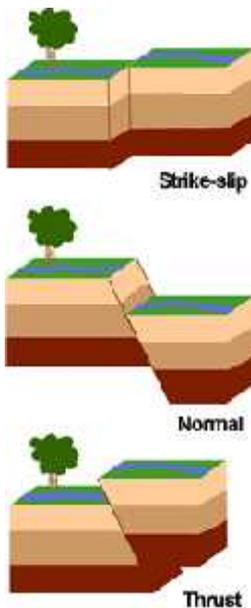


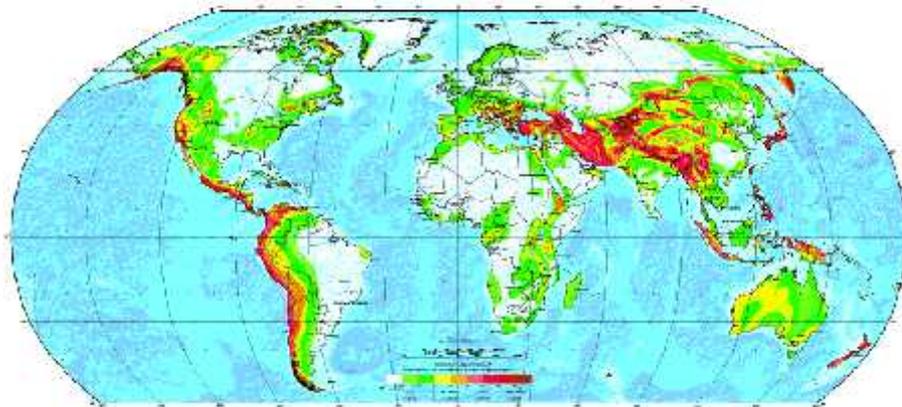
## EARTHQUAKES

An **earthquake** (also known as a **quake**, **tremor** or **temblor**) is the result of a sudden release of energy in the Earth's crust that creates seismic waves. The **seismicity** or **seismic activity** of an area refers to the frequency, type and size of earthquakes experienced over a period of time. Earthquakes are measured with a seismometer (also called a *seismograph*). The moment magnitude (or the obsolete Richter magnitude, numerically similar over the range of validity of the Richter scale) of an earthquake is conventionally reported, with magnitude 3 or lower earthquakes being mostly almost imperceptible and magnitude 7 and over causing serious damage over large areas. The largest earthquakes in historic times have been of magnitude slightly over 9, although there is no limit to the possible magnitude. The most recent large earthquake of magnitude 9.0 or larger was a 9.0 magnitude earthquake in Japan in 2011 (as of March 2011), and it was the largest Japanese earthquake since records began. Intensity of shaking is measured on the modified Mercalli scale. The shallower an earthquake, the more damage to structures it causes, all else being equal. At the Earth's surface, earthquakes manifest themselves by shaking and sometimes displacement of the ground. When a large earthquake epicenter is located offshore, the seabed may be displaced sufficiently to cause a tsunami. Earthquakes can also trigger landslides, and occasionally volcanic activity. In its most general sense, the word *earthquake* is used to describe any seismic event—whether natural or caused by humans—that generates seismic waves. Earthquakes are caused mostly by rupture of geological faults, but also by other events such as volcanic activity, landslides, mine blasts, and nuclear tests. An earthquake's point of initial rupture is called its focus or hypocenter. The epicenter is the point at ground level directly above the hypocenter.

### Naturally occurring earthquakes



GLOBAL SEISMIC HAZARD MAP



Tectonic earthquakes occur anywhere in the earth where there is sufficient stored elastic strain energy to drive fracture propagation along a fault plane. In the case of transform or convergent type plate boundaries, which form the largest fault surfaces on earth, they move past each other smoothly and aseismically only if there are no irregularities or asperities along the boundary that increase the frictional resistance. Most boundaries do have such asperities and this leads to a form of stick-slip behaviour. Once the boundary has locked, continued relative motion between the plates leads to increasing stress and therefore, stored strain energy in the volume around the fault surface. This continues until the stress has risen sufficiently to break through the asperity, suddenly allowing sliding over the locked portion of the fault, releasing the stored energy. This energy is released as a combination of radiated elastic strain seismic waves, frictional heating of the fault surface, and cracking of the rock, thus causing an earthquake. This process of gradual build-up of strain and stress punctuated by occasional sudden earthquake failure is referred to as the elastic-rebound theory. 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 earthquake fracture growth or is converted into heat generated by friction. Therefore, earthquakes lower the Earth's available elastic potential energy and raise its temperature, though these changes are negligible compared to the conductive and convective flow of heat out from the Earth's deep interior.

## Earthquake fault types

There are three main types of fault that may cause an earthquake: normal, reverse (thrust) and strike-slip. Normal and reverse faulting are examples of dip-slip, where the displacement along the fault is in the direction of dip and movement on them involves a vertical component. Normal faults occur mainly in areas where the crust is being extended such as a divergent boundary. Reverse faults occur in areas where the crust is being shortened such as at a convergent boundary. Strike-slip faults are steep structures where the two sides of the fault slip horizontally past each other; transform boundaries are a particular type of strike-slip fault. Many earthquakes are caused by movement on faults that have components of both dip-slip and strike-slip; this is known as oblique slip.

## Size and frequency of occurrence

There are around 500,000 earthquakes each year. About 100,000 of these can actually be felt. Minor earthquakes occur nearly constantly around the world in places like California and Alaska in the U.S., as well as in Guatemala, Chile, Peru, Indonesia, Iran, Pakistan, the Azores in Portugal, Turkey, New Zealand, Greece, Italy, and Japan, but earthquakes can occur almost anywhere, including New York City, London, and Australia. Larger earthquakes occur less frequently, the relationship being exponential; for example, roughly ten times as many earthquakes larger than magnitude 4 occur in a particular time period than earthquakes larger than magnitude 5. In the (low seismicity) United Kingdom, for example, it has been calculated that the average recurrences are: an earthquake of 3.7 - 4.6 every year, an earthquake of 4.7 - 5.5 every 10 years, and an earthquake of 5.6 or larger every 100 years. This is an example of the Gutenberg-Richter law.



The number of seismic stations has increased from about 350 in 1931 to many thousands today. As a result, many more earthquakes are reported than in the past, but this is because of the vast improvement in instrumentation, rather than an increase in the number of earthquakes. The United States Geological Survey estimates that, since 1900, there have been an average of 18 major earthquakes (magnitude 7.0-7.9) and one great earthquake (magnitude 8.0 or greater) per year, and that this average has been relatively stable. In recent years, the number of major earthquakes per year has decreased, though this probably a statistical fluctuation rather than a systematic trend. More detailed statistics on the size and frequency of earthquakes is available from the United States Geological Survey (USGS). Alternatively, some scientists suggest that the recent increase in major earthquakes could be explained by a cyclical pattern of periods of intense tectonic activity, interspersed with longer periods of low-intensity. However, accurate recordings of earthquakes only began in the early 1900s, so it is too early to categorically state that this is the case.

Most of the world's earthquakes (90%, and 81% of the largest) take place in the 40,000-km-long, horseshoe-shaped zone called the circum-Pacific seismic belt, known as the Pacific Ring of Fire, which for the most part bounds the Pacific Plate. Massive earthquakes tend to occur along other plate boundaries, too, such as along the Himalayan Mountains.

With the rapid growth of mega-cities such as Mexico City, Tokyo and Tehran, in areas of high seismic risk, some seismologists are warning that a single quake may claim the lives of up to 3 million people.