EARTHQUAKES

www.geolsoc.org.uk/earthquakes

2017 YEAR OF RISK

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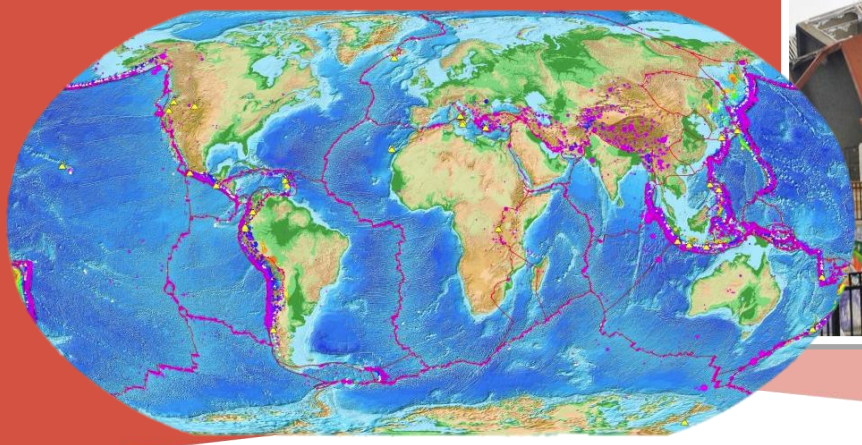

Left: Tectonic plates of Earth, circles denote earthquakes > magnitude 5.
Above: Earthquake damage, Chile, 2010 (Claudio Núñez, Flickr)

More than 500,000 times a year, the Earth's crust shakes. Many of these earthquakes are minor but others can cause devastation and kill thousands, mostly under collapsing buildings and landslides.

By studying earthquakes, geoscientists can help save lives – warning those at risk, showing people how to prepare and protect themselves, and advising on the construction of buildings.

Why do earthquakes happen?

Most earthquakes occur in the areas around the edges of moving **tectonic plates**. As two plates collide or scrape past each other, stress builds up like a compressed spring. The stress is released when the plates suddenly move, either by one plate sliding below, or grinding past, another. When the plates move, waves of energy, known as **seismic waves**, travel through the Earth and shake the surface. People who study earthquakes are called **seismologists.**

Seismogram from the 2011 Tohoku Earthquake in Japan (USGS)

Hazards of earthquakes

Hazard and Risk - it is important in seismology to know the difference between a hazard and a risk. A **hazard** is a dangerous natural event. **Risks** are the consequences of that hazard on people. An earthquake in Antarctica might create all three of the hazards listed below but would pose no risk to people.

Aftershocks - In the days and weeks after an earthquake, further earthquakes known as **aftershocks** can make it dangerous for rescuers to enter damaged buildings. Damage to roads and telephone lines also slows down rescue efforts.

Liquefaction - Almost all soils contain water but when the ground shakes, this water can separate, turning solid ground into quicksand. This liquefaction can sink infrastructure, with particular damage to roads, making it harder for rescuers to reach effected areas.

Tsunamis - If an earthquake occurs at sea it can trigger a wave called a **tsunami**. These can cross oceans and devastate coastal regions far from the original earthquake. **Tsunami Warning Systems** in the Pacific and Indian Oceans monitor water levels and alert communities at risk.

The damage that an earthquake can cause depends not only on magnitude of the quake but also the depth at which the quake originates, the duration of shaking, local geology and infrastructure.

Measuring Earthquakes

Earthquakes are detected using instruments called **seismometers.** These measure the shaking from seismic waves and plot them as a **seismogram**. Although the well-known Richter scale is still in popular use, scientists now use **Magnitude Scales** to measure the energy released by earthquakes. This is a logarithmic scale, which means that for each increase on the scale by one, the energy released actually goes up by about 30 times!

The 12-point **Modified Mercalli Scale** (right) is a qualitative way of measuring the damage caused by earthquakes. It uses shaking and damage reports to describe earthquake impacts.

Index	Description
I	**Earthquake not felt**: only detected by seismometers.
III	**Weak:** vibrations feel like a passing truck.
V-VI	**Felt by all**: houses shake, windows break, furniture moves. Equivalent to 5 on the **Moment Magnitude Scale**
VII	**Damage** to poorly built structures; walls & chimneys crack
VIII-IX	**Major damage**. Most people unable to stand. Buildings partially collapse and shift off their foundations. Soil liquefaction can cause buildings or cars to sink into the ground or fall over.
X-XI	**Severe damage**. Few masonry buildings remain standing. Rails bent, bridges destroyed & damage to gas or water mains can cause fires or floods. Ground fracturing and landslides common.
XII	**Damage total**. Waves seen in the ground surface, objects thrown into the air.

Modified Mercalli Scale

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Major Earthquakes of the last 50 years

Buildings damaged by ground liquefaction, Niigata, Japan 1964

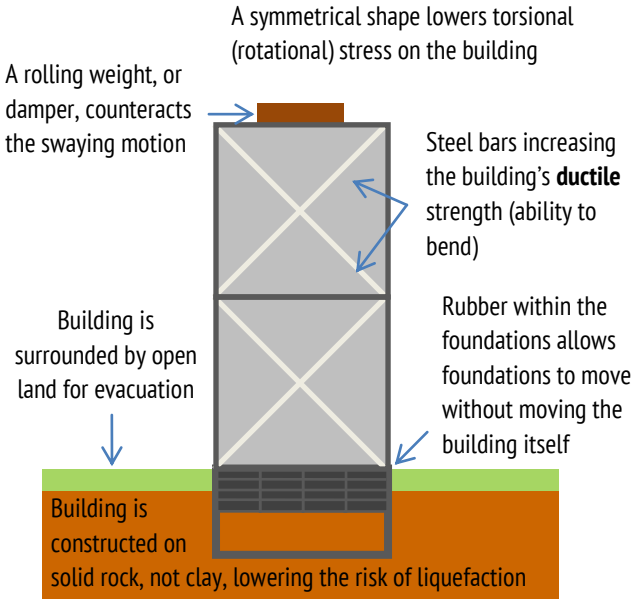
Tsunami flooding, Indonesia 2004

Year	Location	Magnitude (Moment Magnitude)	Deaths	Cost (million US$)
1970	**Peru (Chimbote)**	7.9	67,000	550
1976	**China (Tangshan)**	7.6	290,000	5,600
1985	**Mexico (Mexico City)**	8.3	10,000	4,000
1994	**USA (Los Angeles)**	7.1	61	44,000
1995	**Japan (Kobe)**	6.8	6,348	200,000
1999	**Turkey (Kocaeli)**	7.6	19,118	20,000
2001	**India (Gujarat)**	7.7	19,727	<5,000
2003	**Iran (Bam)**	6.6	26,271	1,000
2004	**Indonesia (Sumatra)**	9.1	230,000	15,000
2010	**Haiti (Port-au-Prince)**	7.0	230,000	14,000
2010	**Chile (Concepcion)**	8.8	432	30,000
2011	**New Zealand (Christchurch)**	6.3	161	11,000
2011	**Japan (Tohoku)**	9.0	>10,000	199,000
2012	**Italy (Emilia)**	6.1	27	15,800
2015	**Nepal (Gorkha)**	7.8	8,964	10,000

Protecting against earthquakes

The type of boundary that a region sits on has a big impact on how well it can protect itself against earthquakes. Boundaries between oceanic and continental plates are narrower than continent – continent plate boundaries, allowing countries to prepare only in the regions where earthquakes are most likely. Pacific countries, like Chile, can prepare for earthquakes in cities that have suffered from them in the past, confident that they will reoccur in similar places. By contrast, the continent – continent boundary in Iran has a wide earthquake region, leaving people unsure of where the next earthquake will hit.

Early Warning Systems are commonly used in developed countries. When an earthquake occurs, the first seismometer to record it sends out a warning which can give cities between a second and a few minutes before the seismic waves reach them, depending on how far away the earthquake strikes. This may not sound like much but it is enough time for buses and trains to be stopped and gas and electricity lines to be turned off, which can prevent fires and therefore save lives.



Ways in which buildings can be designed to reduce damage from an earthquake

Seismologists help work on earthquake mitigation - reducing the damaging effects of earthquakes. Building collapse is a common cause of death during an earthquake but buildings can be designed to withstand violent shaking. For expensive buildings, it is possible to create a scaled down model and test it on a shake table, simulating how it might react to a real earthquake. Education is the best way to reduce life loss. Teaching people how to react to an earthquake, telling them where to go and providing emergency ration kits all contribute to survival rates.

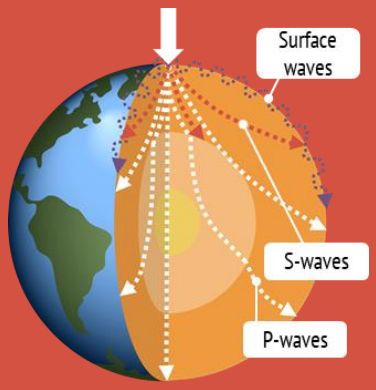
P, S and Surface waves

When an earthquake strikes, the ground vibrates. The vibrations occur as seismic waves, radiating out from a central point – the **focus**. The waves travel through rocks in three ways.

Primary waves are **longitudinal**; they push particles forward in a straight line. These are the fastest waves.

Secondary waves are **transverse**; the vibrations are at right angles to the movement of the particles.

Surface waves travel across Earth's surface and are the vibrations that we feel.



The speed of P and S waves is determined by the density of the material they are moving through. In liquids, S waves don't travel at all. This is very useful as it allows us to work out the inner structure of the Earth. The density difference can also help us find things underground.

FIND OUT MORE...

Plate Tectonics interactive website
www.geolsoc.org.uk/plate-tectonics

Earthquake education resources
www.geolsoc.org.uk/earthquakes