# Physical geology

## Unit :3

## Continental Drift.

### Defintion.

Continental drift is the hypothesis that the Earth's continents have moved over geologic time relative to each other, thus appearing to have "drifted" across the ocean bed.[2] The speculation that continents might have 'drifted' was first put forward by Abraham Ortelius in 1596. The concept was independently and more fully developed by Alfred Wegener in 1912, but his hypothesis was rejected by many for lack of any motive mechanism. Arthur Holmes later proposed mantle convection for that mechanism. The idea of continental drift has since been subsumed by the theory of plate tectonics, which explains that the continents move by riding on plates of the Earth's lithosphere.

### Evidence of continental drift.

Besides the way the continents fit together, Wegener and his supporters collected a great deal of evidence for the continental drift hypothesis.

- Identical rocks, of the same type and age, are found on both sides of the Atlantic Ocean. Wegener said the rocks had formed side-by-side and that the land had since moved apart.
- Mountain ranges with the same rock types, structures, and ages are now on opposite sides of the Atlantic Ocean. The Appalachians of the eastern United States and Canada, for example, are just like mountain ranges in eastern Greenland, Ireland, Great Britain, and Norway (figure 2). Wegener concluded that they formed as a single mountain range that was separated as the continents drifted.
- Ancient fossils of the same species of extinct plants and animals are found in rocks of the same age but are on continents that are now widely separated (figure 3). Wegener proposed that the organisms had lived side by side, but that the lands had moved apart after they were dead and

fossilized. He suggested that the organisms would not have been able to travel across the oceans.

  - Fossils of the seed fern *Glossopteris* were too heavy to be carried so far by wind.
  - *Mesosaurus* was a swimming reptile but could only swim in fresh water.
  - *Cynognathus* and *Lystrosaurus* were land reptiles and were unable to swim
- Grooves and rock deposits left by ancient glaciers are found today on different continents very close to the equator. This would indicate that the glaciers either formed in the middle of the ocean and/or covered most of the Earth. Today glaciers only form on land and nearer the poles. Wegener thought that the glaciers were centered over the southern land mass close to the South Pole and the continents moved to their present positions later on.
- Coral reefs and coal-forming swamps are found in tropical and subtropical environments, but ancient coal seams and coral reefs are found in locations where it is much too cold today. Wegener suggested that these creatures were alive in warm climate zones and that the fossils and coal later had drifted to new locations on the continents.

Take a look at this animation showing that Earth’s climate belts remain in roughly the same position while the continents move and this animation showing how the continents split up.

## Wegener’s and Taylor’s idea of continental drieft.

The theory of continental drift is most associated with the scientist Alfred Wegener. In the early 20th century, Wegener published a paper explaining his theory that the continental landmasses were “drifting” across the Earth, sometimes plowing through oceans and into each other. He called this movement continental drift.

### Pangaea

Wegener was convinced that all of Earth’s continents were once part of an enormous, single landmass called Pangaea.

Wegener, trained as an astronomer, used biology, botany, and geology describe Pangaea and continental drift. For example, fossils of the ancient reptile mesosaurus are only found in southern Africa and South America. Mesosaurus, a freshwater reptile only one meter (3.3 feet) long, could not have swum the Atlantic Ocean. The presence of mesosaurus suggests a single habitat with many lakes and rivers.

Wegener also studied plant fossils from the frigid Arctic archipelago of Svalbard, Norway. These plants were not the hardy specimens adapted to survive in the Arctic climate. These fossils were of tropical plants, which are adapted to a much warmer, more humid environment. The presence of these fossils suggests Svalbard once had a tropical climate.

Finally, Wegener studied the stratigraphy of different rocks and mountain ranges. The east coast of South America and the west coast of Africa seem to fit together like pieces of a jigsaw puzzle, and Wegener discovered their rock layers "fit" just as clearly. South America and Africa were not the only continents with similar geology. Wegener discovered that the Appalachian Mountains of the eastern United States, for instance, were geologically related to the Caledonian Mountains of Scotland.

Pangaea existed about 240 million years ago. By about 200 million years ago, this supercontinent began breaking up. Over millions of years, Pangaea separated into pieces that moved away from one another. These pieces slowly assumed their positions as the continent we recognize today.

Today, scientists think that several supercontinents like Pangaea have formed and broken up over the course of the Earth's lifespan. These include Pannotia, which formed about 600 million years ago, and Rodinia, which existed more than a billion years ago.

## **Taylor's theory.**

F.B, Taylor postulated his concept of 'horizontal displacement of the continents' in the year of 1908 but it could be published only in the year 1910. The main purpose of his hypothesis was to explain the problems of the origin of the folded mountains of tertiary period. Infact, F.B. Taylor wanted to solve the peculiar problem of the distributional pattern of tertiary folded mountains.

The north-south arrangement of the Rockies and the Andes of the western margins of the North and South Americas and west – east extent of the Apline mountains (Alps, Caucasus, Himalayas etc.) posed a serious problem before Taylor which needed careful explanation. He could not find any help from the ‘contraction theory’ to explain the peculiar distribution of tertiary folded mountains and hence he propounded his ‘drift or displacement theory’.

The concept of Taylor, thus, is considered to be first attempt in the field of continental drift though Antonio Snider presented his views about ‘drift’ in the year 1858 in France. Main purpose behind the postulation of ‘drift hypothesis’ of Snider was to explain the similarity of the fossils of the coal seams of carboniferous period in North America and Europe.

Taylor started from cretaceous period. According to him there were two land masses during cretaceous period. Lauratia and Gondwanaland were located near the north and south poles respectively. He further assumed that the continents were made of sial which was practically absent in the oceanic crust. According to Taylor continents moved towards the equator. The main driving force of the continental drift was tidal force.

According to Taylor, continents were displaced in two ways e.g.:
(i) Equator ward movement, and

(ii) Westward movement but the driving force responsible for both types of movement was tidal force of the moon.

Lauratia started moving away from the North Pole because of enormous tidal force of the moon towards the equator in a radial manner. This movement of land mass resulted into tensional force near the North Pole which caused stretching, splitting and rupture in the landmass. Consequently, Baffin Bay, Labrador Sea and Davis Strait were formed.

Similarly, the displacement of the Gondwanaland from the South Pole towards the equator caused splitting and disruption and hence the Gondwanaland was split into several parts. Consequently, Great Australian Bight and Ross Sea were formed around Antarctic Continent.

Arctic sea was formed between Greenland and Siberia due to equator ward movement of Lauratia. Atlantic and Indian oceans were supposed to have been formed because of filling of gaps between the drifting continents with water. Taylor assumed that the landmasses began to move in lobe form while drifting through the zones of lesser resistance. Thus, mountains and island arcs were formed in the frontal part of the moving lobes

The Himalayas, Caucasus and Alps are considered to have been formed during equator ward movement of the Lauratia and Gondwanaland from the north and south poles respectively while the Rockies and Andes were formed due to westward movement of the land- masses.

## **Sea floor spreading.**

### **Definition.**

Seafloor spreading is a geologic process in which tectonic plates—large slabs of Earth's lithosphere—split apart from each other.

Seafloor spreading occurs at divergent plate boundaries. As tectonic plates slowly move away from each other, heat from the mantle's convection currents makes the crust more plastic and less dense. The less-dense material rises, often forming a mountain or elevated area of the seafloor.

### **Mechanism.**

Seafloor spreading and other tectonic activity processes are the result of mantle convection. Mantle convection is the slow, churning motion of Earth's mantle. Convection currents carry heat from the lower mantle and core to the lithosphere. Convection currents also "recycle" lithospheric materials back to the mantle.

Seafloor spreading occurs along mid-ocean ridges—large mountain ranges rising from the ocean floor. The Mid-Atlantic Ridge, for instance, separates the North American plate from the Eurasian plate, and the South American plate from the African plate. The East Pacific Rise is a mid-ocean ridge that runs through the eastern Pacific Ocean and separates the Pacific plate from the North American plate, the Cocos plate, the Nazca plate, and the Antarctic plate. The Southeast Indian Ridge marks where the southern Indo-Australian plate forms a divergent boundary with the Antarctic plate.

Seafloor spreading is not consistent at all mid-ocean ridges. Slowly spreading ridges are the sites of tall, narrow underwater cliffs and mountains. Rapidly spreading ridges have a much more gentle slopes.

The Mid-Atlantic Ridge, for instance, is a slow spreading center. It spreads 2-5 centimeters (.8-2 inches) every year and forms an ocean trench about the size of the Grand Canyon. The East Pacific Rise, on the other hand, is a fast spreading center. It spreads about 6-16 centimeters (3-6 inches) every year. There is not an ocean trench at the East Pacific Rise, because the seafloor spreading is too rapid for one to develop!

The newest, thinnest crust on Earth is located near the center of mid-ocean ridge—the actual site of seafloor spreading. The age, density, and thickness of oceanic crust increases with distance from the mid-ocean ridge.

### *Geomagnetic Reversals*

The magnetism of mid-ocean ridges helped scientists first identify the process of seafloor spreading in the early 20th century. Basalt, the once-molten rock that makes up most new oceanic crust, is a fairly magnetic substance, and scientists began using magnetometers to measure the magnetism of the ocean floor in the 1950s. What they discovered was that the magnetism of the ocean floor around mid-ocean ridges was divided into matching "stripes" on either side of the ridge. The specific magnetism of basalt rock is determined by the Earth's magnetic field when the magma is cooling.

Scientists determined that the same process formed the perfectly symmetrical stripes on both side of a mid-ocean ridge. The continual process of seafloor spreading separated the stripes in an orderly pattern.

### *Geographic Features*

Oceanic crust slowly moves away from mid-ocean ridges and sites of seafloor spreading. As it moves, it becomes cooler, more dense, and more thick. Eventually, older oceanic crust encounters a tectonic boundary with continental crust.

## **Evidence of seafloor spreading.**

Several types of evidence supported Hess's theory of sea-floor spreading: eruptions of molten material, magnetic stripes in the rock of the ocean floor, and the ages of the rocks themselves. This evidence led scientists to look again at Wegener's hypothesis of continental drift.

### Evidence From Molten Material

In the 1960s, scientists found evidence that new material is indeed erupting along mid-ocean ridges. The scientists dived to the ocean floor in *Alvin*, a small submarine built to withstand the crushing pressures four kilometers down in the ocean. In a ridge's central valley, *Alvin's* crew found strange rocks shaped like pillows or like toothpaste squeezed from a tube. Such rocks form only when molten material hardens quickly after erupting under water. These rocks showed that molten material has erupted again and again along the mid-ocean ridge.

### Evidence From Magnetic Stripes

When scientists studied patterns in the rocks of the ocean floor, they found more support for sea-floor spreading. You read earlier that Earth behaves like a giant magnet, with a north pole and a south pole. Surprisingly, Earth's magnetic poles have reversed themselves many times during Earth's history. The last reversal happened 780,000 years ago. If the magnetic poles suddenly reversed themselves today, you would find that your compass needle points .

Scientists discovered that the rock that makes up the ocean floor lies in a pattern of magnetized "stripes." These stripes hold a record of reversals in Earth's magnetic field. The rock of the ocean floor contains iron. The rock began as molten material that cooled and hardened. As the rock cooled, the iron bits inside lined up in the direction of Earth's magnetic poles. This locked the iron bits in place, giving the rocks a permanent "magnetic memory."

Using sensitive instruments, scientists recorded the magnetic memory of rocks on both sides of a mid-ocean ridge. They found that stripes of rock that formed when Earth's magnetic field pointed north alternate with stripes of rock that formed when the magnetic field pointed south. As shown in Figure 17, the pattern is the same on both sides of the ridge.

### Evidence From Drilling Samples

The final proof of sea-floor spreading came from rock samples obtained by drilling into the ocean floor. The *Glomar Challenger,* a drilling ship built in 1968, gathered the samples. The *Glomar Challenger* sent drilling pipes through water six kilometers deep to drill holes in the ocean floor. This feat has been compared to using a sharp-ended wire to dig a hole into a sidewalk from the top of the Empire State Building.Samples from the sea floor were brought up through the pipes. Then the scientists determined the age of the rocks in the samples. They found that the farther away from a ridge the samples were taken, the older the rocks were. The youngest rocks were always in the center of the ridges. This showed that sea-floor spreading really has taken place.

## Plate tectonics.

### Concept of plate tectonics.

In 1977, after decades of tediously collecting and mapping ocean sonar data, scientists began to see a fairly accurate picture of the seafloor emerge. The Tharp-Heezen map illustrated the geological features that characterize the seafloor and became a crucial factor in the acceptance of the theories of plate tectonics and continental drift. Today, these theories serve as the foundation upon which we understand the geologic processes that shape the Earth.

In much the same way that geographic borders have separated, collided, and been redrawn throughout human history, tectonic plate boundaries have diverged, converged, and reshaped the Earth throughout its geologic history. Today, science has shown that the surface of the Earth is in a constant state of change. We are able to observe and measure mountains rising and eroding, oceans expanding and shrinking, volcanoes erupting and earthquakes striking.

The theory of plate tectonics states that the Earth’s solid outer crust, the lithosphere, is separated into plates that move over the asthenosphere, the molten upper portion of the mantle. Oceanic and continental plates come together, spread apart, and interact at boundaries all over the planet.

Each type of plate boundary generates distinct geologic processes and landforms. At divergent boundaries, plates separate, forming a narrow rift valley. Here, geysers spurt super-heated water, and magma, or molten rock, rises from the mantle and solidifies into basalt, forming new crust. Thus, at divergent boundaries, oceanic crust is created. The mid-ocean ridge, the Earth’s longest mountain range, is a 65,000 kilometers (40,390 miles) long and 1,500 kilometers (932 miles) wide divergent boundary. In Iceland, one of the most geologically active locations on Earth, the divergence of the North American and Eurasian plates along the Mid-Atlantic Ridge can be observed as the ridge rises above sea level.

At convergent boundaries, plates collide with one another. The collision buckles the edge of one or both plates, creating a mountain range or subducting one of the plates under the other, creating a deep seafloor trench. At convergent boundaries, continental crust is created and oceanic crust is destroyed as it subducts, melts, and becomes magma. Convergent plate movement also creates earthquakes and often forms chains of volcanoes. The highest mountain range above sea level, the Himalayas, was formed 55 million years ago when the Eurasian and Indo-Australian continental plates converged. The Mediterranean island of Cyprus formed at a convergent boundary between the African and Eurasian plates. Hardened mounds of lava, called pillow lavas, were once on the bottom of the ocean where this convergence occurred, but have been pushed up and are now visible at the surface.

## Types of crustal plats.

This is a list of tectonic plates on Earth's surface. Tectonic plates are pieces of Earth's crust and uppermost mantle, together referred to as the lithosphere. The plates are around 100 km (62 mi) thick and consist of two principal types of material: oceanic crust (also called *sima* from silicon and magnesium) and continental crust (*sial* from silicon and aluminium). The composition of the two types of crust differs markedly, with mafic basaltic rocks dominating oceanic crust, while continental crust consists principally of lower-density felsic granitic rocks.

## Major plates.

These plates comprise the bulk of the continents and the Pacific Ocean. For purposes of this list, a major plate is any plate with an area greater than 20 million km$^2$.

- African Plate – A major tectonic plate underlying Africa west of the East African Rift – 61,300,000 km$^2$
- Antarctic Plate – A tectonic plate containing the continent of Antarctica and extending outward under the surrounding oceans – 60,900,000 km$^2$
- Eurasian Plate – A tectonic plate which includes most of the continent of Eurasia – 67,800,000 km$^2$
- Indo-Australian Plate – A major tectonic plate formed by the fusion of the Indian and Australian plates – 58,900,000 km$^2$ often considered two plate
- Australian Plate – A major tectonic plate, originally a part of the ancient continent of Gondwana – 47,000,000 km$^2$

Indian Plate – A minor tectonic plate that got separated from Gondwana – 11,900,000 km$^2$

- North American Plate – Large tectonic plate including most of North America, Greenland and part of Siberia. – 75,900,000 km$^2$
- Pacific Plate – An oceanic tectonic plate under the Pacific Ocean – 103,300,000 km$^2$
- South American Plate – Major tectonic plate which includes most of South America and a large part of the south Atlantic – 43,600,000 km$^2$

## Minor plates.

These smaller plates are often not shown on major plate maps, as the majority do not comprise significant land area. For purposes of this list, a minor plate is any plate with an area less than 20 million $km^2$ but greater than 1 million $km^2$.

- Somali Plate – Minor tectonic plate including the east coast of Africa and the adjoining seabed – 16,700,000 $km^2$
- Nazca Plate – Oceanic tectonic plate in the eastern Pacific Ocean basin – 15,600,000 $km^2$[note 1]
- Indian Plate – A minor tectonic plate that got separated from Gondwana – 11,900,000 $km^2$
- Amurian Plate – A minor tectonic plate in eastern Asia
- Sunda Plate – A minor tectonic plate including most of Southeast Asia
- Philippine Sea Plate – oceanic tectonic plate to the east of the Philippines – 5,500,000 $km^2$
- Okhotsk Plate – Minor tectonic plate including the Sea of Okhotsk, the Kamchatka Peninsula, Sakhalin Island, Tōhoku and Hokkaidō
- Arabian Plate – A minor tectonic plate consisting mostly of the Arabian Peninsula, extending northward to Mesopotamia and the Levant – 5,000,000 $km^2$
- Yangtze Plate – A small tectonic plate carrying the bulk of southern China
- Caribbean Plate – A mostly oceanic tectonic plate including part of Central America and the Caribbean Sea – 3,300,000 $km^2$
- Cocos Plate – young oceanic tectonic plate beneath the Pacific Ocean off the west coast of Central America – 2,900,000 $km^2$
- Caroline Plate – Minor oceanic tectonic plate north of New Guinea – 1,700,000 $km^2$
- Scotia Plate – Minor oceanic tectonic plate between the South American and Antarctic Plates – 1,600,000 $km^2$
- Burma Plate – A minor tectonic plate in Southeast Asia – 1,100,000 $km^2$
- New Hebrides Plate – Minor tectonic plate in the Pacific Ocean near Vanuatu – 1,100,000 $km^2$

## **Plate movement and their causes.**

Convection currents in the mantle are much slower than those in boiling water. The rock creeps only a few centimeters a year. The diagram below shows convection currents circulating. The tectonic plates in the lithosphere are carried on the asthenosphere like long, heavy boxes moved on huge rollers. Over millions of years, convection currents carry the plates thousands of kilometers. Scientists suspect that two other motions—slab pull and ridge push—help move these huge plates. Slab pull occurs where gravity pulls the edge of a cool, dense plate into the asthenosphere, as shown in the diagram below. Because plates are rigid, the entire plate is dragged along. Ridge push occurs when material from a mid-ocean ridge slides downhill from the ridge. The material pushes the rest of the plate. Putting the Theory Together Geologists combined their knowledge of Earth's plates, the sea floor, and the asthenosphere to develop the The theory states that Earth's lithosphere is made up of huge plates that move over the surface of the Earth. The map on page 195 shows Earth's major tectonic plates and the directions in which they move. They are the African, the Antarctic, the Australian, the Indian, the Eurasian, the Nazca, the North and South American, and the Pacific plates.

## Plate boundries.

The Earth's outer shell, the lithosphere, consisting of the crust and uppermost mantle, is divided into a patchwork of large tectonic plates that move slowly relatively to each other. There are 7-8 major plates and many minor plates. Varying between 0 to 100mm per year, the movement of a plate is driven by convection in the underlying hot and viscous mantle.

Earthquakes, volcanic activity, mountain-building, and oceanic trench formation occur along plate boundaries in zones that may be anything from a few kilometres to a few hundred kilometres wide.

There are three main types of plate boundaries:

1. Convergent boundaries: where two plates are colliding.

Subduction zones occur when one or both of the tectonic plates are composed of oceanic crust. The denser plate is subducted underneath the less dense plate. The plate being forced under is eventually melted and destroyed.

i. *Where oceanic crust meets ocean crust*
Island arcs and oceanic trenches occur when both of the plates are made of oceanic crust. Zones of active seafloor spreading can also occur behind the island arc, known as back-arc basins. These are often associated with submarine volcanoes.

*ii. Where oceanic crust meets continental crust*
The denser oceanic plate is subducted, often forming a mountain range on the continent. The Andes is an example of this type of collision.

*iii. Where continental crust meets continental crust*
Both continental crusts are too light to subduct so a continent-continent collision occurs, creating especially large mountain ranges. The most spectacular example of this is the Himalayas.

2. Divergent boundaries – where two plates are moving apart.

The space created can also fill with new crustal material sourced from molten magma that forms below. Divergent boundaries can form within continents but will eventually open up and become ocean basins.

*i. On land*
Divergent boundaries within continents initially produce rifts, which produce rift valleys.

*ii. Under the sea*
The most active divergent plate boundaries are between oceanic plates and are often called mid-oceanic ridges.

3. Transform boundaries – where plates slide passed each other.

The relative motion of the plates is horizontal. They can occur underwater or on land, and crust is neither destroyed nor created.

Because of friction, the plates cannot simply glide past each other. Rather, stress builds up in both plates and when it exceeds the threshold of the rocks, the energy is released – causing earthquakes.

**Features related to plate tectonics.**

Deep ocean trenches, volcanoes, island arcs, submarine mountain ranges, and fault lines are examples of features that can form along plate tectonic boundaries.

Island arcs.

Island arcs are long chains of active volcanoes with intense seismic activity found along convergent tectonic plate boundaries (such as the Ring of Fire). Most island arcs originate on oceanic crust and have resulted from the descent of the lithosphere into the mantle along the subduction zone.

Island arcs can either be active or inactive based on their seismicity and presence of volcanoes. Active arcs are ridges of recent volcanoes with an associated deep seismic zone. They also possess a distinct curved form, a chain of active or recently extinct volcanoes, a deep-sea trench, and a large negative Bouguer anomaly on the convex side of the volcanic arc. The small positive gravity anomaly associated with volcanic arcs has been interpreted by many authors as due to the presence of dense volcanic rocks beneath the arc. While inactive arcs are a chain of islands which contains older volcanic and volcaniclastic rocks

## **Fold mountain chain.**

Fold mountains are created where two of Earth’s tectonic plates are pushed together. Fold mountains are created where two or more of Earth’s tectonic plates are pushed together, often at regions known as convergent plate boundaries and continental collision zones. The Cape Fold Mountains of South Africa, above, were created as the ancient Falklands Plateau crashed into the African plate.

Earth's hard outer layer is called the crust. It is made up of large slabs called tectonic plates. The plates fit together like puzzle pieces. Fold mountains are created where two or more plates are pushed together. At these boundaries, rocks are folded into hills and mountains.

Fold mountains are created through a process called orogeny. It takes millions of years to create a fold mountain. However, you can easily see how it works. Cover a table with a tablecloth, or place a rug flat on the floor. Now push the edge of the tablecloth or rug. You will see wrinkles fold on top of each other.

Most Famous Mountain Ranges Are Fold Mountains

Fold mountains are the most common type of mountain in the world. Some of the most famous ranges are the Himalayas, Andes, and Alps.

The Himalayas, in Asia, stretch through the borders of China, India, and Pakistan. The crust beneath the Himalayas is still being folded. Here, the Indian tectonic plate is pushing into the Eurasian plate.

The Andes are the world's longest mountain chain. They stretch along the west coast of South America. Here, the Nazca plate is moving down below the South American plate. The Andes are mostly being folded up from the rocks of the South American plate.

The Alps, in Europe, stretch across Italy, Austria, and France. Here, the tiny Adriatic microplate is crashing into the much larger Eurasian plate. The mountains include rocks that were once part of the ocean floor. They were lifted up in the process of folding.

Not all fold mountains are tall peaks. For example, the Appalachians in North America are low, gentle slopes. Long ago, the Appalachians were taller than the Himalayas. The mountains were worn down over millions of years and now they are much smaller.

## **Subduction zone.**

A subduction zone is a region of the Earth's crust where tectonic plates meet. Tectonic plates are massive pieces of the Earth's crust that interact with each other. The places where these plates meet are called plate boundaries. Plate boundaries occur where plates separate, slide alongside each other or collide into each other. Subduction zones happen where plates collide.

When two tectonic plates meet it is like the immovable object meeting the unstoppable force. However tectonic plates decide it by mass. The more massive plate, normally a continental will force the other plate, an oceanic plate down beneath it. This is the subduction zone. When the other plate is forced down the process is called subduction. The plate enters into the magma and eventually it is completely melted. That is how the surface of the earth makes way for the crust created over time at other plate boundaries.

Subduction zones have key characteristics that help geologist and seismologist identify them. The first is mountain formation. Subduction zones always have mountain ranges caused by plate subduction. The next is volcanic activity as a plate is subducted the pressure and heat turns it into magma. These pockets of magma find paths to the surface and create volcanoes. A good example is the subduction zone near Chile. The final sign is deep marine trenches. These are the best evidence of a subduction zone as they are visible evidence of the crease formed by subduction of a plate. The most famous is the Mariana Trench.

There are some interesting theories about why Subduction occurs in the Earth's crust. One common theory is that subduction was initiated by major impacts by asteroids or comets early in Earth's history. This makes a lot of sense due to the geologic evidence of large impacts scattered around the world.

Understanding how subduction zones work is important because it helps scientist to identify areas of high volcanic and seismic activity. Monitoring these areas can help them warn people who live near them of imminent events and also people who could be affected by the side effects of such events such as ash clouds or tsunamis.

Subduction continues to be one of the most powerful and dynamic processes on planet Earth and as technology improves we can come to understand more about this amazing process.

## Trenches.

A trench is a type of excavation or depression in the ground that is generally deeper than it is wide (as opposed to a wider gully, or ditch), and narrow compared with its length (as opposed to a simple hole).[1]

In geology, trenches are created as a result of erosion by rivers or by geological movement of tectonic plates. In the civil engineering field, trenches are often created to install underground infrastructure or utilities (such as gas mains, water mains or telephone lines), or later to access these installations. Trenches have also often been dug for military defensive purposes. In archaeology, the "trench method" is used for searching and excavating ancient ruins or to dig into strata of sedimented material.

## Rift and ramp valley.

A rift valley is a linear shaped lowland between several highlands or mountain ranges created by the action of a geologic rift or fault. A rift valley is formed on a divergent plate boundary, a crustal extension or spreading apart of the surface, which is subsequently further deepened by the forces of erosion. When the tensional forces are strong enough to cause the plate to split apart, a center block drops between the two blocks at its flanks, forming a graben. The drop of the center creates the nearly parallel steeply dipping walls of a rift valley when it is new. That feature is the beginning of the rift valley, but as the process continues, the valley widens, until it becomes a large basin that fills with sediment from the rift walls and the surrounding area.

A fault trough bounded laterally by faults that dip away from the valley axis and underlaid by a depressed block that is supposed to have been forced down by lateral pressure

. A ramp valley develops when blocks of crust are thrust toward one another and up onto an intervening crustal block.

## The ring of fire.

The Ring of Fire, also referred to as the Circum-Pacific Belt, is a path along the Pacific Ocean characterized by active volcanoes and frequent earthquakes. The majority of Earth's volcanoes and earthquakes take place along the Ring of Fire.

The Ring of Fire, also referred to as the Circum-Pacific Belt, is a path along the Pacific Ocean characterized by active volcanoes and frequent earthquakes. Its length is approximately 40,000 kilometers (24,900 miles). It traces boundaries between several tectonic plates—including the Pacific, Juan de Fuca, Cocos, Indian-Australian, Nazca, North American, and Philippine Plates.

Seventy-five percent of Earth's volcanoes—more than 450 volcanoes—are located along the Ring of Fire. Ninety percent of Earth's earthquakes occur along its path, including the planet's most violent and dramatic seismic events.

The abundance of volcanoes and earthquakes along the Ring of Fire is caused by the amount of movement of tectonic plates in the area. Along much of the Ring of Fire, plates overlap at convergent boundaries called subduction zones. That is, the plate that is underneath is pushed down, or subducted, by the plate above. As rock is subducted, it melts and becomes magma. The abundance of magma so near to Earth's surface gives rise to conditions ripe for volcanic activity. A significant exception is the border between the Pacific and North American Plates. This stretch of the Ring of Fire is a transform boundary, where plates move sideways past one another. This type of boundary generates a large number of earthquakes as tension in Earth's crust builds up and is released.

## Valcanic and earth belt related to plate rtectonic.

Plate tectonics is the over-lying theory presently used by most Earth Scientists to describe motion within the outer-most layer of the solid Earth (also know as the lithosphere). Individual plates of varying size move about the surface of the Earth at varying speeds. Where plate pull apart, slide by each other or collide, there is tectonic activity manifested as earthquakes. The great majority of seismicity on the planet occurs at plate boundaries, although intra-plate seismicity can occur as well when stresses build up in the plate. For instance the Mew Madrid Fault zone of the mid-western USA is an example of a intra-plate seismic belt.

In general, the deepest plate boundary earthquakes are at plate collision (or subduction) zones, and the shallowest are at divergent margins. Volcanism is associated with two of the plate boundary types: divergent and convergent margins. The former manifest themselves as long volcanic rifts mostly in the ocean basins (ocean ridges) whereas the latter typically make individual volcanoes on the plate that "wins out" in the collision process (i.e., does not subduct). Where two plates containing continental crust at their margins collide, there is little or no volcanism (such as at the Himalaya). Occasionally, plate boundaries where plates are mostly sliding by each other can experience small amounts of volcanism as well if there is a component of extension across this boundary. Volcanism can also occur at intraplate volcanoes. These volcanoes are believed to have sources deeper down in the Earth's mantle that remain in a relatively fixed location relative to the always migrating plate boundaries. Mauna Loa and Kilauea in Hawaii are the classic examples of intraplate volcanoes. Such volcanoes can also be seismically active, particularly when volcanic structures are built up rapidly. The crust must respond to the extra load and relieves this stress through tectonic activity.

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