There are three kinds of rock. Igneous rocks, such as granite, are formed when magma cools and solidifies. Sedimentary rocks, such as sandstone and limestone, are made from fragments of rock or living things. Metamorphic rocks, such as marble *(right)*, are formed when any kind of rock is changed by great heat or pressure underground.

Fossils are the remains of once-living things preserved in rock. The soft parts rot away, but hard body parts, such as bone, teeth and shell (as in this ammonite, *right*) may remain.

Waterfalls *(left)* form when a river cascades down a cliff, or where its bed changes from hard to soft rock. The river wears away the softer rock more quickly, so a "lip" of hard rock forms on the river bed.

Oil comes from the remains of tiny prehistoric creatures that lived in the oceans millions of years ago. The remains sank to the sea bed where they were buried under layers of sand and silt. These layers gradually turned into sedimentary rock. Bacteria changed the creatures' remains into oil and gas. As movements in the Earth's crust folded and cracked the layers of rock above, oil forced its way up, finally becoming trapped under a layer of hard rock. When oil is found, a drill from a well built on the sea bed sends it gushing to the surface *(above)*.

When rainwater trickles into cracks in limestone, it dissolves the rock, eventually hollowing out caves *(right)*. As water drips from a cave ceiling, the limestone dissolved in it hardens to form icicle-like stalactites. Stalagmites grow up from the floor where the drips fall.

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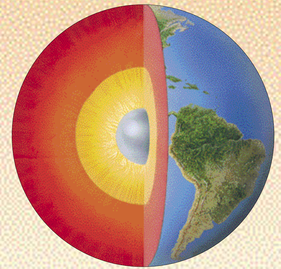
PANORAMAS

EARTH



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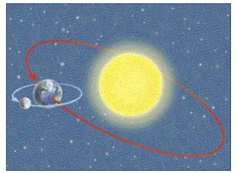
CONTENTS

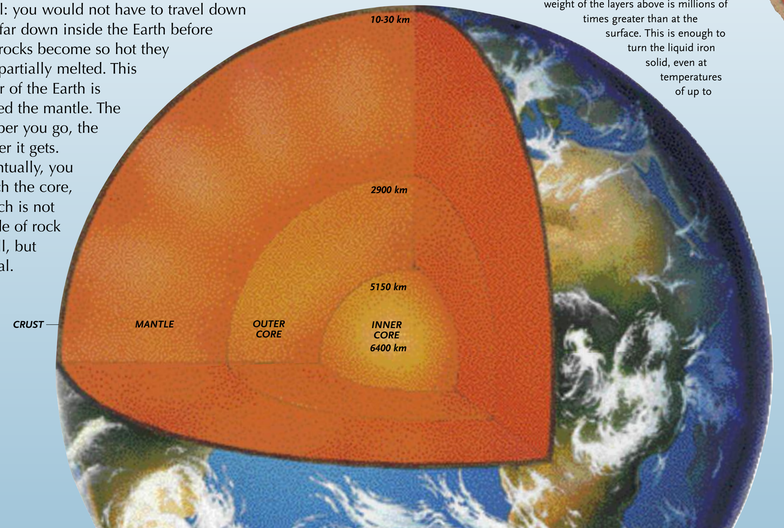


THE EARTH IN SPACE

The Earth is one of eight major planets that go around the Sun, our nearest star. It speeds along at about 30 km per second, taking 365.26 days to complete one orbit. As it goes, it spins like a top once every 24 hours. It is itself orbited by the Moon, which takes 27.3 days to go round.

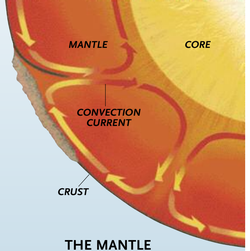
INSIDE THE EARTH

THE SURFACE of the Earth, its crust, is hard and rocky. But the crust is really just a thin shell: you would not have to travel down too far down inside the Earth before the rocks become so hot they are partially melted. This layer of the Earth is called the mantle. The deeper you go, the hotter it gets. Eventually, you reach the core, which is not made of rock at all, but metal.



THE CORE

The core is made of iron, with small amounts of nickel. In the outer core, the temperature rises to more than 3000°C, hot enough for the metal to be liquid. It flows in giant, swirling currents as the Earth spins round. Nearer the centre of the Earth the pressure from the weight of the layers above is millions of times greater than at the surface. This is enough to turn the liquid iron solid, even at temperatures of up to



THE MANTLE

The upper mantle is made of partly melted rock—crystals of solid rock with molten or liquid rock in between. Called magma, its temperature is about 2000°C. It flows like hot tar on a newly surfaced road. Sometimes, magma bursts out of holes or cracks in the crust as the red-hot lava in volcanic eruptions *(see page 6)*.

Below the upper mantle, the enormous weight of the layers above ensures that the lower mantle rocks are solid—but not completely rigid: they can move.

Inside the mantle, the rock actually flows, very slowly in giant circles called convection currents *(above)*. These currents cause the tectonic plates at the surface *(see page 8)* to move about, colliding into, pulling apart from, or sliding past one another.

MOVING PLATES

THE EARTH'S outer layer, the crust coupled together with the top of the upper mantle, is divided into enormous pieces, called tectonic plates. The plates are continually on the move, driven by currrents in the mantle below *(see page 5)*. As they move, their edges rub and grind against each other.

Over hundreds of millions of years, moving plates have resulted in entire continents wandering about the globe, sometimes joining together, sometimes drifting apart.

RIFT VALLEY

Where two plate edges pull away from one another on land, a block of land slips down between them. This creates a large, wide valley, called a rift valley. The Great Rift Valley in East Africa was formed in this way.

PUSH, PULL OR SLIDE

Some plates are moving apart, others are pushing together. In some places, one plate slides down below another. In others, two plates slide past each other, moving in opposite directions. When two plates push together, the land slowly crumples up, forming mountains.

VOLCANOES

Many volcanoes are found close to subduction zones *(see below)*. Forced down to great depths, the rocks eventually melt. Some magma finds its way to the Earth's surface through cracks in the rocks above. There it erupts as lava. Volcanoes rising from the ocean floor may eventually grow large enough to form islands.

A JIGSAW PUZZLE

THE EARTH's surface is like a jigsaw puzzle wrapped around a giant ball. It is divided into jagged-edge pieces, called tectonic plates. There are eight large plates and 12-15 smaller ones. They slide about on a surface of partly molten rock in the upper mantle.

OCEAN TRENCH

Some plates are made mostly of ocean floor, while others consist mainly of land mass or continent. At the boundary between an oceanic plate and a continental plate, the denser oceanic plate slides down beneath the continental one. This is known as subduction. At the surface, a deep ocean trench is formed.

MID-OCEANIC RIDGE

Snaking its way across the floor of all the world's oceans is the mid-oceanic ridge. This marks the boundary between plates. Here the plates are pulling away from one another. As they do so, magma rises up between them from the mantle below. The erupted lava spreads out to either side forming a new ocean floor. The plates move apart by up to several centimetres a year—similar to the rate at which fingernails grow.

BLACK SMOKERS

In some places along the mid-oceanic ridge, hot water jets up through tall "chimneys", called black smokers. Although there is no sunlight at these depths, strange animals are able to exist down here, including red worms that live in white tube shells. They live off the bacteria that thrives on the nutrients in the hot water.

FAULTS

A fault is a crack in the Earth's crust, either side of which rocks may shift in different directions. Some plate boundaries are major faults. One famous example is the San Andreas Fault in California, USA. Here, the North American plate and the Pacific plate are sliding past one another in opposite directions. The area close to the San Andreas Fault is vulnerable to earthquakes *(see pages 12-13)*. These occur when the two plates lock together for a time. Eventually the pressure becomes too great and the rocks suddenly snap apart.

OCEAN FLOOR

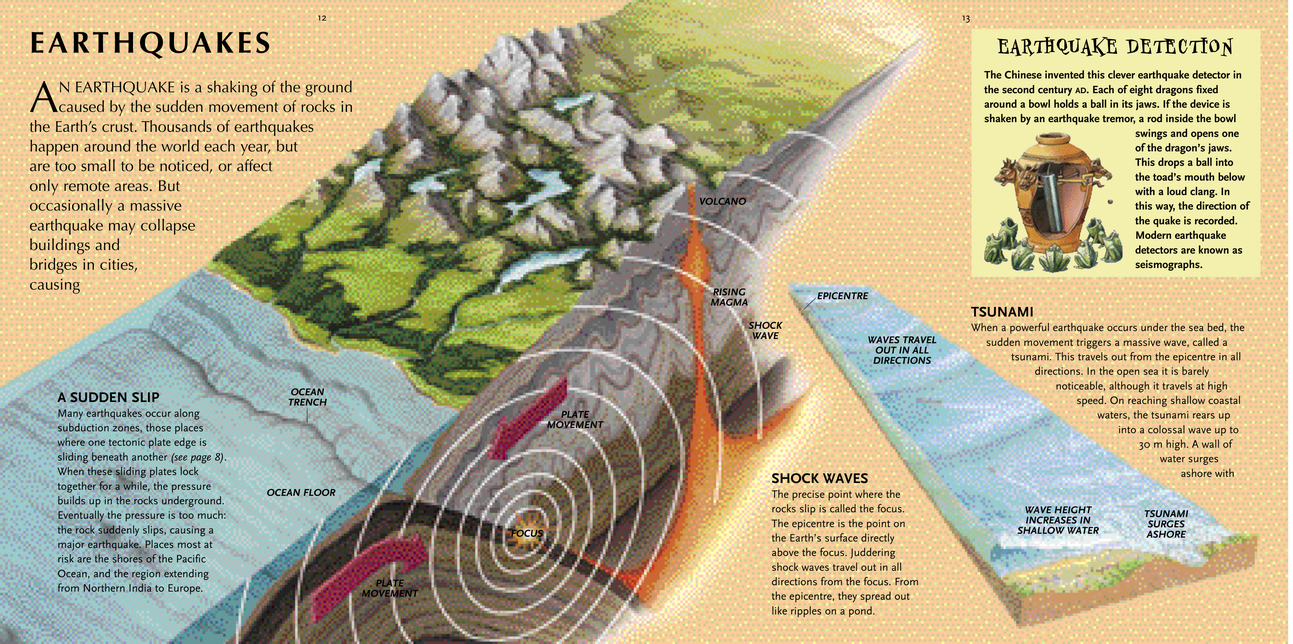
The ocean floor is made from lava that has erupted, rapidly cooled under the water and solidified. As more and more lava erupts, cools and solidifies, a new ocean floor is gradually formed.

EARTHQUAKES

AN EARTHQUAKE is a shaking of the ground caused by the sudden movement of rocks in the Earth's crust. Thousands of earthquakes happen around the world each year, but are too small to be noticed, or affect only remote areas. But occasionally a massive earthquake may collapse buildings and bridges in cities, causing

A SUDDEN SLIP

Many earthquakes occur along subduction zones, those places where one tectonic plate edge is sliding beneath another *(see page 8)*. When these sliding plates lock together for a while, the pressure builds up in the rocks underground. Eventually the pressure is too much: the rock suddenly slips, causing a major earthquake. Places most at risk are the shores of the Pacific Ocean, and the region extending from Northern India to Europe.



SHOCK WAVES

The precise point where the rocks slip is called the focus. The epicentre is the point on the Earth's surface directly above the focus. Juddering shock waves travel out in all directions from the focus. From the epicentre, they spread out like ripples on a pond.

EARTHQUAKE DETECTION

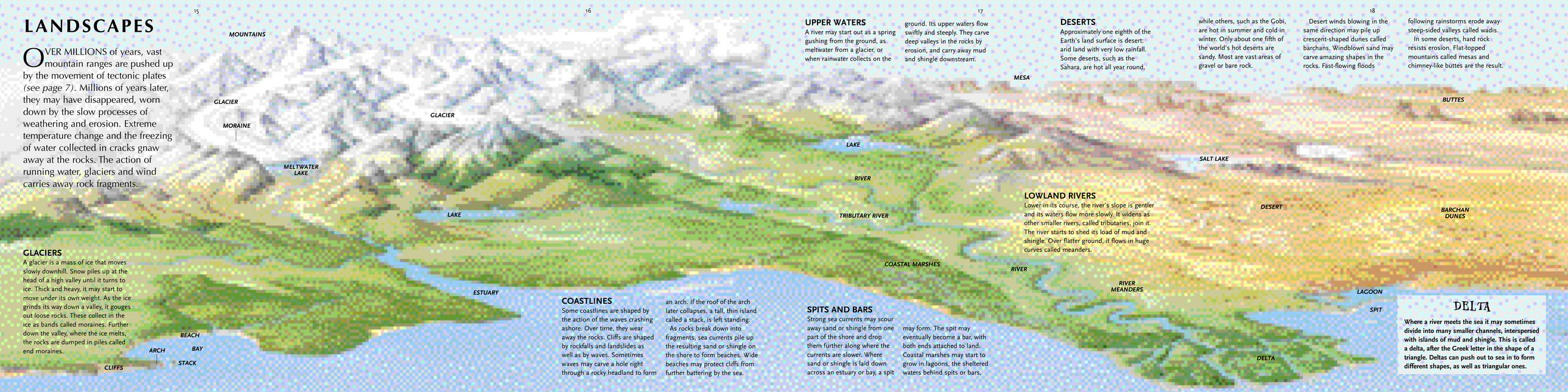
The Chinese invented this clever earthquake detector in the second century AD. Each of eight dragons fixed around a bowl holds a ball in its jaws. If the device is shaken by an earthquake tremor, a rod inside the bowl swings and opens one of the dragon's jaws. This drops a ball into the toad's mouth below with a loud clang. In this way, the direction of the quake is recorded. Modern earthquake detectors are known as seismographs.

TSUNAMI

When a powerful earthquake occurs under the sea bed, the sudden movement triggers a massive wave, called a tsunami. This travels out from the epicentre in all directions. In the open sea it is barely noticeable, although it travels at high speed. On reaching shallow coastal waters, the tsunami rears up into a colossal wave up to 30 m high. A wall of water surges ashore with

LANDSCAPES

OVER MILLIONS of years, vast mountain ranges are pushed up by the movement of tectonic plates *(see page 7)*. Millions of years later, they may have disappeared, worn down by the slow processes of weathering and erosion. Extreme temperature change and the freezing of water collected in cracks gnaw away at the rocks. The action of running water, glaciers and wind carries away rock fragments.



GLACIERS

A glacier is a mass of ice that moves slowly downhill. Snow piles up at the head of a high valley until it turns to ice. Thick and heavy, it may start to move under its own weight. As the ice grinds its way down a valley, it gouges out loose rocks. These collect in the ice as bands called moraines. Further down the valley, where the ice melts, the rocks are dumped in piles called end moraines.

COASTLINES

Some coastlines are shaped by the action of the waves crashing ashore. Over time, they wear away the rocks. Cliffs are shaped by rockfalls and landslides as well as by waves. Sometimes waves may carve a hole right through a rocky headland to form an arch. If the roof of the arch later collapses, a tall, thin island called a stack, is left standing.

As rocks break down into fragments, sea currents pile up the resulting sand or shingle on the shore to form beaches. Wide beaches may protect cliffs from further battering by the sea.

UPPER WATERS

A river may start out as a spring gushing from the ground, as meltwater from a glacier, or when rainwater collects on the ground. Its upper waters flow swiftly and steeply. They carve deep valleys in the rocks by erosion, and carry away mud and shingle downstream.

SPITS AND BARS

Strong sea currents may scour away sand or shingle from one part of the shore and drop them further along where the currents are slower. Where sand or shingle is laid down across an estuary or bay, a spit may form. The spit may eventually become a bar, with both ends attached to land. Coastal marshes may start to grow in lagoons, the sheltered waters behind spits or bars.

LOWLAND RIVERS

Lower in its course, the river's slope is gentler and its waters flow more slowly. It widens as other smaller rivers, called tributaries, join it. The river starts to shed its load of mud and shingle. Over flatter ground, it flows in huge curves called meanders.

DESERTS

Approximately one eighth of the Earth's land surface is desert: arid land with very low rainfall. Some deserts, such as the Sahara, are hot all year round, while others, such as the Gobi, are hot in summer and cold in winter. Only about one fifth of the world's hot deserts are sandy. Most are vast areas of gravel or bare rock.

Desert winds blowing in the same direction may pile up crescent-shaped dunes called barchans. Windblown sand may carve amazing shapes in the rocks. Fast-flowing floods following rainstorms erode away steep-sided valleys called wadis.

In some deserts, hard rock resists erosion. Flat-topped mountains called mesas and chimney-like buttes are the result.

DELTA

Where a river meets the sea it may sometimes divide into many smaller channels, interspersed with islands of mud and shingle. This is called a delta, after the Greek letter in the shape of a triangle. Deltas can push out to sea in to form different shapes, as well as triangular ones.

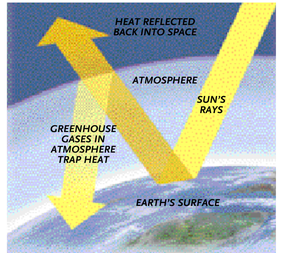
FUTURE EARTH

WHAT WILL the future hold for our planet? Already, people are very concerned about the damage being done to our environment. Emissions from our factories, vehicles, planes and power stations pollute the air and sea—and add greenhouse gases to the atmosphere. Clearing forests removes the natural habitats of many animals. Some species are already threatened with extinction.

GLOBAL WARMING

The Earth is becoming warmer. The average temperature is predicted to rise by 2°C by 2050, although this figure is very uncertain. The effects may be felt by more frequent droughts and shifting climate patterns. The ice caps at both poles will start to melt, resulting in rising sea levels and the flooding of coastal regions where most of the world's cities are located.

Why is this happening? Most scientists are convinced that human activities has resulted in a large increase of greenhouse gases, causing the Earth to warm up *(see opposite)*.



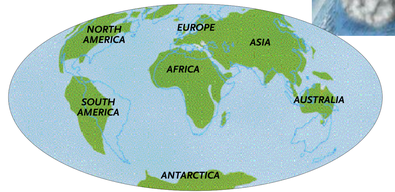
THE GREENHOUSE EFFECT

The Sun's rays warm the surface of the Earth. The surface then reflects this heat back into space. Some gases in the atmosphere, such as carbon dioxide and methane, trap part of this outgoing heat, keeping the surface warm—just like a greenhouse. But too much of these greenhouse gases from burning fossil fuels like coal and oil will warm up the Earth too much ...

ASTEROID COLLISION

Billions of rocks, known as asteroids, orbit the Sun. Many are tiny—only a few metres across—but probably about a billion have diameters of more than 1 km. Most asteroids orbit the Sun in a band between Mars and Jupiter, but some follow orbits that bring them close to Earth's orbit.

What if one of these near-Earth asteroids were ever to collide with our planet? The explosion would cause immense devastation and fill the atmosphere with dust. This would blot out the Sun and lower temperatures for years on end. The consequences for people would be catastrophic. No wonder astronomers are keeping a close eye on asteroids that may get too close for comfort ...



A MAP OF THE FUTURE

This *(left)* is how a map the world might look 50 million years from now. As the tectonic plates have shifted about *(see page 7)*, whole continents and oceans have gradually changed shape. North and South America have separated, East Africa has started to split apart from the rest of Africa, while Australia has moved north to collide with Indonesia.

GLOSSARY

ASH, VOLCANIC Lava that has been blown to powder by the force of the explosion when a volcano erupts.

CONVECTION CURRENTS The continual movement of a substance as it heats up and rises, cools and sinks, then heats up etc.

CORE The innermost portion of the Earth.

CRUST The thin, rocky outer layer of the Earth.

CRYSTALS A solid substance with a regular geometric shape.

EARTHQUAKE A shaking or trembling of the ground, caused by the sudden movement of part of the Earth's crust.

EROSION The wearing away of the Earth's surface by water, ice or wind.

FAULT A crack in the Earth's crust, along which there is movement of one side relative to the other.

FOSSIL The ancient remains of a once-living thing, usually found preserved in rock.

GLACIER A mass of ice, produced by the accumulation of snow, that moves downhill.

IGNEOUS ROCK A type of rock formed from magma that has cooled and hardened.

LAVA Magma that has erupted on to the Earth's surface through volcanoes.

MAGMA Hot, melted (molten) rock that comes from beneath the solid rock of the crust.

MANTLE The layer of the Earth that lies between the crust and the core.

METAMORPHIC ROCK A rock that has changed due to intense pressure or heat.

MID-OCEANIC RIDGE A long mountain range under the ocean, where magma rises to the Earth's surface.

PLATES, TECTONIC The large slabs into which the Earth's surface is divided.

SEDIMENTARY ROCK A type of rock that is formed by the pressing together of rock fragments or the remains of living things.

SUBDUCTION The process by which the edge of one plate slides beneath another.

VOLCANO An opening in the Earth's crust through which magma erupts.

WATER CYCLE The process by which water circulates between ocean, atmosphere and land.

WEATHERING The fragmentation of rocks caused by temperature change, rain or frost.

INDEX