





*The story of an*  
**EARTHQUAKE**



*illustrated by*  
Peter Dennis

 Orpheus



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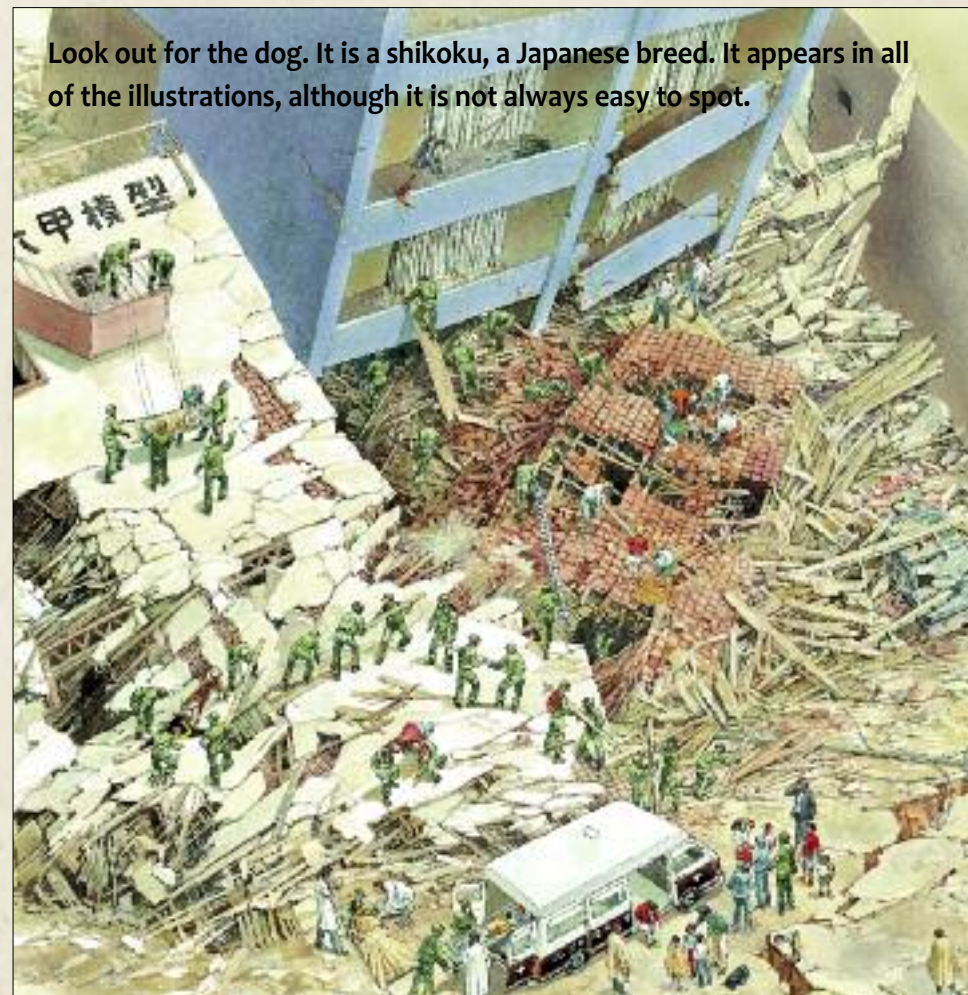
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## JAPAN: EARTHQUAKE ZONE

Japan is no stranger to earthquakes. It is situated close to a plate boundary, an area where two giant slabs that make up the Earth's surface meet. In fact, there are a number of plate boundaries all around the Pacific Ocean. These boundaries are where both volcanic eruptions and earthquakes happen regularly. That is why the rim of the Pacific is sometimes known as the "Ring of Fire".

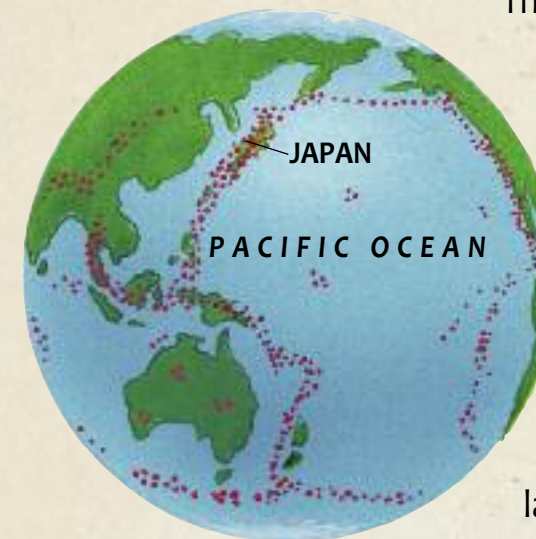
Deep underground, the rocks grind against one another.

This may cause pressure to build up in the rocks above.

Eventually, they crack.

It is this sudden movement that causes earthquakes.

Most quakes cause little damage. But if a major one occurs near a large city, then the consequences can be severe ...





Our story begins 3000 years ago. It is late afternoon on the island of Honshu, Japan. A band of hunters are returning to their village along the coast path. They are startled by a sudden loud, thundering noise. Before their eyes, the cliff on the opposite side of the bay collapses into the sea. Out at sea, waves start to rear up several metres high and crash on to the shore.

The men know that an earthquake has struck. This is not an unusual event – small ground tremors lasting a few moments occur almost weekly – but no damage or injury is usually caused. This quake is different. The men have never seen the cliff collapse before, nor witnessed such colossal waves. Their village, built close to the beach, will certainly be flooded. It is a horrifying sight.





Many centuries have passed. The village has grown into a prosperous city and a busy sea port. The streets are crowded with carts and rickshaws. Street sellers offer all kinds of things for sale, including food, clothing and toys. Amid all the bustle, a funeral procession slowly winds its way through the crowds. In one of the buildings, a tea ceremony is being held.

Over the years, the city has suffered many earthquakes. Most have been far too weak for anybody to notice, although some stronger quakes have caused some minor damage. The city's buildings have been constructed in a particular way that makes them resistant to earthquake shaking. External walls are made of wood; internal ones of paper. The wooden beams holding up the thatch roofs are tied with rice straw ropes.



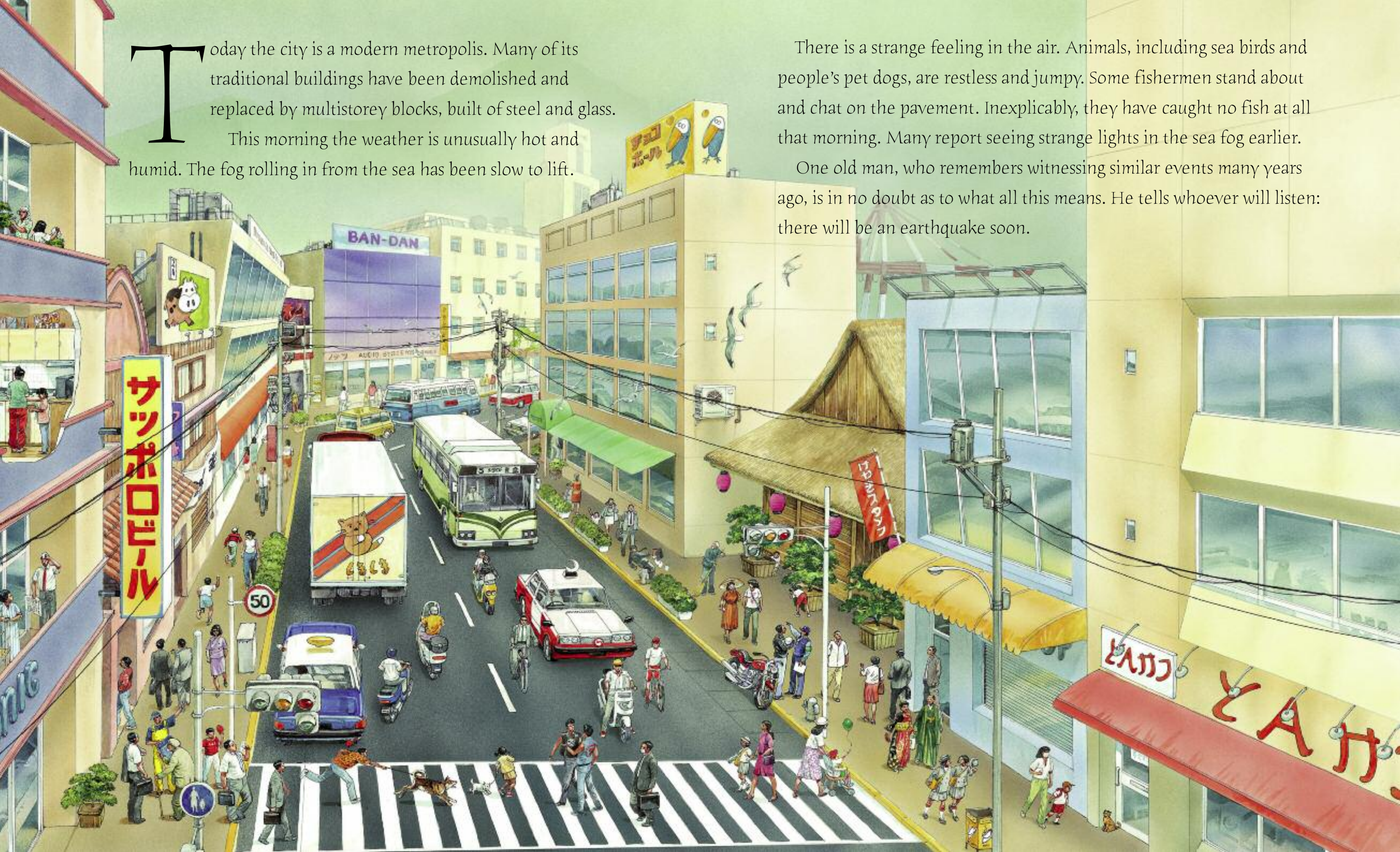


Today the city is a modern metropolis. Many of its traditional buildings have been demolished and replaced by multistorey blocks, built of steel and glass.

This morning the weather is unusually hot and humid. The fog rolling in from the sea has been slow to lift.

There is a strange feeling in the air. Animals, including sea birds and people's pet dogs, are restless and jumpy. Some fishermen stand about and chat on the pavement. Inexplicably, they have caught no fish at all that morning. Many report seeing strange lights in the sea fog earlier.

One old man, who remembers witnessing similar events many years ago, is in no doubt as to what all this means. He tells whoever will listen: there will be an earthquake soon.









Inside an apartment, a family just sitting down to a meal find themselves being hurled around their kitchen. The rocking and juddering causes plates to tip out of cupboards, pots and pans to crash to the floor and even the furniture and electrical appliances to slide around the room. Cracks appear in the ceiling and lumps of plaster start to crash down amid clouds of dust.

The children scream. Their mother shouts to them to get under the table. Everyone is terrified. It feels like a sickening roller-coaster ride where everything is breaking up around them.





Just outside the city, farmers in the ricefields are flung to the ground by the force of the earthquake. To the alarm of the terrified onlookers, the land itself rises and falls like the surface of the ocean as waves surge across it. In the fields, fountains of mud spurt into the air like miniature volcanoes. Cracks appear in the field and a nearby road buckles, throwing cars off the edge.

With a deafening crack, a railway bridge suddenly give way as its concrete supports collapse. The tracks start to slump. The train driver slams on his brakes in a desperate attempt to stop his train from plunging to the ground.







After 20 seconds the quake is over. But the violent shuddering of the ground has not only caused buildings to collapse. Up on a hillside overlooking the city, the rocks and soil just beneath the surface have been made unstable by recent heavy rain. Now, triggered by the quake, the slope itself gives way. In a gigantic landslide, tonnes of boulders and soil, together with trees and shrubs, surge downhill.

Houses, cars and anything else in the way of the landslide are carried along with it. People dash from their houses and flee for their lives ...





During the quake, some people did not have time to escape before the buildings they were in collapsed. Miraculously, a few strong beams held up parts of the building in this street and saved people from being totally crushed. But they are now buried beneath piles of rubble. They have only dusty air to breathe and there is a risk that an aftershock (a lesser tremor that takes place after the main quake) will destroy their fragile shelter. They cry out, hoping someone will rescue them quickly.

Soon, a crowd of helpers, including firemen, emergency medical teams and some brave people who did manage to escape the falling buildings, rush to the scene. Listening out for shouts of help, they lift away the rubble and cut through wood and twisted metal. Eventually a loud cheer goes up as the first survivors are hauled to safety.

They are carefully stretchered over the rubble to a waiting ambulance. Just then, an aftershock causes the remains of the building to collapse.

The rescuers were just in time!



**O**n the sea front, a group of people suddenly notice a massive wave out to sea, getting bigger all the time and rapidly moving towards them. "Tsunami!" they yell, and everybody runs for their lives. Soon, a massive wall of water some 30 metres high looms into view.

Ships and boats of all sizes are picked up and, as the giant wave surges across the docks, are hurled on to the shore. Many more tsunami follow, one after the other, over the next few hours. A hotel building on the sea front escapes destruction by allowing the torrents of water to pass unhindered through its lower floors.





Night has fallen, but the effects of the earthquake are far from over. Fire has broken out in the city. Sparked by fallen power lines and fed by gas escaping from broken gas pipes, the flames quickly fan out among the stricken city's buildings.

Broken water pipes make it very difficult for the firemen to put out the fires. Instead, they use a pump to bring in water from other parts of the city where pipes are still intact. Elsewhere, they will have to blow up some buildings to stop the fire from spreading.

People who have been rescued from fallen buildings sit together in the street as the firefighters attempt to save their homes. Meanwhile, rescue workers continue their search for survivors. They still have hopes that more people can be brought out from underneath the rubble.





**D**awn breaks on a scene of utter devastation. A reporter flies over the city in a helicopter, relaying to his shocked radio listeners what he can see below. Many buildings are damaged or totally destroyed. Large sections of the elevated roadway have collapsed. Fire and flooding have ravaged much of the city.

But the story is not wholly gloomy. Many buildings specially built to withstand earthquakes have remained undamaged. They include a number of old buildings, with their wooden or paper walls and thatched roofs. And, despite the great ferocity of the quake, most of the city's inhabitants escaped harm. They have spent the night sleeping in tents. For the next few weeks, they will be without electricity and running water, but at least they are alive.







A few years have passed since the earthquake. A museum has been built as a record of that terrible event. The exhibits tell people all about earthquakes. There are models showing the inside of the Earth's crust. The visitors watch a video of what happened during the quake in their city and gaze at a model of the immense damage it caused. There are also exhibits that show how traditional houses were built to withstand earthquakes. A seismograph records small tremors as they actually happen in the city today (these are very common).

Children have a go on an earthquake simulator. The floor shakes around, making it very difficult for them to stand upright. They have a lot of fun falling about, but their parents remember that when the real earthquake struck, the shaking was so violent they feared for their lives.



# HOW EARTHQUAKES OCCUR

The outer layer of the Earth is made up of a number of giant slabs, called tectonic plates. These are always on the move. This movement is very slow — about 1 cm a year — but the pressure is enormous. When plate edges grind against one another, they send out shock waves through the ground. We feel these as vibrations, and call them earthquakes. Most earthquakes are small tremors that do no damage. But when plates “lock” together, pressure builds up in the rocks under the ground. Eventually the pressure becomes too much for the rock to withstand. It snaps, causing a major earthquake.

## SLIDING PLATES

Many earthquakes occur along what are called subduction zones, those places where one tectonic plate edge is sliding beneath another. As the rocks grind against one another, great pressure builds up in the rocks above. Eventually, they suddenly crack, triggering an earthquake. Places most at risk of quakes are the shores of the Pacific Ocean and the region extending from Northern India to Europe.

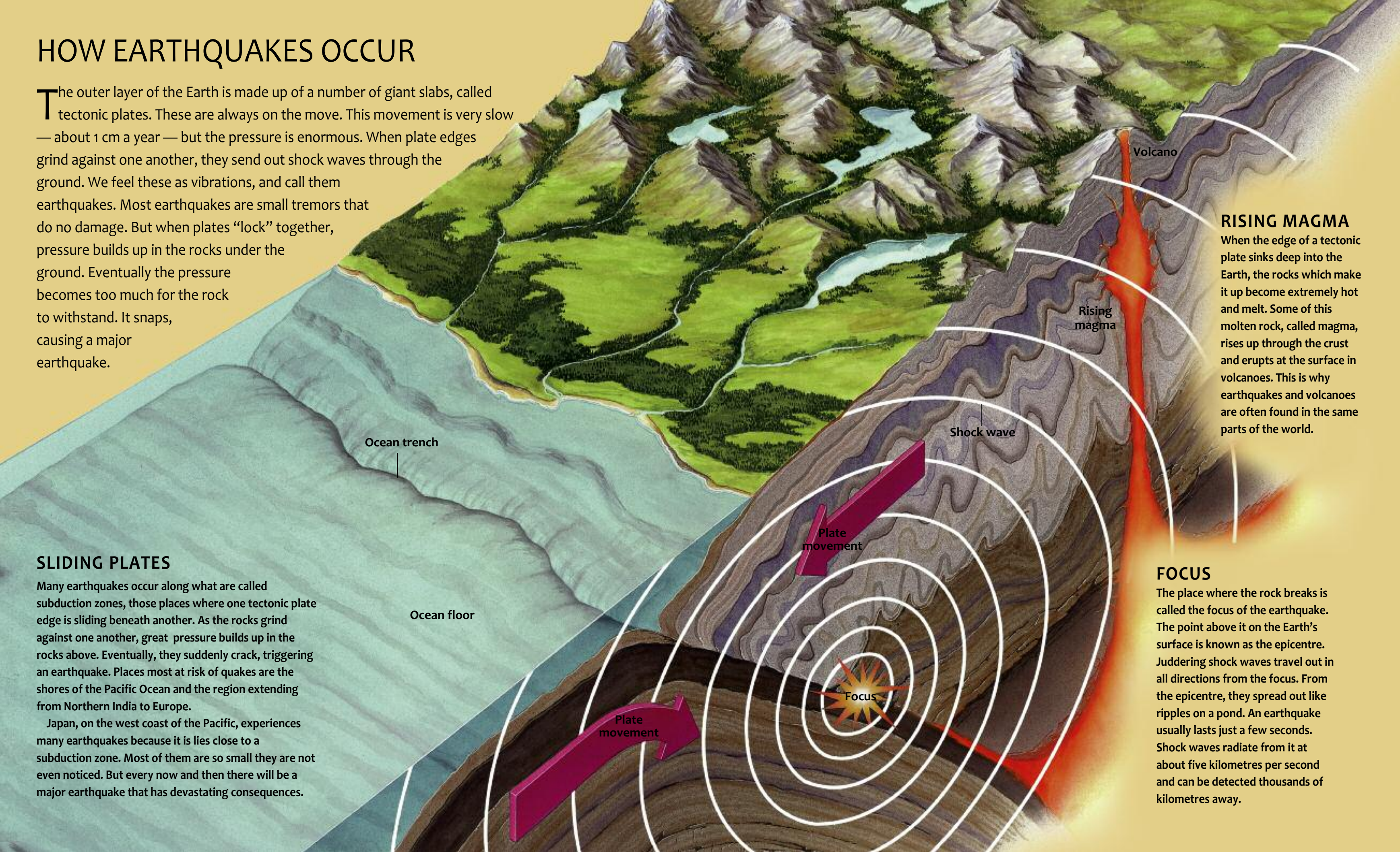
Japan, on the west coast of the Pacific, experiences many earthquakes because it lies close to a subduction zone. Most of them are so small they are not even noticed. But every now and then there will be a major earthquake that has devastating consequences.

## RISING MAGMA

When the edge of a tectonic plate sinks deep into the Earth, the rocks which make it up become extremely hot and melt. Some of this molten rock, called magma, rises up through the crust and erupts at the surface in volcanoes. This is why earthquakes and volcanoes are often found in the same parts of the world.

## FOCUS

The place where the rock breaks is called the focus of the earthquake. The point above it on the Earth's surface is known as the epicentre. Juddering shock waves travel out in all directions from the focus. From the epicentre, they spread out like ripples on a pond. An earthquake usually lasts just a few seconds. Shock waves radiate from it at about five kilometres per second and can be detected thousands of kilometres away.





# GLOSSARY

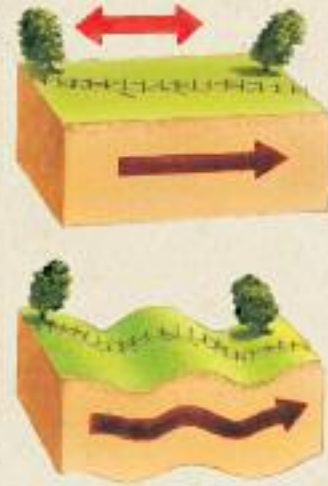
**Aftershock** A lesser tremor that takes place after the main earthquake. There may be many aftershocks, sometimes continuing for months afterwards.

**Crust** The rocky outer layer of the Earth.

**Earthquake** A shaking of the ground caused by the sudden movement of part of the Earth's crust. Earthquakes usually (but not always) occur at or near the boundaries of tectonic plates.

**Epicentre** The point on the Earth's surface directly above the focus of an earthquake.

**Fault** A crack in the Earth's surface. The rocks move in opposite directions on either side of the fault, causing a quake.



When rocks snap, two kinds of shock waves are released from the earthquake's focus. Primary (P) waves (left, top) squeeze and stretch the rocks. Secondary (S) waves (bottom) shake them up and down and from side to side.

**Focus** The point in the Earth's crust where the rocks suddenly break, releasing shock waves.

**Foundations** The base of a building constructed so that its weight is supported on firm ground or bedrock.

**Landslide** The sudden and rapid movement of soil and rock down a slope.

**Liquefaction** The process by which moist sediments, when shock waves are passed through them, become almost like a liquid.

**Mercalli Scale** A measure of the intensity of damage caused by earthquake shaking, based on the effects on buildings and the landscape.

The Transamerica Building in San Francisco (right), specially designed to withstand quakes.



**P(rietary) wave** A shock wave released from the focus of an earthquake. P-waves cause the rocks to shake back and forth in the direction of wave movement.

**Richter Scale** A measure of the magnitude (size or strength) of an earthquake. An increase of 1 point means that an earthquake is 30 times stronger. An earthquake with a magnitude of less than 4 is minor; 4-5 light; 5-6 moderate; 6-7 strong; 7-8 major; 8-9 great.

**S(econdary) wave** A shock wave released from the focus of an earthquake. S-waves cause the rocks to shake from side to side and up and down at right angles to the direction of the wave movement.

**Sediments** Eroded rock fragments, such as sand and gravel, transported and laid down by wind, water or ice.

**Seismograph** A device that makes records of an earthquake shaking.

**Seismometer** An instrument that measuring movements in the Earth's crust.

**Shock wave** A wave of energy released from the focus of an earthquake. Also called a seismic wave.

**MEASURING EARTHQUAKES**

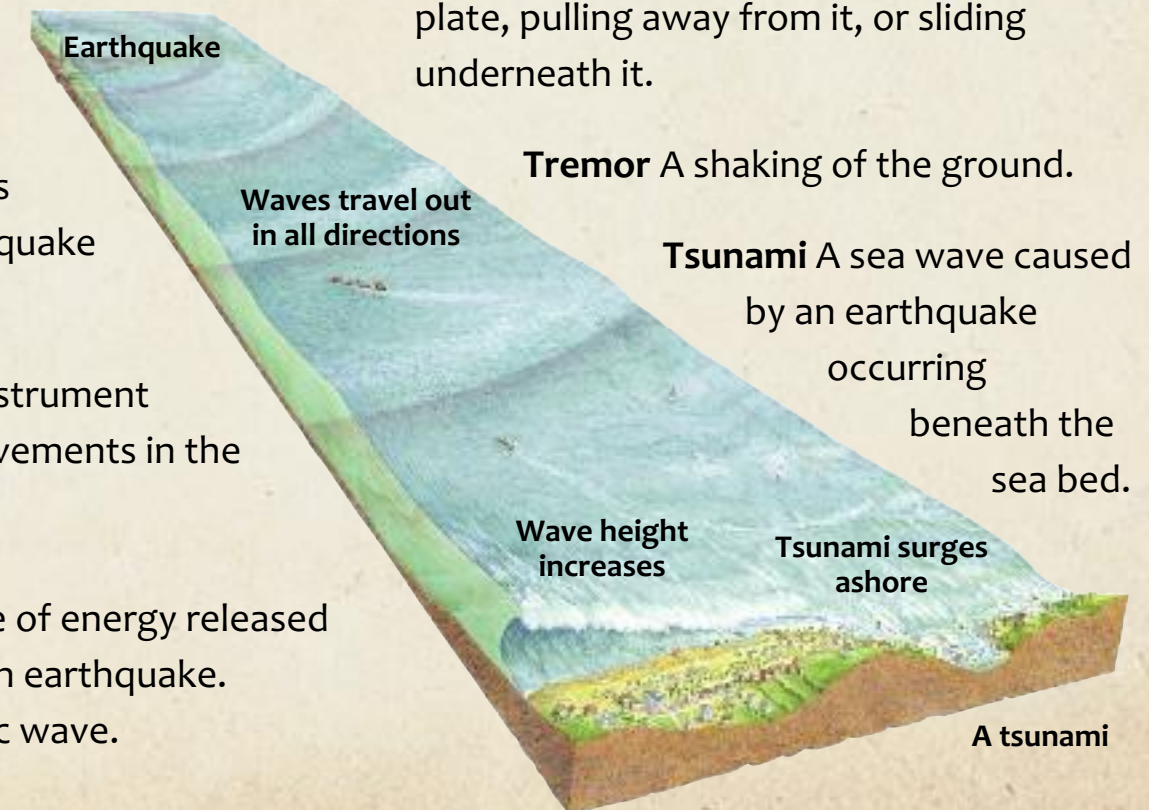
The Mercalli Scale records the intensity of damage caused by an earthquake.

I-II Felt only by a few. III-IV Vibration as if by passing lorry. V Buildings tremble, vases fall, trees shake. VI Bells ring, plaster cracks, people shaken. VII Loose tiles, old walls fall, chimneys crack. VIII Damage to buildings. IX Ground cracks, buildings collapse. X Landslides, bridges damaged, rails bent. XI Dams wrecked. XII Total devastation.

**Tectonic plates** The large slabs into which the Earth's surface is divided. Each plate moves slowly, either pushing into another plate, pulling away from it, or sliding underneath it.

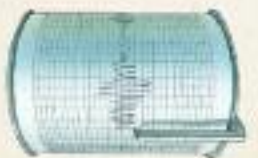
**Tremor** A shaking of the ground.

**Tsunami** A sea wave caused by an earthquake occurring beneath the sea bed.



## RECORDING EARTHQUAKES

The Chinese invented this earthquake detector (right) in AD 132. When shaken, a rod inside it swings and opens one of the dragons' mouths, releasing a ball into a toad's mouth with a loud clang. It records the direction of the quake. Seismographs (below) measure the size of shock waves caused by an earthquake.



Vibrations are recorded by a pen on a paper trace rolled over a drum.



