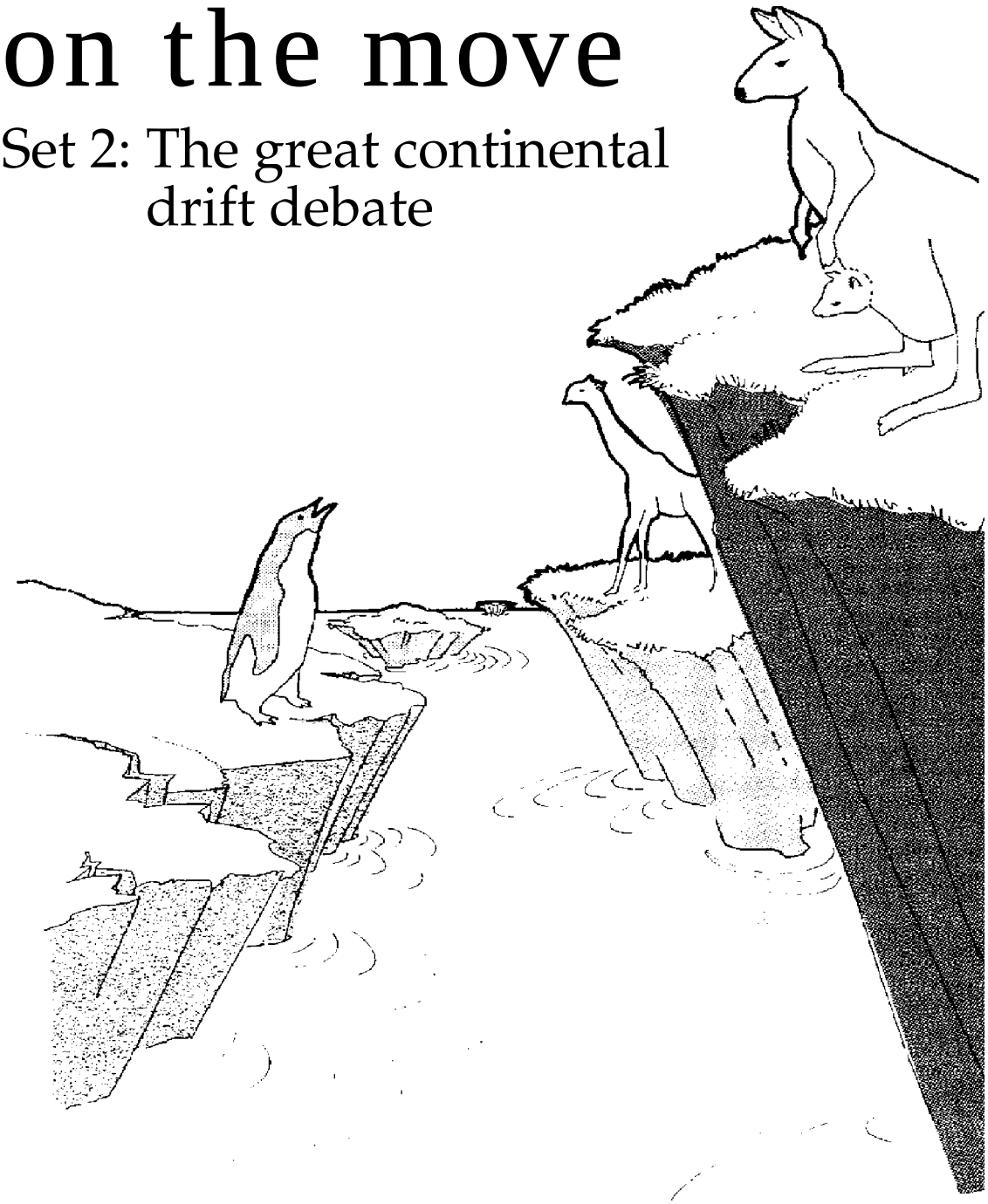
Science Stage 5

Set 2: Lessons 7 to 12

NEW SOUTH WALES
DEPARTMENT
OF EDUCATION
AND TRAINING

Continents on the move

Set 2: The great continental drift debate



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Continents on the move

Here are the names of the lessons in this unit.

Set 2: The great continental drift debate

Contents

What will you learn in Set 2?

At the end of this set, you should be able to:

- judge some cases where present environmental conditions and information from fossils do not match
- explain why scientists need to be curious, creative, objective and/or logical to solve problems in which information does not seem to match
- define hypothesis
- suggest some hypotheses to explain locations of some fossils
- state Wegener's hypothesis of continental drift
- list some evidence that supports Wegener's hypothesis of continental drift
- evaluate evidence to see if it supports or refutes a hypothesis
- extract information from a stratigraphic column
- apply the principle that the age of rocks increases down a stratigraphic column
- match rock types with the conditions in which they may have formed
- use the sequence of rocks in a stratigraphic column to develop a geological history
- use a scale to measure and mark distances on a map.

What do you need for Set 2?

Here is a reminder of the items you need for Set 2. To save time, it might be a good idea to get all these things ready before you start.

Lesson 8

- ruler

Lessons 9 and 10

- scissors
- glue

Lessons 11 and 12

- scissors
- glue
- thin cardboard, such as a breakfast cereal box
- sheet of white paper
- texta or black pen

Lesson 7

Problems, problems!

Today we know a great deal about the rocks
that are found on the Earth's surface.
But this has not always been so.

Only two hundred years ago, scientists were not sure
how rocks were formed.

Early ideas about rocks

Scientists who study rocks are known as **geologists**.
Unfortunately, the early geologists did not know much
about observations and inferences. They did not always
make careful observations and so many of their inferences
were incorrect.

Some early geologists thought that all rocks had been
formed by the drying up of a great ocean which covered
the whole Earth. Other geologists believed that all rocks
were laid down in a huge flood.

In the late eighteenth century, some geologists realised
that different rocks were formed in different ways.
Rocks with joining crystals were formed by the cooling
of molten rock. Other rocks were produced
when sediment was laid down in dunes, rivers, lakes or
under the ocean.

By the late nineteenth century, geologists realised that
they could use rocks to infer the climate and
environment at the time that the rocks were formed.

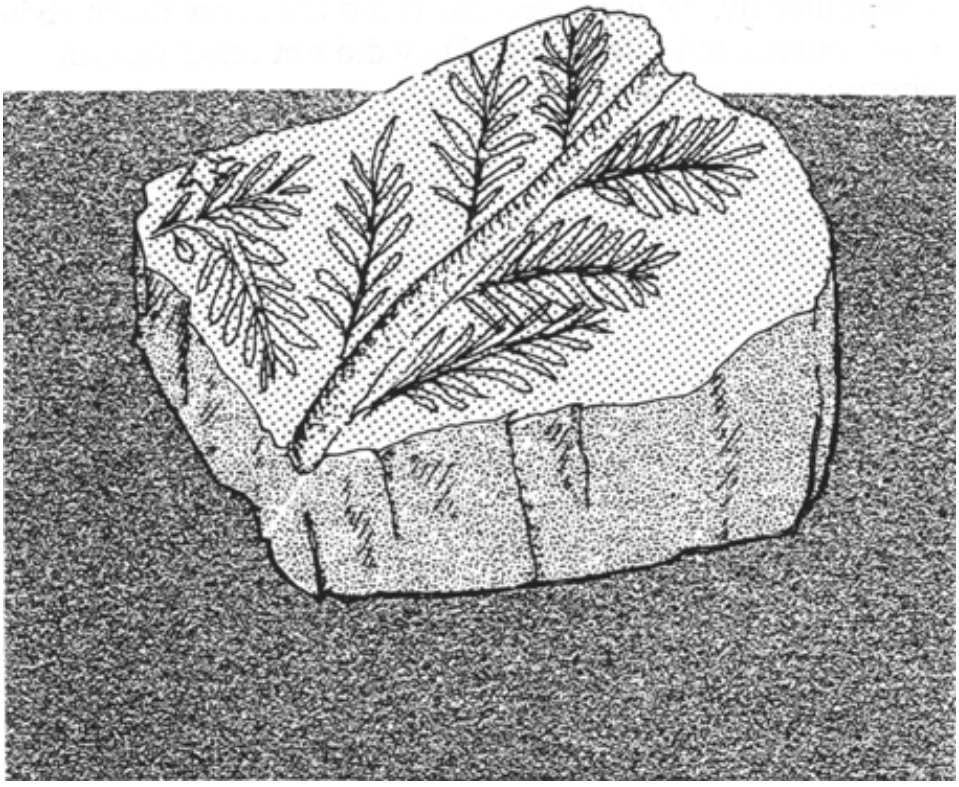
With this new knowledge, geologists began
more careful studies of rocks and fossils. They wanted
to find out what the Earth's surface was like in the past.

Let's look at some of the things they found out.

What does it all mean?

One group of geologists investigated rocks around London.
They collected lots of rocks and studied them carefully.
They searched for evidence to help them understand
when and how the rocks were formed.

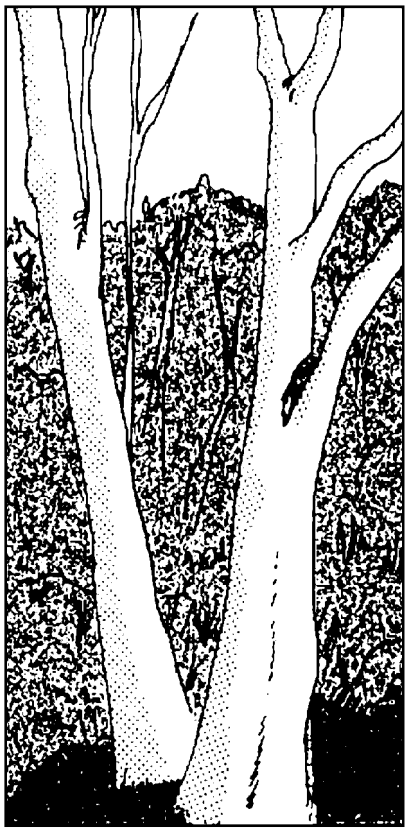
The rocks in this area contained many fossils.
A typical example has been drawn below.



The geologists were curious about the plant fossil
that they discovered. They compared the fossil
with plants that were alive throughout the world
but they couldn't find one that was the same.
They decided that the plants preserved in this rock
were extinct.

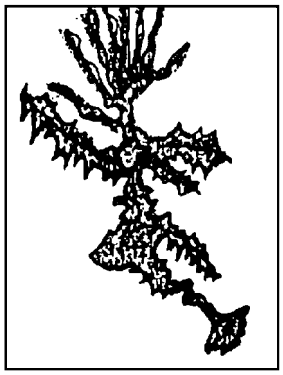
And there was another problem. It didn't make sense
to them that this fossil could be in rocks near London.
Can you see the problem they saw?

1. Which of the following plants does the fossil look most like?
   Circle the best answer: A B C D.

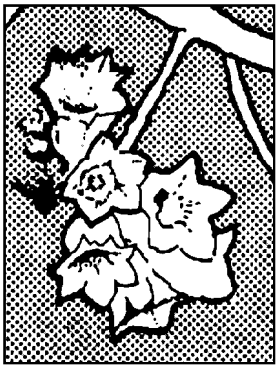


A. a gum tree

B. a fern



C. some seaweed



D. a flowering plant

2. Think about the plant that you selected in Question 1. In what sort of climate does this plant usually grow?
   Circle the best answer.

   A. warm and wet
   B. cold and wet
   C. hot and dry
   D. cold and dry

3. The fossil pictured on page 2 is about 200 million years old. What does the fossil tell you about the climate in London about 200 million years ago?

4. Describe the present climate in London.

_____

_____

5. Why did the discovery of the fossil plant puzzle geologists?

_____

_____

_____

Please turn to the answer pages and compare your answers with the solutions given.

Mastery test 1
How can this rock be here?

In 1908, a famous English explorer, Captain Scott, led an expedition to reach the South Pole. On the journey across Antarctica to the South Pole, Scott and his team made an interesting discovery. They found layers of coal containing plant fossils in a sandstone cliff below the Beardmore Glacier.

Do you remember how coal forms? It is made from plants that are laid down in layers, and gradually turned into rock. The plants usually grow in warm swamps.

Why do you think scientists were surprised when they found coal in Antarctica?

_____

_____

_____

There's an answer in the answer pages.

Send-in page Name _____

Lesson 7: Problems, problems!

Exercise 7 Puzzling rocks

By the end of the nineteenth century, geologists had a good understanding of the way in which rocks were formed. They thought they would be able to find out the history of the Earth's surface by studying rocks exposed on its surface.

But this did not happen. Geologists found it very difficult to explain some of their discoveries.

1. What are two examples of discoveries that geologists found difficult to explain?
   - _____
     _____
   - _____
     _____

2. Why were these discoveries puzzling?

   _____

   _____

3. How would you explain these discoveries? (Put down any ideas that you have!)

   _____

   _____

   _____

   _____

Think about the ideas that you wrote in your answer to Question 3.
Here are some words that could describe you and your ideas.

- **curious**
  Are you curious about the puzzle?
  Would you like to find out the answer?
- **creative**
  How many ideas could you think of?
  Do you think that your ideas are different from other people's ideas?
- **objective**
  Did you think about the evidence?
  Did you base your ideas on information?
- **logical**
  Do your ideas make sense?
  Can you use them to explain the evidence?

These four words describe scientists and how they try to solve problems.
They can describe the geologists who puzzled about rocks
that were found in environments where they did not belong.

4. Choose one of the words (curious, creative, objective or logical).
   Explain why the geologists trying to solve this rock problem
   needed to be curious or creative or objective or logical.

The scientists suggested ideas to explain the evidence,
just as you did in Question 3. These ideas are called hypotheses.
(Use the word hypothesis when you refer to one idea only.)
A **hypothesis** is an idea that tries to explain evidence.

Geologists made many hypotheses to try to explain their observations
of rocks and fossils. You'll learn about two of these hypotheses
next lesson.

But hypotheses must do more than just explain observations.
They must be able to be tested.

Optional questions

Can you think of a way to test one of your ideas from your answer to Question 3?

5. What evidence would let you think that your hypothesis is correct? (This evidence would **support** the hypothesis.)

6. What evidence would show you that your hypothesis is wrong? (This evidence would **refute**, or discount, the hypothesis.)

Lesson 8

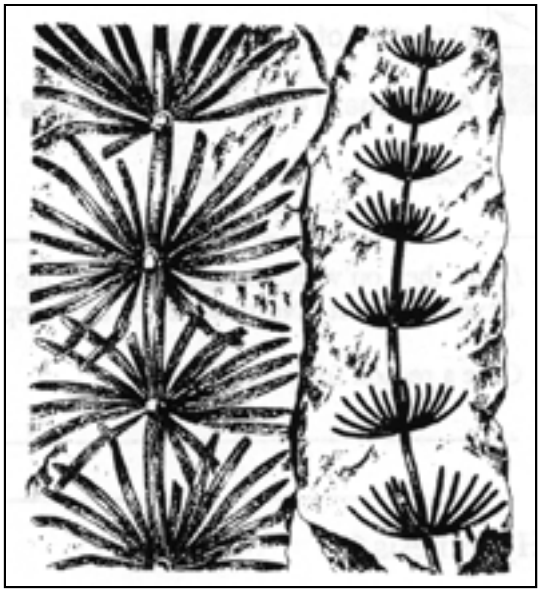
Making hypotheses

While geologists were making detailed studies of the rocks in Europe, similar studies were taking place in North America.

The results of these studies were surprising. Geologists found the same types of rocks in both North America and Europe.

Many of the rocks contained fossils. Some of these fossils are shown below.

Fossil plants found in England

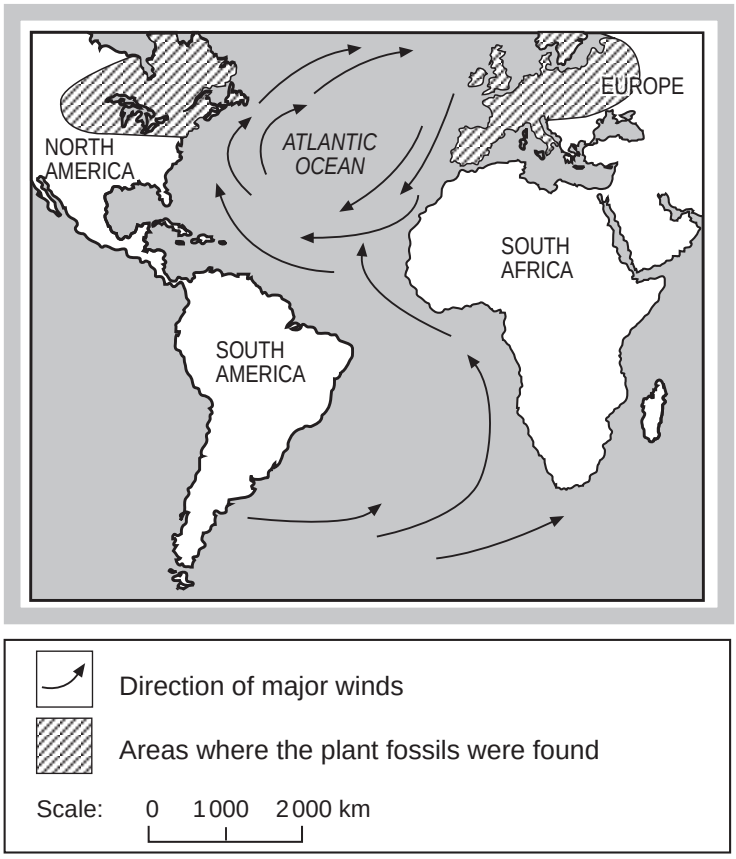


Fossil plants found in USA

Look at the diagrams carefully.

Can you notice any similarities between these fossil specimens?

This map shows the places where the plant fossils were found.



Geologists found that many types of European fossils were the same as fossils found in North America.
How did they try to explain this?
Geologists put forward hypotheses to try to explain why the same fossils were found so far apart.

A **hypothesis** is an idea that tries to explain evidence.

Hypothesis 1

Some scientists suggested that wind may have carried plant seeds across the Atlantic Ocean from one continent to the other.

Look at the map at the top of this page again.
Do you think that Hypothesis 1 is logical?

Yes or no? _____

The hypothesis is logical because it makes sense that seeds could be blown by major winds from North America to Europe, or even from Europe to North America.

Scientists also knew that seeds are often carried long distances by wind.

1. How could you test Hypothesis 1?

_____

_____

One way would be to see if seeds really could be carried so far by the wind.

How far is it from North America to Europe?

2. Use the scale on the map to calculate the minimum distance from the coastline of North America to the coastline of Europe.

   Here are the steps.

   (a) Measure the distance on the map, in centimetres.
   _____ cm

   (b) Look at the scale on the map. It shows that each centimetre of distance on the map represents 1000 kilometres.

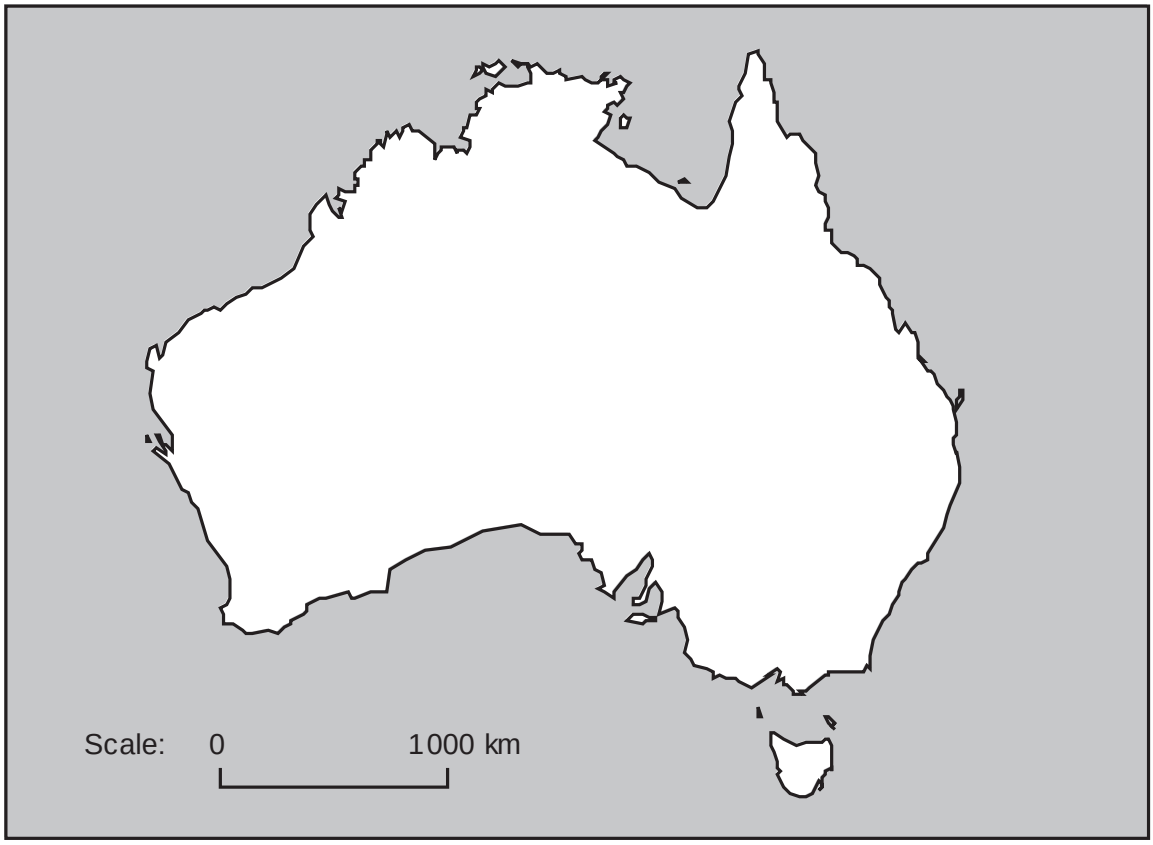
   Your measurement from the map is about 3 cm. What distance does this represent?
   _____ km

   (c) Complete this statement:
   The distance from North America to Europe is about _____ kilometres.

Can you imagine how far 3000 km is?

3. Draw a line representing 3000 km on the map of Australia below.

   Remember to check the scale on this map.



There is an answer in the answer pages.

4. What do you think?
   Could wind carry seeds this distance?

_____

3000 km is a long way! It's possible that seeds might be carried this far by the wind but it is unlikely that many seeds could make such a long journey.

Hypothesis 2

Snider-Pelligrini (1858) and the joining of continents

As early as 1858, a French geologist named Snider-Pelligrini suggested that North America and Europe might once have been joined together. Most people thought this was a very silly idea and quickly forgot about it.

Which word or words would you use to describe Snider-Pelligrini's idea?
Circle your answer(s) below.

creative curious objective logical

As more information was collected, Snider-Pelligrini's idea seemed more possible. Not only fossils, but also rocks seemed to match up across the ocean! The idea that continents had once been joined together and then moved apart would certainly help to explain these puzzling discoveries.

Most scientists disagreed. They thought that continents were far too large to move around. Only a small group of geologists continued to look for evidence which supported (agreed with) or refuted (disagreed with, or discounted) the idea of moving continents.

A hypothesis is **supported** when evidence agrees with the hypothesis.

A hypothesis is **refuted** when evidence disagrees with the hypothesis.

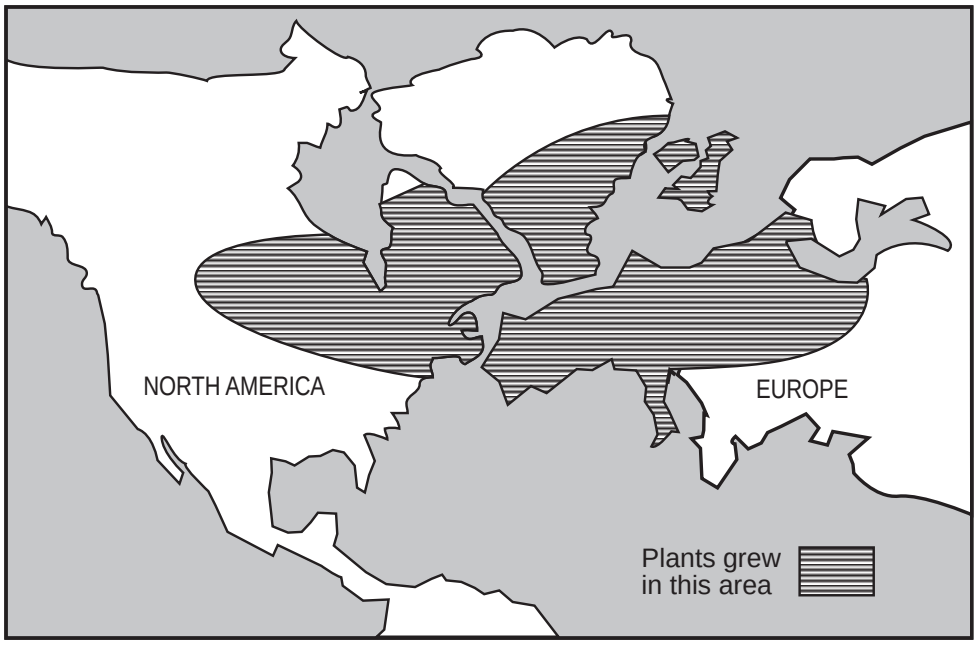
One geologist who thought it was logical that the continents could have been joined together, then moved apart, was Wegener.

Wegener (1912) and continental drift

In 1912, a German scientist named Alfred Wegener published some essays about moving continents.

Wegener thought that all of the continents had once been joined together, like the pieces of a jigsaw puzzle. According to Wegener, the continents had then started to break up and had eventually drifted apart.

This hypothesis is called **continental drift**. According to the continental drift hypothesis, the plants in the fossils shown on page 9 grew while the North American and European continents were still close together. The fossils formed at this time.



When the continents split up, the areas where the plants had grown moved apart. Some plant fossils were separated by thousands of kilometres of ocean.

However, most scientists thought that Wegener's ideas were extremely silly. Continents are very, very large. How could it be possible for them to move?

Even though Wegener supplied evidence to support his hypothesis, his ideas were not taken seriously until many years later.

Send-in page Name _____

Lesson 8: Making hypotheses

Exercise 8 Hypotheses and evidence

1. What does the word hypothesis mean?

_____

2. Geologists put forward several hypotheses to explain why the same fossils were found in Europe and North America.

   (a) Write two of these hypotheses.

   - _____

     _____

   - _____

     _____

   (b) Are these the only two possible hypotheses? _____

   (c) Based on what you learned in Set 1 about fossils and environments, can you think of another hypothesis? If so, write it below.

   _____

   _____

   (d) Can you think of any reasons why this hypothesis was not put forward?

   _____

   _____

3. Hypothesis 1, on page 10, said that the wind may have carried plant seeds across the Atlantic Ocean from one continent to the other.

   Decide if each observation below supports Hypothesis 1. Tick (✓) the box in the middle column if it does.

   Decide if each observation refutes Hypothesis 1. Cross (✗) the box in the right hand side column if it does.

   Be warned! The observations may not support or refute the hypothesis.

Observation	Supports Hypothesis 1	Refutes Hypothesis 1
Fossils of tropical plants have been found in both North America and Europe.	☐	☐
Strong winds blow across the Atlantic Ocean from west to east.	☐	☐
The distance from Europe to North America is about 3000 kilometres.	☐	☐
Rocks found in parts of Europe are the same as those found in North America.	☐	☐

Lessons 9 and 10

Reading the rocks

Information about the past history of the Earth comes from rocks. Geologists observe rocks and then infer how the rocks were formed.

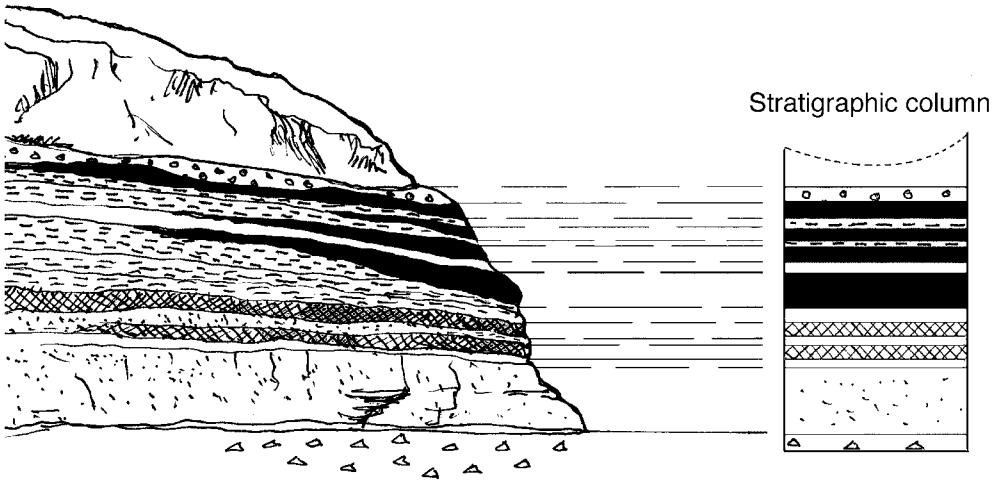
In this lesson you are going to see how rocks can be used to find out what happened millions of years ago.

The stratigraphic column

In cliff faces and road cuttings, you can see where different rocks have been laid down one on top of another.

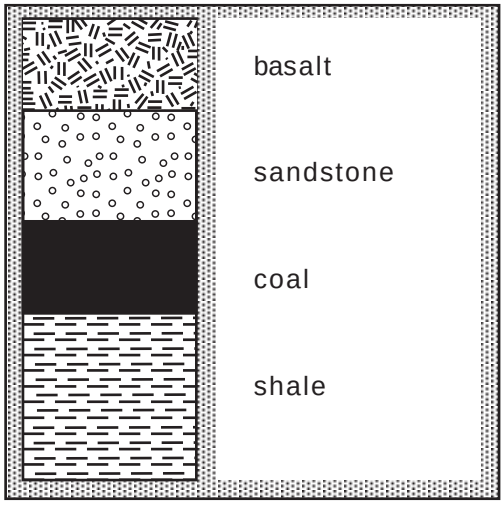
It is often necessary for geologists to make a record of the rocks that are present. A diagram showing rock layers is called a **stratigraphic column**.

In a stratigraphic column, different rock types are shown using different symbols.



Let's see how stratigraphic columns can be used.

The diagram below shows another example of a stratigraphic column.



Shale is the rock at the bottom of the column.

The other rocks lie on top of the shale.
This means that shale was laid down first.

The next rock to be laid down was coal, followed by sandstone.

At some time later, there was a lava flow which cooled to form basalt.

The events that produced these rock layers are the **geological history** of this area. The stratigraphic column contains evidence that lets you infer this geological history.

Use information from the stratigraphic column to answer the following.

1. What is the oldest rock in this stratigraphic column?

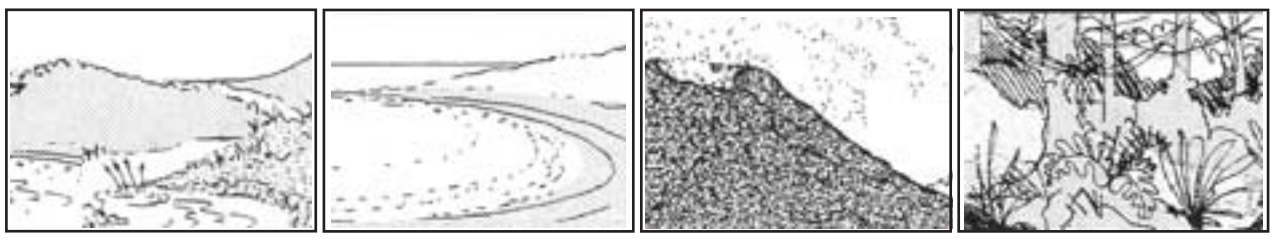
   _____

2. Name one rock which is younger than coal.

   _____

3. How has the environment in this area changed?
   (a) Here are four drawings of what this area may have been like. Label each drawing with the name of the rock that may have been formed.

   Then number the drawings from 1 (oldest) to 4 (youngest).



Rock formed _____ _____ _____ _____

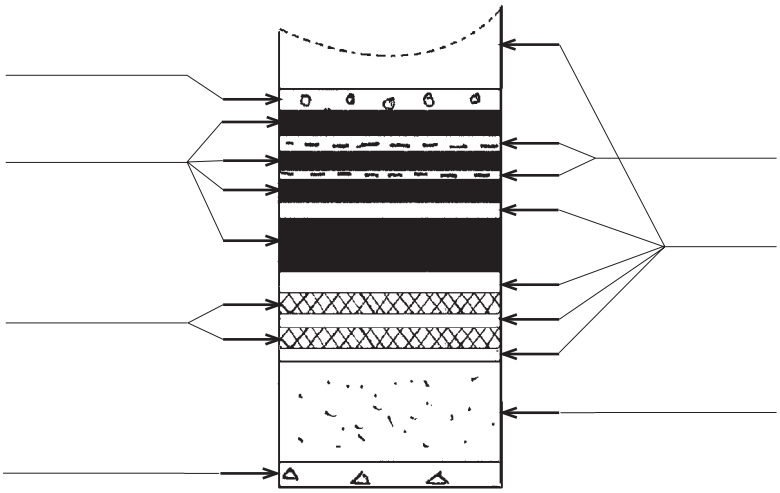
Order formed _____ _____ _____ _____

(b) Write a paragraph describing how the environment in this area has changed over time.

Turn to the answer pages and check your answers now.

Mastery test 2
Analysing a stratigraphic column

Here again is the stratigraphic column from page 17.
There is a problem with this column – the key should include the pattern that represents each rock in the column.



Key:

- coal
- conglomerate
- mudstone
- sandstone
- shale
- shale with leaf fossils
- shale with shell fossils

Use the clues below to label each rock layer in the stratigraphic column.
Then complete the key.

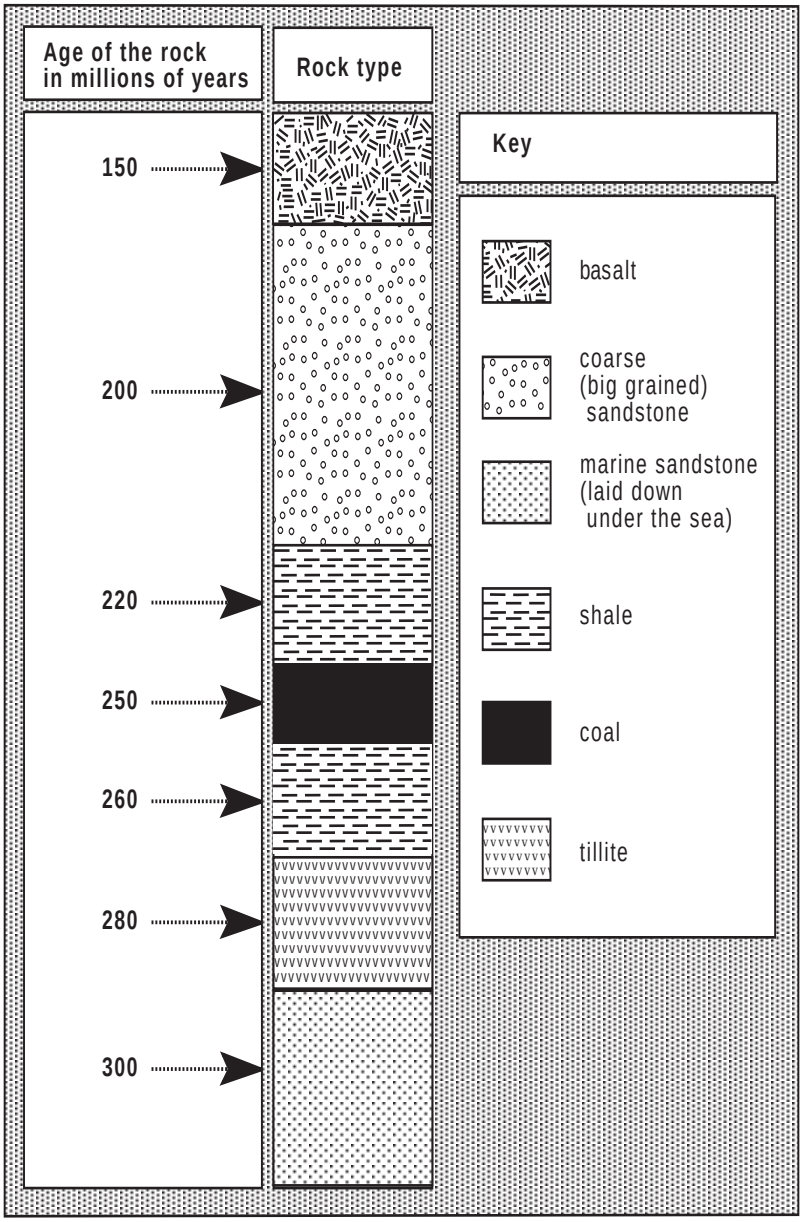
- The same rocks have the same pattern in the stratigraphic column. Different rocks have different patterns.
- The oldest rock is conglomerate.
- The youngest rock is shale.
- There are four layers of coal in this stratigraphic column.
- Shale containing shell fossils formed after all of the coal layers.
- A thick layer of sandstone formed before any shale formed.
- Layers of mudstone separate some of the layers of shale.
- The remaining layers are shale containing leaf fossils.

Please compare your answers with the solutions in the answer pages.

Using a stratigraphic column to construct a geological history

Sometimes geologists gather information from many different places. Then they can draw stratigraphic columns to show the types of rocks laid down over a large area.

The stratigraphic column below shows the types of rocks laid down in part of South Africa from 150 to 300 million years ago.



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Lessons 9 and 10: Reading the rocks

Exercise 9 Using a stratigraphic column

1. List the rocks in the stratigraphic column on page 20 from oldest to youngest.

oldest → youngest

2. Decide if the statements below are observations (O) or inferences (I).

- ☐ The kind of rocks formed in this area has changed between 150 and 300 million years ago.
- ☐ The environment in this area has changed between 150 and 300 million years ago.
- ☐ This environment was warm, wet and swampy about 240 million years ago.
- ☐ Tillite formed before coal.
- ☐ The rocks were laid down in layers.
- ☐ Most of the rocks in this column are sedimentary rocks.
- ☐ This environment was once under the ocean.
- ☐ Each layer is a different kind of rock.
- ☐ Coarse sandstone formed at a different time from marine sandstone.
- ☐ The stratigraphic column records the geological history of this area.

3. This plant is a fern called Dicroidium.
It lived about 200 million years ago.

In which rock in the stratigraphic column on page 20 would you look for fossils of this plant?

4. What evidence would you look for to find out about the geological history in this area in the last 150 million years?

5. Check that you remember how different rocks are formed.
(Look back through Set 1 if you don't remember!)
Match the descriptions below with the name of each rock.

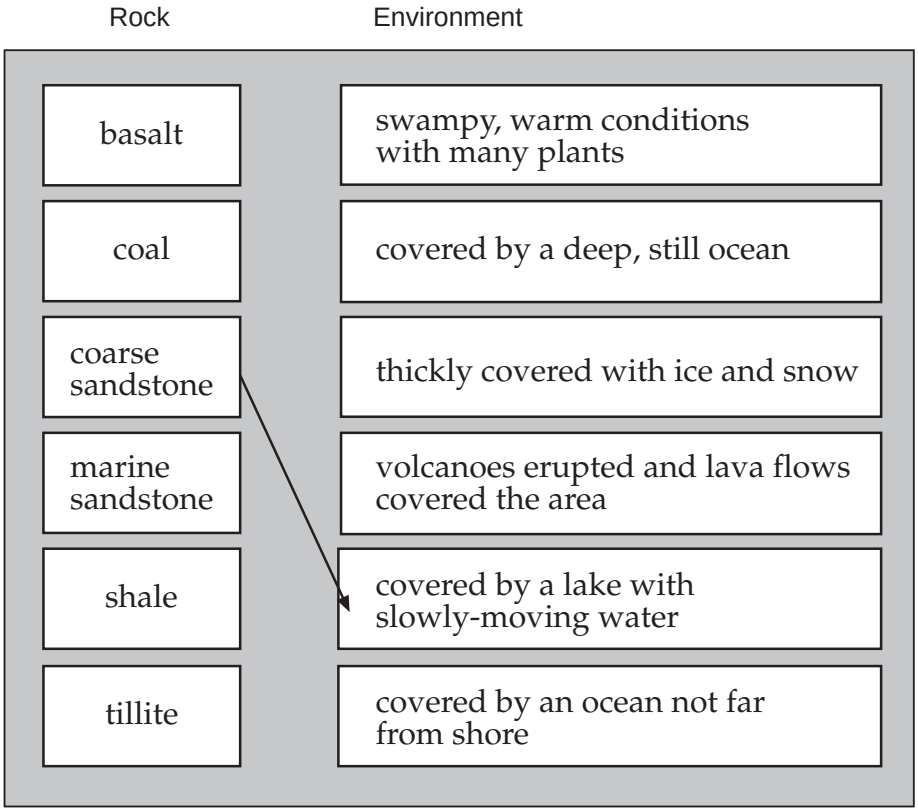
Rock	How the rock formed
basalt	cooled lava flows
coal	mud and clay settle in still oceans or lakes
sandstone	plants form layers in tropical swamps
shale	icy glaciers dump sand, pebbles and boulders together
tillite	sand settles in streams, oceans or lakes or is blown into dunes by wind

Send-in page Name _____

Lessons 9 and 10: Reading the rocks (continued)

6. Here are some descriptions of the environment in the area for the stratigraphic column on page 20.

   Match each description with the name of the rock that may have formed in that environment.
   One has been completed for you as an example.



7. Write a paragraph describing how the environment in this area has changed over time.

_____

_____

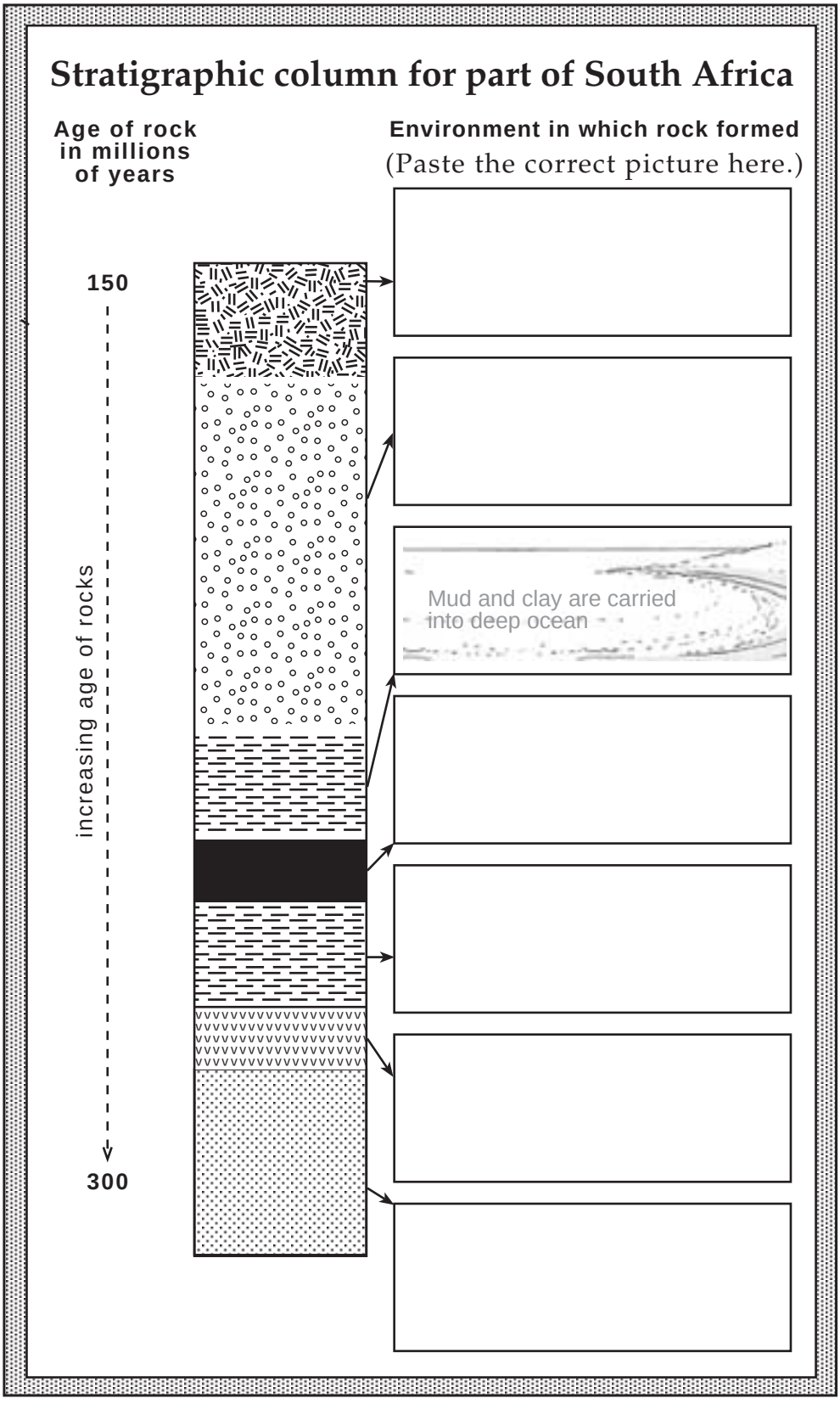
_____

_____

_____

Exercise 10 Constructing a geological history

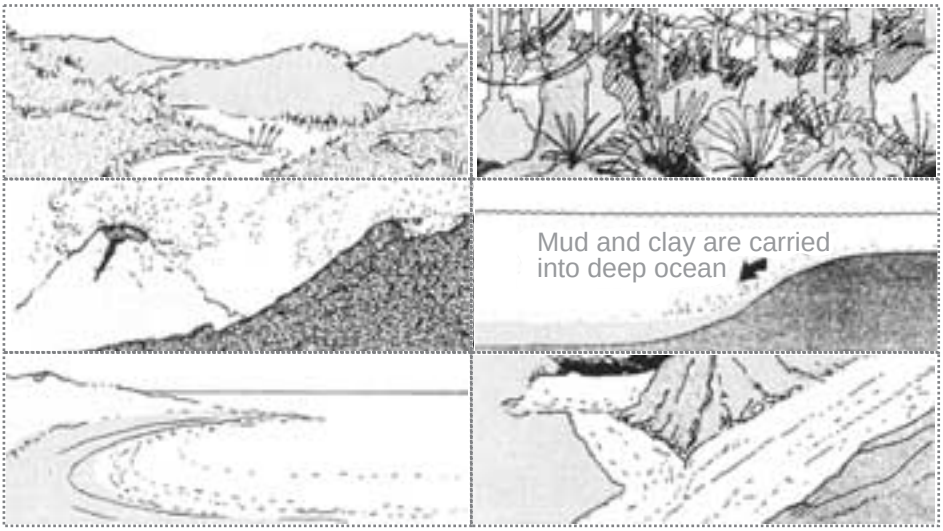
For this exercise, follow the instructions on page 25.



The drawings below show possible environments from the geological history of this area of South Africa.

Cut out the six drawings and match them with the layers in the stratigraphic column on page 24. One drawing has already been included as an example. You will need to use information from the stratigraphic column on page 20 and your answers to Question 5 on page 22 and Questions 6 and 7 on page 23.

Once you are confident of your answer, paste each drawing into its box.



Another puzzle!

Look carefully at the stratigraphic column on page 24.
Can you see something that it is difficult to explain?

Here is the problem.

280 million years ago, large areas of tillite were laid down across South Africa. Therefore, most of South Africa was probably covered with ice and snow. It must have been very cold at that time, like it is at the South Pole today.

Only 30 million years later, thick layers of plant material were laid down. These plants had grown in tropical swamps where conditions were warm and wet.
The plant material was buried and eventually turned into coal.

How could the climate change that much in 30 million years?
The geologists of the early 1900s had no idea!

Wegener's suggestion

Unlike other scientists at the time, Wegener thought that the rocks found in South Africa provided important evidence for his continental drift hypothesis.

Wegener suggested that the climatic changes could be explained by continental drift.
The tillite deposits in South Africa could have formed while the African continent was near the South Pole.
The continent then drifted closer to the equator and into the tropics where the coal was formed.

But was this idea really possible? Even Wegener admitted that he did not know how the continents could have moved.

Mastery test 3
Why has the environment changed?

In Lesson 8 you saw that fossils of tropical plants were found in Europe. Most scientists in the 1900s could not explain how tropical plants would have grown in a cold place such as Europe.

How would Wegener have explained this?

If you'd like to check your answer, turn to the answer pages.

Lessons 11 and 12

The continental jigsaw

Wegener's essays on continental drift were important because he supported his creative ideas with evidence. You have already seen that rocks in South Africa and fossils in North America and Europe provided important evidence for Wegener's hypothesis.

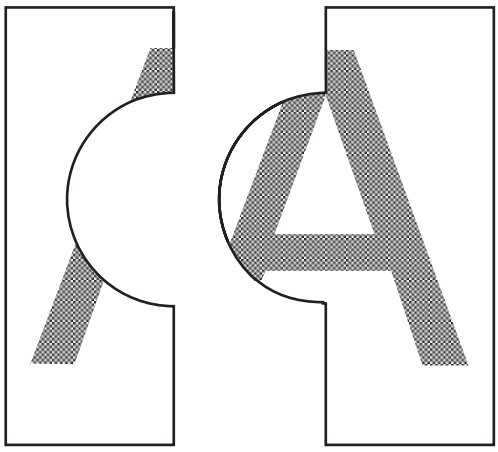
Let's now look at some other evidence that Wegener provided.

Putting the pieces together

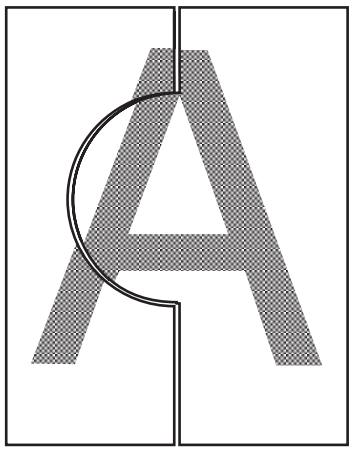
Wegener suggested that all of the continents on the Earth's surface were once joined together like the pieces of a jigsaw puzzle.

When you put a jigsaw puzzle together, there are two things that you need to look for.

1. The shapes of the pieces need to fit together.



2. The patterns on the pieces need to match up.



If the continents had once been joined, you would expect them to fit together. You would also expect the patterns on the continents to match. These patterns may be rock units (large areas of one type of rock) and old mountain ranges.

In the following activity you are going to test
Wegener's jigsaw idea for the southern continents.

Read the following section and carefully follow the instructions.
You will need:

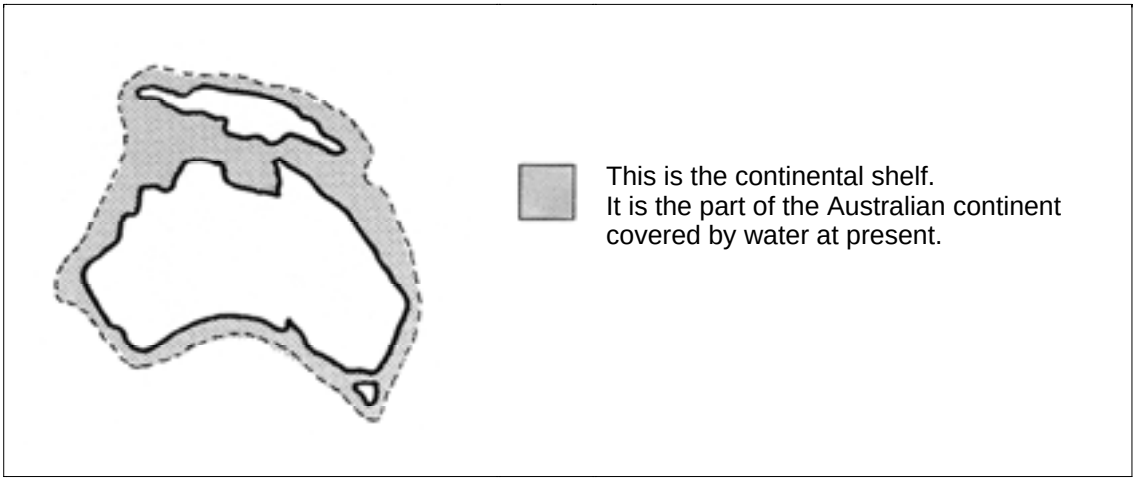
- scissors
- glue
- some thin cardboard, for example from a breakfast cereal packet
- a sheet of white paper
- a texta or black pen.

Making the continental jigsaw

When people talk about continents, they usually mean
the parts of the Earth's surface that rise above sea level.

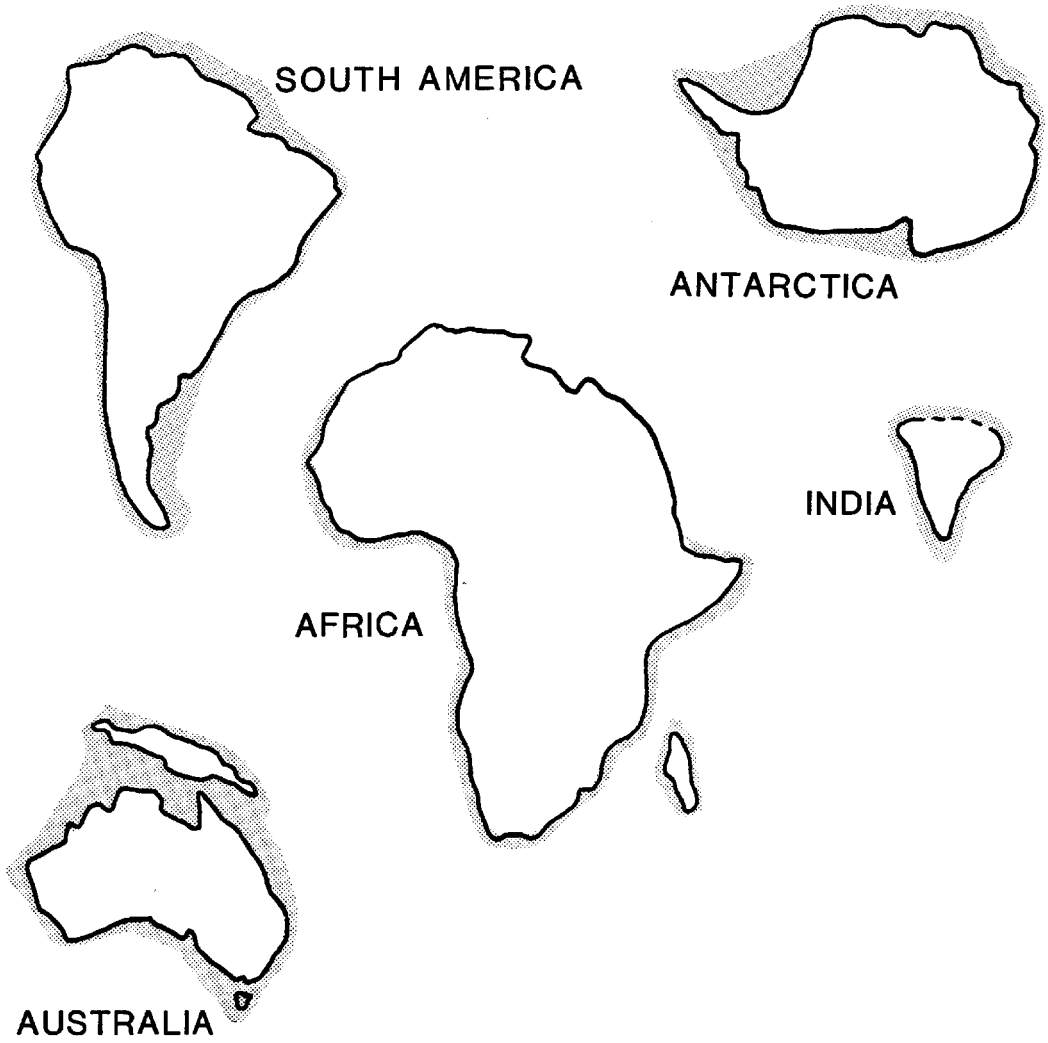
However, geologists have a slightly different meaning for
the word **continent**. Geologists have found that rocks which
make up continents are different from rocks that make up
the seafloor. A continent ends where the continental rocks finish
and the seafloor rocks start. In most cases, the sea covers up
the edges of continents. The underwater edges of a continent
are called the **continental shelf**. So to a geologist, a continent is
the land above sea level plus the continental shelf.

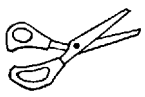
Australia and New Guinea are really part of one continent.
They only look like separate islands because the sea
has covered an area of continental shelf between them.



When you use the continents in a continental jigsaw,
you must use the real shape of each continent and not just
the part that sticks out of the ocean.

Here are the outlines of the continents which are now in the southern part of the world. India is included because it was a separate continent millions of years ago. (Now, India is joined to Asia and is called a subcontinent.) The shaded part of each continent is its continental shelf.

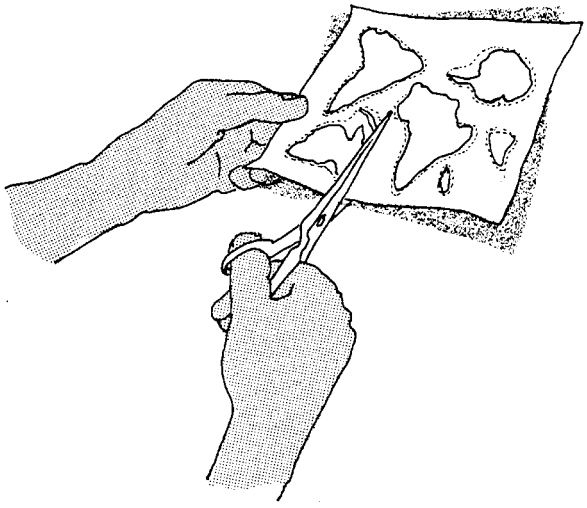




1. It will be easier to handle the jigsaw pieces if they are mounted on cardboard.

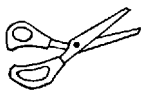
   Paste the top of this page onto your thin piece of cardboard. You will need to put glue all over the back of the paper.

2. Let the glue dry then carefully cut out each of the continental outlines.

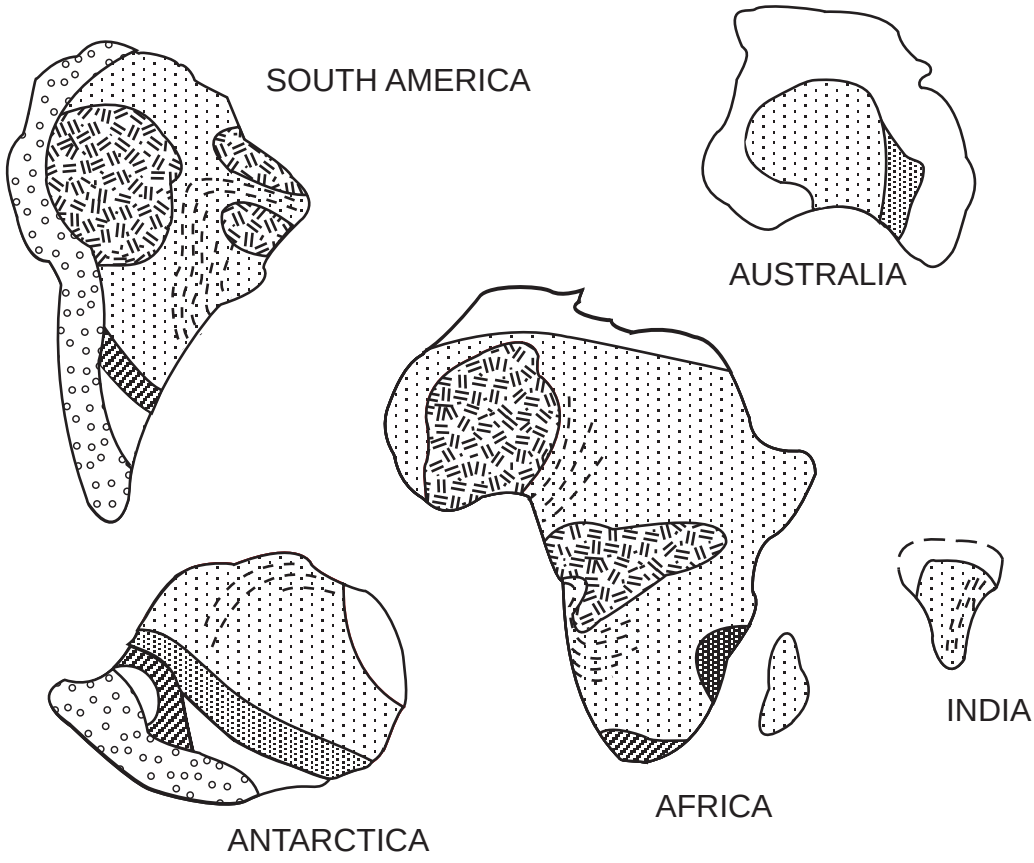


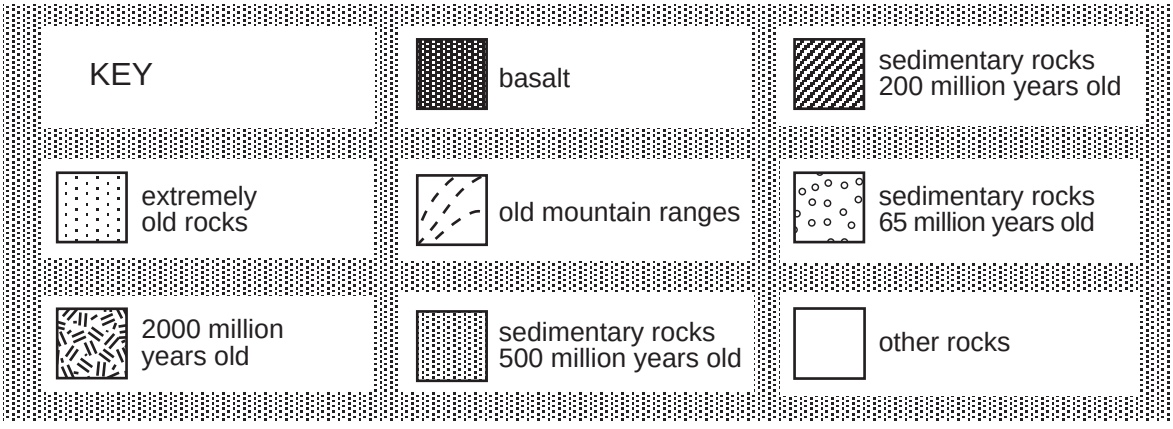
3. Next you will put a pattern on each jigsaw piece.

   The patterns for the continents are features such as mountain ranges and rock units. The most important patterns are shown in the diagrams below.

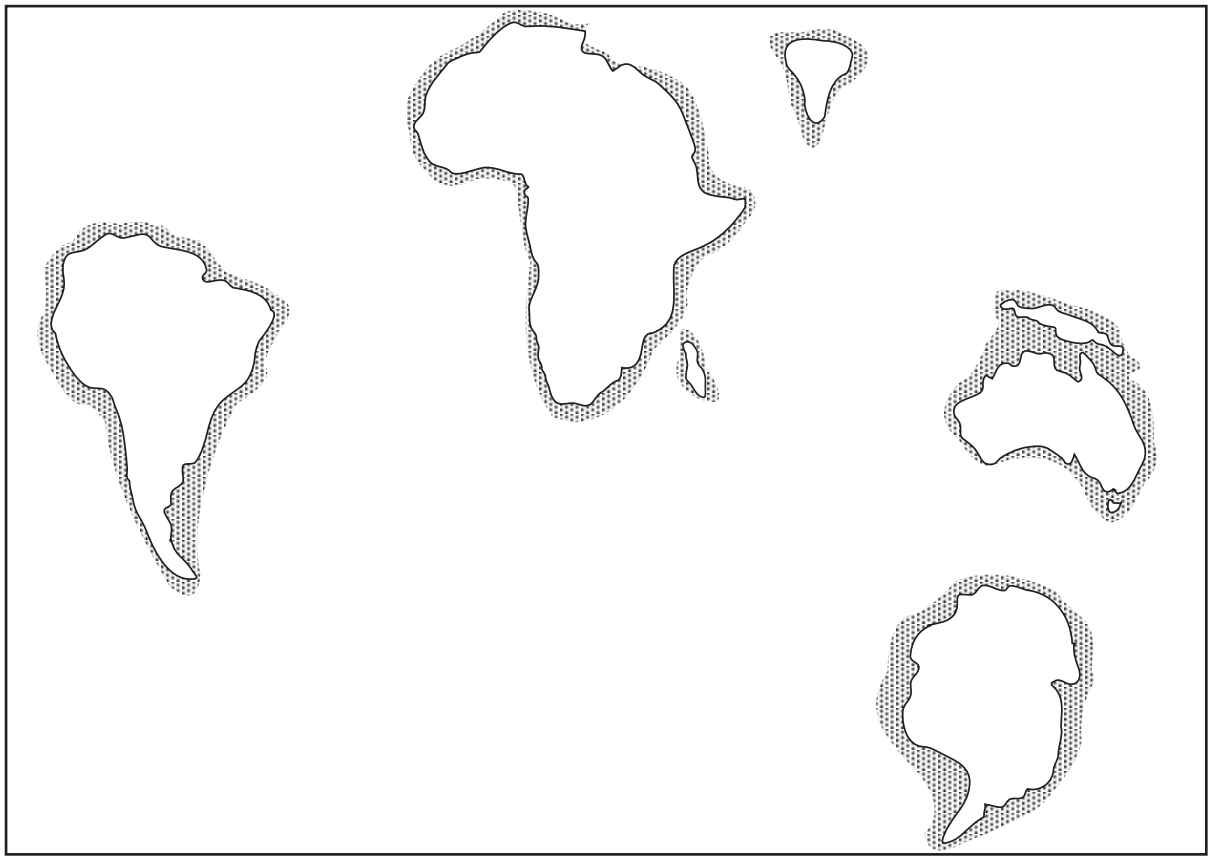


   Cut out each of these patterned shapes and paste them onto your cardboard continent shapes.





4. Spread the cardboard continent pieces
on a piece of white paper in front of you.
Arrange them to match the map below.
These are the positions of the southern continents today.



5. Look for matches in the shapes and patterns of the pieces.
Join the southern continents together to make one big continent.
This is called a **supercontinent**.

If you have problems, check the solution in the answer pages.

Use your completed continent jigsaw to complete the send-in exercise.

Then organise all the send-in pages from this set and return them to your teacher.

Send-in page Name _____

Lessons 11 and 12: The continental jigsaw

Exercise 11 Using evidence from the jigsaw

Wegener did a jigsaw, just like yours! He thought that the way the continents fitted together was evidence for his hypothesis.

1. What was Wegener's hypothesis?

_____

_____

2. (a) Do you think that the fit of the southern continents supports Wegener's hypothesis? Yes or no? _____

   (b) Give a reason for your decision.

_____

_____

3. Can you think of any other reason why the continents fit together? If so, write it below.

_____

_____

4. Can you think of any reasons why the match of the continents is not perfect? If so, list these below.

_____

_____

_____

5. You are trying to convince someone that Wegener's ideas are quite logical and sensible.

   What evidence would you use to support your statement?

   Hint: Look back through all of the lessons in this set.

6. Paste your completed continental jigsaw in the space below.

7. In the jigsaw, you can observe that the patterns of the rock units tend to match across the boundaries of the continents.

   Use a black pen or texta to mark an 'x' on three places where the match is very good.

8. (a) What would you expect to have happened in this jigsaw activity if Wegener's hypothesis were wrong?

   (b) Would a new hypothesis be needed?

Remember to put all your send-in pages together and send them to your teacher.

Suggested answers

Lesson 7 Problems, problems!

Pages 3 and 4

1. Which of the plants on page 3 does the fossil look most like?

   B. a fern

2. In what sort of climate does this plant usually grow?

   A. warm and wet

3. The fossil pictured on page 2 is about 200 million years old. What does this tell you about the climate in London 200 million years ago?

   The climate was probably warm and wet.

4. Describe the present climate in London.

   London has cool summers and cold winters, often with ice and snow.

5. Why did the discovery of the fossil plant puzzle geologists?

   They did not understand how the climate could have changed.

Page 4 Mastery test 1 – How can this rock be here?

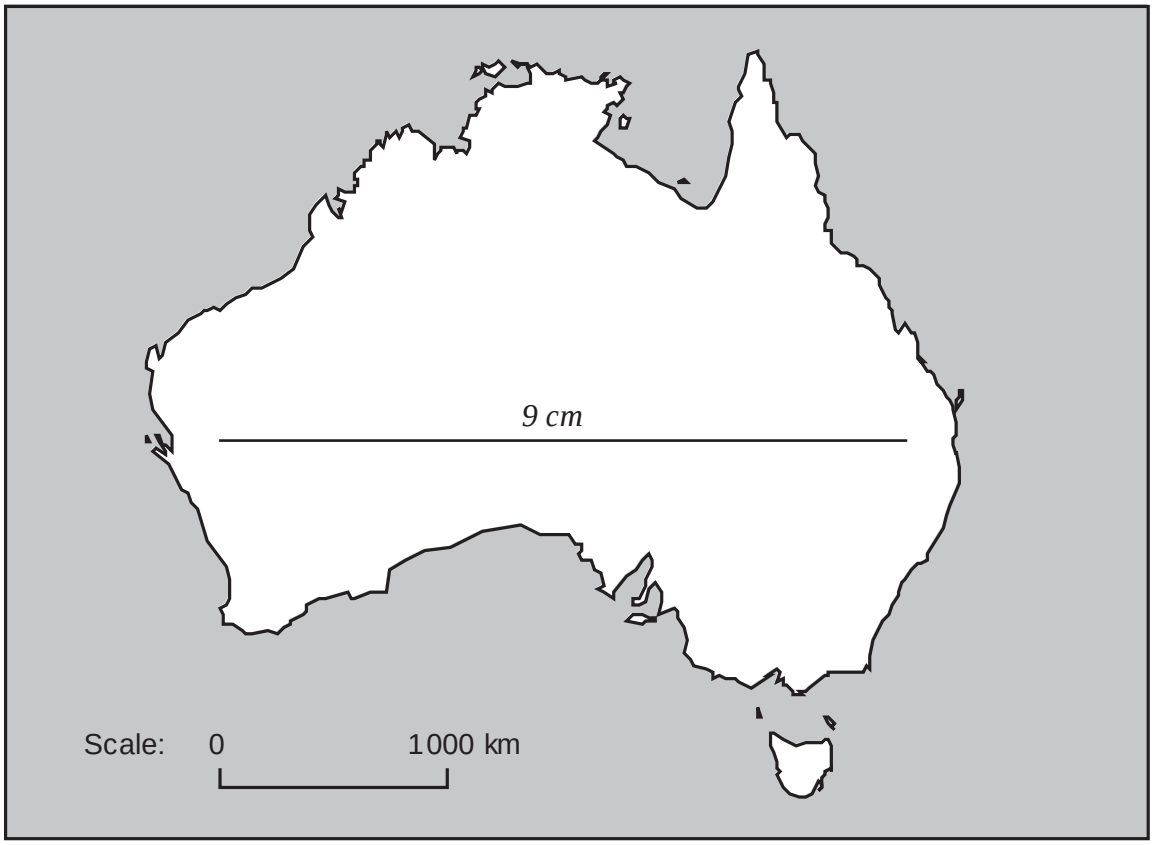
Why were scientists surprised when they found coal in Antarctica?

Antarctica is much too cold for coal-forming plants to grow.
For these plants, the climate is usually warm.
How could the environment have changed so much?

Lesson 8 Making hypotheses

Page 12 Hypothesis 1

3. Draw a line representing 3000 km on the map of Australia.
   Using the scale on the map, a line representing 3000 km would be 9 cm long.



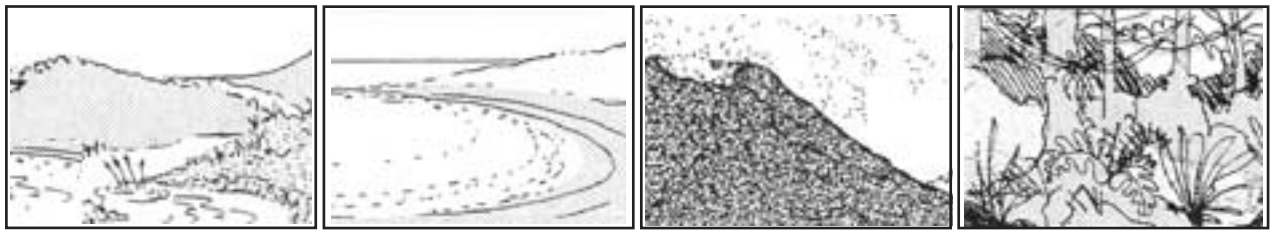
Lessons 9 and 10 Reading the rocks

Page 18 The stratigraphic column

1. What is the oldest rock in this stratigraphic column?
   shale (because it is at the bottom of the column)

2. Name one rock which is younger than coal.
   sandstone or basalt (because both these rocks are higher than coal in the column)

3. (a) How has the environment changed?



Rock formed	*shale*	*sandstone*	*basalt*	*coal*
Order formed	*1*	*3*	*4*	*2*

It is OK if you reversed the drawings for shale and sandstone – they can form in similar places.

Lessons 9 and 10 continued

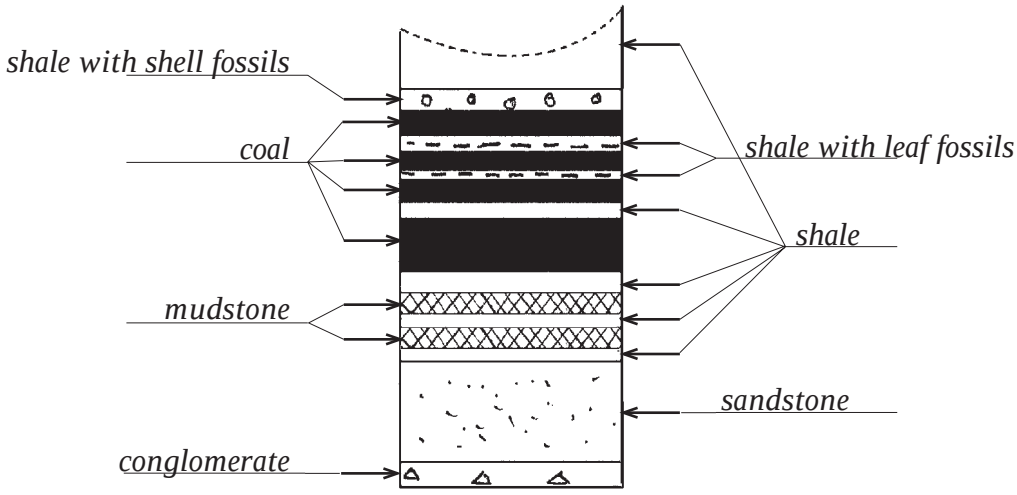
Page 19 3. (b) Write a paragraph describing how the environment in this area has changed over time.

Here is a sample answer.

The area was a quiet lake. Then the weather became warmer and wetter and the area was swampy with many plants. Then sand blew over the area or maybe the sea rose over it. Finally there were volcanoes and lava flows over this area.

Page 19 **Mastery test 2 – Analysing a stratigraphic column**

Here is the labelled stratigraphic column from page 19.



And here is the completed key.

Key:

- coal
- conglomerate
- mudstone
- sandstone
- shale
- shale with leaf fossils
- shale with shell fossils

Lessons 9 and 10 continued

Page 28 **Mastery test 3 – Why has the environment changed?**

How would Wegener have explained why tropical plant fossils could be found in a cold place such as Europe?

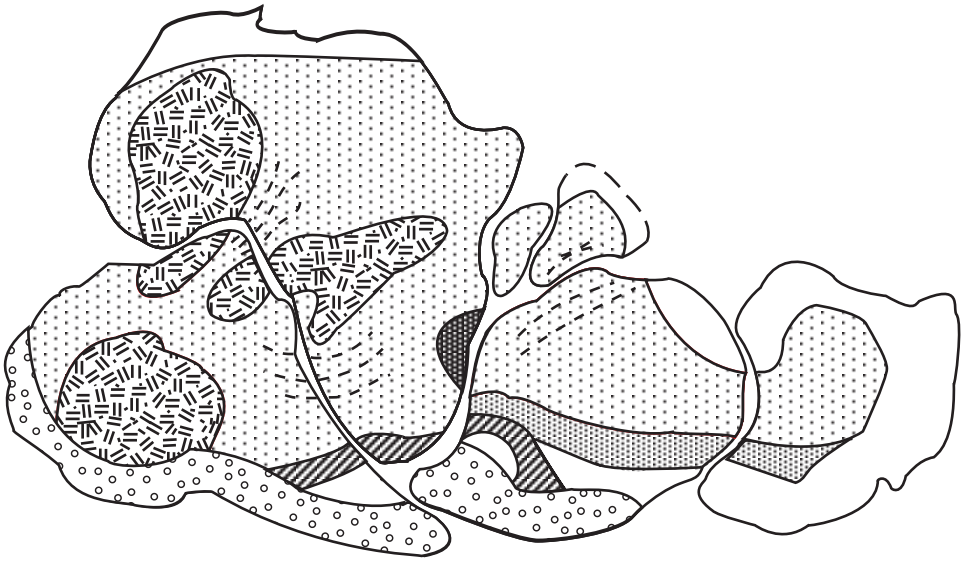
Wegener would say that the tropical plants grew when the European continent was close to the equator. Since then, the continent has moved away from the equator and towards the North Pole.

Lessons 11 and 12

The continental jigsaw

Page 35 **Making the continental jigsaw**

Your continental jigsaw should be similar to the one below.



This supercontinent is called Gondwanaland.