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Research Paper

Earthquake: its Causes, Types & Mearurement

Biology

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Karamveer Kaur Assistant Professor in Physics &R.S.D.College, Firozepur City,152002(Punjab)India.

ABSTRACT

-In the review paper, a study on earthquakes has been done. The cause of earthquake is the formation of faults and the release of energy in the form of seismic waves. The various types of earthquake include tectonic, volcanic, collapse and explosion earthquakes. For the measurement of earthquake Richter scale, moment magnitude scale and Mercalli Scale are used.

INTRODUCTION

Earthquakes occur throughout the world, but the vast majority occurs along narrow belts which are a few tens to hundreds of kilometers wide. These belts mark boundaries on the planet's surface that are very active geologically. Also intra-plate earthquakes occur but less commonly. These take place in the relatively stable interior of continents, away from plate boundaries. Earthquakes affect many parts of the world every year. Earthquakes further lead to tsunamis and volcanic eruptions causing even more damage. The world is divided into seismic zones based on the tectonic plates and the magnitude of earthquakes. 10 most earthquake prone countries in the world include Japan, Nepal, India, Ecuador, Philippines, Pakistan, El Salvador, Mexico, Turkey and Indonesia. The earthquake has caused immense damage in these countries [1].

CAUSES:

Earthquakes are the Earth's natural means of releasing the stress. When the Earth's plates move against each other, they put forces on themselves and each other. When this stress is great enough, the lithosphere breaks or shifts which is called faulting. When the break occurs, the stress is released as energy which moves through the Earth in the form of waves called seismic waves, which we feel and call an earthquake. The faults and seismic waves are the main causes of earthquakes

- **Faults and their types**

A fault can be defined as the displacement of once connected rocks along a fault plane. Faults form in rocks when the stresses overcome the internal strength of the rock resulting in a fracture. This can occur in any direction with the blocks moving away from each other.

There are various different types of faults:

Normal faults form when the hanging wall drops down. Normal faults occur due to tensional forces acting in opposite directions. These cause one slab of the rock to be displaced up and the other slab down.

Reverse faults form when the hanging wall moves up. These faults develop when compressional forces exist. Compression causes one block to be pushed up and over the other block.

Transcurrent or Strike-slip faults have walls that move sideways, neither up nor down. These faults are vertical in nature and are produced where the stresses are exerted parallel to each other [2].

Graben fault is produced when tensional stresses result in the subsidence of a block of rock. On a large scale these features are known as Rift Valleys.

Horst fault is the development of two reverse faults causing a block of rock to be pushed up. Faults have an economic importance. Horsts are good sites for oil accumulation forming oil reservoirs whereas Grabens are suitable for water accumulation forming aquifers or groundwater basins [3].

- **Seismic waves and their types:**

Seismic waves are generated when rock within the crust breaks, producing a tremendous amount of energy. The energy released moves out in all directions as waves. These are recorded on seismographs.

There are several different kinds of seismic waves, and they all move in different ways. The two main types of waves are **body waves** and **surface waves**. Body waves can travel through the earth's inner layers, but surface waves can only move along the surface of the planet.

Body Waves

Traveling through the interior of the earth, body waves arrive before the surface waves emitted by an earthquake. These waves are of a higher frequency than surface waves. The body waves are of two types P and S waves [4].

P Waves: The first kind of body wave is the P wave or Primary wave. This is the fastest kind of seismic wave. The P wave can move through solid rock and fluids, like water or the liquid layers of the earth. It pushes and pulls the rock it moves through just like sound waves push and pull the air. Sometimes animals can hear the P waves of an earthquake. Usually people can only feel the bump and rattle of these waves. Subjected to a P wave, particles move in the same direction that the wave is moving in, which is the direction that the energy is traveling in, and is sometimes called the 'direction of wave propagation'.

S waves: The second type of body wave is the S wave or Secondary wave. These waves directly follow the P waves. An S wave is slower than a P wave and can only move through solid rock, not through any liquid medium. S waves move rock particles up and down, or side to side perpendicular to the direction of wave propagation.

Surface waves

The second type of wave, and the slowest, is the surface wave. These waves move close to or on the outside surface of the ground. These are of a lower frequency than body waves, and are easily distinguished on a seismogram as a result. It is surface wave that are almost entirely responsible for the damage and destruction associated with earthquakes. The two types of surface waves are love waves and Rayleigh waves.

Love waves: The first kind of surface wave is called a Love wave, named after A.E.H. Love, a British mathematician who worked out the mathematical model for this kind of wave in 1911. It moves the ground from side to side. Confined to the surface of the crust, Love waves produce entirely horizontal motion.

Rayleigh Waves: The other kind of surface wave is the Rayleigh wave, named for John William Strutt, Lord Rayleigh, who mathematically predicted the existence of this kind of wave in 1885. These move both horizontally and vertically in a vertical plane

pointed in the direction of travel [5].

TYPES OF EARTHQUAKES

There are two main types of earthquakes: natural (tectonic and volcanic and man-made (collapse and explosion). Naturally occurring earthquakes occur along tectonic plate lines while man-made earthquakes are always related to explosions caused by man. The type of earthquake depends on the geological make-up of the region.

Tectonic earthquake is one that occurs when the earth's crust breaks due to geological forces on rocks and adjoining plates. Tectonic earthquakes will occur anywhere there is sufficient stored elastic strain energy to drive fracture propagation along a fault plane. Plate boundaries move past each other smoothly if there are no irregularities or asperities along the boundary that increase the frictional resistance; however, most boundaries do have such asperities that lead to stick-slip behavior. Once the boundary has locked, continued relative motion between the plates leads to increasing stress and stored strain energy around the fault surface. The energy increases until the stress breaks through the asperity, suddenly allowing sliding over the plate and releasing the stored energy. This energy is released as a combination of radiated elastic strain seismic waves, frictional heating, and cracking of the rock, which all adds up to an earthquake. It is estimated that only 10 percent or less of an earthquake's total energy is radiated as seismic energy. Most of the earthquake's energy is used to power the fracture growth or is converted into heat generated by friction.

Occasionally, naturally occurring earthquakes happen away from fault lines. When plate boundaries occur in continental lithosphere, deformation is spread out over a much larger area than the plate boundary. And strains are developed within the broader zone of deformation. This leads to earthquakes to occur away from the plate boundary. Also, all tectonic plates have internal stress fields caused by their interactions with neighboring plates and sedimentary loading or unloading. These stresses may be sufficient to cause failure along existing fault planes, giving rise to intra-plate earthquakes [6].

Volcanic earthquake is any earthquake that results from tectonic forces which occur in conjunction with volcanic activity.

Collapse earthquake are small earthquakes in underground caverns and mines that are caused by seismic waves produced from the explosion of rock on the surface.

Explosion earthquake is an earthquake that is the result of the detonation of a nuclear or chemical device.

MEAURING THE SEVERITY OF EARTQUAKES

In recent years, scientists have used a variety of magnitude scales to measure different aspects of the waves produced by an earthquake. The original scale for the measurement of earthquakes was the Richter scale.

- **Richter scale**

The Richter magnitude scale was developed by Charles F. Richter. It was a mathematical device to compare the size of earthquakes. On the Richter scale, magnitude is expressed in whole numbers and decimal fractions. At first, the Richter scale could be applied only to the records from instruments of identical manufacture. Now, instruments are carefully calibrated with respect to each other. Thus, magnitude can be computed from the record of any calibrated seismograph.

The magnitude of an earthquake is an estimate of the energy released by it. The Richter reading won't be affected by the observer's distance from the earthquake. The Richter reading by itself does not give enough information to tell what the effects will be in any particular place. However, in general, the larger the Richter reading, the greater the damage will be close to the epicenter.

The Richter scale is not commonly used anymore, as it has been replaced by another scale called the moment magnitude scale which is a more accurate measure of the earthquake size [7].

- **The Moment Magnitude Scale**

The moment magnitude scale [8], abbreviated M_w, is preferred nowadays as it works over a wider range of earthquake sizes and is applicable globally. The moment magnitude scale is based on the total moment release of the earthquake. Moment is a product of the distance a fault moved and the force required to move it. It is derived from modeling recordings of the earthquake at multiple stations. Moment magnitude estimates are about the same as Richter magnitudes for small to large earthquakes. But only the moment magnitude scale is capable of measuring M8 and greater events accurately. Magnitude scales can be used to describe earthquakes so small that they are expressed in negative numbers. The scale also has no upper limit, so it can describe earthquakes of unimaginable intensity, such as magnitude 10.0 or beyond.

- **Mercalli Scale**

The Mercalli Scale [9] of earthquake damage measures the intensity of an earthquake at a particular place. It was invented by Giuseppe Mercalli in 1902. It uses the type and amount of damage. Unlike the Richter scale, it does not measure the absolute strength of the earthquake, but how strongly it is felt at a particular place. This scale uses the observations of the people who experienced the earthquake to estimate its intensity. The Mercalli scale isn't considered as scientific as the Richter scale because the amount of damage caused by the earthquake may not accurately record the strength of the earthquake.

CONCLUSIONS

Earthquakes are natural disasters causing huge damage to the humanity. The main causes of earthquakes are faults and seismic waves which are produced due to breakage of rocks. Naturally occurring earthquakes include tectonic and volcanic earthquakes while manmade includes collapse and explosion earthquakes. The various types of scales used for the measurement of earthquake intensity include richter scale, moment magnitude Scale and mercalli Scale.

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