

Plate Tectonics

Teaching Notes and Answer Keys

Subject area: Earth Science

Topic focus: plate tectonics, continental drift

Learning Aims:

- identify and describe the interior sections of the Earth
- learn about the hypothesis of continental drift (Pangaea) and the objections to Wegener's theory
- explain and illustrate the basic concepts of plate tectonics
- describe the different types of plate boundaries and their effects on the earth

Skills:

Reading: decoding information, scanning for specific information

Writing: taking notes, writing definitions

Speaking: summing up the content of a text, giving a short presentation

Inside the Earth, p. 48

- 1 Pre-teach vocabulary related to the text. The chemical substances that are mentioned could be presented with their chemical symbols:

Aluminium = Al

Nickel = Ni

Calcium = Ca

Oxygen = O

Iron = Fe

Silicon = Si

Magnesium = Mg

Before they read the text you can also ask the students how they think scientists are able to predict what the inside of our Earth looks like. Explain that geologists drill into the Earth, study energy waves from earthquakes, and study rocks that spew from volcanoes in order to learn more about our planet and that they have concluded that it is made up of numerous layers. Check glossary on p. 63 for challenging words: *brittle*, *core*, *innermost*, *outermost*.

- 1 1 inner core, 2 Moho, 3 mantle, 4 crust, 5 lithosphere, 6 outer core, 7 asthenosphere
2 1 C, 2 B, 3 B, 4 C, 5 A, 6 B

Continental Drift, pp. 48-49

- 3 Lead in: have the students look at a world map and say if they see any continents that might fit together like two jigsaw puzzle pieces (*e.g. the east coast of South America and western Africa look like they could fit together*). Check whether they can place the periods on a time line (*Permian: 225 million years ago, Triassic: 200 million, Jurassic: 135 million, Cretaceous: 65 million*).

- 3 B 1, A 2, C 3

TR 13 - CLIL Plate Tectonics 4

- 4 Pre-teach the challenging words: *bulge*, *drift*, *range*, *slide* (s. glossary on p. 63).

Info

Alfred Wegener (1880, Berlin -1930, Greenland) was a German meteorologist and geophysicist. After earning a Ph.D. in astronomy (1905), he became interested in paleoclimatology and travelled to Greenland to research polar air circulation. He presented the first complete statement of the continental drift hypothesis in his book *The Origin of Continents and Oceans* (1915).

- 4 1 B, 2 D, 3 C, 4 A

- 5 Have the students first work in pairs to come up with an answer orally; then have them write their individual answers.

5 Model answer

- 1 ... all present continents were once connected and collectively known as a 'supercontinent' called Pangaea and they slowly moved into their current positions.
- 2 ... matching continent coastlines, fossil evidence, glacier evidence, corresponding mountain ranges.
- 3 ... why and how continents move

Plate Tectonics, pp. 50-52

TR 14 - CLIL Plate Tectonics 6

- 6 Have the students try to predict the content of the text by using the pictures which are quite important here to illustrate the information provided in the text. Point out the geographical locations mentioned and let the students find them on a world map.
- 7 Have the students work in pairs or small groups. If necessary, have them read through the texts in activity 6 again, then have them fill in the flow chart.

- 7 1 lithosphere, 2 boundaries, 3 convergent, 4 divergent, 5 transform, 6 subduction, 7 rifts, 8 earthquakes, 9 trenches.

Check your knowledge, p. 52

Test A focuses on subject knowledge. Test B focuses on students' knowledge of subject-specific vocabulary.

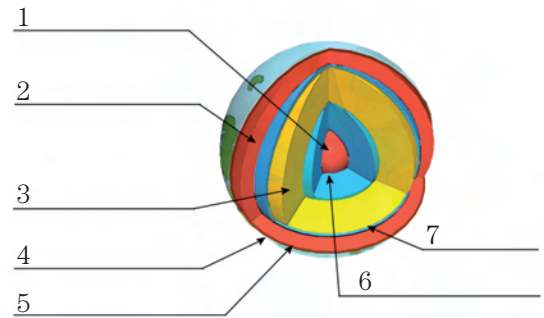
- A**
- 1 The Earth's outer core contains iron and the flowing action generates a magnetic field.
 - 2 Mountain ranges matched up on each side of the Atlantic Ocean.
 - 3 Identical fossilised animals and plants from the same time period were found on different continents. Many of these organisms could not have travelled across the vast oceans that currently exist.
 - 4 When two ocean plates converge, one is usually subducted under the other and where one plate sinks downward, a trench is created. A line of volcanoes commonly forms parallel to this trench.
- B**
- 1 mantle, 2 inner core, 3 lithosphere, 4 magma, 5 mid-ocean ridge, 6 trench, 7 plate, 8 crust, 9 divergent, 10 outer core

Inside the Earth

1 What are the layers that make up our planet Earth? Read the description and label the picture.

The Earth is made up of four main layers. Its outermost surface or **crust** is typically 25-90 km thick beneath the continents, and 6-11 km thick beneath the oceans. It is relatively light, brittle and quite thin. The second layer, called the **mantle**, is very thick and it is here that magma forms from molten rock. There is an upper mantle and a lower mantle extending all the way down to the innermost and hottest part of the Earth. The third and fourth layers make up the **outer core** and the **inner core**.

The mantle is composed of silicon, oxygen, magnesium, iron, aluminium, and calcium. The upper mantle is rocky and fairly rigid as one part of it, together with the crust, makes up the **lithosphere** (from *lithos*, Greek for stone). The crust and the upper mantle are separated by the **Moho** or Mohorovicic discontinuity. The region just below the lithosphere in the second part of the upper mantle is the **asthenosphere** (from *asthenes*, Greek for weak), characterised by layers of weaker and stronger, low-density, partially molten rocks. This is the slowly flowing zone generally located between 72 and 250 km beneath the Earth's surface upon which the rigid lithospheric plates of the Earth's crust move about. Below this lies the lower mantle which is relatively flexible, flowing at a rate of a few centimetres per year. Beneath the mantle is the Earth's iron-nickel core which consists of a fluid outer core and a solid inner core. Because the core mainly contains iron, the flowing motion of the outer core generates the Earth's electromagnetic field.



2 Read the text in activity 1 and choose the correct answer.

- 1 Which layer of the Earth is partially molten?
 - A core
 - B crust
 - C mantle
- 2 Which layer of the Earth is brittle?
 - A core
 - B crust
 - C mantle
- 3 Which of the following statements about the Moho is **true**?
 - A The Moho separates denser rocks below from less dense rocks above.
 - B The Moho separates the crust from the mantle.
 - C The Moho marks the top of a partially molten layer.
- 4 The partially molten layer beneath the lithosphere is called the _____.
 - A lower mantle
 - B crust
 - C asthenosphere
- 5 Which of the following statements about the Earth's core is **true**?
 - A The inner core is solid and the outer core is liquid.
 - B The inner core is liquid and the outer core is solid.
 - C The inner core and the outer core are both liquid.
- 6 What element makes up most of the Earth's core?
 - A oxygen
 - B iron
 - C silicon

Continental Drift Theory



Permian

3 At the beginning there was only one! How did the continents come to look as they do today? Number the pictures A-C in chronological order.



A Jurassic



B Triassic



C Cretaceous



Present Day

4 **TR 13 - CLIL Plate Tectonics 4** Read and complete the passage with the reference to the appropriate picture.

Nearly a century ago, in 1912, the German geologist Alfred Wegener first proposed his theory of Continental Drift, which states that parts of the Earth's crust slowly drift atop a liquid core. He noticed that all of the continents seemed to fit together like the pieces of a giant puzzle: North Africa fit the shape of the coast of North America while Brazil fit along the coast of Africa beneath the bulge 1 Picture ____. He

proposed that the seven continents we know today were once all joined together in a single, giant landmass that broke up and drifted apart over time. He named this supercontinent *Pangaea* (meaning "all lands") and the one enormous body of water surrounding it, he called *Panthalassa* (meaning "all seas"). *Pangaea* existed from the Permian period through the Jurassic.

Wegener collected geological and biological evidence to explain his theory: identical fossilised animals (*Mesosaurus*, a land animal) and plants (*Glossopteris*) from the same time period were found in South America and Africa and similarly for Europe and in North America, the same fossils were found on both continents; the same was true for Madagascar and India 2 Picture ____. Many of these organisms could not have travelled across the vast oceans that currently exist.

Also, certain mountain ranges matched up on each side of the Atlantic Ocean: the Appalachian Mountains match mountains in the British Isles and Scandinavia which are comparable in age and structure 3 Picture ____.

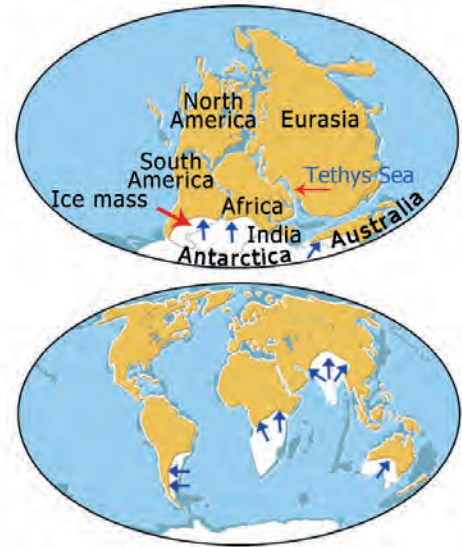
Another form of evidence that Wegener used to support his continental drift hypothesis was ancient climate patterns. When the continents are put together and we look at what was *Pangaea*, the remains of glacial matter match to form a pattern much like the large ice sheets that cover our poles today 4 Picture ____.

One of the geologist's suggested causes of continental drift was the centrifugal force from the Earth's rotation which made the continents slide into each other and move around on the surface. But this idea was quickly rejected by the scientific community, primarily because the actual forces generated by the rotation of the Earth were calculated to be insufficient to move continents. Wegener's hypothesis lacked an explanation for *how* and *why* continents would rift and drift. Evidence from ocean floor exploration and other studies in the 1960's made Wegener's theory more plausible and led to the development of the theory of Plate Tectonics.

5 Complete the following statements.

- 1 The Theory of Continental Drift states that ...
- 2 Evidence for the Theory included ...
- 3 Wegener's theory could not explain ...

Picture A



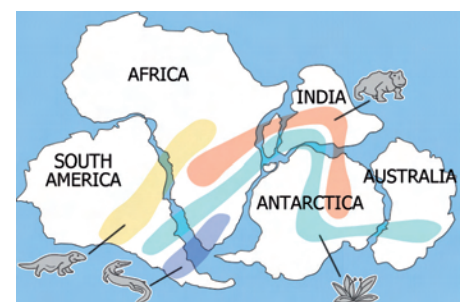
Picture B



Picture C

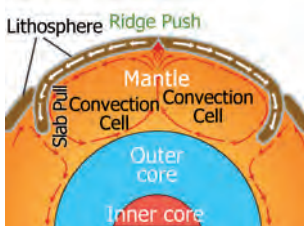
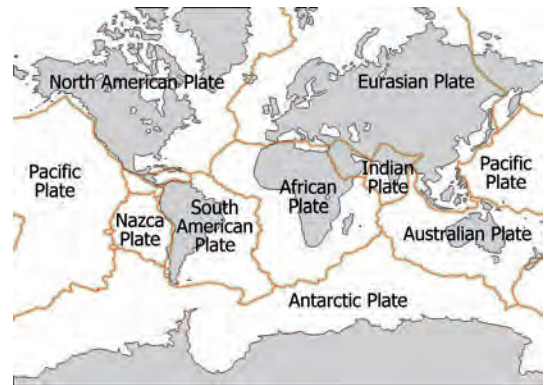


Picture D



The Theory

The development of the Plate Tectonics Theory was built upon the evidence for Pangaea with additional scientific information about the nature of the ocean floor, Earth's ancient magnetism, the distribution of volcanoes and earthquakes, the flow of heat from Earth's interior, and the worldwide distribution of plant and animal fossils. The theory states that Earth's rigid outer layer, the lithosphere, is broken into 7 large, pieces called *plates*: the African, North American, South American, Eurasian, Australian, Antarctic, and Pacific plates. Several minor plates also exist, including the Arabian, Nazca, and Philippines plates. These solid but lightweight plates float on top of a denser, more fluid layer underneath, the asthenosphere.



How do plates move?

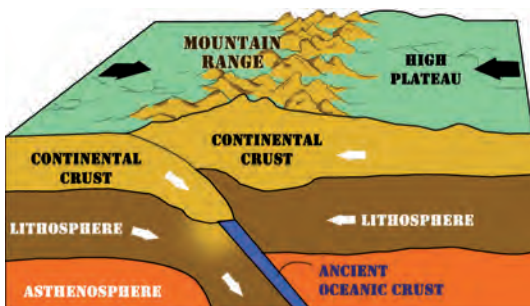
The plates move on the upper mantle in response to *convection currents* within the mantle. The intense heat in the Earth's inner core causes molten rock in the mantle layer to move in a rotational pattern called a convection cell. These cells form when warm material rises, cools, and eventually sinks back down; as this cooled material is warmed it rises again.

Plate boundaries

The plates are all moving in different directions and at different speeds (from 2 cm to 10 cm per year) in relation to each other (the term plate tectonics comes from the Greek *tektyn*, meaning builder). The place where the edges of the plate meet and tectonic activity takes place is called *boundary*. Boundaries have different names depending on how the two plates are moving in relation to each other: a *convergent boundary* is the place where plates move towards each other and crash together, at a *divergent boundary* plates spread apart, whereas at a *transform boundary* plates slide past one another.

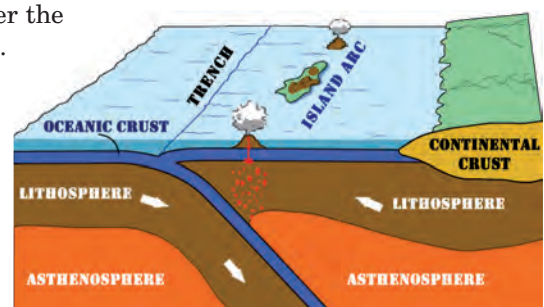
Convergent boundaries

When two plates collide, one plate usually slides under the other and is forced down towards the Earth's core. This process is called *subduction* and it is dependent on the density and chemical composition of the plates (continental plates are made of granite, oceanic plates are made of basalt). As the subducted plate moves downward, its edges melt down in the hot magma and melted crust rises back towards the surface where volcanoes and islands are made. The plate that rides over another one responds differently according to what type of plates are converging.

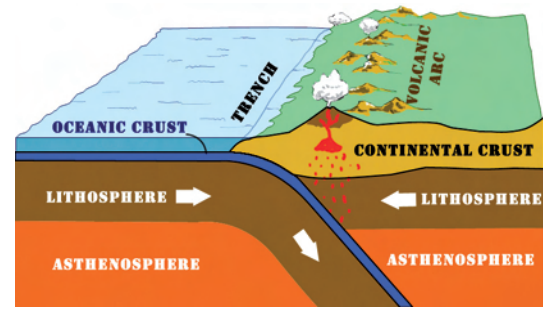


When two *continental plates* converge, such as where the Indian Plate is colliding with the Eurasian Plate, their edges compress, curl upwards and form mountains such as the Himalayan Mountains.

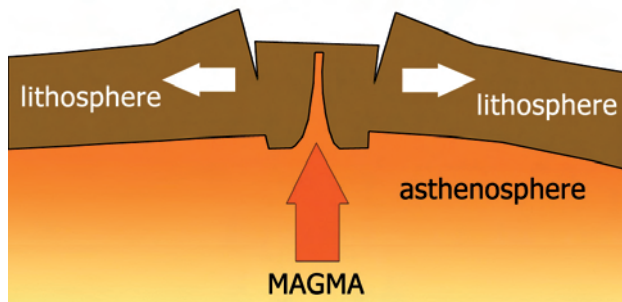
When two *ocean plates* converge, one is usually subducted under the other and where one plate sinks downward, a trench is created. A line of volcanoes commonly forms, parallel to this trench. Over years of eruptions, these volcanoes may eventually grow large enough to rise above the ocean surface and create a chain of islands. The Mariana Trench, just east of the Mariana Islands in the western part of the North Pacific, is the deepest seafloor depression in the world at 11,033 metres. It is located in the so-called Ring of Fire, the most volcanically and seismically active subduction zone on Earth.



When an *ocean plate meets a continental plate*, the continental plate usually rides over the denser oceanic plate and a trench forms just off the coast of the continental plate. An example of this type of collision is found on the west coast of South America where the oceanic Nazca Plate is slowly crashing into the continent of South America: the crash formed the Andes Mountains, the long string of volcanoes along the mountain crest, and the deep trench off the coast in the Pacific Ocean. All that folding and bending makes rock in both plates break and slip, causing earthquakes.



Divergent Plate Boundary



Divergent boundaries

The places where plates move away from each other are called *divergent boundaries*: the Earth's fragile surface layer (the lithosphere) is pulled apart and it breaks along parallel cracks. The block between the cracks drops down into the soft asthenosphere. The sinking of the block forms a valley called a *rift*. Magma from the asthenosphere rises upwards to fill the cracks. In this way, new crust is formed along the boundary. Earthquakes occur along these fractures and volcanoes form where the magma reaches the surface.

Examples of a divergent boundary crossing the land include the East Africa rift in Kenya (with the volcanic mountains Kilimanjaro and Mount Kenya) and the Rio Grande rift in New Mexico.

Where a divergent boundary crosses the ocean floor, the rift valley runs along the top of a mid-ocean ridge. The mid-ocean ridges of the world are all connected and form a global network of underwater volcanic mountains running along the ocean basin for about 80,000 km. Examples of a major ridge is the Mid-Atlantic Ridge, running under the Atlantic Ocean about midway between North America and Europe and the East Pacific Rise running from the Gulf of California to a point west of the southern tip of South America.

Most of the mountains in a mid-ocean ridge lie hidden under hundreds of meters of water. However, there are places where the ridge pokes above the surface. For example, the island of Iceland is part of the mid-ocean ridge that rises above the surface in the North Atlantic Ocean.

Transform boundaries

Transform boundaries are places where plates slide along each other in opposite directions to accommodate relative lateral motion. More commonly known as *faults*, they are also called conservative boundaries because no new crust is created or destroyed as the plates are not torn apart or crunched together.

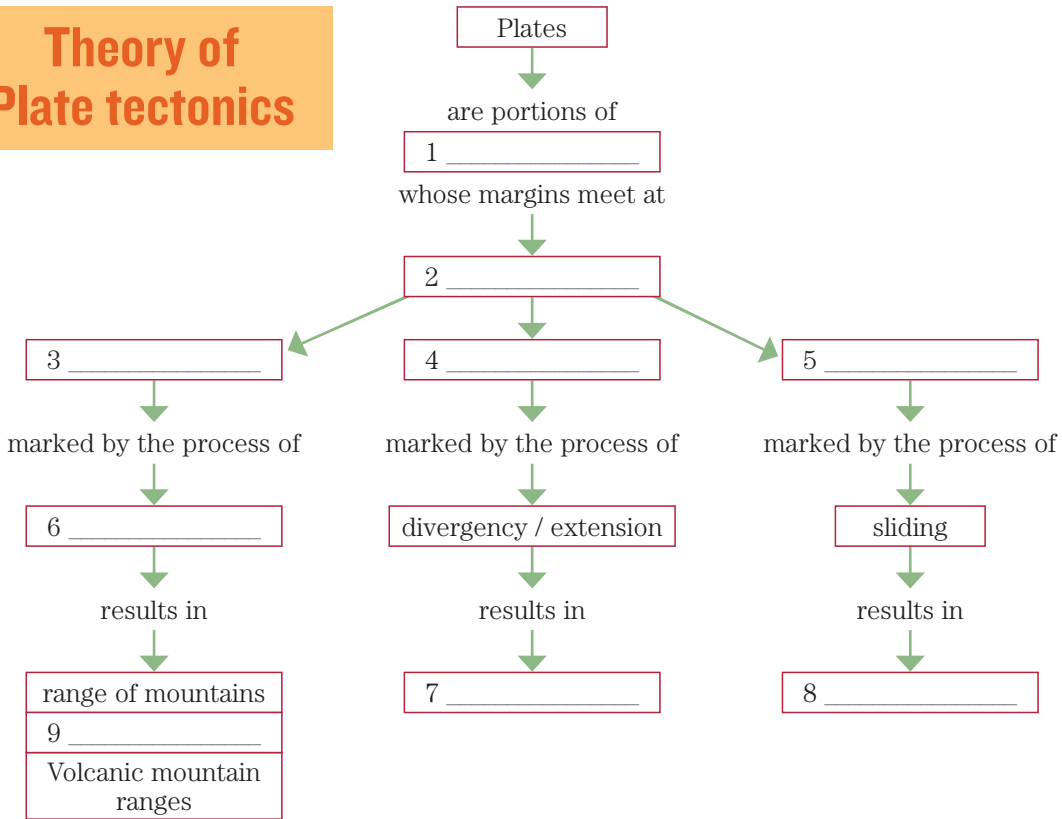
As the two plates slide past each other, stress builds up in both plates. When stress reaches a level that exceeds the capacity of rocks to support it on either side of the faults, the accumulated potential energy is released as strain, or motion along the fault. The massive amounts of energy released are the cause of earthquakes, a common phenomenon along transform boundaries.

The classic example of a transform plate boundary is the San Andreas Fault in California. The North American and Pacific Plates are moving past each other in a north-westerly direction at this boundary, which is the location of many earthquakes.



7 Complete this flow chart using the information from activity 6 on pp. 50-51.

Theory of Plate tectonics



8 Use the flow chart to prepare a short talk about Plate Tectonics. Add geographic references.

Check your knowledge

A The Plate Tectonics Test

- 1 Explain the reasons for the Earth's magnetic field.
- 2 Explain how mountain chains provided evidence for the existence of Pangaea.
- 3 Explain how fossils provided evidence for the existence of Pangaea.
- 4 Explain why volcanic activity is associated with convergent boundaries.

B Plate Tectonics Crossword Puzzle

- 1 The thickest layer of the Earth
- 2 Earth's hottest solid layer
- 3 Crust and upper mantle
- 4 Another word for molten rocks inside the Earth
- 5 Divergent boundary in ocean crust
- 6 A deep spot in an ocean at converging oceanic plates
- 7 A portion of continental and oceanic crust
- 8 The surface of the Earth
- 9 Type of boundary between plates moving apart
- 10 Earth's hottest liquid layer

