1. With the help of suitable examples, examine the correlation between plate tectonics and earthquakes.

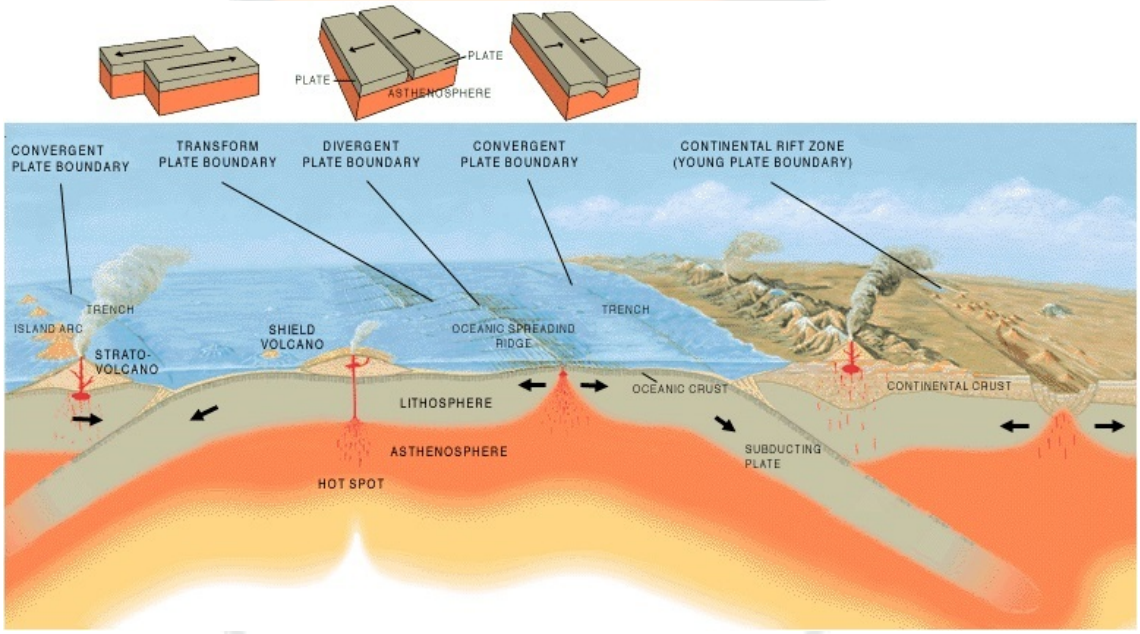
Introduction

According to the theory of plate tectonics, Earth is an active planet. Its surface is composed of many individual plates that move and interact, constantly changing and reshaping Earth's outer layer. Volcanoes and earthquakes both result from the movement of tectonic plates.

Body

- The interior of the earth is hot. Heat flow and movement of material within the earth cause earthquakes and volcanic eruptions and create mountains and ocean basins. There are worldwide patterns to major geological events (such as earthquakes) that coincide with plate boundaries. Earthquakes often occur along the boundaries between colliding plates.
- The Earth's lithosphere is broken into distinct plates which are floating on a ductile layer called the asthenosphere (upper mantle). The tectonic plates) vary from minor plates to major plates, continental plates (Arabian plate) to oceanic plates (Pacific plate), sometimes a combination of both continental and oceanic plates (Indo-Australian plate).
- Three main types of boundaries exist between tectonic plates. The first, called a divergent boundary, occurs most often at mid-oceanic ridges. Here, two plates move away from each other, forming a break, or rift, in Earth's crust. Magma from the mantle rises to fill the gap, creating new crust.
- Earthquakes (shallow focus) are common along divergent edges.
- Example: East African Rift Valley, Mid-Atlantic Ridge, minor earthquakes near Azores and Iceland etc
- The second type, called a convergent boundary occurs where two plates moving toward each other meet. If at least one of the plates is made up of relatively dense oceanic crust, the denser of the two plates subducts, or slides beneath the other. If both plates are made up of continental crust, very little subduction occurs. Instead, the plates buckle and fold to create valleys, ridges, and high mountain ranges.
- These boundaries tend to produce most of the earthquakes that have magnitudes greater than 6.0, and subduction zones produce the deepest earthquakes.
- Examples include deep ocean trenches like the Peru–Chile trench, Himalayan Boundary Fault, Andes etc
- The last type of boundary is called a transform boundary. At these locations, plates slide roughly alongside each other in opposite directions. The plates often get stuck as they move past each other, leading to a build-up of tension, which is ultimately released in the form of an earthquake.

- Transform boundaries typically produce large, shallow-focus earthquakes. Although earthquakes do occur in the central regions of plates, these regions do not usually have large earthquakes.
- Examples include the San Andreas Fault and the Anatolian fault, earthquakes close to and in California
- The zones along plate boundaries are the most geologically active regions on Earth. Earthquakes are common along all types of boundaries and occur all over the world. One of the most well-known plate boundaries encircles the Pacific Ocean, and the frequent earthquakes and volcanic activity along this circle of boundaries have caused it to be dubbed the Ring of Fire.



Conclusion

Seismologists associate different kinds of seismic activity with what is happening at different types of plate boundaries. The theory of plate tectonics can be used to provide a simplified explanation of the global distribution of earthquakes, their evolution and provide a background research for sustaining loss and resistive measures.

2. How is volcanic eruption responsible for developing various landforms? Illustrate with the help of suitable examples.

Introduction

Volcano is a rupture in the crust of a planetary-mass object, such as Earth, that allows hot lava, volcanic ash, and gases to escape from a magma chamber below the surface. The process is called Volcanism and has been ongoing on Earth since the initial stages of its evolution over 4 billion years ago.

Body

Volcanic landforms are divided into extrusive and intrusive landforms based on weather magma cools within the crust or above the crust. Rocks formed by either plutonic (cooling of magma within the crust) or volcanic (cooling of lava above the surface) are called 'Igneous rocks'.

Extrusive Volcanic Landforms These are formed from material thrown out during volcanic activity. The materials thrown out during volcanic activity includes lava flows, pyroclastic debris, volcanic bombs, ash and dust and gases such as nitrogen compounds, sulphur compounds and minor amounts of chlorine, hydrogen and argon.

Various landforms associated with volcanic activities

- Conical Vent and Fissure Vent
  - A conical vent is a narrow cylindrical vent through which magma flows out violently. Conical vents are common in andesitic (composite or strato volcano) volcanism.
- **Composite Cones or Strato volcanoes**
  - They are conical or central type volcanic landforms.
  - Along with andesitic lava, large quantities of pyroclastic material and ashes find their way to the ground.
  - They are accumulated in the vicinity of the vent openings leading to formation of layers, and this makes the mounts appear as composite volcanoes.
  - Example: Vesuvius, Mt. Fuji, Stromboli (Lighthouse of the Mediterranean) etc.
- **Shield Volcanoes or Lava domes**
  - These volcanoes are mostly made up of basalt, a type of lava that is very fluid when erupted. They are not steep.
  - They become explosive if somehow water gets into the vent; otherwise, they are less explosive.
  - Example: Mauna Loa (Hawaii).
- **Lava Plains and Basalt Plateaus**
  - Sometimes, a very thin magma escapes through cracks and fissures in the earth's surface and flows after intervals for a long time, spreading over a vast area, finally producing a layered, undulating (wave like), flat surface.
  - Example: Deccan traps (peninsular India), Snake Basin, U.S.A, Icelandic Shield, Canadian Shield etc.
- **Cinder cone (Tephra cones)**
  - Cinder cones are small volume cones consisting predominantly of tephra that result from strombolian eruptions.
  - They usually consist of basaltic to andesitic material.
- **Calderas**
  - After the eruption of magma has ceased from the cones, the crater frequently turns into a lake at a later time.

  - Water may collect in the crater. This lake is called a 'caldera'.
  - Example: Lake Toba in Sumatra, Crater Lake in Oregon, USA.
- **Mid-Ocean Ridges**
  - These volcanoes occur in the oceanic areas. There is a system of mid-ocean ridges more than 70,000 km long that stretches through all the ocean basins. The central portion of this ridge experiences frequent eruptions.
  - The lava is basaltic in nature.
  - Cools slowly and flows through longer distances.
  - The lava here is responsible for sea floor spreading.
  - Example: Mid-Atlantic ocean ridge; extension is seen in the Iceland.

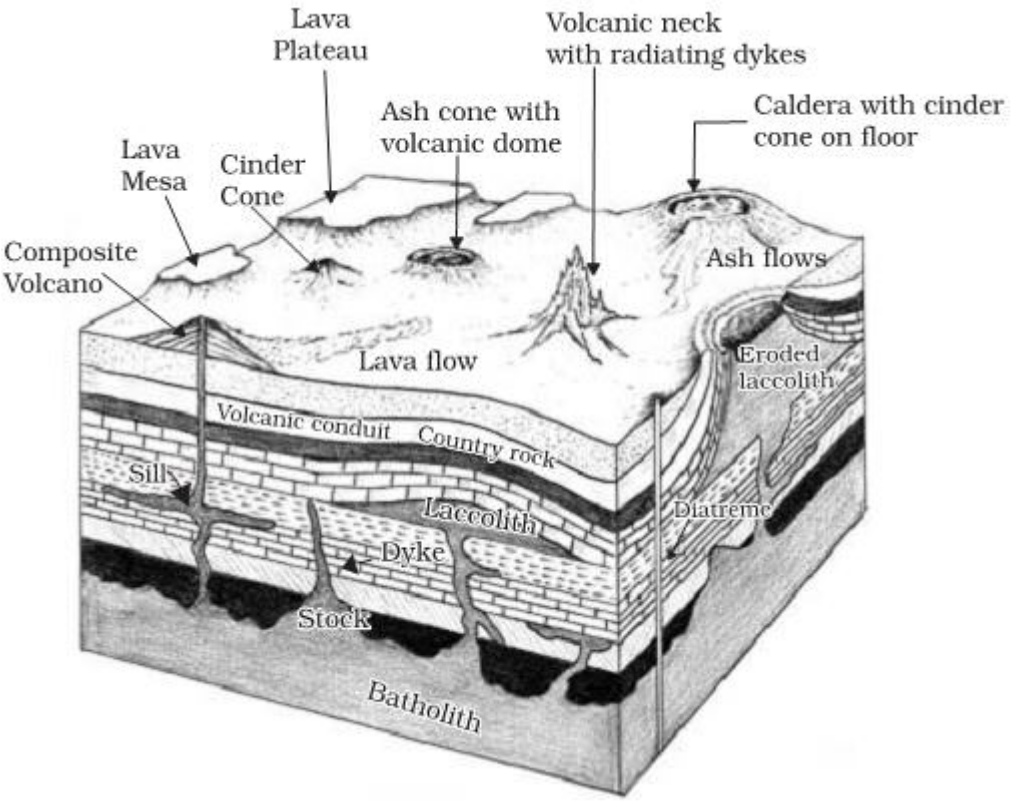
Intrusive Volcanic Landforms: Intrusive landforms are formed when magma cools within the crust. The intrusive activity of volcanoes gives rise to various forms.

Batholiths

- These are huge mass of igneous rocks, usually of granite.
- These rock masses formed due to cooling down and solidification of hot magma inside the earth.
- They appear on the surface only after the denudation processes remove the overlying materials and may be exposed on surface after erosion.
- Example: Wicklow mountains of Ireland; the uplands of Brittany, France.

Laccoliths

- These are large dome-shaped intrusive bodies connected by a pipe-like conduit from below.
- These are basically intrusive counterparts of an exposed domelike batholith.
- Example: The laccoliths of Henry mountains in the Utah, USA.



- **Lopolith**
  - As and when the lava moves upwards, a portion of the same may tend to move in a horizontal direction wherever it finds a weak plane.
  - In case it develops into a saucer shape, concave to the sky body, it is called Lopolith.
  - Example: The Bushveld lopolith of Transvaal, South Africa.

- **Phacolith**
  - A wavy mass of intrusive rocks, at times, is found at the base of synclines or at the top of anticline in folded igneous country.
  - Such wavy materials have a definite conduit to source beneath in the form of magma chambers (subsequently developed as batholiths). These are called the Phacoliths.
  - Example: Corndon hill in Shropshire, England.
- **Sills**
  - These are solidified horizontal lava layers inside the earth.
  - The near horizontal bodies of the intrusive igneous rocks are called sill or sheet, depending on the thickness of the material.
  - The thinner ones are called sheets while the thick horizontal deposits are called sills.
  - Example: Great whin sill of NE England
- **Dykes**
  - When the lava makes its way through cracks and the fissures developed in the land, it solidifies almost perpendicular to the ground.

- It gets cooled in the same position to develop a wall-like structure. Such structures are called dykes.
- These are the most commonly found intrusive forms in the western Maharashtra area. These are considered the feeders for the eruptions that led to the development of the Deccan traps. Cleveland Dyke of Yorkshire, England.

Conclusion

Volcanic activities have a profound influence on earth's landforms. Solid, liquid or gaseous materials may find their way to the surface from some deep-seated reservoir beneath.

3. How do temperate cyclones affect the weather pattern in the Indian subcontinent? Explain.

Introduction

The systems developing in the mid and high latitude (35° latitude and 65° latitude in both hemispheres), beyond the tropics are called the Temperate Cyclones or Extra Tropical Cyclones or Mid-Latitude Cyclones or Frontal Cyclones or Wave Cyclones.

Much of the highly variable & Cloudy weather in temperate zone is direct result of these travelling cyclones, so called temperate cyclone. It is in these latitude zones that the polar and tropical air masses meet and form polar fronts, most of these cyclone form wavelike twist i.e. wave cyclone.

Body

- In continental Europe the largest number of winter cyclones form over the Baltic Sea and sharp contrast between the temperature of the Baltic Sea and adjoining land area leads to formation of storms in this region. Under similar condition numerous storms form over Mediterranean basin. These storms move north-eastward reaching Russia or travel to east as far as northern India. It is associated with instability so called western disturbance.
- Western disturbances, specifically the ones in winter, bring moderate to heavy rain in low-lying areas and heavy snow to mountainous areas of the Indian Subcontinent.
- They are the cause of most winter and pre-monsoon season rainfall across northwest India. Precipitation during the winter season has great importance in agriculture, particularly for the Rabi crops.
- Western disturbances are usually associated with cloudy sky, higher night temperatures and unusual rain.
- Over the Indo-Gangetic plains, they occasionally bring cold wave conditions and dense fog.
  These conditions remain stable until disturbed by another western disturbance. When western disturbances move across northwest India before

the onset of monsoon, a temporary advancement of monsoon current appears over the region.

Conclusion

Temperate cyclones play an important role in weather pattern in the Indian subcontinent through massive heat transfer.

4. In terms of origin, propagation and impact, differentiate between hurricanes and tornadoes.

Introduction

Hurricanes and tornadoes are extreme weather events caused due to the creation of extreme low-pressure regions and strong winds circulated because of pressure gradient created.

Body

Both the weather events are spins like a top around a fixed point in the center. Both are storms with strong winds that swirl around and around and are very destructive. Though, both are very similar, there are certain features differentiating both.

In terms of Origin:

- Hurricanes originates over moisture rich region typically over pacific-ocean. It starts as a wave of low-pressure air and derives its energy from the warm ocean waters.
- Tornadoes on the other hand called as twisters form over land which produce powerful updrafts of wind that twist as they rise.

In terms of Propagation:

- Speed: the strongest tornadoes can have wind speeds over 200 mph, but even the strongest hurricanes rarely produce wind speeds around 100 mph.
- Size: The largest tornado every observed was 4 km wide, but most tornadoes are about 0.8 km wide. Hurricanes are much larger, ranging from about 160 km to 1600 km wide.
- Life cycles: A tornado's lifetime is short, ranging from a few seconds to a few hours. A hurricane's life cycle can last from days to weeks.

In terms of Impact:

Tornadoes tends to be more destructive than hurricanes for the reasons

- Speed of tornadoes are typically high than hurricanes

- As tornadoes originate and propagate over land, the destruction level on ground is high.
- As the size of tornado is small, the destruction intensity is higher.

The impact of hurricane is more seen in the coastal regions when compared to tornadoes, whose impact is majorly seen in hinterland.

Table for reference:

How are hurricanes different from tornadoes?

	Hurricanes	Tornadoes
Where they form	Hurricanes form over warm water in the tropical oceans and develop best when far from the jet stream.	Tornadoes form over land and form within storms that are often very close to the jet stream
How big they are	Can be up to several hundred miles wide	Usually no more than $\frac{1}{4}$ mile wide
How long they last	Can last up to 3 weeks	Usually last no more than an hour
How strong the winds are	Usually less than 180 mph	The most severe ones can be up to 300 mph
Occurrences per year	An average of 10 tropical storms in the Atlantic Ocean	In the United States, 800-1000
Advance warning from forecasters	Several days	Usually no more than 15-30 minutes

Conclusion

Very often, Hurricanes after making a landfall spawn tornado. The changing climate is believed to be resulting in more frequent and more destructive and is a cause of concern.

Additional information: take this as an opportunity to know differences between tornado ad cyclone as well.

Differences between Tornado and cyclone

	Tornado	Cyclone
Definition	A tornado is a rotating column of air ranging in width from a few	A cyclone is an atmospheric system of rapidly circulating

	yards to more than a mile and whirling at destructively high speeds, usually accompanied by a funnel-shaped downward extension of a cumulonimbus cloud. Winds 40-300+ mph.	air massed about a low-pressure centre, usually accompanied by stormy often destructive weather. Storms that begin in the Southern Pacific are called cyclones
Rotation	Clockwise in the southern hemisphere and counter clockwise in the northern hemisphere	Clockwise in the southern hemisphere and counter clockwise in the northern hemisphere.
Forms of precipitation	rain	Rain, sleet, and hail
Frequency	The United States records about 1200 tornadoes per year, whereas the Netherlands records the highest number of tornadoes per area compared to other countries. Tornadoes occur commonly in spring and the fall season and are less common in winters	10-14 per year
Location	Tornados have been spotted in all continents except Antarctica	Southern Pacific Ocean, Indian Ocean. Cyclones in the northwest Pacific that reach (exceed) 74 mph are "typhoons".
Occurrence	Places where cold and warm fronts converge. Can be just almost anywhere.	warm areas

5. What are tsunamigenic forces? Which parts of the world are more vulnerable to tsunamis and why? Discuss.

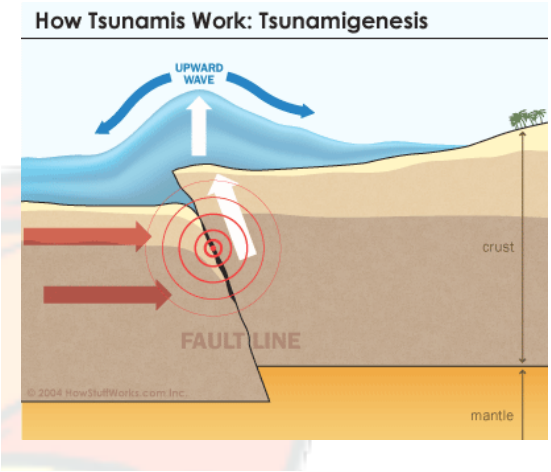
Introduction

Tsunamigenic is referring to those earthquakes, commonly along major subduction zone plate boundaries such as those bordering the Pacific Ocean, that can generate tsunamis. More broadly, tsunamigenic forces refer to any geological force capable of generating a tsunami in an ocean body.

Body

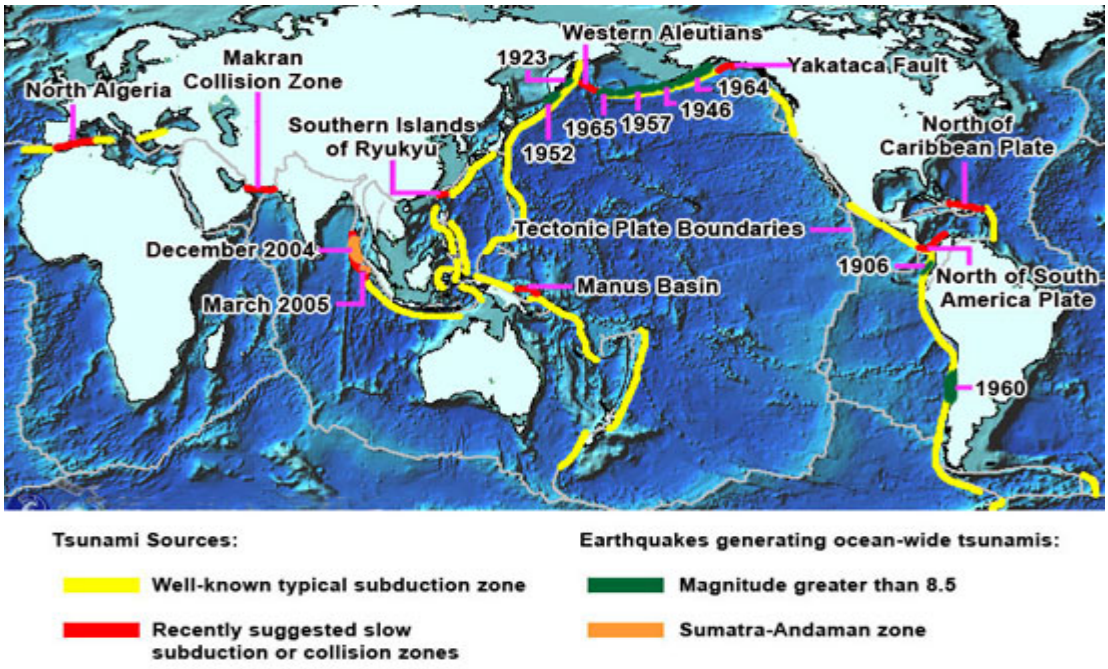
- Most shallow large earthquakes in subduction zones cause tsunamis. An earthquake is tsunamigenic if it generates a tsunami, and it is "tsunami earthquake" if it generates a much larger tsunami than expected from its seismic waves.

- In some cases of subduction, part of the seafloor connected to the lighter plate may "snap up" suddenly due to pressure from the sinking plate. This results in an earthquake. The focus of the earthquake is the point within the Earth where the rupture first occurs, rocks break and the first seismic waves generate. The epicenter is the point on the seafloor (or other part of the Earth's surface) directly above the focus.



- When this piece of the plate snaps up and sends tons of rock shooting upward with tremendous force, the energy of that force transfers to the water. The energy pushes the water upward above normal sea level. This is the birth of a tsunami. The earthquake that generated the Dec. 26, 2004, tsunami in the Indian Ocean had a magnitude of 9.1 -- one of the biggest in recorded history.
- The occurrence of several mega-thrust tsunamigenic earthquakes in the last decade, including but not limited to the 2004 Sumatra-Andaman, the 2010 Maule, and 2011 Tohoku earthquakes, has been a dramatic reminder of the limitations in our capability of assessing earthquake and tsunami hazard and risk.

All low lying coastal areas can be struck by tsunamis, some of them can be very large; their height can be as great as 10 meters or more (30 meters in extreme cases), and they can move inland several hundred meters, depending on the slope of the ground. All oceanic regions of the world can experience tsunamis, but in the Pacific Ocean and its marginal seas, there is a much more frequent occurrence of large, destructive tsunamis because of the many large earthquakes along the margins of the Pacific Ocean.



These regions of the world are more vulnerable to tsunamis as they come under the regions of subduction zones of interacting plates in earth's interior. For example, the Pacific ring of fire where most of the tsunami generating earthquakes occur underwater.

Conclusion

Short-term disaster response gives vital resources and hope to people living through disasters. But at the same time, longer-term solution like reducing the vulnerability of people in poverty by helping them create sustainable livelihoods to reduce their exposure to such risk should be focused upon to improve humanity's fight against devastating natural calamities.