened in such a way that they are rigid enough to keep from whipping back and forth and flexible enough to sway.
- High rises are buttressed with braces and shock absorbers bolted to inner steel skeletons. These allow movement but prevent catastrophic swaying.
- Reinforced, earthquake-resistant buildings almost never collapse. Reinforcing concrete walls and pillars, digging deep foundations, adding special joints that ease internal stress when buildings start to shake and sway.

- <u>Eliminate resonance:</u>
  - Change height of building
  - Move weight to lower floors
  - Change shape of building
  - Change building materials
  - Change attachment of building to foundation
  - Hard foundation (high-frequency vibrations) → build tall, flexible building
  - Soft foundation (low-frequency vibrations) → build short, stiff building

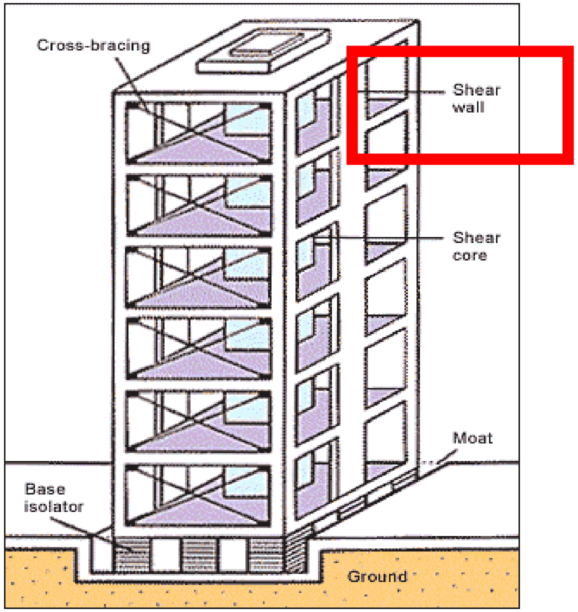


<u>Building in earthquake-prone countries</u> :

- Base Isolation
  - –Devices on ground or within structure to absorb part of earthquake energy
  - –Use wheels, ball bearings, shock absorbers, ‘rubber doughnuts’, etc. to isolate building from worst shaking
- Braced Frames
  - –Bracing with ductile materials offers resistance. Wrapping jacket of steel around column
- Retrofit Buildings
  - –Increase resistance to seismic shaking

SHEAR WALL

- Wall composed of braced panels
- Flexible
- Counters the effects of swaying on a structure



REINFORCEMENT

- Shorter buildings can resist seismic forces.
- Instead of adding stories, expand the first floor of your home.