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Geofacts

EARTHQUAKES

An earthquake is the rapid shaking of the earth's surface – sometimes violent – that follows the sudden release of energy within the earth. The energy release can be created by various means, such as a sudden fracture between large blocks of material, a volcanic eruption, or the movement of molten material at depth.

Most earthquakes are caused by sudden breaks in the rocks of the upper layers of the earth's crust. Over geological time, the earth is subjected to stresses and distortions that cause mountains to be built and continents to drift apart. While these stresses appear to be acting very slowly, in fact they are continually pulling, pushing, squeezing and tearing the rocks of the earth over most of the globe. Under these forces, rocks gradually bend or stretch. They do this until they can resist no longer, until the stress is greater than the strength of the rocks. Then they break, or 'snap', into a new position. This snap creates vibrations, or 'seismic waves', in the same way breaking a stick causes a sound. It is these vibrations that we feel as an earthquake when they reach the surface.

The fractures or breaks between rocks are called faults. They are characterized geologically by the kinds of movements that have occurred along them. They can vary from almost horizontal surfaces where one set of rocks may slide over another (thrusts) to vertical or near-vertical fractures along which one set of rocks has dropped or slid past the other. Earthquakes tend to reoccur along previous faults because they are weak zones in the crust. Often, however, there is no trace of these faults at the surface.

The place at which the energy is released is called the focus of an earthquake. The focus is usually within 20 or 30 km of the surface, although beneath active volcanic ranges focal depths may reach many hundreds of kilometres. Seismic waves travel from this focus through the earth and up to the surface. The speeds at which the waves travel depend on the waves themselves and the type of rocks through which they pass, but may be between one and ten kilometres per second. Some of the waves are of high enough frequency to be audible, while others are of very low frequency with seconds or minutes between them. If the earthquake is large enough, the seismic waves will travel through the entire planet causing it to 'ring' like a bell or a tuning fork.

Earthquakes create two main types of waves: compressional waves and shear waves. Both waves pass through the earth's interior from the focus, but only compressional waves pass through the molten outer core. Compressional waves travel faster and arrive at the surface first. From this they came to be known as primary waves, or P waves. Shear waves do not travel as fast and are called secondary, or S waves. To the observer the first indication of a small earthquake may be a sharp 'thud', which signals the arrival of the P waves. This is followed by the arrival and stronger shaking of the S waves. The times that the two wave sets arrive and the differences between those times are used by seismologists to determine the distance and time of occurrence of the earthquake, in much the same way as the time difference between the flash of lightning and the sound of thunder can be used to estimate a storm's distance from the observer.

The size of an earthquake is measured on the magnitude scale developed by Charles Richter. It is estimated from the amplitude of the seismic waves that are recorded by sensitive instruments (seismographs) and

relates to the energy released at the focus. The scale is logarithmic, so that each whole number represents a tenfold increase in recorded amplitude. A magnitude of 7, for example, indicates measured amplitudes that are ten times greater than those of magnitude 6 and 100 times greater than those of magnitude 5. Earthquakes with magnitudes of about 2.0 or less are usually called microearthquakes and are normally too small to be felt. Earthquakes with magnitudes of about 5 or greater are strong enough to be recorded by seismographs all over the world and earthquakes of 6 or greater can do damage. Great earthquakes have magnitudes of 8 or higher and, on average, one such event occurs somewhere in the world each year. The last great earthquake in Canada was a magnitude 8.1 earthquake in the Queen Charlotte Islands in 1949.

The point on the earth's surface directly above the focus of an earthquake is called the epicentre. The ground motions produced when the waves from an earthquake reach the surface around the epicentre are highly variable. They depend on the depth of the focus, local surface and subsurface conditions (such as unstable ground or firm rock) and on the magnitude of the earthquake. The intensity of these ground motions is most severe at the epicentre and generally decreases with distance away from it.

The intensity of the effects of an earthquake at the surface is measured on the Modified Mercalli Scale. These effects may range from "I – Not felt except by a very few under especially favorable conditions" to "XII – Damage total. Lines of sight and level are distorted. Objects thrown upward into the air". Eyewitness accounts are extremely useful in establishing the location of an epicentre and in estimating the magnitude of older earthquakes that have not been recorded by modern instruments.

The waves created by earthquakes are used by scientists to study the deep structure of the earth. Because the waves pass through the interior of the earth and through rocks that are physically inaccessible, the changes in the velocity and character of the waves can provide important information about the nature, condition and shape of the rock formations of the deep earth. This is how it was discovered that the outer part of the earth's core was liquid.

The study of earthquakes is clearly of considerable importance in understanding and minimizing the damage and destruction that may occur during an earthquake. Scientists are concerned with determining areas of greatest risk, frequency of earthquake occurrence, and potential ground shaking that can be expected in any given area. Such information is incorporated into seismic zoning maps, which are incorporated into Canada's National Building Code, a set of guidelines for the design and construction of safe buildings.

By understanding the processes that are involved in earthquakes, scientists may be able to estimate the size, location or even the time of a future event. Although detailed earthquake prediction would be of immense value and is the goal of much research, so far it is limited to just a few regions in Canada.

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