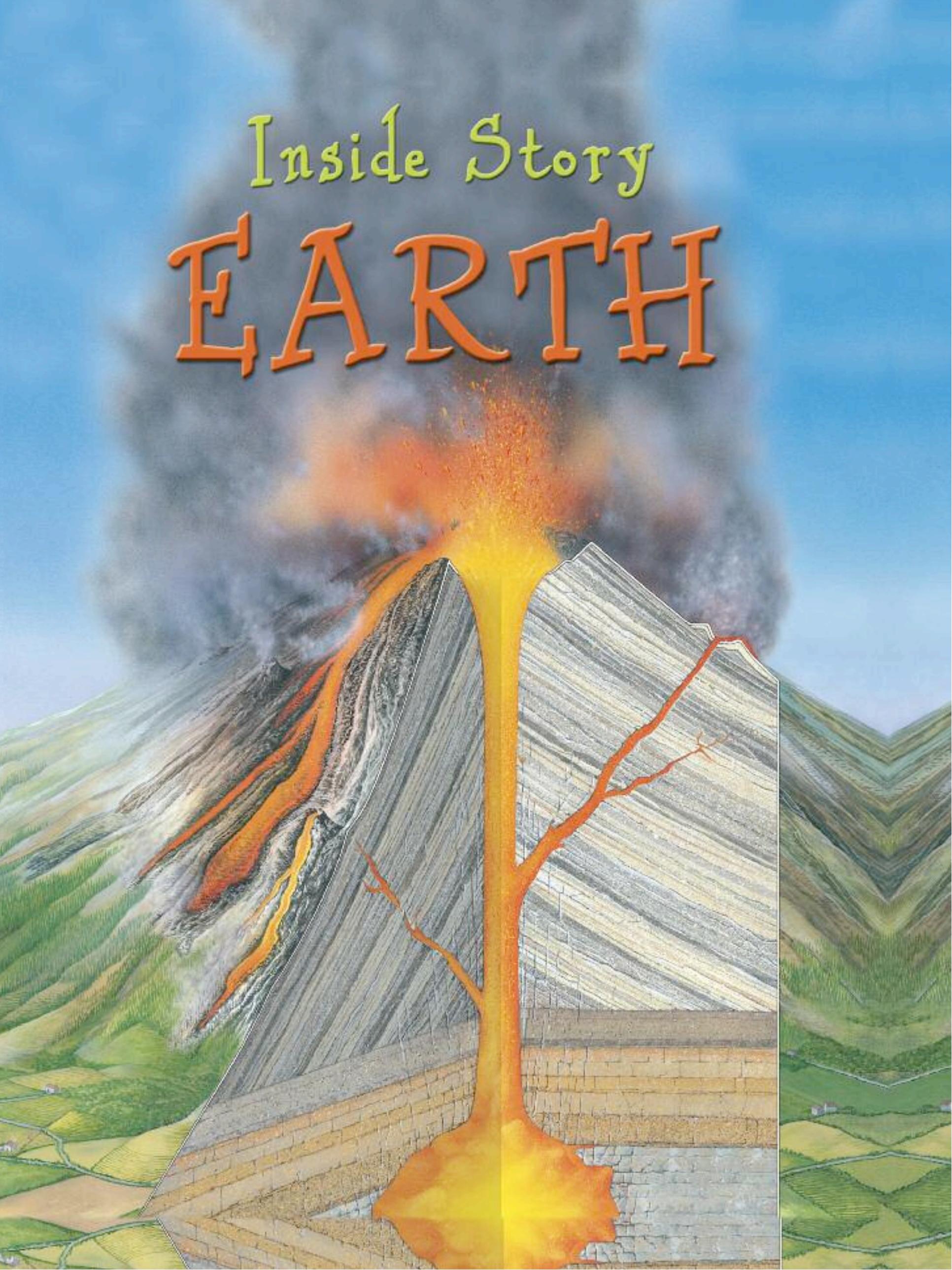
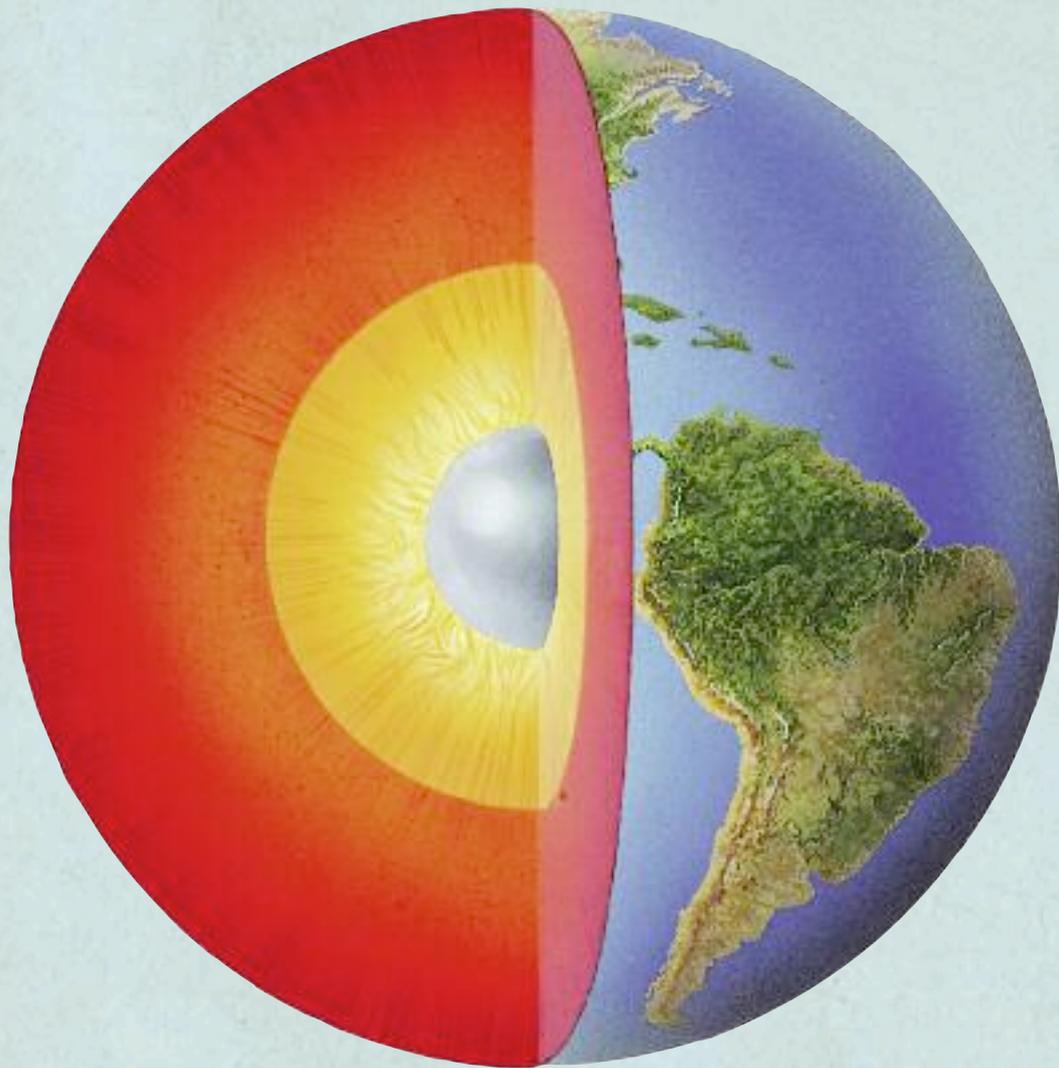


Inside Story
EARTH



Inside story
EARTH



Illustrated by Gary Hincks and Nicki Palin

 Orpheus

Contents

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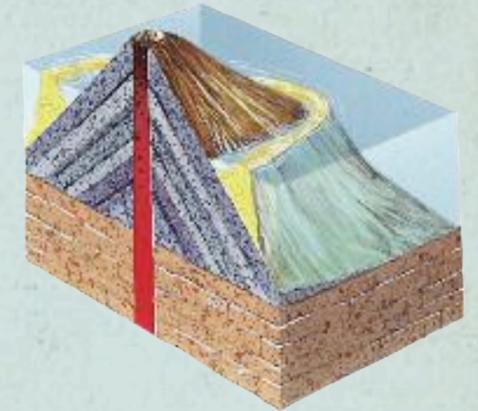
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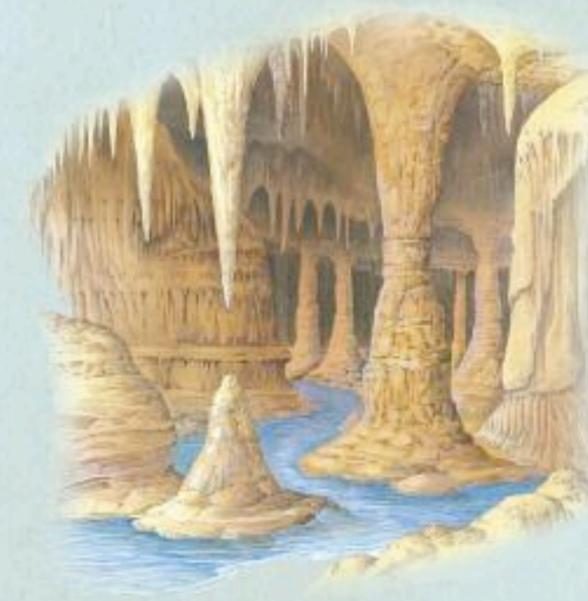
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Planet Earth

The Earth's outer layer is divided into enormous curved pieces, called tectonic plates.

Each plate consists of a piece of the Earth's outer layer, the crust, plus a portion of outer mantle below it. Forces within the Earth mean that these plates, carrying the continents and oceans with them, are in constant motion: pulling apart, bumping together, or sliding past each other.

These movements and collisions along the edges of the plates cause volcanoes and earthquakes. They build mountains and create new sea bed.



A JIGSAW PUZZLE

The Earth's surface is divided into jagged-edge pieces, called tectonic plates. There are eight large plates and 12-15 smaller ones. They slowly move around the globe, driven by heat flows in the upper mantle.



BENEATH THE WAVES

This is what the Earth would look like if all the ocean waters were drained away. Snaking down the middle of the Atlantic Ocean is the Mid-Atlantic Ridge. This underwater mountain range is actually a series of ridges separated by cracks that run at right angles to the ridges.

This is the INSIDE STORY of our planet Earth. On the following pages you will discover, what lies beneath surface: the internal layers of the Earth, the soil and rocks just under your feet or deep beneath ocean waters.

Inside the Earth

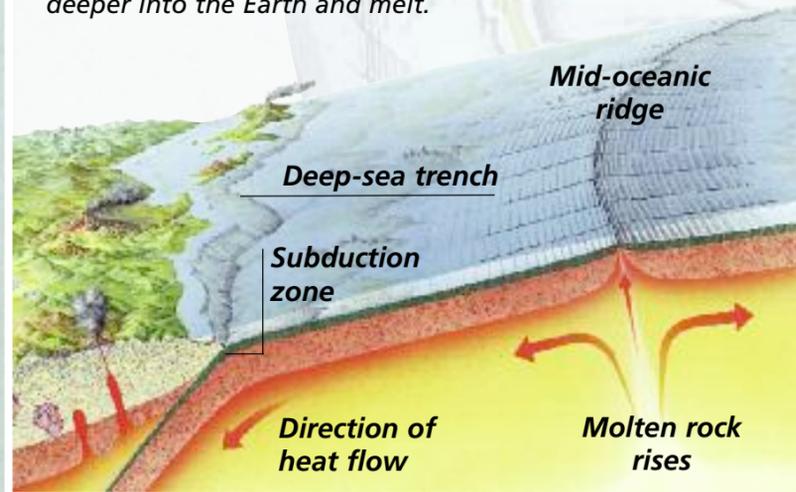
The Earth has a thin, rocky shell, called the crust, on the outside. Beneath it lie several layers.

The first, the mantle, is made of rocks so hot they have partially melted. Farther down is the outer core, made of liquid metal. At the centre of the Earth is a solid inner core, made of iron.

SEAFLOOR SPREADING

All along a mid-oceanic ridge—a crack between the ocean plates—molten rock rises from inside the Earth. As it emerges into the cold water, it cools rapidly and becomes solid. The more molten rock oozes out, the more the ocean floor spreads apart. This process is called seafloor spreading.

When an oceanic plate collides with a continental plate, the edge of the thinner, denser ocean plate slides beneath it in a subduction zone. The rocks of the ocean floor sink deeper into the Earth and melt.



LAYERS OF THE EARTH'S INTERIOR

Compared to the Earth's total size, the crust, its rocky outer layer, is very thin. Imagine sticking a postage stamp on a football. If the ball represents the Earth, the crust would only be the thickness of the postage stamp. Beneath the crust is the mantle, a dense rocky layer about 2900 km thick.

Below the mantle is the outer core, a liquid mass of white-hot melted iron and nickel. At the very centre of the Earth is a solid inner core, also made of iron with a small amount of nickel.

Temperatures here reach 6000°C—that's as hot as the the outer surface of the Sun.

LOWER
MANTLE

OUTER
CORE

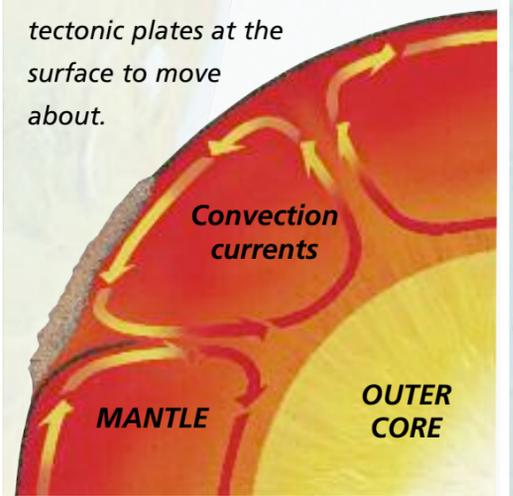
INNER
CORE

UPPER MANTLE

Crust

THE MANTLE

The upper mantle is made of magma—crystals of solid rock with molten or liquid rock in between. The pressure in the inner mantle is so great that the rock here is solid, but not completely rigid: it can still move. Inside the mantle, the rock actually flows, very slowly in giant circles called convection currents. These currents cause the tectonic plates at the surface to move about.



Volcano

The snowy summit and green slopes of this volcano disguise its turbulent core deep underground. A volcano is an opening in the Earth's crust through which molten rock, called magma, erupts. (We think of volcanoes as cone-shaped mountains, but many are simply fissures in the Earth's crust). A kilometre below the surface, pressure is building up in a magma chamber. An eruption can be only seconds away...

ACTIVE, DORMANT OR EXTINCT?

When a volcano has been known to erupt in the last few hundred years, it is said to be active. A dormant volcano is one that has not erupted for many years or even centuries. Mount St. Helens in the USA, for example, was a dormant volcano that came back to life spectacularly in 1980. An extinct volcano has not erupted for tens of thousands of years.

PREDICTING ERUPTIONS

There are warning signs to look out for before a major eruption. Smoke and steam being ejected from the main vent, or even small lava eruptions, can indicate that a much bigger eruption is on the way. Earth tremors are also a sign of impending trouble. Sometimes the sides of a volcano bulge before an eruption as pressure builds up inside.

FERTILE SLOPES

Volcanic ash and lava are full of the minerals and chemicals needed by plants to thrive. Although newly erupted lava and ash is a hostile environment for plants, over time the rocks break down, releasing the nutrients within them. Eventually, very fertile soils can develop on old lava and ash flows.

Some of the world's finest wines and coffee are made from crops grown on volcanic soils. But growers should beware. There is always the danger that the very same volcano that provided their fertile soil may erupt again and turn fields back into barren wastelands.

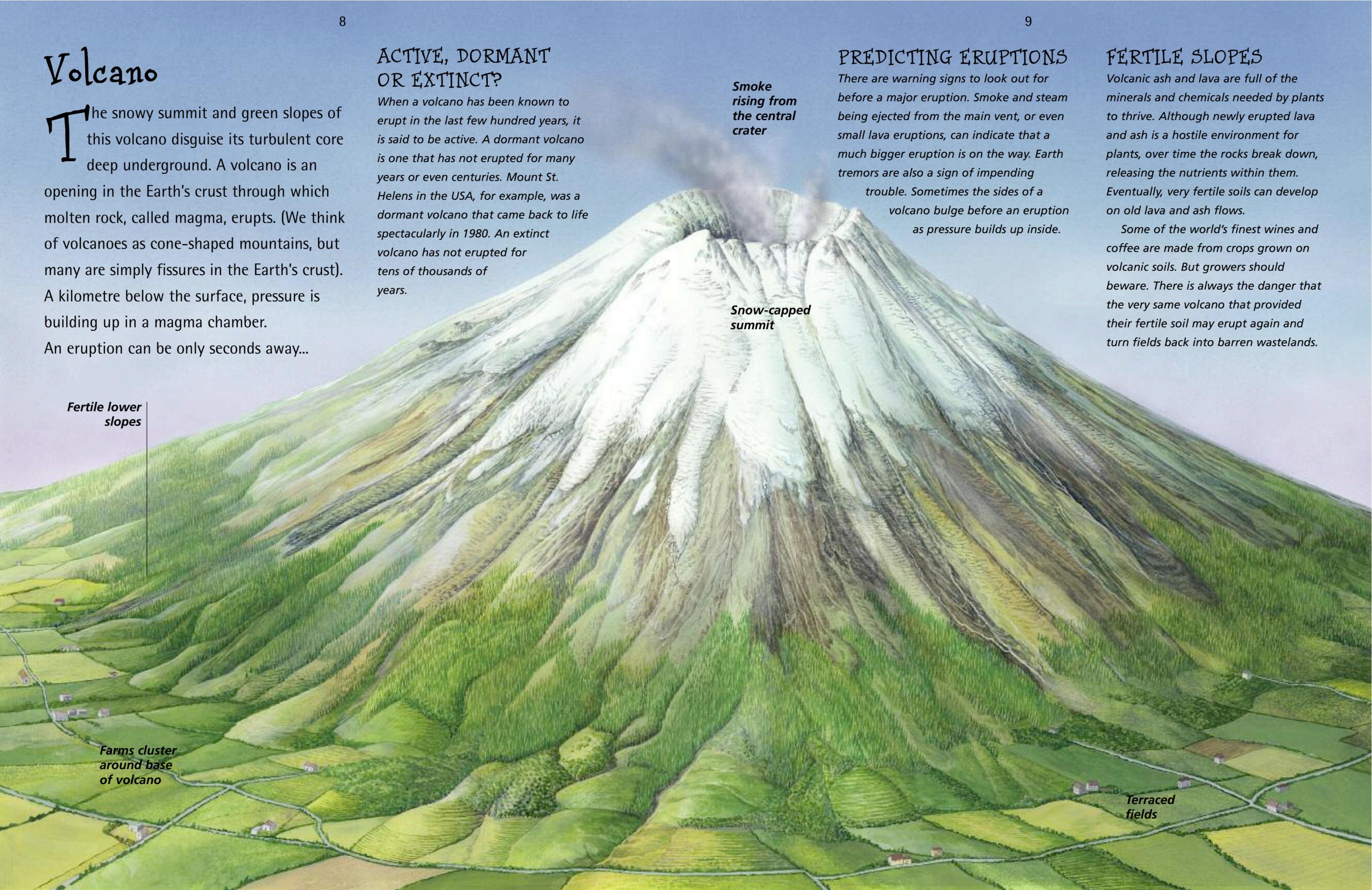
Smoke rising from the central crater

Snow-capped summit

Fertile lower slopes

Farms cluster around base of volcano

Terraced fields



Volcanic ash seen under a microscope



LAVA AND ASH

When melted rock, called magma, emerges above ground it is called lava. Some lava is thin and runny, but in explosive eruptions, lava is thick and sticky. Volcanoes eject other substances too: gases and fumes rich in sulphur. Some give out clouds of ash and cinders. A few volcanoes are so explosive that they burst out huge lumps of molten rock as big as houses.



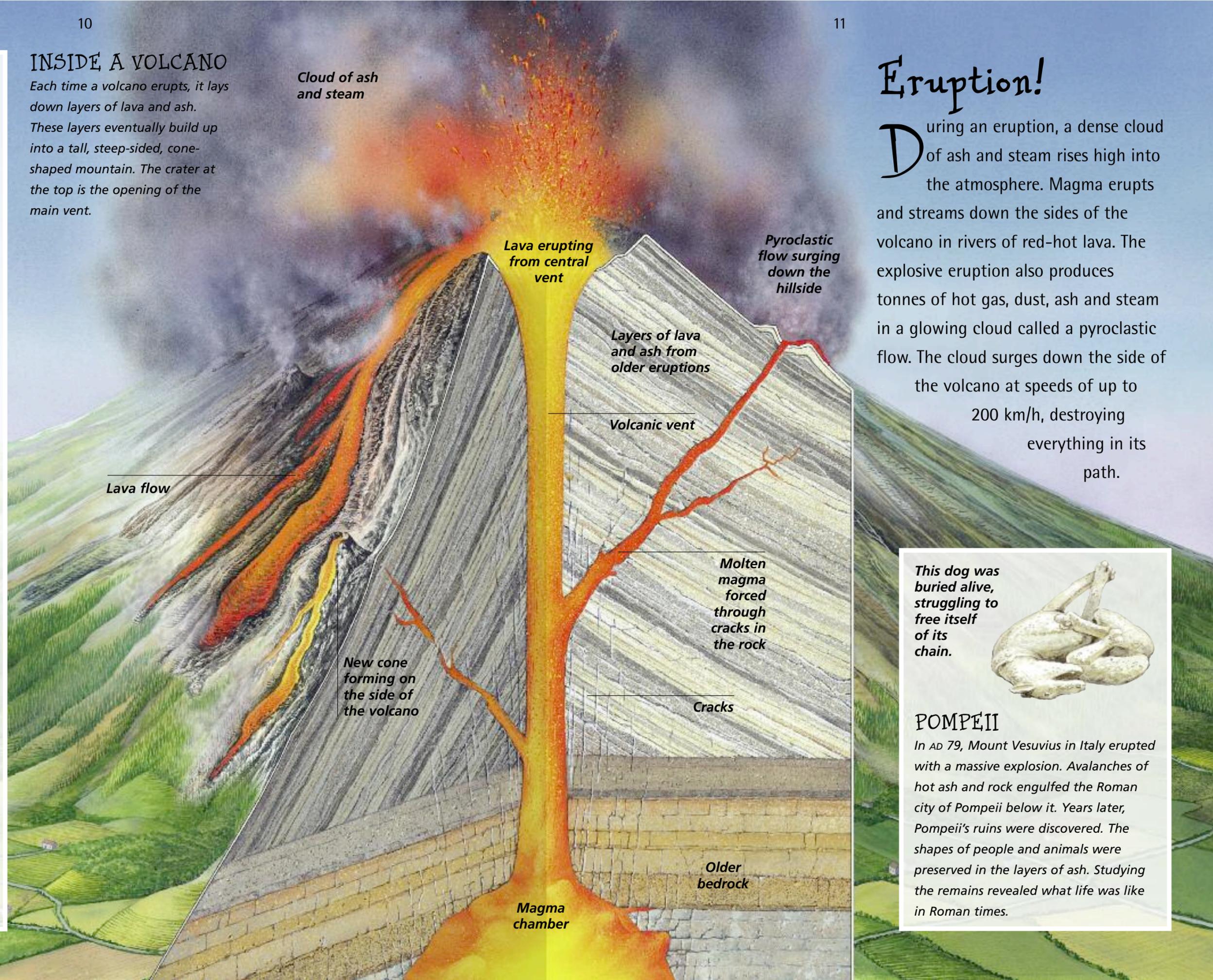
VOLCANIC ROCKS

Most magma never makes it to the Earth's surface, turning instead to solid rock while still underground. The rock takes the shape of its surroundings. A plug, a column of magma that has cooled inside a volcano, may remain after the softer, outer layers of the volcano have been eroded away.

INSIDE A VOLCANO

Each time a volcano erupts, it lays down layers of lava and ash. These layers eventually build up into a tall, steep-sided, cone-shaped mountain. The crater at the top is the opening of the main vent.

Cloud of ash and steam



Eruption!

During an eruption, a dense cloud of ash and steam rises high into the atmosphere. Magma erupts and streams down the sides of the volcano in rivers of red-hot lava. The explosive eruption also produces tonnes of hot gas, dust, ash and steam in a glowing cloud called a pyroclastic flow. The cloud surges down the side of the volcano at speeds of up to 200 km/h, destroying everything in its path.

This dog was buried alive, struggling to free itself of its chain.



POMPEII

In AD 79, Mount Vesuvius in Italy erupted with a massive explosion. Avalanches of hot ash and rock engulfed the Roman city of Pompeii below it. Years later, Pompeii's ruins were discovered. The shapes of people and animals were preserved in the layers of ash. Studying the remains revealed what life was like in Roman times.

Earthquake

This busy city is no stranger to earthquakes. It is built on a plate boundary, an area where two plates meet. Deep underground, the edge of one plate is slowly forcing its way beneath another. This causes pressure to build up in the rocks above. One day they will suddenly crack and grind against each other. It is the sudden movement along these cracks, called faults, that causes earthquakes. Even now, a few kilometres out to sea, massive pressure has built up along an old fault line. The rocks may give way at any moment...

EARTHQUAKE ZONES

Every year, about 100,000 earthquakes occur across the world. Most of these are so small they are not even noticed. But every now and then there will be a major earthquake that has devastating consequences. Most earthquakes occur along plate boundaries. This is where the Earth's plates are slowly pushing or grinding against each other. Places most at risk are the shores of the Pacific Ocean and the region extending from Northern India to Europe.

DESIGNED FOR DANGER

New buildings in earthquake-prone areas are designed to withstand tremors and absorb shocks. Taller buildings, for instance, can be made larger at the bottom than the top. This shape is more stable during an earthquake, so the buildings are less likely to collapse.

Newer buildings reinforced to withstand earthquakes

LANDSLIDE RISK

Up on a hillside overlooking the city, the rocks and soil just beneath the surface have been made unstable by recent heavy rain. In an earthquake they could cause a landslide, with tons of boulders, soil, trees and shrubs surging downhill.

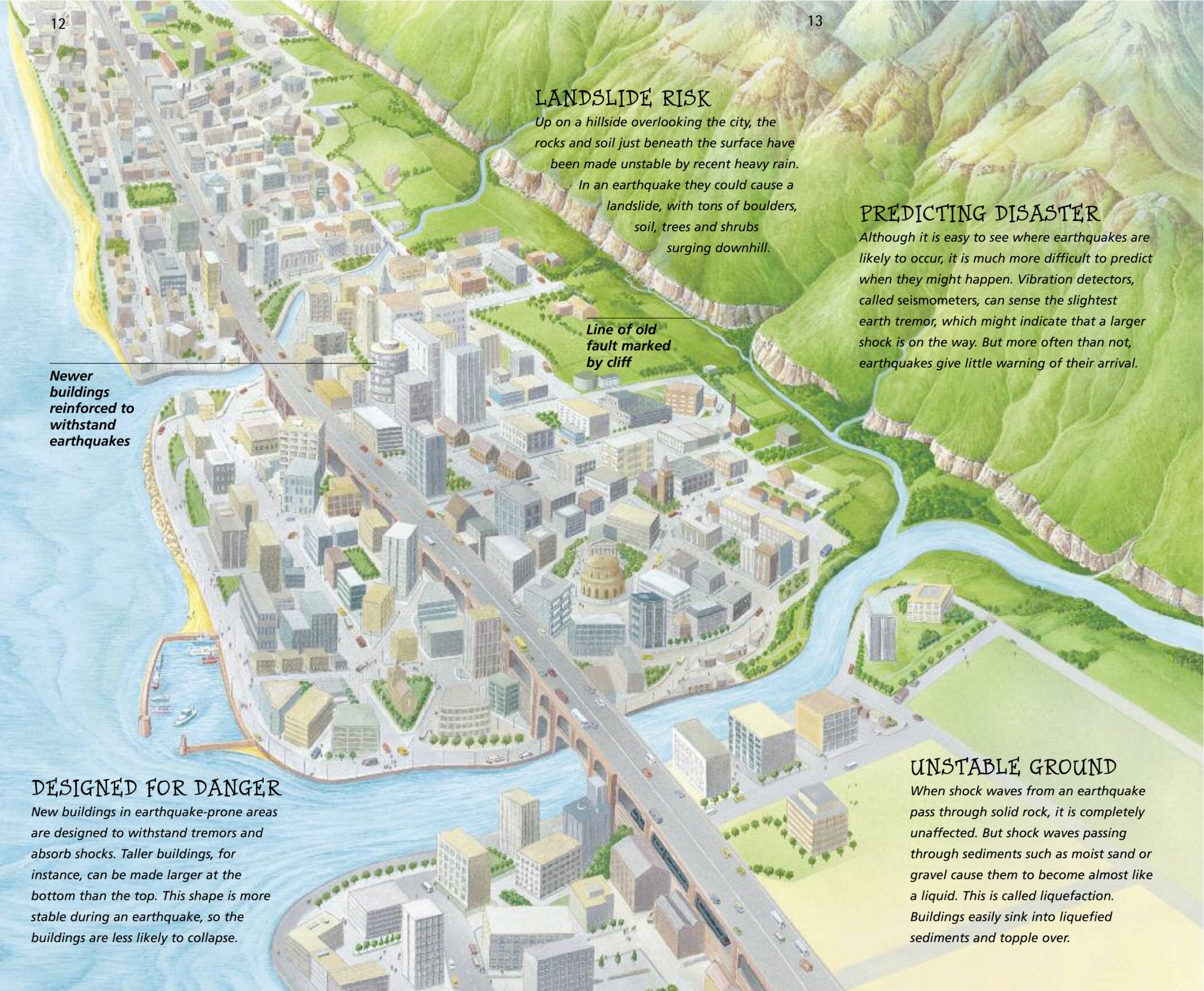
Line of old fault marked by cliff

PREDICTING DISASTER

Although it is easy to see where earthquakes are likely to occur, it is much more difficult to predict when they might happen. Vibration detectors, called seismometers, can sense the slightest earth tremor, which might indicate that a larger shock is on the way. But more often than not, earthquakes give little warning of their arrival.

UNSTABLE GROUND

When shock waves from an earthquake pass through solid rock, it is completely unaffected. But shock waves passing through sediments such as moist sand or gravel cause them to become almost like a liquid. This is called liquefaction. Buildings easily sink into liquefied sediments and topple over.



Tsunami

Pressure build-up along the offshore fault has resulted in a massive earthquake out at sea. A large block of the sea bed has dropped nearly 15 metres. This has caused the sudden movement of the thousands of tonnes of water above it, creating a wave called a tsunami. The wave travels out in all directions at hundreds of kilometres an hour. As it approaches the shallow waters near land, the tsunami increases in height, rearing up to form huge waves.

Tsunami reaching the shore

SCALES

The Mercalli Scale measures the effects of a quake on a scale of 1 to 12, where 1 is barely noticeable and 12 is total devastation. The Richter Scale is a measure of energy. A "moderate" earthquake—that is, one strong enough to damage buildings—would measure about 5.5 on the Richter Scale.

WALL OF WATER

On reaching shallow water near the shore, waves grow much bigger. When a tsunami hits land, waves can be up to 30 metres high. The wall of water comes ashore like a violent, onrushing tide. There are normally not just one, but several waves coming ashore minutes, or sometimes hours, apart.



AN EARTHQUAKE STRIKES

Shock waves from the earthquake have reached the city causing massive destruction. The shock waves moving through the crust cause the ground to shake, triggering landslides and damaging roads and buildings.

Landslides

Destruction of buildings and roads

Fires break out in damaged buildings

Old fault line

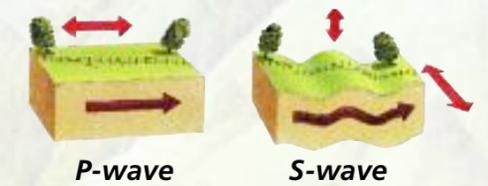
The rocks on this side of the fault slipped down during an earthquake many centuries ago.

Direction of movement along the fault

Shock waves from the earthquake pulse outwards through the Earth.

FAULTY ROCKS

Faults are large cracks in the Earth's crust where the rocks move against each other. It is not easy to shift massive chunks of crust, so it takes a great amount of pressure to build up before the rocks will move. When they do, the movement is often sudden and violent, sending vibrations through the Earth in all directions. These vibrations are what we call earthquakes.

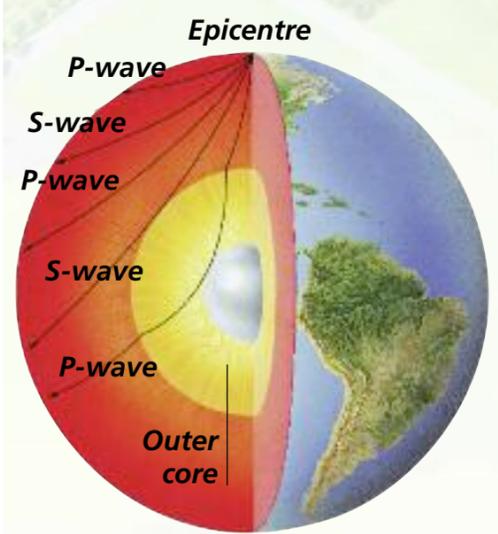


TYPES OF WAVE

When rocks snap, two kinds of shock waves are released. Primary (P) waves (above, left) squeeze and stretch the rocks. Secondary (S) waves (above, right) shake them up and down and from side to side.

An earthquake lasts just a few seconds, but shock waves radiate from it like ripples in a pond. They spread out from a place called the focus, where the rocks snapped, reaching the surface first at the epicentre, directly above the focus. Shock waves can be detected thousands of kilometres from the epicentre.

P (primary) waves travel quickly through the Earth, although its inner layers bend them (below). S (secondary) waves are slower and cannot travel through the Earth's liquid outer core.



The ocean

The oceans cover more than two-thirds of the Earth's surface. There are five great oceans: the Pacific, Atlantic, Indian, Arctic and Southern Ocean. Much ocean water seems completely empty—a great expanse of featureless water, dotted with the occasional island. But beneath the waves it is a different picture. Five or six kilometres down lies a dramatic landscape of vast plains, jagged mountains, erupting volcanoes and deep canyons.

Volcanic island

Active volcano

Barrier reef

Lagoon

Dormant volcano

Fringing reef

Coral atoll

The waters within a coral atoll are shallow and warm.

VOLCANIC ISLANDS

Sometimes, volcanoes erupting on the ocean floor grow large enough to poke above the ocean surface. The highest mountain above sea level is Everest in the Himalayas, at 8848 metres, but the tallest mountain from base to peak is Mauna Kea on the island of Hawaii, at 10,205 metres—with 6000 metres below the waves.

Herring gull

Harbour

Estuary

Sand spit

CURRENTS

Ocean waters move around the globe in huge swirling currents. Near the coast, sea currents may scour away sand from one part of the shore and drop it further along where currents are slower. Where sand is laid down, a spit may form.

COASTLINES

Many things have an effect on the shape of the coastline, but one of the most important of these is waves. Some waves are very powerful and attack the coast, wearing away the rocks and creating cliffs and caves. Gentler waves tend to lay down sand and pebbles, creating beaches, spits and flats, much like the coastline seen here.

Some ocean birds spend their entire lives at sea.

School of dolphins

CORAL REEF WILDLIFE

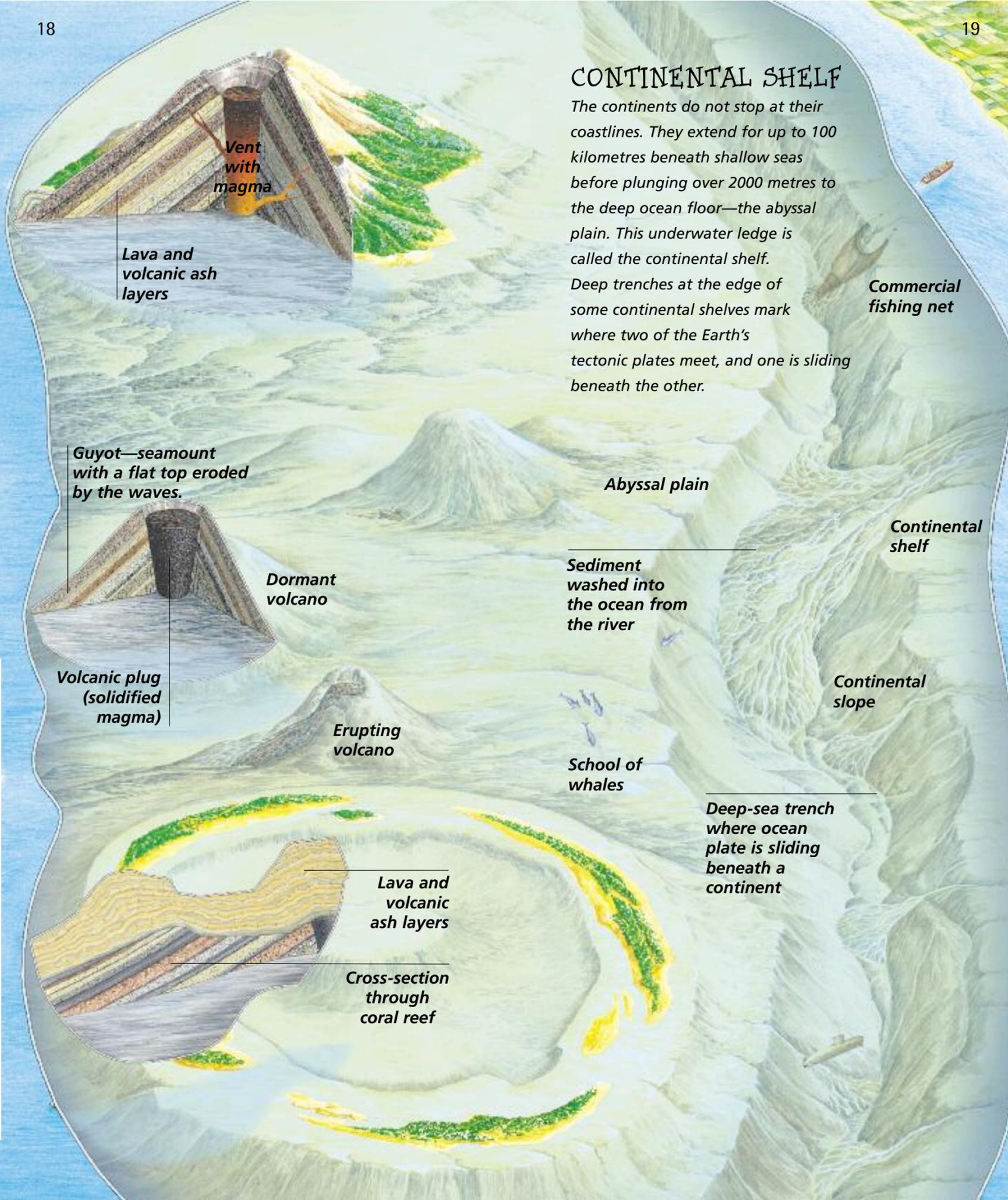
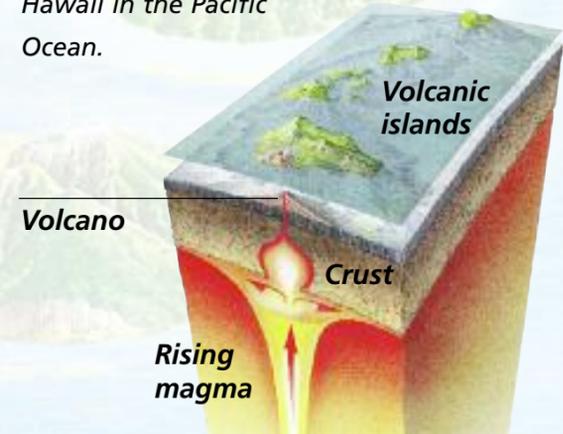
Coral reefs are home to thousands of species of marine animals. Some animals feed on tiny plants that float in the waters and grow on corals. The coral itself is consumed by some reef animals. Other animals, such as sharks and rays, prey on smaller reef creatures.

Ocean floor

The ocean floor is mostly made up of a flat plain, the abyssal plain. It lies at an average depth of around 4500 metres. The rocky bottom is covered by a thick layer of "ooze": mud, gravel and billions of skeletons of tiny animals that have collected over the years. Around the edges of the abyssal plain in the Pacific Ocean are deep-sea trenches. The Mariana Trench, east of the Philippines, is the deepest of all, with its deepest point, Challenger Deep, 10,920 metres below the ocean surface.

HOT SPOTS

There are places on the ocean floor where hot, molten rock, called magma, from deep within the mantle, has burst through the crust and erupted to form volcanoes. These places are called hot spots. The volcanoes sometimes form volcanic islands, like Hawaii in the Pacific Ocean.



CONTINENTAL SHELF

The continents do not stop at their coastlines. They extend for up to 100 kilometres beneath shallow seas before plunging over 2000 metres to the deep ocean floor—the abyssal plain. This underwater ledge is called the continental shelf. Deep trenches at the edge of some continental shelves mark where two of the Earth's tectonic plates meet, and one is sliding beneath the other.

Commercial fishing net

Abyssal plain

Sediment washed into the ocean from the river

Continental shelf

Continental slope

School of whales

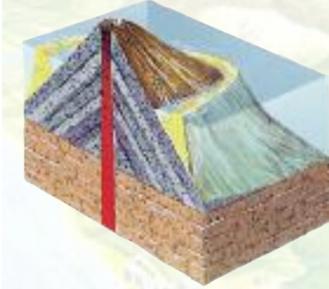
Deep-sea trench where ocean plate is sliding beneath a continent

Lava and volcanic ash layers

Cross-section through coral reef

CORAL ATOLLS

In tropical waters coral reefs form in the shallows



around volcanic islands.

A volcano may eventually sink back into the ocean floor.

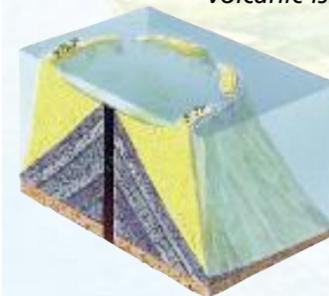
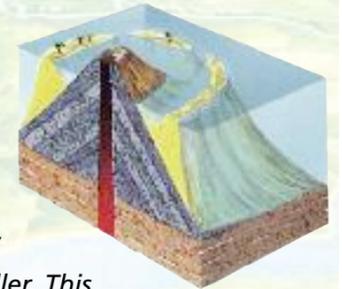
Coral animals must stay near the light, so they

build the reef taller. This

forms a circular barrier reef. At its centre is a lagoon, containing the disappearing

volcanic island. The

volcano's tip may sink out of sight, leaving a ring of coral islands—an atoll.



HYDROTHERMAL VENTS

Snaking across the ocean floor are undersea mountain chains called mid-oceanic ridges. Here, magma rises to the surface of the sea bed. In some places, water seeping down into the rocks is heated by the magma. The water, full of sulphur and other minerals from inside the crust, shoots up through cracks in the ocean floor, known as hydrothermal vents.



SWALLOW HOLES

Large, vertical holes in the limestone are called swallow holes or sink holes. These are formed by the rock being dissolved or worn away by water, or by the collapse of a cavern roof.

Swallow hole

Potholers (cave explorers) descend into a cave through a swallow hole.

Dry valley

Limestone pavement

Swallow hole

LIMESTONE PAVEMENT

Natural cracks or joints in the limestone criss-cross the surface. These are gradually widened by water dissolving the rock to form a limestone pavement. The raised lumps are called clints, and the eroded cracks are called grykes.

Emerging stream

Limestone cliff

DRY VALLEYS

Normally, surface water drains away very quickly on limestone through cracks in the rock. But 20,000 years ago, during the last Ice Age, the ground was frozen and water could not seep away, so streams and rivers were able to flow

over the limestone and carve out valleys. Once the ice melted, the rivers disappeared underground leaving distinctive dry valleys on the surface.

Dry valley

Visitor centres, tell you more about the area and how best to enjoy the environment without damaging it.

Visitor centre

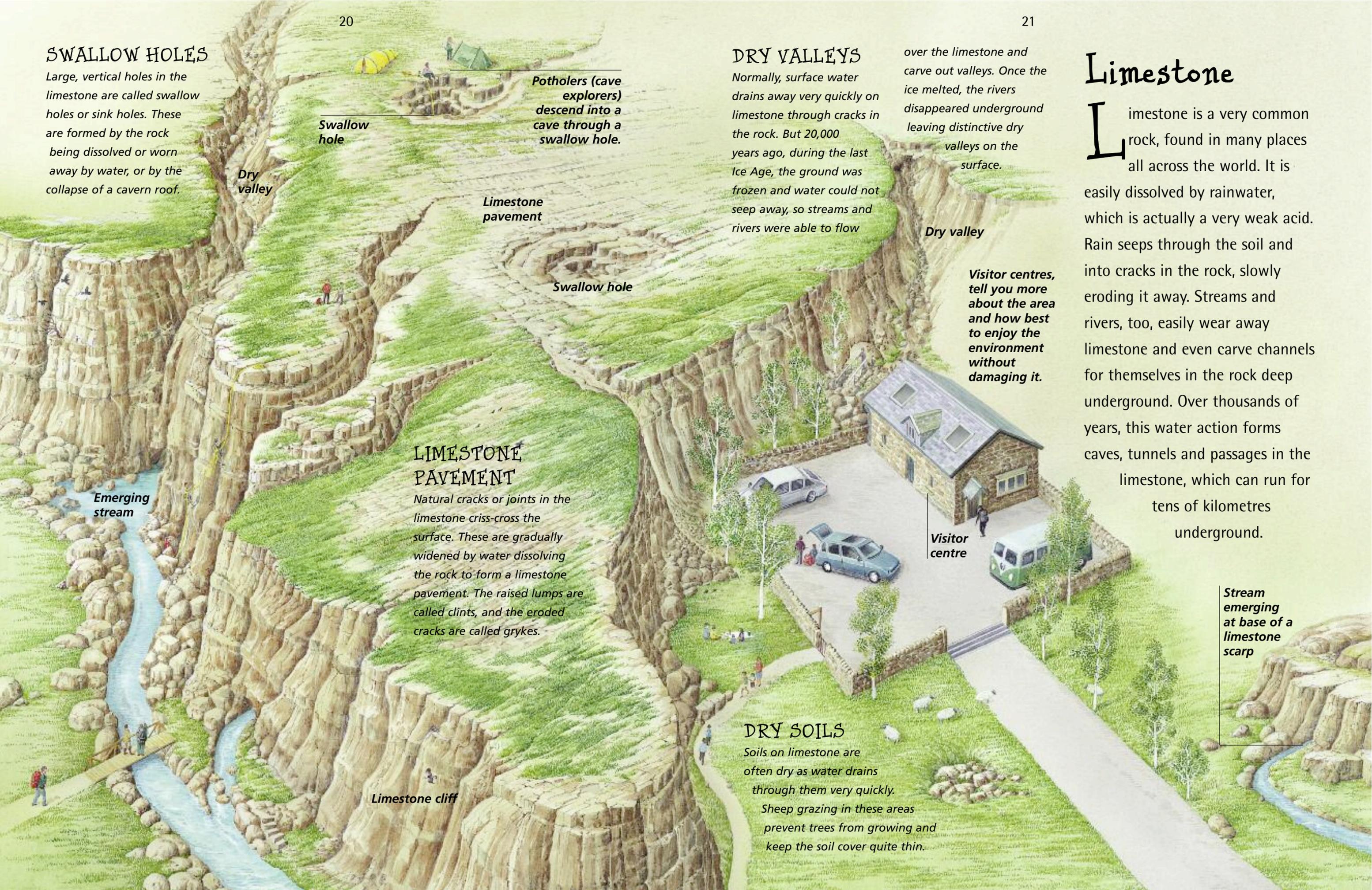
DRY SOILS

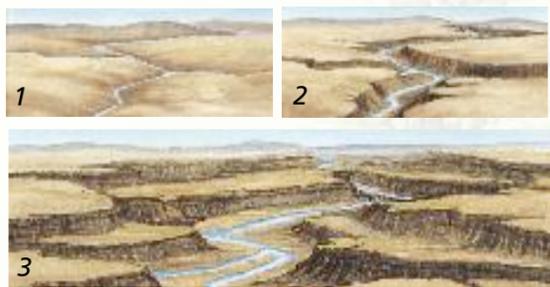
Soils on limestone are often dry as water drains through them very quickly. Sheep grazing in these areas prevent trees from growing and keep the soil cover quite thin.

Limestone

Limestone is a very common rock, found in many places all across the world. It is easily dissolved by rainwater, which is actually a very weak acid. Rain seeps through the soil and into cracks in the rock, slowly eroding it away. Streams and rivers, too, easily wear away limestone and even carve channels for themselves in the rock deep underground. Over thousands of years, this water action forms caves, tunnels and passages in the limestone, which can run for tens of kilometres underground.

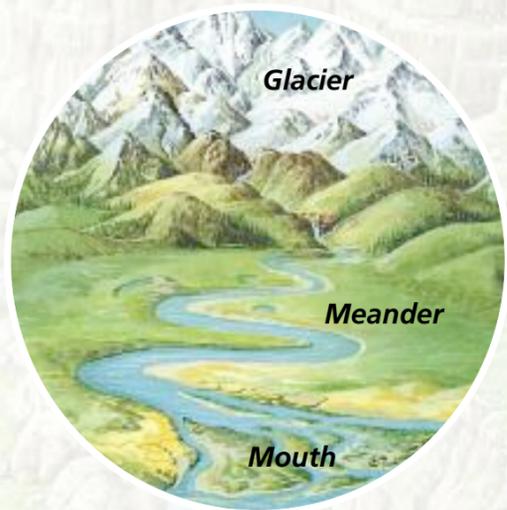
Stream emerging at base of a limestone scarp





EROSION

Erosion is the removal of fragments of rock by the action of water, wind or ice. A famous example of erosion is the Grand Canyon in the USA. The Colorado River once flowed across a flat desert (1), but as the land rose, the river cut a deeper and deeper valley (2). Today, hard rock layers stand out as near-vertical cliff faces (3).



A RIVER'S COURSE

Rivers are natural channels of water that run downhill. A river starts as a spring, meltwater from a glacier, or collected rainwater. Near its source, the river flows quickly. Further along its course, other streams, called tributaries, join the river. It becomes wider, deeper and more slow-moving. The river winds across a plain in a series of looping bends called meanders and enters the sea at its mouth.



STALACTITES

Water seeping through the rocks dissolves the minerals that make up the limestone. If the water then drips into a cave or cavity it leaves a small amount of the dissolved minerals behind as it falls. Over time, these form limestone "icicles", called stalactites, hanging from the cave roof. Stalagmites are mineral towers built up from water dripping on to the floor.

Inside a cave

Surface water may seep into cracks in the limestone, slowly wearing it away. Over thousands of years, underground water may form a cave system of many chambers, some with underground lakes, and linked by upright shafts and horizontal galleries. As water drips from the ceiling, dissolved minerals in it gradually harden to form icicle-like shapes of rock, called stalactites, hanging down.

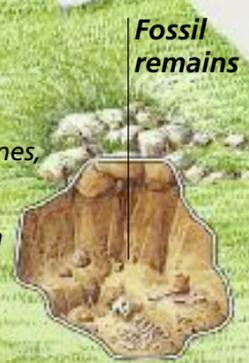
ANCIENT LANDSCAPE

The Guilin Hills, southern China (below), are the remains of an ancient limestone landscape, weathered away by rainwater. Movements in the Earth's crust about 200 million years ago caused the land to be pushed up, exposing the limestone to the erosive power of water. Vast quantities of limestone were dissolved and washed away, leaving behind the more resistant pinnacles. These now tower above the plain.



CAVE DWELLERS

Caves provided vital shelter to prehistoric people. Ancient bones, man-made objects and even wall paintings have all been found in limestone caves.



WOODLANDS

Woodlands are found in parts of the world that have a temperate climate, with warm summers and cool winters. This woodland is deciduous: in winter, its trees will lose their leaves and shut down their growth.

Roe deer
with faun

Grey squirrel

Molehill

Badger sett

Rabbit in
burrow

Wild
boar

Partridge

Pheasant

Sparrowhawk
stooping
after prey

Nuthatch

Tawny owl

Great tit

Vole

Green
woodpecker

LEAF LITTER

During autumn, fallen leaves build up into a thick layer on the ground, providing insects, worms and small mammals with a warm hibernation site. In the spring, insects and other invertebrates feed on the leaf litter, breaking it down into nutrients in the soil, where it is taken up by growing plants.

Stoat

Hedgehog

Primroses

Molehill

Fox

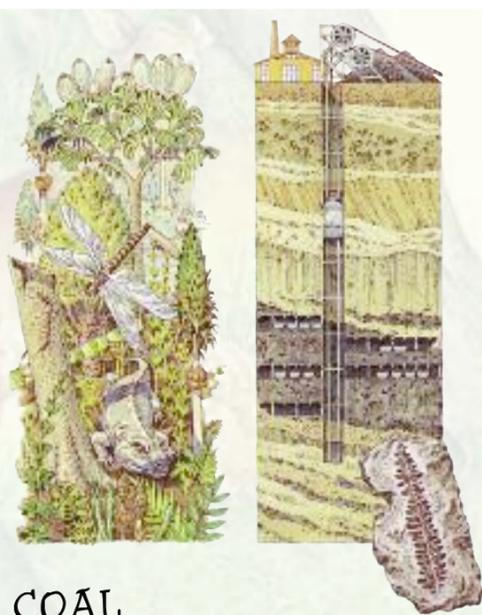
Fly agaric
toadstools

Life on Earth

Perhaps as many as 20 million species of plants, animals and other living things—such as bacteria and fungi—share our planet. Living things all depend on one another for survival. Plants provide food for plant-eating animals, which become prey for flesh-eating animals. They, in turn, might be eaten by larger flesh-eating animals. This is known as the food chain. Since animals eat more than one kind of food, many food chains link together to make a food web.

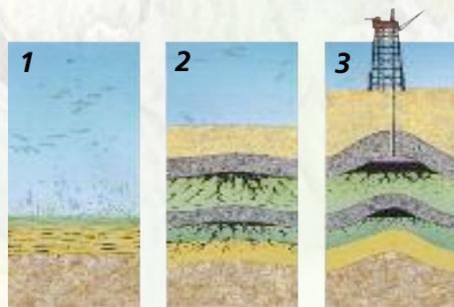
SOIL-DWELLERS

The soil is home to millions of tiny creatures such as mites, earthworms and centipedes. Larger animals, like badgers and rabbits dig nests and burrows in the soil too.



COAL

Coal began to form about 350 million years ago, when swampy forests covered the tropics (above, left). As trees decayed, they formed a thick black soil called peat, that later hardened to coal. Today, shafts are made so people can mine the coal layer (above, right).



OIL AND GAS

Oil and gas were formed in the seas. When tiny plants and animals died and sank, they were buried under layers of sand (1). These were compressed into layers of sedimentary rock. The heat action of bacteria changed the remains into oil and gas (2). A drill is used to release the oil (3).

TIME TRAVEL

Digging into the ground is like going back in time. The deeper you go, through layers of soil and down through ancient rocks, the further back in time you travel.

Below ground

Soil is a mixture of rock fragments and decaying plant and animal (organic) matter. Air and water fill the spaces between the soil particles. The most fertile layer of soil is the topsoil, which contains the most organic matter. Below that is subsoil, containing larger rock fragments. Below that is the bedrock on which the soil originally formed.



Bottle: six months old

Topsoil

Bottle: 100 years old

Subsoil: 800 years old

Badger skeleton: one year old

Boulder clay: 12,000 years old

Chest: 200 years old

Chalk rock: 100 million years old

Dagger: 400 years old

Ichthyosaur fossil: 180 million years old

Sandstone: 220 million years old

Coal measures: 350 million years old

FOSSILS

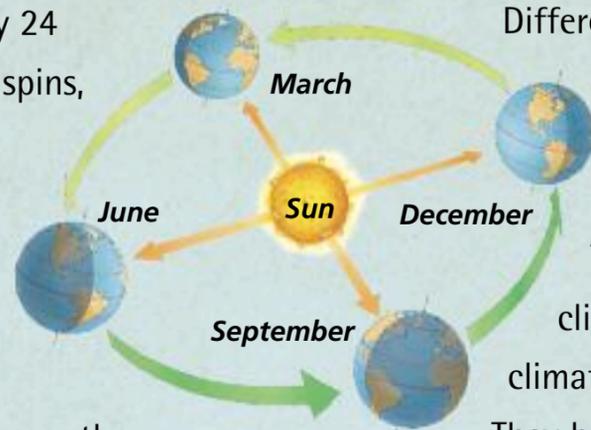
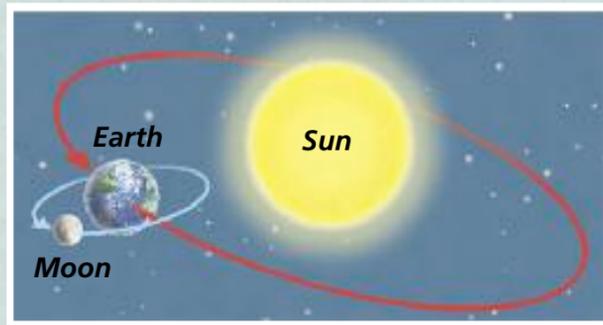
Fossils are the remains of once-living things preserved in rock. Most fossils, like this ammonite,



a prehistoric sea creature, are of the hard parts such as a shell or bone. After the soft parts have rotted away, the remains of a creature are buried in sediments such as sand, silt or mud, usually under water. The original shell is dissolved away and replaced by minerals in the water. Over millions of years the sediments are gradually compressed into rock and the fossil is preserved in the rock layers.

Seasons and climates

The Earth takes just over 365 days to complete a full circuit, or orbit, around the Sun. It also spins on its own axis once every 24 hours. As the Earth spins, it is slightly tilted. This tilt gives us the seasons of the year. When the northern hemisphere leans nearer the Sun, it is summer there. At the same time, the southern hemisphere, which is tilted away from the Sun, has winter.

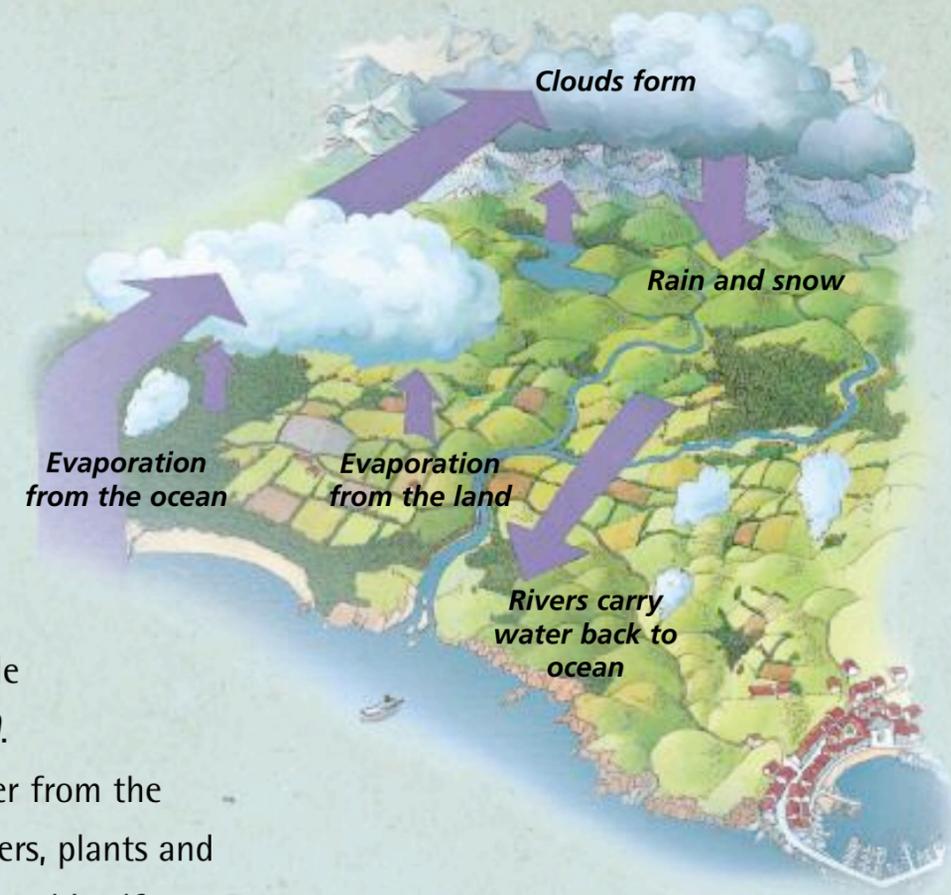


Different regions of the world have different patterns of weather: for example, dry summers, mild winters and so on. These patterns are called climates. Regions with tropical climates lie close to the Equator. They have hot, wet weather all year. Temperate regions have warm summers and cold winters. Deserts have hardly any rain. Polar lands are always cold.



Water cycle

The oceans play a vital part in the weather and climate of the Earth. Driven by the heat of the Sun, water goes round and round from ocean to atmosphere and back again in an endless cycle called the water cycle (right).



The Sun's heat causes water from the oceans—along with lakes, rivers, plants and the ground itself—to evaporate. The warm water vapour rises high into the atmosphere. Moist air may be also forced to rise as it moves across high land. As the air starts to cool, the water vapour may then turn to liquid water or ice. It begins to condense (turn back to liquid) around tiny particles in the air, such as sea salt or dust. Millions of these tiny droplets gather together to form clouds. In the highest clouds, the water freezes into ice.

When the ice or water droplets (left) become too heavy to stay up, they fall as rain, or snow if the air below is freezing. Much rain or snow falls directly back into the ocean. But winds may carry the warm air or clouds across the land. The rain or snow falls to the ground, and the water finds its way into streams and rivers. On land, the water may be frozen in ice in the form of ice caps or glaciers. Rivers carry the water back to the oceans. Some water seeps into the ground and flows very slowly through cracks or pores (tiny holes) in the rocks themselves. This is called groundwater.

Glossary

Abyssal plain A flat region of the ocean floor. It is made of volcanic rock covered by thick sediments.

Atoll A coral island ring that forms above a submerged oceanic island.

Boulder clay A deposit of fine clay mixed up with larger boulders that is left behind by glaciers.

Continental shelf The part of a continent that extends beneath the sea. It ends at the continental slope.

Core The innermost layers of the Earth, made of iron and nickel. The outer core is liquid, the inner is solid.

Crust The thin, rocky outer layer of the Earth.



Earthquake A shaking of the ground caused by the sudden movement of the Earth's crust along a fault.

Erosion The wearing away and removal of rocks by the action of wind, ice, water etc.

Fault A crack in the Earth's crust along which movement of the rocks occurs.

Ice Age A period during the Earth's history when the Earth's temperature dropped and the polar ice caps expanded.

Lava Molten rock erupted by volcanoes.

Magma Molten rock created deep in the crust or the upper mantle.

Mantle The layer of the Earth beneath the crust. The upper mantle and the crust together form tectonic plates.

Mid-ocean ridge A volcanic mountain range along the ocean floor where tectonic plates are moving apart.

Soil A mix of mineral grains and organic material that forms on top of bedrock.

Tectonic plates Large slabs that make up the Earth's surface. They fit like jigsaw pieces and move relative to each other.

Tsunami A large wave caused by a earthquake or landslide on the sea floor.

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