Tremble after the tremors—EARTHQUAKE Explained

Part of: GS-I- Earthquake (PT-MAINS-PERSONALITY TEST)

The NCR shook seven times in the last 20 days, fuelling fears of a high-magnitude earthquake. Seismologists have ruled out an immediate threat though they insist the region remains at risk of a ‘great’ Himalayan quake.

Since May 15, the National Center for Seismology has recorded seven small earthquakes, ranging from 1.8 to 4.5 on the Richter scale, with epicentres at Faridabad, Rohtak and New Delhi. The spate of tremors—the most recent one occurring last (June 3)—has fuelled speculation about the possibility of a bigger earthquake in this region.

The experts have discredited this theory but warned that the region—situated close to the ‘most active fault line on earth’—would be at risk in the event of a widely anticipated ‘great’ Himalayan earthquake.

Misinterpreted threat

- The Director of Wadia Institute of Himalayan Geology, Kalachand Sain, was recently quoted in a news article saying, “There is consistent seismic activity happening in the NCR and can trigger a major earthquake in Delhi.”
- But he told The Hindu that his words were misinterpreted. In fact, he clarified he meant quite the opposite and the recent earthquakes were a sign that “the region was unlikely to have a greater earthquake”.
- Earthquakes in this region were due to “release of stress” accumulated from the movement of the Indian tectonic plate and its collision with the Eurasian tectonic plate, Dr. Sain explained.
- Consequently, the recent tremors would have diffused the accumulated stress, reducing the risk of a more serious earthquake, he added.
- Vineet Gahalaut, former director of National Center for Seismology, too dismissed the fears of a devastating earthquake. “There is something called background seismicity level, which continues over a region over time and that is normal for it.”
- Such tremors have been occurring in this region for the last 40-50 years. That would be a cause for concern only if they occurred in regions where tectonic plates met,” he said.
- Only larger faults and larger systems trigger bigger earthquakes, explained Kusala Rajendran of Centre for Earth Sciences at Indian Institute of Science in Bangalore.
- “That is why you have great earthquakes only along the plate boundaries such as the Sumatran plate boundary [near Indonesia], Andaman plate boundary or Himalaya and California,” she said, while reiterating that Delhi had a history of only small tremors.

Not risk-free

- Concerns about the risk of a major earthquake in Delhi, however, may not be unfounded. “An earthquake of 5.5 to 6 magnitude can never be ruled out anywhere,” citing the instance of the 1993 earthquake in Latur, Maharashtra.
- At that time, the area fell under zone 1 of the country’s seismic zonal maps, which was the category with least risk.
With a magnitude of 6.2 on the Richter scale, the earthquake left thousands dead. The same can’t be ruled out here.

“Though there are pockets of localised seismicity in Delhi, that is not new... As a seismologist who has been working on earthquakes for a long time, my feeling is that the real fear for Delhi is from the Himalayas,” adding that it is very close to the most active fault line in the world.

Several researchers have hypothesised the probability of a great earthquake, something of the magnitude of eight and above, striking the Himalayan region.

Based on historical, archaeological and geological data, that such an event has not taken place in the area for at least a 1,000 years.

Others peg it at 500 years. This, along with GPS-based modelling of the speed of movement of the Indian plate, suggests that an earthquake is due, she said, and added: “That means it can happen any time.”

Impact on Delhi

“Even a strong earthquake in the Himalayan belt [as experienced in the recent past] may pose a threat to Delhi-NCR,”. He based this on the fact that this region is only 150-odd km from the active Himalayan seismic belt. Also, the “large sediment thickness (loose soil) in the Ganga Alluvial Plains” to the north of Delhi tends to amplify the impact of earthquakes. Given the presence of high-rises in the area, large number of buildings and a dense population, he said, it was imperative to strictly impose building codes as a precautionary measure.

An earthquake in Uttarakhand’s Chamoli district in March 1999, measuring 6.5 on the Richter scale, which caused damage to some buildings in Patparganj in Delhi, 280 km from the epicentre. She also raised concerns over the vulnerability of buildings in Delhi-NCR and whether the authorities had taken steps to make them secure.

About EARTHQUAKE

Earthquakes

- An earthquake is shaking or trembling of the earth’s surface, caused by the seismic waves or earthquake waves that are generated due to a sudden movement (sudden release of energy) in the earth’s crust (shallow-focus earthquakes) or upper mantle (some shallow-focus and all intermediate and deep-focus earthquakes).
- A seismograph, or seismometer, is an instrument used to detect and record earthquakes.

Focus and epicentre

- The point where the energy is released is called the focus or the hypocentre of an earthquake.
- The point on the surface directly above the focus is called epicentre (first surface point to experience the earthquake waves).
- A line connecting all points on the surface where the intensity is the same is called an isoseismic line.

Foreshocks and aftershocks
Usually, a major or even moderate earthquake of shallow focus is followed by many lesser-size earthquakes known as aftershocks.
A mild earthquake preceding the violent shaking movement of an earthquake is known as a foreshock.

Swarms

- Large numbers of small earthquakes may occur in a region for months without a major earthquake.
- Such series of earthquakes are called earthquake swarms.
- Earthquakes associated with volcanic activity often occur in swarms.
- Earthquake swarms can serve as markers for the location of the flowing magma throughout the volcanoes.

Causes of Earthquakes

- Fault Zones
- Plate tectonics
- Volcanic activity
- Human Induced Earthquakes

Fault Zones

- The immediate cause of most shallow earthquakes is the sudden release of stress along a fault rupture (crack) in the earth’s crust.
- Sudden slipping of rock formations along fault rupture in the earth’s crust happens due to the constant change in volume and density of rocks due to intense temperature and pressure in the earth’s interior.
- The longer the length and the wider the width of the faulted area, the larger the resulting magnitude.

- The longest earthquake ruptures along thrust faults (convergent boundary) are approximately 1,000 km.
- The longest earthquake ruptures on strike-slip faults (transform fault) are about half to one third as long as the lengths along the thrust fault.
- The fault ruptures along normal faults (divergent boundary) are shorter.

Plate tectonics

- Slipping of land along the faultline along convergent, divergent and transform boundaries cause earthquakes.
- **Reverse faults (convergent boundary)** are associated with the most powerful earthquakes, **megathrust earthquakes**, including almost all of those of magnitude 8 or more.
- **Megathrust earthquakes** occur at subduction zones, where one tectonic plate is forced underneath another. E.g. 2004 Indian Ocean earthquake.
- Strike-slip faults, particularly **continental transforms**, can produce major earthquakes up to about magnitude 8.
- **San Andreas Fault** is a transform fault where Pacific plate and North American plate move horizontally relative to each other causing earthquakes along the fault lines.
- Earthquakes associated with normal faults (divergent boundary) are generally less than
Volcanic activity

- Volcanic activity also can cause an earthquake, but **the earthquakes of volcanic origin are generally less severe and more limited in extent** than those caused by fracturing of the earth’s crust.
- Earthquakes in volcanic regions are caused by the consequent release of elastic strain energy both by tectonic faults and the movement of magma in volcanoes.
- Such earthquakes can serve as an **early warning of volcanic eruptions**, as during the 1980 eruption of Mount St. Helens.
- There is a clear correspondence between the geographic distribution of volcanoes and major earthquakes, particularly in the Circum-Pacific Belt and along oceanic ridges.
- Volcanic vents, however, are generally several hundred kilometres from the epicentres of most major shallow earthquakes, and many earthquake sources occur nowhere near active volcanoes.

Human Induced Earthquakes

- Human Induced Earthquakes refers to typically minor earthquakes and tremors that are caused by human activity like mining, large scale petroleum extraction, artificial lakes (reservoirs), nuclear tests etc.

Reservoir-induced seismicity

- The pressure offered by a column of water in a large and **deep** artificial lake alter stresses along an existing fault or fracture. Also, the percolation of water weakens the soil structure and lubricates the faults.
- Loading and unloading of water can significantly change the stress. This significant change in stress can lead to a sudden movement along the fault or fracture, resulting in an earthquake.
- The 6.3 magnitude 1967 **Koynanagar earthquake** occurred near the Koyna Dam reservoir in Maharashtra and claimed more than 150 lives. There have been several earthquakes of smaller magnitude since then.
- Some geologists believe that the earthquake was due to reservoir-triggered seismic activity.
- The **2008 Sichuan earthquake**, which caused approximately 68,000 deaths, is another possible example. It is believed that the construction and filling of the Zipingpu Dam may have triggered the earthquake.

Earthquakes based on the depth of focus

- Earthquakes can occur anywhere between the Earth’s surface and about 700 kilometres below the surface.
- For scientific purposes, this earthquake depth range of 0 – 700 km is divided into three zones: **shallow, intermediate, and deep**.
- Shallow focus earthquakes are found within the earth’s outer crustal layer, while deep focus earthquakes occur within the deeper subduction zones of the earth.
- **Shallow earthquakes are 0 – 70 km deep.**
- **Intermediate earthquakes are 70 – 300 km deep.**
- **Deep earthquakes are 300 – 700 km deep.**
- Of the total energy released in earthquakes, about **12-15 per cent comes from intermediate earthquakes**, about **3-5 per cent from deeper earthquakes** and about **70-85 per cent from the shallow earthquakes**.

- A quake’s destructive force depends not only on the energy released but also on location, distance from the epicentre and depth.

- On 24 August 2016, a 6.2 earthquake rocked Central Italy killing about 300 people. An even bigger 6.8 hit Myanmar the same day killing just a few people.

- Italy’s quake was very shallow, originating within 10 kilometres underground. By contrast, the quake in Myanmar was deeper; 84 kilometres.

**Shallow-focus earthquake**

- The great majority of earthquakes have shallow-focus. Hence, they are also called as ‘**crustal earthquakes**.’

- Majority of the shallow focus earthquakes are of smaller magnitudes (usual range of 1 to 5). But a few can be of a higher magnitude and can cause a great deal of destruction.

- They occur quite frequently and at random. However, as most of them are either of smaller magnitudes or occur along submarine ridges, they are often not felt.

- **Though comparatively of low magnitude, shallow focus earthquakes can cause relatively greater damage at the surface (as the whole energy is directed towards a small area) compared to their deep-focus counterparts.**

**Deep-focus earthquake**

- In general, the term “deep-focus earthquakes” is applied to earthquakes deeper than 70 km.

- The deeper-focus earthquakes commonly occur in patterns called **Benioff zones** that dip into the Earth, indicating the presence of a **subducting slab (zone of subduction)**.

- Hence, they are also known as **intraplate earthquakes** (triggered by the collision between plates).

- They happen as **huge quakes with larger magnitudes** (usual range of 6 to 8), as a great deal of energy is released with the forceful collision of the plates.

- **But the earthquakes alone may not cause much destruction as the foci of the quakes lie at great depths and the energy of the quakes dissipates over a wide area.**

- The strongest deep-focus earthquake in seismic record was the magnitude 8.3 Okhotsk Sea earthquake that occurred at a depth of 609 km in 2013.

- The deepest earthquake ever recorded was a 4.2 earthquake in Vanuatu at a depth of 735.8 km in 2004.

**Wadati–Benioff zone: Earthquakes along the Convergent boundary**

- Wadati Benioff zone is a zone of subduction along which earthquakes are common. **The most powerful earthquakes occur along this zone** (most powerful earthquakes occur along the convergent boundary).

- Differential motion along the zone produces numerous earthquakes, the foci of which may be as deep as about 700 kilometres.

- **Wadati–Benioff zones** can be produced by slip along the **subduction thrust fault** (Himalayan Region – C-C convergent boundary) or slip on faults within the
downgoing plate (O-O and C-O convergent boundary).

Distribution of Earthquakes

- Earth’s major earthquakes occur mainly in belts coinciding with the margins of tectonic plates.
- The most important earthquake belt is the Circum-Pacific Belt, which affects many populated coastal regions around the Pacific Ocean—for example, those of New Zealand, New Guinea, Japan, the Aleutian Islands, Alaska, and the western coasts of North and South America.
- The seismic activity is by no means uniform throughout the belt, and there are many branches at various points.
- Because at many places the Circum-Pacific Belt is associated with volcanic activity, it has been popularly dubbed the “Pacific Ring of Fire.”
- **The Pacific Ring of Fire accounts for about 68 per cent of all earthquakes.**
- A second belt, known as the Alpine Belt (Himalayas and Alps). The energy released in earthquakes from this belt is about 15 per cent of the world total.
- The mid-world mountain belt (Alpine Belt) extends parallel to the equator from Mexico across the Atlantic Ocean, the Mediterranean Sea from Alpine-Caucasus ranges to the Caspian, Himalayan mountains and the adjoining lands.
- There also are striking connected belts of seismic activity, mainly along oceanic ridges—including those in the Arctic Ocean, the Atlantic Ocean, and the western Indian Ocean—and along the rift valleys of East Africa.