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Earthquake

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Abstract

Earthquakes are movements within the earth caused by natural and man-made stresses. Forces inside the earth sometimes push and stretch rocks in the crust. The rocks can absorb this energy for a time, but eventually as the energy accumulates, the stress can exceed the binding energy and the rocks suddenly shift or break. The energy is released as seismic waves, which are vibrations that spread through the rocks rapidly in all directions that can cause one of the most powerful events in nature, as earthquake.

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Introduction

The tremors at or near the surface of the earth are called an earthquake. If the magnitude of the tremor is negligible, we are not able to feel it, and if it is more, we can feel. There are thousands of tremors occur at the surface of the earth every year, but only a few become problematic and are taken in to account.

Earthquakes unleash energies on the scale of nuclear explosions. While they rarely announce their arrival in advance, even the strongest quakes are over in a matter of movements. Even the moderate earthquakes leave behind death and destruction that occupy victims and caregivers for years. The effect of an earthquake depends on nature of the earth's crust and epicenter.

Causes of Earthquake

Forces Inside The Earth

Forces inside the earth cause faulting. Rocks break and move along surfaces called faults. The rocks on either side of a fault move in different directions. What causes the forces that cause faults to form? Obviously some thing must cause the rocks to move, otherwise, the rocks would rest quietly without any stress building up in them. However, the earth's crust is in constant motion because of forces inside the earth. These forces cause sections of the earth's crust to move, putting stress on rocks. To relive these stresses, the rocks tend to bend, compress, and stretch like plastic or rubber bands. But if the force is great enough, the rock breaks. This breaking produces vibrations, called earthquakes.

Types of Faults

Rocks experience several types of forces where plates of the earth's crust and upper mantle meet. There are three forces - compression, tension, and shear. Compression is a force or stress that squeezes and compresses, while tension is the stress that causes stretching and elongation. Shear is the force that causes slippage and the rock on either side of fault to move fast each other.

Normal Faults: Where forces inside the earth cause plates to move apart, the plates and the rocks that compose them are subjected to the force of tension. Tension can pull rocks apart and create a normal fault. Along a normal fault, rock above the fault surface moves downward in relation to rock below the fault surface.

Reverse Faults: Compression forces are generated where the earth's plates come together. Compression pushes on rocks from opposite directions and causes them to bend and sometimes break. Once they break, the rocks continue to move along the reverse fault surface. At a reverse fault, the rocks above the fault surface are forced up and over the rocks below the fault surface.

Strike Slip Faults: At a strike slip fault, rocks on either side of the fault surface are moving past each other without much upward or downward movement. As the rocks move fast each other at a strike-slip fault, their irregular surfaces snag each other, and the rocks are twisted and strained. Not only are they deformed, but also, the snagging of the irregular surface hinders the movements of the plates. As forces keep driving the plates to move, the stress builds up and the rocks reach their elastic limit. When the rocks are stressed past their elastic limits, they break and an earthquake results.

Earthquake Information

Types of Seismic Waves

When we play with a coiled spring toy, energy waves are sent through it. Seismic waves, generated by an earthquake, are similar to the waves of the toy. Where are seismic waves formed? How do they move through earth and how can we use the information that they carry?

Earthquake Focus: When rock move along a fault surface, energy is released and damage occurs. The point in the earth's interior where this energy-release occurs is the focus of the earthquake. Seismic waves are produced and travel outward from the earthquake focus.

Earthquakes Depths: The earth's crust is broken in to sections, called plates. Movement of these plates generates stress within the rocks that must be released. When this release of stress is sudden and rock break, an earthquake occurs.

Seismic Waves: Waves that move through the earth by causing particles in the rocks to move back and forth in the same direction are called primary waves. Secondary waves move through earth by causing particles in rocks to move at right angles to the direction of the wave.

The point on the earth's surface directly above on earthquake's focus is the epicenter. Energy that reaches the surface of earth generates waves that travel outward from the epicenter. These waves are surface waves.

Surface waves cause most of the destruction during an earthquake. Because most buildings are very rigid, they begin to fall apart when surface waves pass. The waves cause one part of the building to move up while another part moves down.

Locating an Epicenter: Primary, secondary and surface waves do not travel through earth at the same speed. Primary waves are the fastest; surface waves are the lowest. Scientists use the different speeds of seismic waves to determine the distance to the earthquake epicenter.

Seismograph Stations: Based on the different speeds of seismic waves, primary waves arrive first at seismograph stations, secondary waves second and surface waves last. This enables the scientists to determine the distance to an earthquake epicenter. The farther apart the waves, the farther away the epicenter is. When the epicenters are far from the seismograph station, the primary wave has more time to put distance between it and secondary and surface waves.

Epicenter Location: If seismic wave information is obtained at three seismograph stations, the location of the epicenter can be determined. To locate an epicenter, draw circles around each station on a map. The radius of each circle equals that station's distance from the earthquake epicenter. The point where all three circles intersect is the location of the earthquake epicenter. Scientists have found that at certain depths within earth, the speed and path of seismic waves change

These changes make the boundaries of the layers in earth with different densities.

Structure of the Earth: The word lithosphere refers to the layers of rock material on the earth's surface, both on the continents and the ocean floors. Lithosphere forms a relatively thin (50-100 km thick), which is thick in the continents than on the ocean floors. The outer crust layer is of lighter density than the inner layers. Since the outer crust layer comprises of rocks rich in silica and aluminum, it is called the 'Sial' layer. 'Sial' is solid and 8 to 45 km thick. Inner layers are 45 to 100 km thick and is partly molten state. Below the lithosphere lies the mantle, which extends up to a depth of 2,900 km thick. Mantle like lithosphere can also be divided into outer, 100 to 400 km thick, asthenosphere (i.e. inner silicate layer; outer silicate layers from inner part of lithosphere) having materials rich in silica and magnesium, hence called 'Sima' layer, and inner, 2,400 to 2,750 km thick, mesosphere which is transitional zone of mixed materials and silicates; also known as wholly 'Sima'. The central part of the earth, core is about 3,500 km thick, outer core, about 2,000 km and inner core about 1,500 km thick. The core consists of metals in liquid state due to high temperature and pressure. Core is composed of nickel and iron, hence also called 'Nife' and accounts for the earth's magnesium. The earth's outermost layer is the crust.

Discontinuous masses called 'plates' comprise the earth's crust. The visible parts of these plates are the continents. The plates collide, stressing the contact boundaries. The braiding stresses build up and, ultimately fracture the rocks along weak planes (faults) or zones, releasing incredibly powerful shock waves in upward and lateral jerks. The fractured rocks jostle for position in a series of after shocks, some more damaging than the original spasms.

Moho Discontinuity

Seismic waves speed up when they reach the bottom of the crust. It is separated from the mantle by Moho discontinuity. The boundary was discovered a Yugoslavian scientist Andrea Mohorovicic, who inferred that seismic waves speed up because they are passing into a denser layer of the lithosphere which is made up of the rigid crust and upper mantle. Primary and secondary waves slow down when they hit the asthenosphere, which is the part of the upper mantle and then speed up again when they are transmitted through solid lower mantle.

Destruction by Earthquake

Measurement of Earthquakes

There are two main methods of measuring the strength of earthquakes. In 1935 C.F. Richter, an American seismologist, devised a formula for calculating the strength of an earthquake from instrumental recordings of its magnitude. This is related to the total amount of energy stored in the rock under stress and released during an earthquake shock by the initial rock fractures at the point of origin or focus

The depth of the focus can be calculated. Shallow earthquakes have a focus above boundary between the earth's crust and the deeper mantle. A single earthquake produces three main types of shock waves, referred to as P, S and L waves. P, or 'primae', or push and pull waves are analogous to sound waves, in which each particle of rocks vibrates longitudinally. S, or 'Shear' waves are more like light waves in that each particle of rock has a shear motion. While P waves can pass through solids, liquids and gases, S waves pass through solids only. P waves travel more quickly than S waves and therefore, are picked up first by a distant seismograph. A third, even slower set of waves is L, or 'Long' wave, which passes through the earth's crust and are the last to be picked up by a seismograph.

The behavior of the various types of wave can be used to study the nature and relative thickness of the earth in different regions (Bisacre 1988).

Magnitude

An earthquake of the magnitude of M 8 represents seismograph amplitudes ten times larger than the earthquake of M 7. The biggest earthquakes have been estimated at M 8.9. Each successive whole number on the Richter scale represents an increase of about 30 times in the energy released. An M 6 earthquake releases energy almost equal to that of the Hiroshima bomb (Arya1994)

Intensity

The intensity, a measure of vibrations at specific locations, is of greater practical interest than magnitude. It is severest at the epicenter and decreases as it ripples outwards. The modified tectonic motion cannot be prevented, but the probability of the occurrence of earthquakes of different magnitudes can be estimated. Safety measures can then be undertaken in advance. Damage control is a life saving and cost effective alternative to reconstruction (Arya 1994).

There are several ways to measure the magnitude of an earthquake. Most seismologists use a precise scale called the moment magnitude scale to measure the earthquake, especially those larger than magnitude M 6.5. The moment magnitude scale calculates the total energy released by a quake. More than one million earthquakes are recorded by seismologists each year but most of these are too small to be felt (about 2 on the Richter scale).

A magnitude M 5 earthquake usually causes property damage. Every five years or more, a great earthquake occurs with a reading of 8 or higher. Such quakes usually cause massive property destruction and kill large numbers of people. Few people die directly from the seismic waves, but rather from collapsed buildings or fires started by ruptured gas lines (Raven 2003).

Tsunamis

Most earthquake damage happens when surface waves cause buildings, bridges, and roads to collapse. An earthquake under the sea causes abrupt movement of the ocean floor. The movement pushes against the water, generating a powerful wave that travels to the surface. Ocean waves generated by earthquakes are called seismic sea waves, or Tsunamis.

Tsunami, a giant sea wave caused by an under water earthquake or volcanic eruption, can sweep through the water at more than 750 km/hr. They have caused thousands of deaths particularly along the Pacific Coast. Today the Pacific Tsunami warning system can monitor submarine earthquakes and warn people of approaching Tsunamis.

One of the most geologically active places in North America is California's San Andrews fault, which runs parallel to the California coast from the Mexican border to northern California - a length of more than 1,100 km (Raven 2003).

Earthquake Distribution

In 1906, much of San Francisco, which is located near the San Andreas fault, was destroyed by a magnitude M 8.3 earthquake and the fire, caused by ruptured gas lines, that followed it. In 1989, a magnitude M 6.9 earthquake along the San Andreas fault in Loma Pieta, about 90 km south of San Francisco, killed 67 people and cause US$ 6 billions in damage to the San Francisco Bay area.

Not all earthquakes occur at plate boundaries. Some occur on smaller faults that crisscross the large plates - the major earthquakes that damaged Northridge, California in January 1994, and Kobe, Japan in January 1995, for example. Such earthquakes pose a seismic hazard that is difficult to evaluate because major quakes occur along a given small fault only every 1,000 to 5,000 years, in contrast to a larger fault line, which may have a major quake every century or so. The greatest Hanshin Earthquake killed more than 6,400 people and injured more than 400,000 and was the most powerful tremor in the country after 1923 (Raven 2003)

In 1960, the Agadir Earthquake in Morocco, killed 1,200 people and nearly 50,000 died as a result of the Peruvian Earthquake of 1970. There are some parts of the world, seismic regions, where earthquakes are common occurrences. These lie along relatively narrow and unstable sections of the earth's crust that are also often areas of volcanic activity (Feather 1997).

When stress is released by rock, shifting along fault planes causes crack in the earth. These movements are known as tectonic events. In the San Fernando earthquake in 1971 small aftershocks went on for more than three days after the main shock. The stresses that cause major earthquakes, however, build up along the edges of the plates or layers, which form the earth's outer crust.

When the rocks yield under stress, a series of shocks radiate in all directions. At the beginning of an earthquake, there will be minor shocks that may be barely felt, then several more violent tremors speed from a few seconds to a few hours apart. These are followed by small aftershocks, which can continue for several days, while the disturbed rocks in the region of origin readjust and settle down (Bisacre 1988).

Many earthquakes occur in coastal regions or under the ocean floor, resulting in a sudden shift in the level of seabed. Huge waves or Tsunami are created by the water displacement and their effect may be fit for hundreds of miles. As the waves near shore and reaches shallower water, however, it gets larger and larger and travels at great speed. The result is a tidal wave or tsunami, which sometimes surges for inland, especially along the coasts with long narrow inlets. A Tsunami can affect a region far removed from an earthquake. People have been drowned in Hawaii as a result of an earthquake in the Aleutian Trench, over 3,000 km away in northern Pacific Ocean.

One of the most disastrous earthquakes in history was the Lisbon Earthquake of 1 November 1755 in Portugal. "This was felt over a wide area as witnessed by the Gentleman's Magazine of March 1756 by Mr. Stoqueler, the Hamburg consul, in Lisbon, who was about 30 km to the northwest of the city that day. The day broke with a serene sky, the wind continuing east; but at 9 o'clock the sun began to grow dim, and about half-an-hour after 9, we heard a rumbling like that of carriages, which increased so much as to resemble the noise of the loudest cannon; and immediately we felt the first shock, which was succeeded by a second, third and fourth." In Lisbon itself, the first shock brought down many buildings while worshippers were at church - thousands were crushed. Many more were killed by fires and Tsunami, which then swept parts of the city.

While many in Europe found evidence of God's or the Devil's work in these events, a small number of scientists pursued their own investigations. Thus, Mr. Stoqueler noted some of the local effects away from the city, such as springs drying up and new ones appearing, a swampy lake uplifted to form dry land and the sea retreating so that you walk almost dry to places where before you could not wade (Michael 1988).

On 26 January 2001, 7.7 M earthquake struck the state of Gujarat in the north EW corner of India were killed several thousands of people and damaged several buildings and properties.

On 13 February 2001, a magnitude 6.5 earthquake occurred about 40 km E south W of the capital city of San Salvador in central El Salvador and triggered thousands of land slides. Earthquake induced liquefaction and lateral-spreading of landslides caused local damage to homes and other structures, this damage was most prevalent in the village of San Augustine. The effects and damage from the 13 February Earthquake were more localized. Three hundred fifteen fatalities and 3,399 injuries are attributed to the February event

The 22 December 2003, San Simon, California, M 6.5 earthquake caused damage to houses road surfaces, and underground utilities.

A tremor of magnitude M 8 hit northern Japan last September, the strongest any where in the world in recent years. The quake hit hardest in under populated area, it caused no fatalities and only seriously injured a handful of people.

A magnitude M 6.6 earthquake occurred on Saturday, 23 October 2004 near the west coast of Honshu, Japan. US GS reports over 30 people killed and thousands injured to data, with over 100,000 people in shelters. Hundreds of buildings destroyed and thousands damaged. Several roads, bridges and rail lines were also damaged, along with gas, water and power lines. More than 150 landslides and over ten fires occurred.

Japan is one of the most earthquake-prone countries in the world, perched on top of several converging tectonic plates. Geological instability causes around 1,000 tremors in the country each year, although many of these go undetected by the public (Internet).

Man-made Earthquake

Man-made earthquakes are created by nuclear explosions, major constructions such as dams and reservoirs, and injection of liquid into underground reservoirs. The energy released by a nuclear explosion can equal that of a moderately strong earthquake, although the pattern of shockwaves is different and can be distinguished from that of natural earthquake. Sudden changes in water level of a reservoir may lead to earthquakes. The pumping of liquid waste into deep wells near Denver, Colorado, and of water under pressure in the Rangeley oil field, Colorado, have both triggered off earthquakes in previously quiet areas (Michael 1988).

Earthquake Prediction and Control

In Japan and Soviet Union slight changes in the inclination of the ground have been detected prior to an earthquake. The most important observation is the local change in the earth’s magnetic field, which has been detected prior to an earthquake. Another recent discovery suggests that there is a marked variation in the velocity of ‘P’ waves recorded from micro-quake during quite long periods prior to major earthquakes. According to this theory, observations suggest that San Francisco and central California will remain free from major earthquakes for at l E the next 25 years.

Small earthquakes could be induced by injecting fluids in faulted areas. From this, it has been inferred that strains built up along fault such as the San Andreas fault in California could be released in a relatively controlled manner by artificially triggering small earthquakes. This could prevent a major natural earthquake that would otherwise appear to be unavoidable along the California fault.

Specially designed modern buildings can withstand significant tremors. Populations are also slowly being educated to take sensible shelter indoors instead of running in to the open streets where debris from collapsing buildings may cause them injury. By taking such precautions it may be possible to minimize the devastation and loss of life caused by earthquakes in the future.

One of the first steps in earthquake safety is to study the earthquake history of a region. If you live in an area that’s had earthquakes in the past, you can expect them to occur there in the future. Most earthquakes happen along plate boundaries.

Many believe that our environment may become a tool to predict. The presence of fore shocks, groundwater fluctuations, difference in thermal anomaly of the earth, presence of radon gas, swelling of ground surface, increase of strain in composed minerals of rock, change in the relative positions on either side of faults, increase of ionic concentrations in the atmosphere, anomalous behavior of animals, especially rodents, etc., are some of the symptoms exhibited by nature before this disaster.

Quake-proofing Your Home

Make your home as earthquake-safe as possible. Take heavy objects down from high shelves, and place them on lower shelves. Reduce the chances of fire from broken gas lines, see that hot water heaters and gas appliances are held securely in place. During an earthquake, keep away from windows and avoid anything could fall on you. Watch for fallen power lines and possible fire hazards.

Seismic Safe Structures: Seismic safe structures are resistant to vibrations that occur during an earthquake. Notice that earthquake in America (Dec. 1998), in Loma Pieta (Oct.1989), and in Iran (Jun.1990) were all close to each other in magnitude. However, the loss of life in each of these earthquakes was quite different. Why were so many more lives lost in America and Iran than in Loma Pieta.

People in earthquake-prone areas should prepare Loma Pieta. Countries like Japan are very susceptible to earthquake. People living in California and Japan have been getting ready for big earthquakes for many years. Since 1971, stricter building codes have been reinforced. In other parts of the world, such seismic safe structures are rare or do not exist at all.

Today in California, some new buildings are anchored to flexible, circular moorings made of steel plates filled with alternating layers of rubber and steel. Tests have shown that building supported with these moorings up to 8.3 on the Richter scale without major damage.

Sharing Seismic Safe Technology

Highways and buildings in earthquake-prone areas can be made relatively seismic safe. Lives and property could be saved by replacing underground water and gas pipes with ones that will bend, but not break, during an earthquake. However, seismic safe structures are expensive and many communities in earthquake-prone areas simply cannot afford them. In these areas, seismic-safe structures can only be constructed if sound seismic principles are employed people.

Conclusion

Earthquakes extract their major costs during the seismic terrors and in the years of reconstruction there after. They are extremely destructive and non-linear. They will not vanish ever. Earthquakes do not respect national boundaries. Most of the lives lost during an earthquake are due to the destruction of human-made structures. By taking precautions it may be possible to minimize the devastation and loss of life caused by earthquakes

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