

Earthquakes – Nature and Predictability

The 'Earthquakes' are the most devastating events on the globe and cause enormous loss to property and human lives whenever and wherever they occur. The losses are great if such earth quakes occur in densely populated areas. Many Earthquakes of varying magnitudes occur all over the globe with varying frequencies. The earliest earthquake occurred in China as described by the Chinese earthquake catalog in the year 1177 B.C. Earthquakes in Europe are mentioned as occurred as early as 580 B.C. In the America, the earliest known Earthquake was in the late 14th century and in Peru in 1471. By the 17th century, descriptions of the effects of Earthquakes were being published around the world to provide an understanding about the damage potential of the Earthquakes. In India, there was a record of Earthquake in 9th century AD and the largest intra-plate Earthquake of 1819 in Runn of Kutch occurred with magnitude of 8.0. In the past two decades, India has witnessed major earthquakes Uttarkasi (1991, 6.6), Latur (1993, 6.3), Jabalpur (1997, 6.0), Chamoli (1999, 6.8) and Bhuj (2001, 6.9). The more recent occurrence is the Japan's Earthquake (2007, 7.1).

As the scientific studies indicate, Earth is not a complete uniform sphere but it is a shape having huge plates that form the Earth's surface and for more than millions of years, the forces of plate tectonics have shaped it. The Earth is formed of several layers that have very different physical and chemical properties. The outer layer, known as Earth's crust, which averages about 45 kilometers in thickness, consists of about a dozen large, irregularly shaped plates that slide over, under and past each other on top of the partly molten inner layer. It is seen that the movement sometimes is very gradual and at other times the plates are interlocked together and this inter-locking of two Earth's plates unable the release of accumulated energy in them. This energy grows enough, the plates break free from each other. This sudden movement of the Earth causes an Earthquake. This Earthquake is nothing but an abrupt or sudden release of accumulated strain in plate boundaries over a period of time. Most earthquakes occur at the boundaries where the plates meet. There are three types of plate boundaries, namely, Spreading zones, Transform zones and Subduction zones.

Earthquakes can also occur within plates, although plate-boundary earthquakes are much more common. Less than 10 percent of all earthquakes occur within plate interiors. As plates continue to move and plate boundaries change over geologic time, weakened boundary regions become part of the interiors of the plates. Some of the Earthquakes can also occur in the rupture zones or fault zones in the earth's crust. A **fault** is a fracture in the Earth's crust along which two blocks of the crust have slipped with respect to each other. **Faults** are divided into three main groups, depending on how they move, namely, Normal faults, Thrust faults and lateral faults. The fault zones are the zones of weakness in the Earth's crust.

Underneath the earth's surface from where the energy originates is known as focal depth of the earthquakes which is classified as per the depth from the surface, namely, shallow focus (0-45 Km), intermediate focus (45-300 Km) and deep focus (300 to >700 Km). Furthermore, the **epicenter** of an earthquake is the point on the Earth's surface directly above the focus. The location of an earthquake is commonly described by the geographic position of its epicenter and by its focal depth. The **magnitude** of an earthquake, usually expressed by the logarithmic **Richter scale**, is a measure of the amplitude of the seismic waves. Earthquakes with a Richter value of 6 or more are

commonly considered **major; great earthquakes** have magnitude of 8 or more on the Richter scale. The **intensity**, as expressed by the **Modified Mercalli scale**, is a subjective measure that describes how strong a shock was felt at a particular location. The Modified Mercalli scale expresses the intensity of an earthquake's effects in a given locality in values ranging from I to XII. The **moment magnitude** of an earthquake is a measure of the amount of energy released - an amount that can be estimated from seismograph readings.

In the process of breaking, vibrations called "**seismic waves**" are generated. These waves travel outward from the source of the earthquake along the surface and through the Earth at varying speeds depending on the material through which they move. Generally, during the occurrence of earthquakes two types of vibrations are noticed viz. Surface waves and Body waves (compressional and shear). Both types pass through the Earth's interior from the focus of an earthquake to distant points on the surface, but only compressional waves travel through the Earth's molten core. Because compressional waves travel at great speeds and ordinarily reach the surface first, they are often called "primary waves" or simply "P" waves. P waves push tiny particles of Earth material directly ahead of them or displace the particles directly behind their line of travel. Shear waves do not travel as rapidly through the Earth's crust and mantle as do compressional waves, and because they ordinarily reach the surface later, they are called "secondary" or "S" waves. Instead of affecting material directly behind or ahead of their line of travel, shear waves displace material at right angles to their path and therefore sometimes called "transverse" waves. Surface waves usually have the strongest vibrations and probably cause most of the damage done by earthquakes.

The vibrations produced by earthquakes are detected, recorded, and measured by instruments called seismographs. The zigzag line made by a seismograph, called a "seismogram," reflects the changing intensity of the vibrations by responding to the motion of the ground surface beneath the instrument. From the data expressed in seismograms, scientists can determine the time, the epicenter, the focal depth, and the type of faulting of an earthquake and can estimate how much energy was released. The goal of earthquake prediction is to give warning of potentially damaging earthquakes early enough to allow appropriate response to the disaster, enabling people to minimize loss of life and property. In India, there are at present 57 seismological observatories to monitor the seismic activity and in general to study the earth's crust. Of these in the northeast region, Kolkata, Tura, Siliguri, Lakhimpur, Shillong, Imphal and Agartala stations have equipments to record the seismic activity with headquarters at New Delhi. The Shillong observatory provides data in both digital and analog forms with equipment to record microseismic activity. The northeast in general is in Zone V and Sikkim in particular in Zone IV indicating that this region is more vulnerable to earthquakes. Earthquakes of magnitude 5.0 or more are likely in these zones.

Scientists study the past frequency of large earthquakes in order to determine the future likelihood of similar large shocks. For example, if a region has experienced four magnitude 7 or larger earthquakes during 200 years of recorded history, and if these shocks occurred randomly in time, then scientists would assign a 50 percent probability (that is, just as likely to happen as not to happen) to the occurrence of another magnitude 7 or larger quake in the region during the next 50 years. Another way to estimate the likelihood of future earthquakes is to study how fast strain accumulates. When plate movements build the strain in rocks to a critical level, like pulling a rubber band too tight, the rocks will suddenly break and slip to a new position. Scientists measure how much

strain accumulates along a fault segment each year, how much time has passed since the last earthquake along the segment, and how much strain was released in the last earthquake. This information is then used to calculate the time required for the accumulating strain to build to the level that might result in an earthquake. This simple model is complicated by the fact that such detailed information about faults is rare.

Scientific understanding of earthquakes is of vital importance to any country. As the population increases, expanding urban development and construction works encroach upon areas susceptible to earthquakes. With a greater understanding of the causes and effects of earthquakes, we may be able to reduce damage and loss of life from this destructive phenomenon. The knowledge about fault zones in India, plate boundaries and weak zones within the Indian Plate would immensely help in marking the zones of Earthquake potential. Geologists have found that earthquakes tend to reoccur along faults. Earthquakes beneath the ocean floor sometimes generate immense sea waves or tsunamis. These waves travel across the ocean at speeds as great as 1000 kilometers per hour and may be 15 meters high or higher by the time they reach the shore. In this regard, it would be appropriate to refer to the Sumatra Earthquake (2004, 7.9) which caused enormous damage to the East Coast off Tamilnadu due to Tsunami Wave which was triggered by the Earthquake.

Earthquakes of large magnitude do not necessarily cause the most intense surface effects. The effect in a given region depends to a large degree on local surface and subsurface geologic conditions. An area underlain by unstable ground (sand, clay, or other unconsolidated materials), for example, is likely to experience much more noticeable effects than an area equally distant from an earthquake's epicenter but underlain by firm ground such as granite. An earthquake's destructiveness depends on many factors. In addition to magnitude and the local geologic conditions, these factors include the focal depth, the distance from the epicenter, and the design of buildings and other structures. The extent of damage also depends on the density of population and construction in the area shaken by the quake. In fact, the locations of earthquakes and the kinds of ruptures they produce help scientists define the plate boundaries.

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