Part 2: Tectonics – a planet on the move

PART 2

Activity 2.1 Earth surface jigsaw

Activity type

What can the locations of some southern hemisphere fossils tell us about the geological history of the Earth?

Before the age of dinosaurs Australia had dense forests of these trees, called Glossopteris. They have been extinct for over 200 million years but their fossil remains are still here in some of our important coal deposits. There were also huge forests in India, Africa, South America and even Antarctica.

Fossilised Glossopteris leaves from coal deposits at Dunedoo, NSW.

In 1912 Alfred Wegener suggested that the shapes of the southern continents, and the distribution of fossils provided evidence that the continents had moved over time.

Glossopteris

What to do:

Your teacher will provide you with a worksheet, scissors and glue. Colour in each fossil type a different colour. Cut out the continents. Follow Alfred Wegener's reasoning and noting which continents share the same fossil deposits, fit them together to form the giant supercontinent that existed in the past.

Lystrosaurus fossils found in Africa, India and Antarctica

Mesosaurus fossils found in Africa and South America

Cynognathus fossils found in Africa and South America

OTHER IMPORTANT SOUTHERN HEMISPHERE FOSSILS.

Activity 2.2 Ring of Fire

Activity type

DOWNLOAD e-NOTEBOOK

Natural disasters grab the news headlines. They seem to happen randomly, hitting different areas by chance. But is there a pattern?

Ferdinand Magellan
(1480 – 1521)

Ferdinand Magellan was a Portuguese explorer.

He circumnavigated the world in 1521.

He encountered favourable winds in the Pacific Ocean and named it *Mar Pacifico* (Portuguese for 'peaceful sea').

The Pacific Ocean is the world's largest ocean.

It contains many famous and idyllic islands well known to past explorers and modern holiday-makers. But around its rim lie some dangers.

? Why is the Pacific Rim also referred to as the Ring of Fire?

Are some regions of the earth more dangerous than others?

RECENT MAJOR VOLCANIC ERUPTIONS IN THE PACIFIC REGION.

Out of 20 major eruptions that have occurred around the world since 2000, 16 have occurred in the Pacific region and are shown in the following table.

(Source - https://en.wikipedia.org/wiki/List_of_large_volcanic_eruptions_in_the_21st_century)

Volcanic eruption	Year
Ulawun	2000
Shiveluch	2001
Ruang	2002
Revantador	2002
Menam	2004
Rabaul	2006
Mt Okmok	2008
Chaiten	2008
Kasatochi	2008
Sarychev Peak	2009
Mount Merapi	2010
Puyehue-Cordón Caulle	2011
Mount Sinabung	2014
Kelud	2014
Mount Ontake	2014
Calbuco	2015

Mapping volcanoes

What to use:

The CLASS will require:

- map of Pacific region printed on A3 paper.

The GROUP will require:

- internet access.
- **Each STUDENT will require:**
- map of Pacific region on A4 paper.

What to do:

Step 1
Your teacher will assign a selection of the volcanoes listed in the table to each student group.

The task of each group is to research each volcano, noting particularly its geographical location, and at least one interesting fact about the eruption.

Step 2
Each group should clearly mark their volcanoes on the class map. As they do this they should describe their interesting fact to the whole class.

Step 3
Once all the volcanoes have been marked on the class map each student should transfer the data onto their own map.

Discussion:

As a class discuss the pattern that you observe and draw a conclusion. Record this in your ***Notebook.***

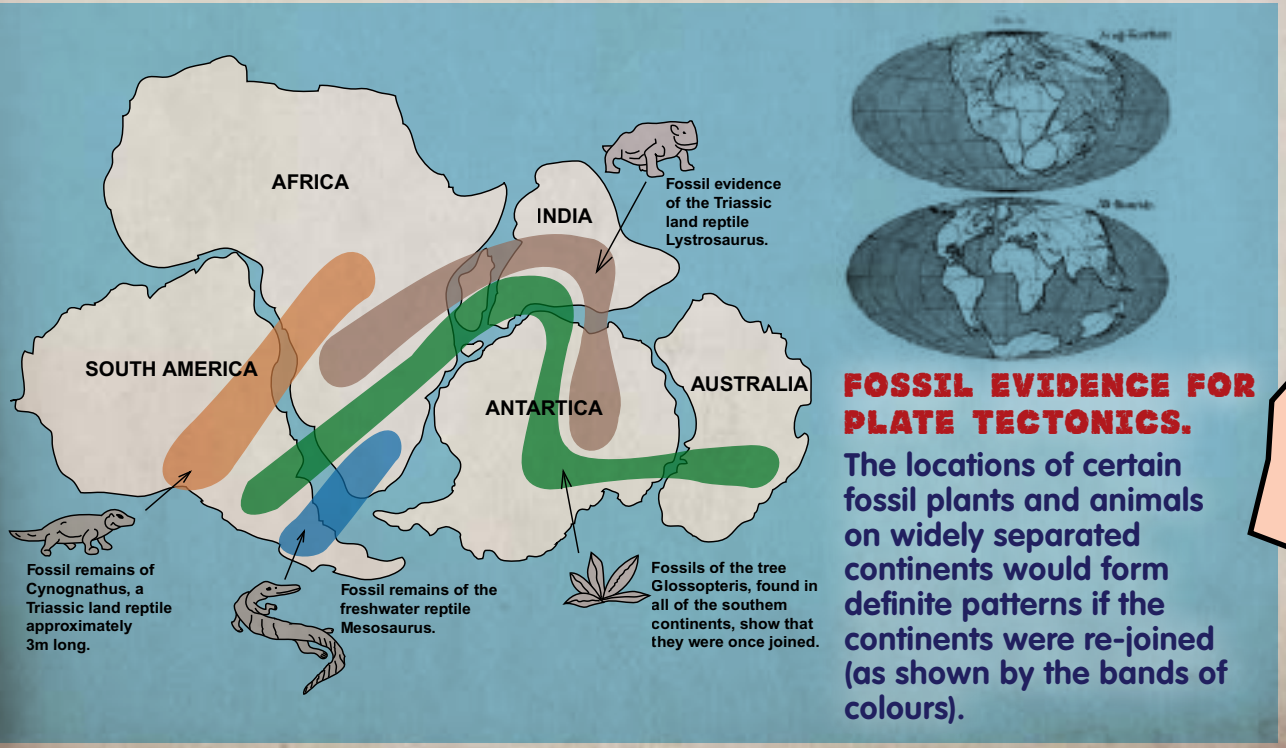
Click here to explore the Ring of Fire.

Activity 2.3 Plates on the move

Activity type

Alfred Wegener (1880 – 1930)

In 1912 Alfred Wegener, a German meteorologist, published a small book 'The Origin of the Continents and Oceans'. He proposed that the Earth's crust is divided up into many plates. These plates appear to float and move across the Earth's surface. All the plates are moving. This movement has completely changed the appearance of the Earth's surface over geological time. It also explains many phenomena related to the distribution of flora and fauna, geological patterns around the world, and the formation of the world's great mountain ranges. It took almost 50 years for his theory to be widely accepted by the scientific world. Today it is one of the foundation ideas of geology.



FOSSIL EVIDENCE FOR PLATE TECTONICS.

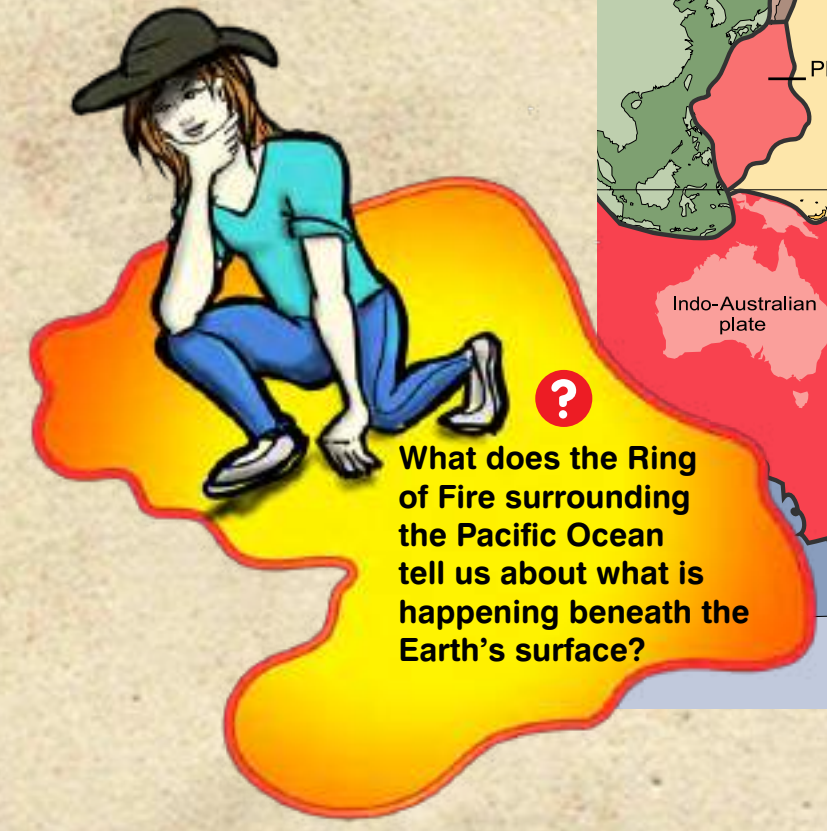
The locations of certain fossil plants and animals on widely separated continents would form definite patterns if the continents were re-joined (as shown by the bands of colours).

The surface of the Earth is like a thin, hard crust floating on a denser layer of semi-molten rock (the asthenosphere or upper mantle).

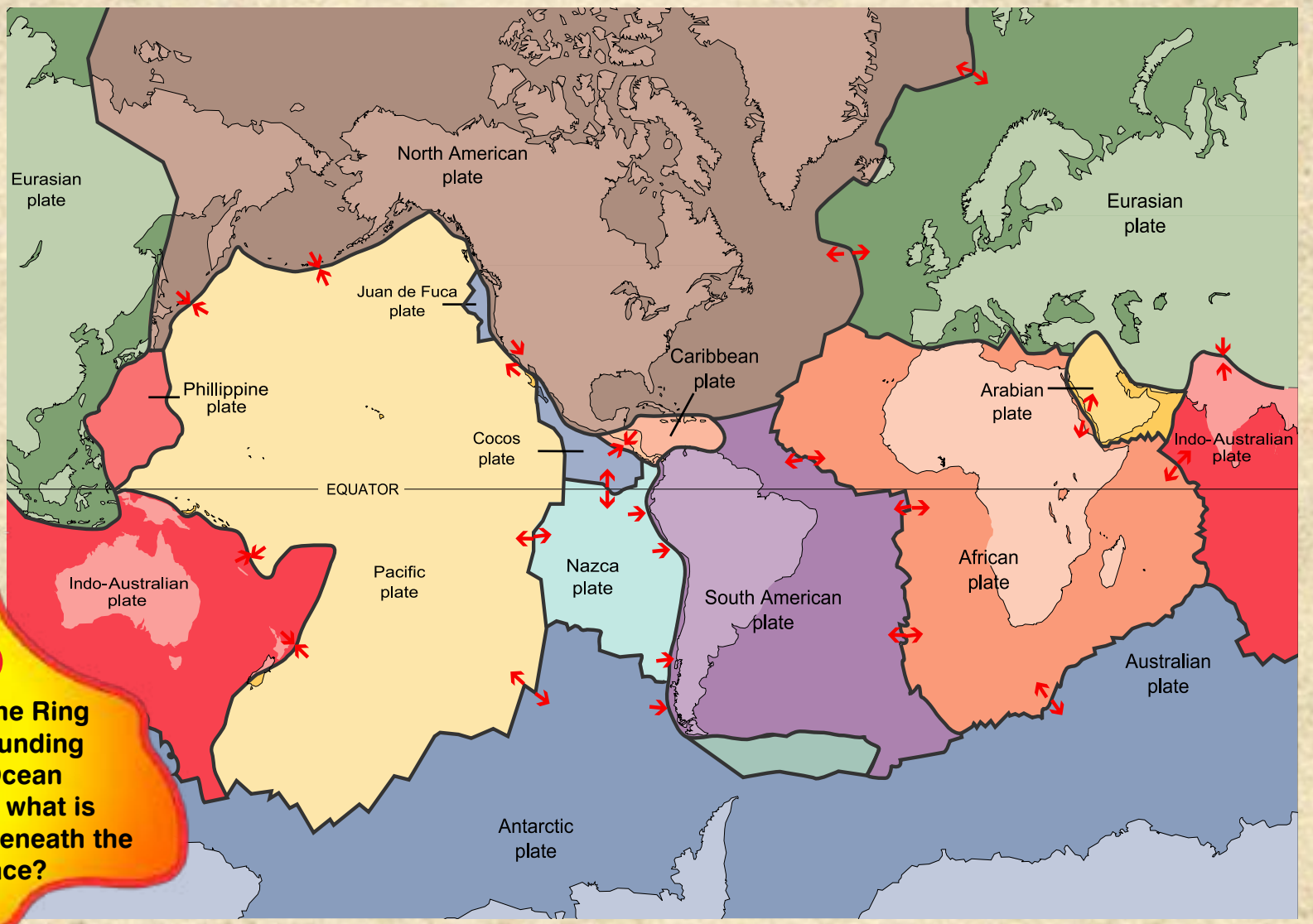
The crust is cracked into several sections called tectonic plates. These float on the semi-solid mantle below and move slowly over long periods of time. This process is called continental drift. Australia sits on the Indo-Australian plate, which is the fastest moving plate on Earth. We are drifting northwards at a rate of around 6 cm/year.

KEEP GOING

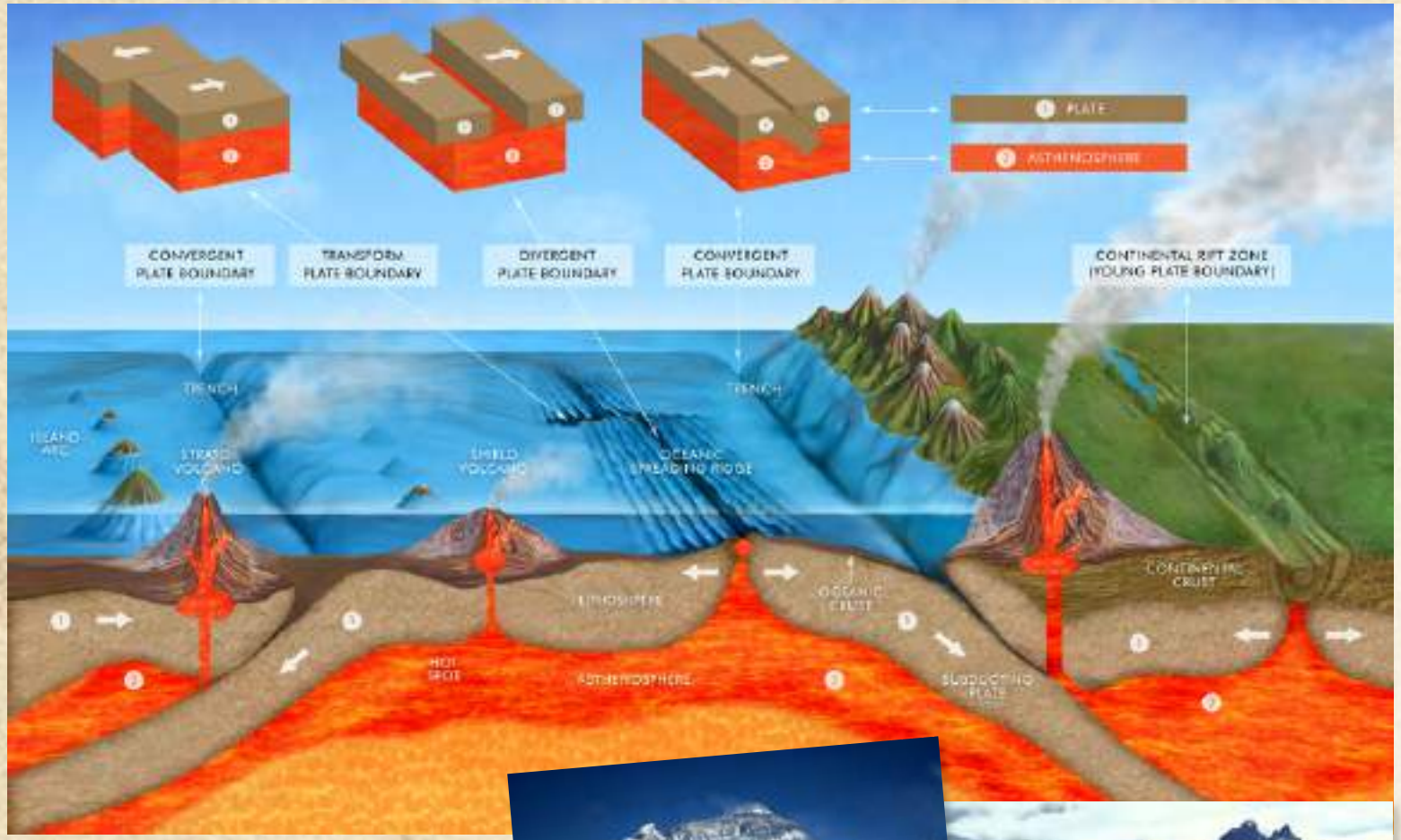
The **RING OF FIRE** shows the boundary of the Pacific Plate. It is the largest tectonic plate on Earth. It is having a rough time at the moment. As it slowly (but quickly in geological terms) moves towards the north west it is colliding and grinding past several other plates. The result of these violent interactions is the Ring of Fire.



What does the Ring of Fire surrounding the Pacific Ocean tell us about what is happening beneath the Earth's surface?



KEEP GOING



The Himalayas and the Andes are two of the world's mightiest mountain ranges. They are both the result of a collision at convergent boundaries between tectonic plates. These mountain ranges are quite young.

The Himalayas began rising around 50 million years ago, and the Andes around 30 million years ago.

The Himalayas

The Andes

Click here to explore how the tectonic plates have moved over time.

TYPES OF TECTONIC PLATE BOUNDARIES

A **CONVERGENT BOUNDARY** occurs where one plate is pushed beneath another. These often happen near the edges of continents. When these occur in the middle of an ocean there are often islands created. Can you find an example of this near Australia using the map provided on the previous page?

A **DIVERGENT BOUNDARY** occurs when two plates pull apart. Most happen in the middle of oceans and are called mid-ocean ridges where new ocean floor is made. Can you see on the previous page a divergent boundary that is not in the middle of an ocean? When a divergent boundary occurs on land it is called a continental rift boundary. There is one of these currently forming in north Africa. It is called the Great Rift Valley.

A **TRANSFORM BOUNDARY** (or conservative boundary) occurs when two plates slide past each other; e.g. the San Andreas fault in California.

Activity 2.4 Ocean floor conveyors

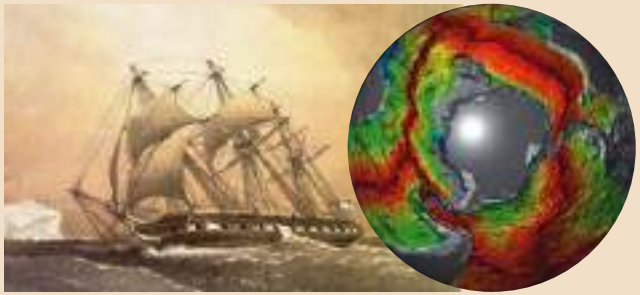
Activity type

The Earth's crust beneath the oceans is very different from the continental crust we live on.

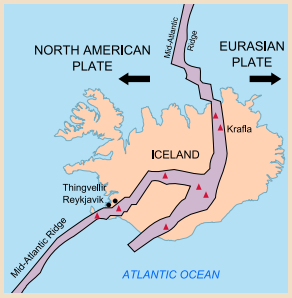
First, it is thin. While the crust beneath our feet extends around 50 km the crust beneath the major oceans is only around 7-10 km thick.

Second, it is young. Oceanic crust is often less than 100 million years old. Parts of Western Australia (continental crust) are up to 4 billion years old; almost as old as the Earth itself.

We know that rocks beneath the oceans are relatively young. Where did they come from, and where do they go?

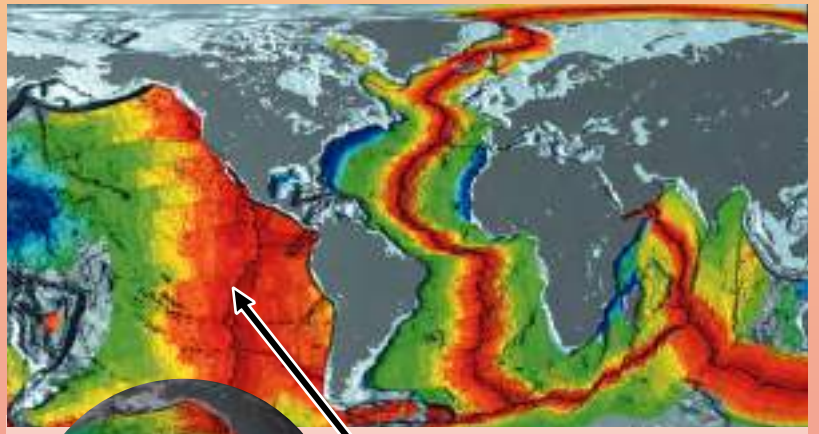


In 1872 an expedition aboard HMS Challenger discovered an enormous ridge extending the length of the Atlantic Ocean from north to south down the middle of the ocean.
It is actually a part of a continuous series of mid-ocean ridges that circle the globe.

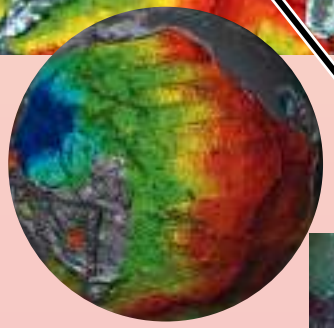


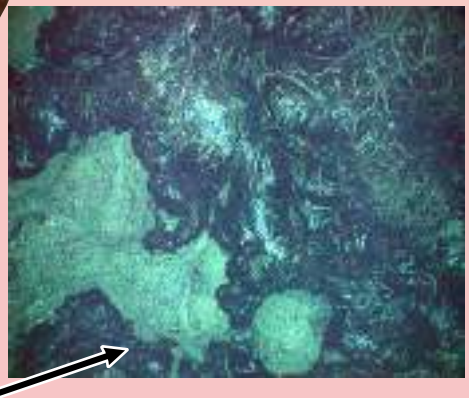
At mid-ocean ridges hot lava often oozes out, cooling quickly to form basalt. Here it is occurring on land, where the mid-Atlantic ridge crosses Iceland.

Rock outcrops in Iceland. Visitors are walking between the North American plate on the left and the Eurasian plate on the right.



In the Pacific Ocean the mid-ocean ridge is called the East Pacific Rise.





In 2006 scientists using a camera towed at a depth of 2.5 km photographed fresh, black lava flowing over the sandy sea floor on the East Pacific Rise. This is brand new oceanic crust.

Click here to explore the process of sea floor spreading.

Activity 2.5 Movement beneath the surface

Activity type

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What powers the movement of tectonic plates?

There is a strange world beneath the Earth's crust.

Deep beneath the Earth's surface the rocks in the mantle are superheated. Where does this heat come from? We don't know exactly but scientists believe that much of it comes from the decay of radioactive elements, such as uranium.

When these superheated rocks burst to the surface from a volcano they are molten and flow as lava. But what are they like hundreds of kilometres below the surface?

Beneath the surface the mantle seethes with convection currents of rock super heated by the Earth's core.

Modelling mantle plumes

What to use:

Each GROUP will require:

- 200 mL beaker
- tea candle and matches
- dark ink
- 1 mL plastic syringe or pipette
- tripod.

What to do:

Step 1
Fill the beaker with cold water. Let it sit for a while so there are no water currents.

Step 2
Use the syringe to place some ink gently at the bottom of the beaker.

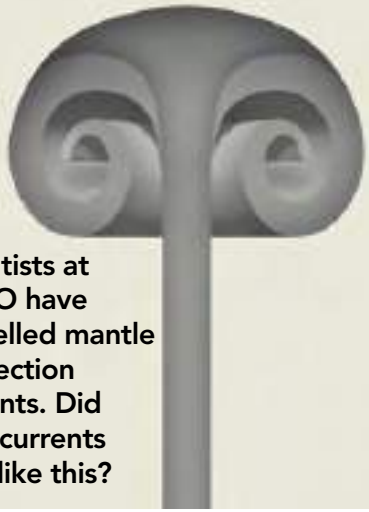
Step 3
Place the burning candle underneath the beaker so that it is below the patch of ink.

Step 4
Observe the ink as it heats. Record a photo or video of the ink plume as it forms. Record your observations in your ***Notebook.***

Step 5
Observe what happens to the plume as it reaches the surface and cools down. Record this observation in your ***Notebook.***

Discussion:

1. How closely did your plume match the theoretical models shown here?
2. What happened to the plume when it reached the cooler surface?
3. In your model what:-
   a. represented the initial heating of the plume at the core/mantle boundary?
   b. represented the plume reaching the cooler and more solid lithosphere?



Scientists at CSIRO have modelled mantle convection currents. Did your currents look like this?

Magma moves in huge convection currents. These can have a variety of shapes.

IDEALISED PLUME GEOMETRIES

According to theory, plumes could have a variety of shapes. Often they start as a spout and then become a mushroom as they rise.

Click here to explore how heat powers the movement of whole continents.

Activity 2.6 From tectonics to landforms

Activity type

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WE OFTEN FIND SEDIMENTARY LAYERS THAT ARE NOT FLAT AND NOT HORIZONTAL.

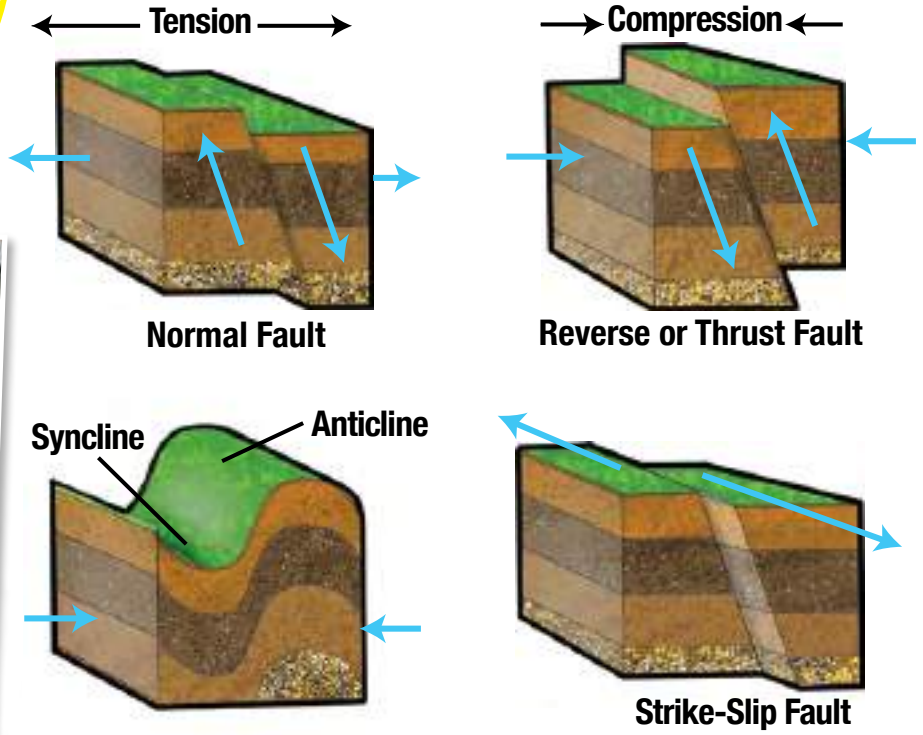
Folded rock layers

Folded and broken layers. The breaks are called fault lines.

? What is going on? What could have caused such upheaval?

? Where do hills, mountains and valleys come from?

Typical folding and faulting patterns for sedimentary rock formations.



Click here to explore the foundations of parliament and one of the most spectacular landform changes in the history of the Earth.

Activity 2.7 A dynamic Earth

Activity type

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Looking carefully at geological and geographical formations in Earth's upper layers helps us understand what is underneath.

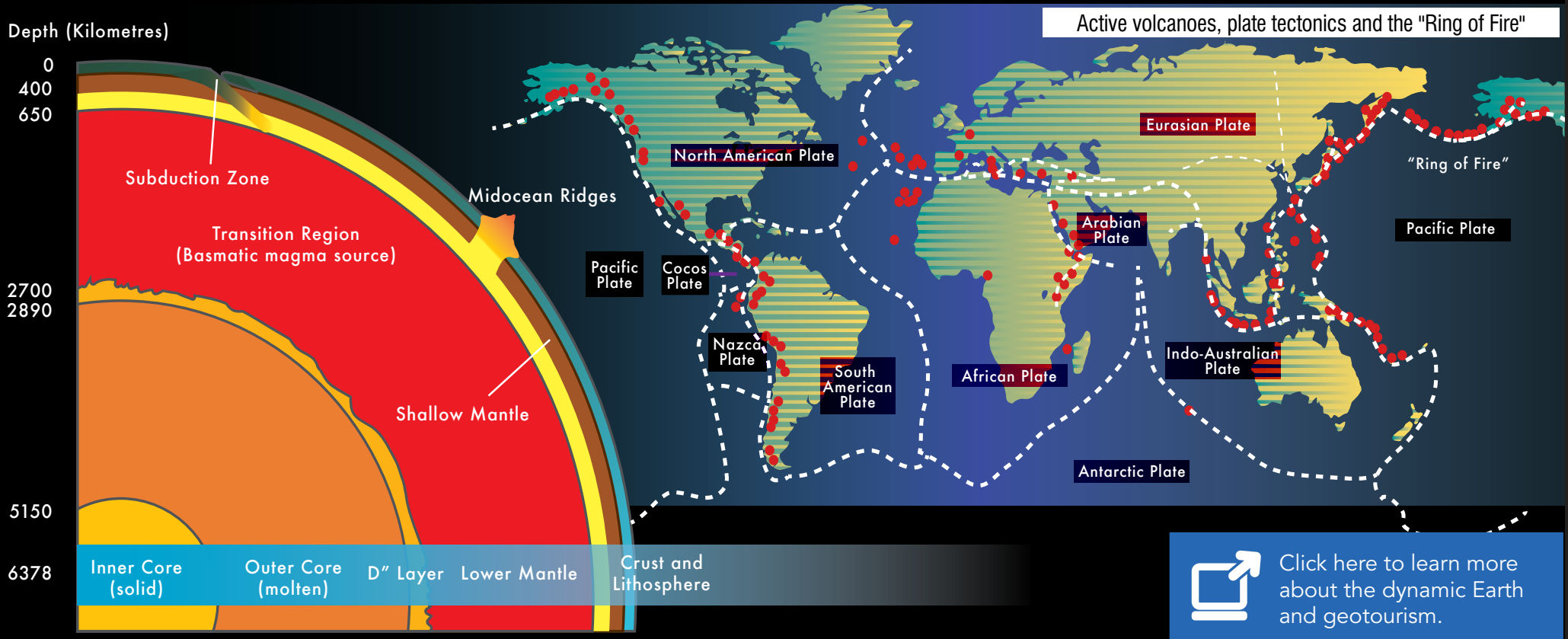
Are the Earth's layers, inclusive of tectonic plates, considered a system?

Use the diagrams below to revise the tectonic plate theory and layers of the Earth. Make a few summary dot points and drawings in your Notebook for each.

Catastrophic events such as tsunamis, earthquakes and volcanic eruptions give us insights into the location, magnitude and direction of the Earth's dynamic forces. Why do these occur?

In your *Notebook* explanation, refer to the tectonic plate theory and the Earth's layers.

Which do you think has the biggest impact on the way we live – what is below the Earth or what is above it? Discuss as a class.



Click here to learn more about the dynamic Earth and geotourism.

Summary

PART 2

The Earth's surface, or crust, is not perfectly continuous. It is divided into a series of **tectonic plates** that float on the more liquid **mantle** below. As the tectonic plates move relative to each other they sometimes produce large scale geological activity, such as earthquakes and volcanoes, at their **margins**. The Pacific Ocean sits on a large, fast moving, tectonic plate called the Pacific Plate. The boundary between the Pacific Plate and other plates next to it are very active, with many active volcanoes. This boundary is referred to as the **Ring of Fire**.

At boundaries tectonic plates can move in different ways. A region where one plate is pushed underneath another plate is called a **convergent boundary**. A region where two plates are pulling apart is called a **divergent boundary**. A region where two plates are sliding past each other is called a **transform boundary**.

The crust beneath the oceans **(oceanic crust)**, is quite different to the crust beneath continents **(continental crust)**. It is thinner and mostly much younger than continental crust. New oceanic crust is being actively formed at divergent boundaries beneath the Atlantic and Pacific Oceans. Evidence for the creation of new crust includes records of the Earth's changing magnetic field in the rocks.

The movement of tectonic plates is powered by enormous **convection currents** in the mantle deep within the Earth.

Evidence for geological activity linked to the movement of tectonic plates can be found in the rocks beneath our feet and landforms around us. Beds of rock can be broken and bent under the immense pressures produced as tectonic plates interact. The Himalayas are the highest mountain range on Earth, and are the result of a collision between the Indo-Australian plate and the Eurasian plate. This collision is still occurring today.

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