Continental drift

UNIT 8

This unit studies the process of the development of the theory of continental drift and leads to reflection on the limitations of science.

Using this unit

Students should have already covered the topic on the structure of the Earth before tackling this unit. They need to know the terms 'crust' and 'mantle' and also 'continental crust' and 'oceanic crust'.

In this unit the term 'crust' is used throughout as it is used in the National Curriculum. Geologists would substitute the more accurate term 'lithosphere' for 'crust'. The 'lithosphere' is the outer 'rigid' shell of the earth and includes some of the mantle.

This unit should be followed by a more detailed examination of the theory of plate tectonics to be found in modern science textbooks.

The unit is written so that the students can work through it independently, or it may be more effective if the activities are carried out as small group work. It could be set as a homework.

The practical Activity 3 can be carried out at home.

Activity 4 is suitable for more able students.

Links with GCSE

Sc3 Materials and their properties

- The Earth's crust consists of a number of pieces called plates which move and collide (the theory of plate tectonics).
- The evidence for this theory:
  - the fit of the continents;
  - fossil remains (e.g. reptiles);
  - magnetic reversal patterns in oceanic crust (Higher Level only).
- The effects of heat and pressure upon rocks at plate boundaries (metamorphic change).

Sc0 The nature of science

- An understanding of how scientific ideas are accepted and rejected on the basis of empirical evidence, and how scientific controversies can arise from different ways of interpreting such evidence.

Moral and spiritual aims

- To show how scientific ideas can be wrong and how some correct scientific ideas are sometimes rejected.
- To illustrate the dangers of 'scientism' (e.g. of giving to science the false image of being free from error and the source of all truth).
- To show that a belief is justified on the basis of the evidence perceived and can sometimes be contrary to our common sense.
- To show that a scientific theory does not explain away and deny a purpose (reductionism) and should not be used in this way. Rather it can be seen as illustrating the grandeur of the creation and the intricacies involved.

TEACHER'S NOTES

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Notes on the activities

Activity 1: Would you have believed it?

1. Statements supporting Wegener's theory of continental drift are B, C, D, G, H, J.
2. This is a dicussion question and there will be a variety of answers.
   (a) D and G might be more convincing than B, C, H and J. If students suggest H, they may change their minds after Activity 2.

Activity 2: Making the evidence fit

This activity could be optional. It may only require duplicating a few copies of the map because students could work in groups. It makes easier handling if the continent and continental shelf outlines are cut out of card. Moving the pieces of card on an OHP is an effective way for the students to present their argument to the rest of the class.

Probably the arguments that the continents do not fit together is as convincing as the argument that they do. Scientific controversies often arise from different ways of interpreting the same evidence.

Students should be made aware of the problems of transferring a 3D global map into two dimensions. Piecing together the continental jigsaw is not a straight forward exercise! Iceland has to be removed when fitting continents either side of the Atlantic. The 1000metre depth line was also used, and a computer then programmed to produce the best fit arrangement.
The pattern put forward for the 'fit' is shown below.

Activity 3: Alfred Wegener's theory

Students will need custard powder or cornflour and a small container.

Activity 4: How have the continents moved?

1. 350 million years ago.
2. The correct order is D, C, B, E, F, A.
3. (a) Tropical rainforests were growing in Britain at this time. These were submerged and buried to form coal deposits.
   (b) Antarctica was not always at the South Pole. 160 million years ago it was at the same latitude as Australia is today.
4. India and Australia were joined together up to 100 million years ago.
5. India has been moving north at an average speed of 0.047 metres per year (47 mm per year).

Activity 5: Are scientists always right?

1. (a) Probably because scientists are thought of as being entirely 'honest', 'unemotional', basing all their opinions on fact and never being wrong!
   (b) Many people distrust politicians.
   (c) Usually professional scientists readily admit to the limitations of science.
2. The 'nothing but' approach can be a failure of some scientists. It is called reductionism and while there is nothing wrong with explaining why coincidences have occurred, science does not claim to explain away a purpose or an aspect of creation.
3. Examples include water cycle, nitrogen cycle, carbon cycle, oxygen or carbon dioxide cycle.

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In the past most people would have automatically rejected the idea that the continents were moving or drifting (continental drift). The Earth's surface, both the land (continental crust) and under the sea (oceanic crust), was thought to be made up of solid rock. It went against common sense to suggest that one continent could move away from another continent.

1 Would you have believed it?

Up until 1960 the scientific evidence in favour of continental drift was not very strong.

Below is a list of evidence that may support or contradict the theory.

A No forces could be strong enough to move the massive weight of the continents.
B There were similar 'land-based' fossils found in different continents.
C Geologists had found that the crust was thicker under the mountains. This suggested a continental crust could be floating on a bed of oceanic crust.
D There was a similarity in the types of rocks and types of mountains in different continents. They could have been joined up previously.
E Mountains could easily be caused by the surface being stationary and shrinking as it cooled over a long period of time. No movement of continents was involved.
F The mantle (underneath the crust) appeared to be solid. (Both transverse (s) and pressure (p) seismic waves could pass through it.)
G Shock waves from earthquakes had shown that the Earth's crust was lighter than the mantle rocks underneath. This suggests the crust might be 'floating' on the mantle (like ice floating on water).
H A look at the world map showed how well the east coast of South America would fit into the west coast of Africa.
I No one had managed reliably to measure any movement between continents from one year to the next.
J Coal is found in Siberia. The weather there is much too cold for tropical forests to grow, so in the past Siberia may have been nearer the tropics and nearer the equator.

1. List the letters of the statements which
   (a) support the continental drift theory
   (b) undermine the continental drift theory.

2. If you had been a scientist before 1960, which piece of evidence do you think would have convinced you most that:
   (a) it was true
   (b) it was false?

2 Making the evidence fit

Sometimes evidence can be disputed. For example, some argued that there used to be a land bridge between Africa and South America and this would explain why the fossils of both are similar.

Sometimes the *same* evidence can be used to support both sides of an argument. Evidence can be interpreted in different ways by scientists.

Follow the instructions for either Task A or Task B.

Task A
Cut out the shape of the continents from the map of the world you have been given.

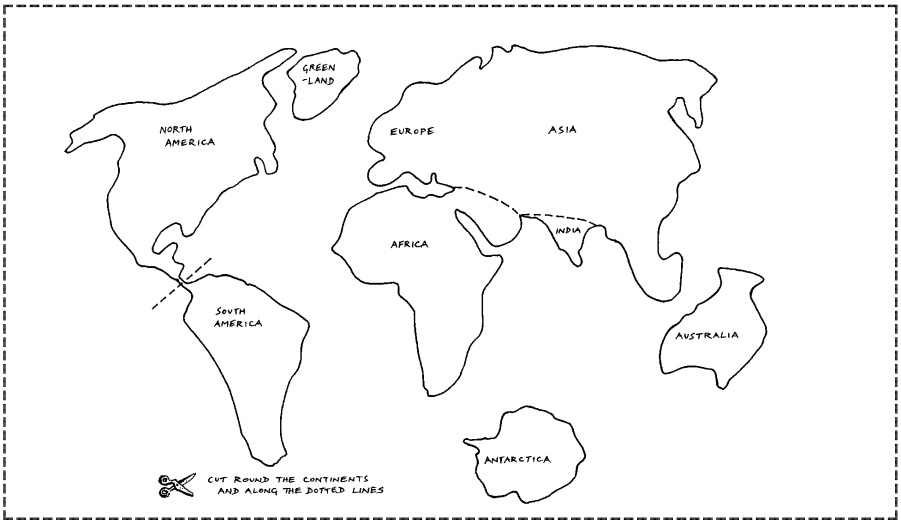
Put together a strong argument that the continents do *not* link up and have never fitted together in the past.

Present your argument to the rest of the class, using an overhead projector if available.

Task B
Cut out the shape of the continents from the map of the world you have been given.

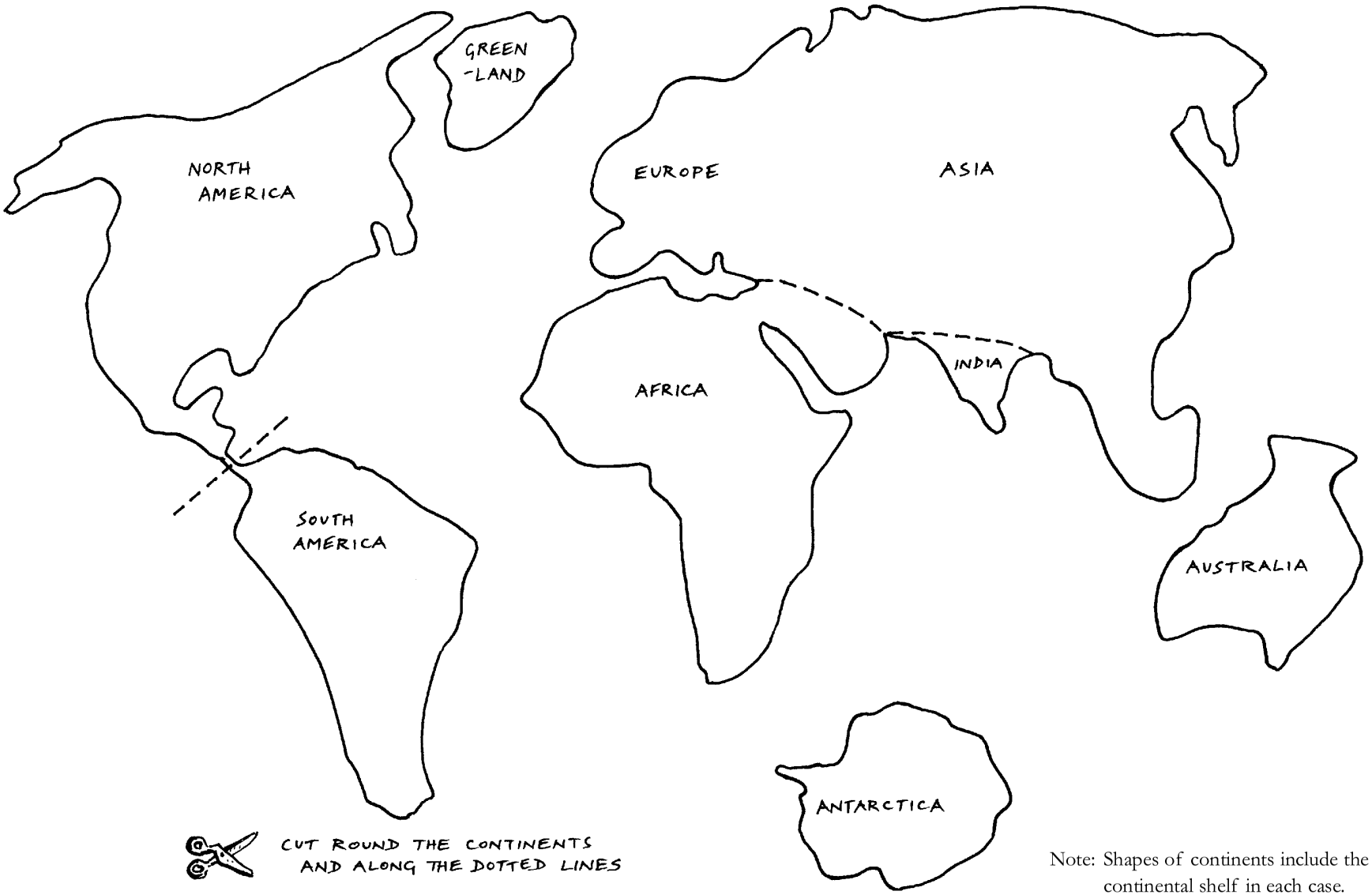
Put together a strong argument that the continents *do* link up and that they fitted together in the past.

Present your argument to the rest of the class, using an overhead projector if available.



Were you totally convinced by either one of the arguments?

Which did you think was most persuasive and why?



Note: Shapes of continents include the continental shelf in each case.

3 Alfred Wegener's theory

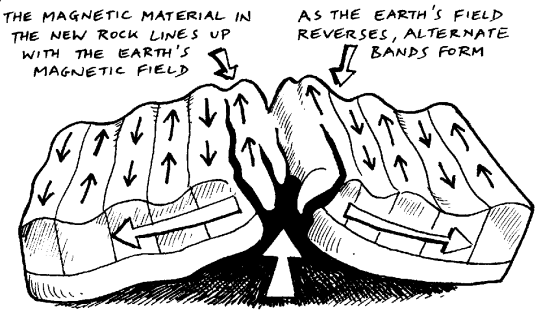
Alfred Wegener (1880-1930) was the first person to propose seriously the idea of continental drift. He was using some of the evidence you have considered in section 1.

However his ideas put forward in 1912 were ridiculed by other scientists at the time. This may have been partly because of their prejudices. Wegener was German and a meteorologist, not a geologist. He was regarded with suspicion outside Germany.

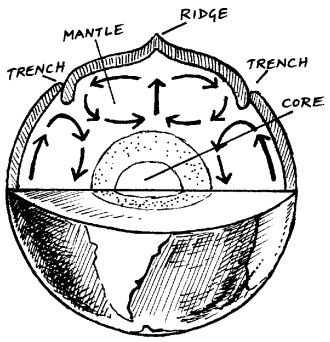
The evidence also needed to be much stronger before all of the previous ideas of the scientific world could be overturned. It was not until 50 years later, in the 1960s, that sufficient evidence at last came to light that would convince the scientific world that continental drift was taking place.

Bar code

As molten rock wells up from the ridge and freezes, magnetic material in the rocks sets in a certain way, lining up with the Earth's magnetic field. Because the field reverses every now and then, bands of new magnetic material set in alternate directions, creating a sort of 'bar code' containing the history of how the sea floor spread out. A mirror image is produced either side of the ridge.



This evidence led to the acceptance of Wegener's theory. The force for this continental drift is now believed to have started from the convection currents in the Earth's hot mantle.

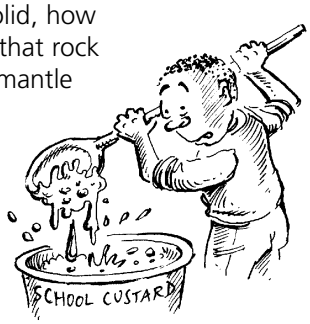


Convection currents in the mantle are thought to be responsible for the movement of the crust on the surface of the earth.

Plastic rock experiment

When an earthquake occurs, pressure waves (seismic waves) pass through the mantle. They can then be detected in other parts of the earth.

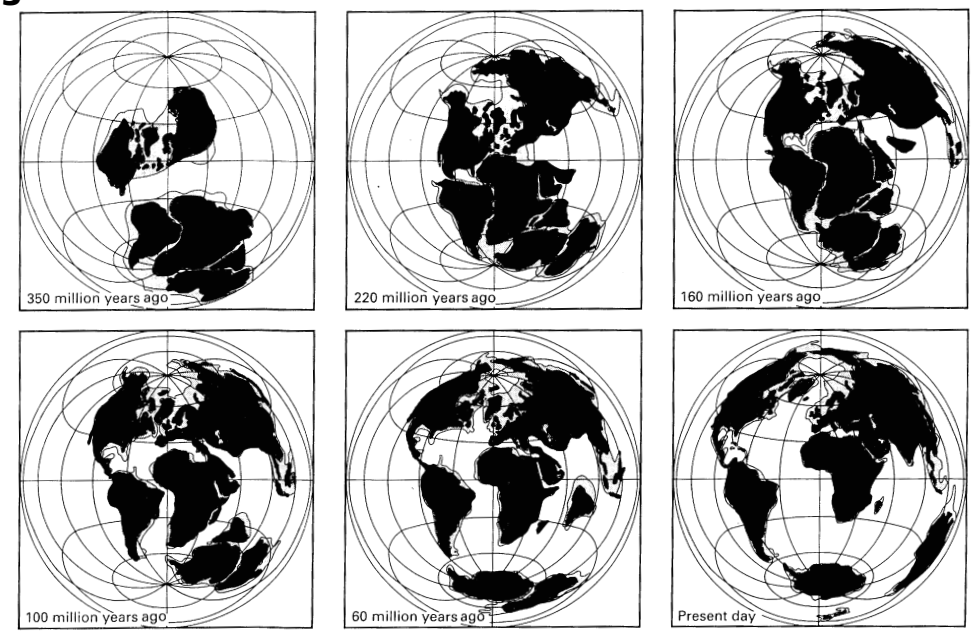
So seismic waves suggest that the Earth's mantle is solid rock. But if it is solid, how can the crust move over it as if it were floating on a liquid? The answer is that rock can be both fluid (liquid) and rigid. When gradual pressure is applied, the mantle flows like mud. But if it gets a sharp shock, it turns solid.



If this sounds odd, try this experiment. Mix two teaspoons of custard powder or cornflour with two teaspoons of water. Drag a spoon gently through the paste and it flows like liquid. Push sharply and it goes hard and cracks.

4 How might the continents have moved?

It has now become possible for geologists to suggest how the different continents have moved over a period of 350 million years, and maps have now been produced.



1. At what time was Britain closest to the equator?

2. Put the following statements in the correct order to explain how the continents might have moved over the years.

A The Atlantic widens further, India collides into Asia and Africa moves further north colliding with Europe.
B The Central Atlantic region starts to move apart.
C A single 'mega' continent comes together.
D Two large areas Laurasia and Gondwana exist as land areas.
E The South Atlantic begins to open up and also India, Australia and Antarctica drift apart.
F The North Atlantic begins to open up and India is moving north relatively rapidly.

3. (a) 345 million years ago is taken to be the time of the Carboniferous Age. If Britain had not been situated near the equator at that time, then the Industrial Revolution would never have taken place in Britain, and we would have had to import coal. Explain why.
   (b) The beauty of Antarctica is under threat because it contains coal as well as other mineral deposits. Since trees would never grow in the cold conditions of the South Pole, can you suggest how the deposits originated?

4. Some rocks in India contain a fossil plant called Glossopteris, and a similar fossil plant is found in Australia. Suggest a possible explanation.

5. Find India on the present day map and see if you can detect where it was situated 100 million years ago. Since that time it has moved 4,700 km north (from the Tropic of Capricorn to the Tropic of Cancer). Can you calculate the average speed it has been moving in metres per year?

The Earth's crust is divided into sections called plates. Some plates have continents riding on top of them. They all fit together like a jigsaw puzzle. The movement of these plates and therefore the movement of continents has led scientists to develop a more detailed theory called PLATE TECTONICS.

This theory explains why continents today are moving in certain directions. It also explains why at the boundary of the plates there can be areas of volcanic and earthquake activity. It explains why there are areas where new mountains are being formed and why sedimentary rocks are being changed into metamorphic rocks or igneous rocks by pressure and heat.

Was there a purpose in all this movement?

Some of the outcomes of continental drift are:

- There is a wide variety of different rock types across the continents. They include a mixture of igneous, metamorphic and sedimentary rocks and these can all be put to various uses.
- Oil and coal deposits were laid down in many different continents providing a rich source of energy.
- It helped to produce a concentration of metal ores vital for the development of civilisation.
- It resulted in mountain building which is essential to combat the weathering down of the land surface.
- It can produce a source of geothermal power (power from the hot rocks under the earth's surface).
- In the past it provided volcanic pools, which is thought to be where simple life forms first began.
- It resulted in the formation of wonderful and varied scenery within each continent.

What would life be like today if continental drift had not taken place? Many scientists would now argue that there could not be life as we know it! Continental drift was an essential part of the creation of the Earth and necessary for the development of humankind.

5 Are scientists always right?

1. Can you think of an advertisement that uses a scientist or somebody playing the part of a scientist to sell you something (e.g. a washing powder).
   (a) Why do you think a scientist is used?
   (b) Could they use a politician to advertise the same product?
   (c) Are scientists always right? Some advertisements make us believe that they are. This belief is an example of scientism. Do you think this is the fault of the scientists or non-scientists? Explain why.

2. Some would say the earth is nothing but a movement of crust of different thicknesses that has happened to produce a place in which humans can develop. Do you think this 'nothing but' approach explains away incredible coincidences? Are scientists sometimes guilty of overlooking this?

3. No one used to think that the continents had moved, and yet now most scientists see it as an essential part of the evolution of the Earth and believe that it made the Earth habitable.

   Other cycles of nature are being discovered. Few people perhaps recognise that there is a balance in nature between mountain building and erosion. This keeps the cycle of the Earth and creation continuing.

   List one other cycle in nature that maintains creation and explain why it is also important.