BRICKS

Geography

Proefhoofdstuk

Earthquakes and volcanoes

BRICKS *Geography* guided tour

BRICKS *Geography* is all about... geography!
But how do you use it, in order to learn in the most effective way?

1

The introduction always offers two pages which can also be used as an advance organiser. This introduction helps you to connect new information with what you already know.

The large picture introduces the main subject of the chapter in an attractive way.

The smaller pictures show certain aspects of the subject. Watch, and talk about what you see!

Which geographical level(s) does this chapter focus on?

What are you going to learn? The main learning objectives of this chapter in content and language aims.

What's this chapter all about?

The sections in this chapter.

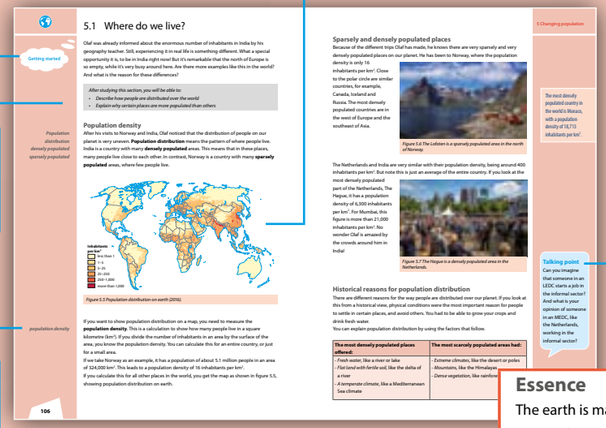
After the introduction, you will dig deeper into the subject. The textbook offers information which you will process in the workbook or online. Every section in the workbook contains a beginning and an end: 'Getting started' and 'Looking back'. Doing assignments that match the introduction and the essence, will help you process the key information more effectively.

2

The textbook contains information in text and images. You will process this information in your workbook or in the digital version.

Get introduced to the subject of the section by reading the 'Getting started'.

Illustrations and their captions provide important information.



The introduction of the section always mentions the learning objectives.

Talking points offer statements you can discuss with a classmate. In this way, you will practise your speaking skills.

Essences give a brief summary of the section.

Definitions of the words in the margin are given at the end of each chapter.

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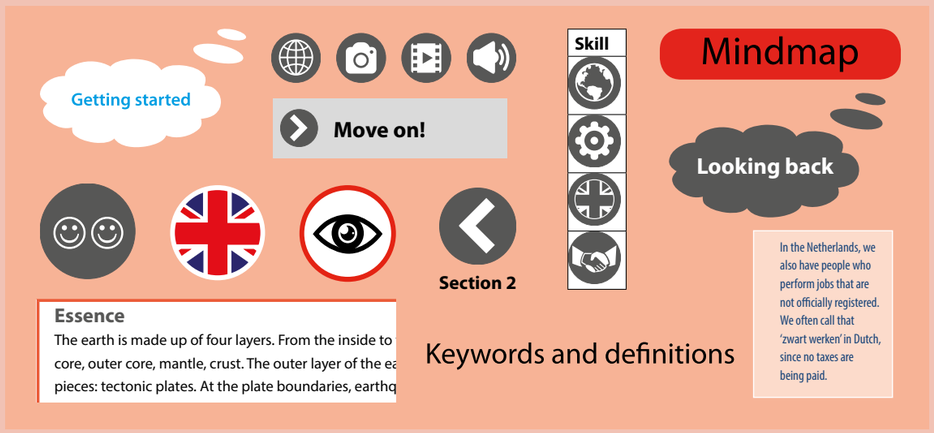
3

A lot of information in BRICKS *Geography* is labelled. Talking points, extension boxes and so on are all part of effective learning strategies.



All these items are part of the BRICKS didactics. These didactics consist of a variety of effective strategies, such as: activating and linking with prior knowledge (content and language), focusing on the learning objectives, advanced organising, practising and processing in activating exercises, deepening and broadening of knowledge, increasing motivation, giving feedback, summarising, testing yourself, etcetera.

4

Providing information, and the way it is processed, needs a clear view on learning. BRICKS *Geography* offers you relevant information and support in achieving your learning objectives.

Time to put it to the test!

- Definitions of important concepts at the end of the chapter
- All learning objectives in one clear questionnaire to check your understanding
- In the online version, you will find a digital self-test at the end of each chapter
- A special section dedicated to the basic skills
- Essences that contain the essential information per section
- Mind maps of the key concepts and their mutual connections to structure the content on a more abstract level

Figure 3.1

Figure 3.2

Figure 3.3

Figure 3.4

3 Earthquakes and volcanoes

After watching the news, Saskia stares at the television in shock. An earthquake, in Ecuador! Quickly she grabs her phone and sends a message to her pen-pal Ana Paula. Ana Paula lives in Ecuador. Saskia hopes Ana Paula and her family and friends are all doing well and that their houses are still standing. Saskia wonders what it is like to experience an earthquake or a volcano eruption, like Ana Paula wrote about a few months ago. Luckily there are no volcanoes or earthquakes in the Netherlands. Or are there? Where do earthquakes and volcanoes even come from? In this chapter, we will discuss earthquakes and volcanoes: where do we find these phenomena and what are the causes and consequences of these events?

In this chapter, you will learn:

Content
- *What tectonic plates are and how plate tectonics works*
- *Why volcanoes and earthquakes happen at specific locations*
- *What the effects are of earthquakes and volcanic eruptions*
- *That the effects of earthquakes and volcanic eruptions can vary between LEDCs and MEDCs*

Language
- *To explain the steps in a process using keywords and linking words*
- *To compare the causes and effects of the different endogenous forces, using keywords and proper English phrases*

3.1 The earth's layers and plates

Getting started

Sitting behind her computer, Saskia types into Google: "Ecuador earthquake". Many news articles from the last few days pop up on the screen. She scrolls down the webpage until she finds what she is looking for: an encyclopaedia article. Ecuador, she reads, often faces earthquakes and there are volcanoes too. This has something to do with tectonic plate boundaries.

After studying this section, you will be able to:
- *Describe how the earth's layers fit together*
- *Describe what tectonic plates and tectonic plate boundaries are*

The layers of the earth

inner core

outer core

mantle

crust

The earth consists of different layers. Some of these layers are solid rock, but others are more liquid. At the centre of the earth is the **inner core**. The centre is solid. It is made out of two metals: iron and nickel. The inner core is very hot, and metals normally melt at such high temperatures. But the inner core is solid, due to the weight of the layers above.
The layer around the inner core is called the **outer core**. This layer is liquid.
If we move further outward, we find the **mantle**, the thickest layer. The rock in this layer is solid; but over very long periods of time the rock in the lower part of the mantle can actually move. It is a bit like silly putty which is solid, but can flow due to gravity.
The outside layer is the **crust**. The crust is solid. This layer is very thin, compared to the other layers. Depending on the location, it is 8 to 75 kilometres thick. Nevertheless, it is the layer that geographers are most interested in, because it is the layer we live on!

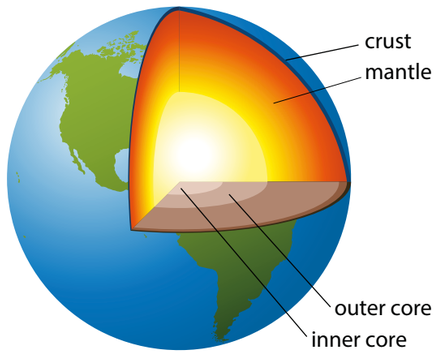


Figure 3.5 The layers of the earth.

It is tricky to measure the temperature of the inner core of the earth; but scientists have discovered that it is between 5200 and 6200°C.

The puzzle pieces of the crust

tectonic plates

The crust and the top of the mantle is not one big piece of rock. It is broken up into several pieces, called **tectonic plates**. These plates fit together like puzzle pieces. The tectonic plates are "floating" on the mantle.
There are seven large and eight smaller tectonic plates. The largest plate is the Pacific Plate. Around the edges of the Pacific Plate is the Ring of Fire. In this Ring of Fire, many earthquakes and volcanoes occur. In section 2, you will find out why.
To see the Pacific Plate more clearly, some maps place the Americas in the centre. Figure 3.6 is an example of such a map.

All tectonic plates move slightly. Some plates move quite fast, at about 15 centimetres per year. Other plates crawl along, at only 2.5 centimetres per year. This movement is called **plate tectonics**.

plate tectonics

Normally you hardly notice the movement of the plates. But sometimes the movement can cause chaos. This is particularly the case around the **plate boundaries**: the place where two plates meet. The earthquake Ana Paula felt is an example of this: Ecuador is located close to the boundary between the Nazca Plate and the South American Plate. In the next section, you will read more about how and why these plates move.

plate boundaries

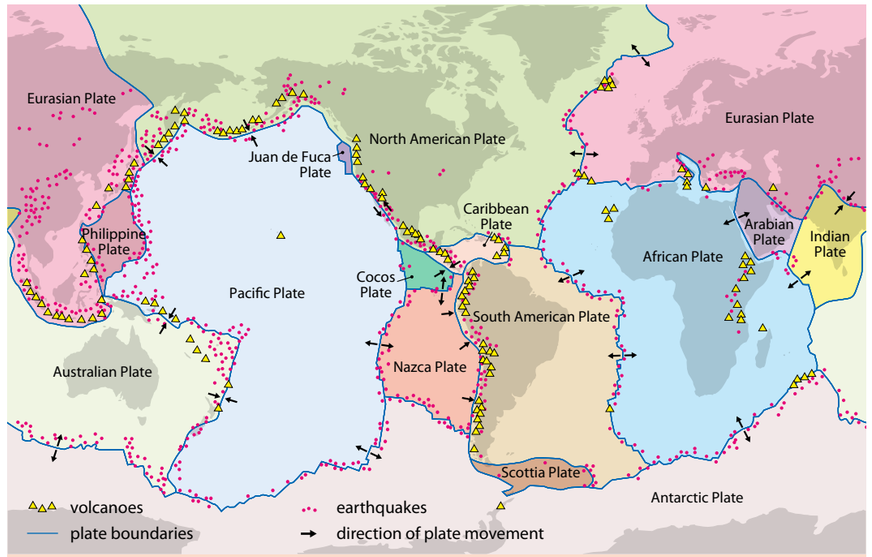


Figure 3.6 Tectonic plates of the world.

Tectonic plate types

oceanic plate

Tectonic plates are divided into two categories. The first type is **oceanic plate**. As the name suggests, these plates can be found under the oceans. The Pacific Plate is an example of an oceanic plate.
Oceanic plates are quite thin, only up to 10 kilometres. However, the type of rock – basalt – is heavier than the rock that makes up continental plates.

continental plate

The second type is **continental plate**. These plates make up the continents.
Continental plates are much thicker than oceanic plates, generally between 35 and 40 kilometres. Underneath large mountains, such as the Himalayas, the crust can even be up to 75 kilometres thick. However, the rock material of which continental plates are made – granite – is lighter than that of oceanic plates.

Most plates are a combination of oceanic plate and continental plate. The South American Plate for example, is continental on the western side and oceanic on the eastern side. This is the plate where we can find Ecuador.

Getting started

Kilometres or kilometers? Centre or center?
The average distance to the centre of the earth is 6,371 kilometres. But the Americans would say: The average distance to the cent*er* of the earth is 6,371 kilometer*s*. Spelling between British English and American English can vary. The ending –re or –er is just one example of the differences between the two types of English. Other differences include the ending –our or -or, such as in the British colour and the American col*or*. Or –ise and –ize for the British organise and the American organ*ize*. BRICKS Geography uses British English.

Pangea

Pangea

The slow movement of the tectonic plates can cause a very different view of the world: if you could only wait long enough. Only 300 million years ago, all the continental plates were stuck together. They formed a supercontinent called Pangea. 175 million years ago, these plates started to move slowly apart.

Figure 3.7 The supercontinent Pangea.

Talking point
The knowledge we have about the earth changes all the time. Can we be sure that what we know is true?

One of the reasons scientists think there once was a supercontinent are the locations of the fossils of certain animals. Some fossils have been found in areas that are now separated by a large ocean. An example is the fossil of a freshwater reptile called the Mesosaurus. This reptile lived around 270 million years ago. Fossils of this reptile were found in both Africa and South America.

Figure 3.8 A fossil of the Mesosaurus, found in Brazil.

Essence

The earth is made up of four layers. From the inside to the outside the order is: inner core, outer core, mantle, crust. The outer layer of the earth is divided into different pieces: tectonic plates. At the plate boundaries, earthquakes can happen and volcanoes can be found. There are two types of tectonic plates: oceanic plates and continental plates.

3.2 Moving plates

Saskia is ready to make sense of recent events: her friend has experienced a big earthquake. The earthquake happened in Ecuador. That country is located close to a plate boundary. But it is still unclear to Saskia, how these slabs of rock move.

After studying this section, you will be able to:
- *Describe in which direction the tectonic plates move*
- *Explain why earth's tectonic plates move*

Plates moving apart

There are three types of plate boundaries. When you look at figure 3.6 in the previous section, you might notice the arrows. Between the North American Plate and the Eurasian Plate there are arrows that point away from each other (←→).
This is a **divergent plate boundary**: a plate boundary where two tectonic plates move apart. Here mantle rock first changes into **magma**: underground lava. Then it rises up to the crust. At the crust, it cools and hardens to form new crust.

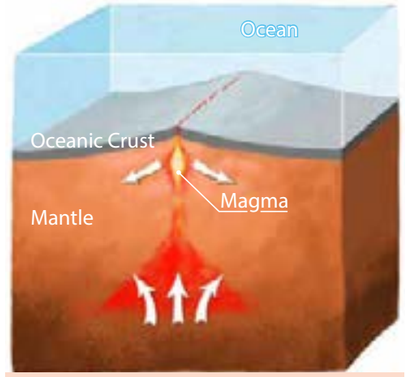


Figure 3.9 A divergent plate boundary allows magma to escape.

divergent plate boundary

magma

At some divergent plate boundaries, an **oceanic ridge** can be found. An example is the Mid Atlantic Ridge. This oceanic ridge is found in the middle of the Atlantic Ocean. Iceland is one of the few places on earth where you can actually see the Mid Atlantic Ridge with your own eyes. At a diverging plate boundary, such as on Iceland, you will find volcanoes.

oceanic ridge

Figure 3.10 The Mid Atlantic Ridge is visible in Iceland.

convergent plate boundaries
mountain range
collision zone
fold mountains
subduction
trench
transform plate boundary
endogenous force

Plates moving towards each other

At other plate boundaries in figure 3.6, the arrows point towards each other (→←). These are **convergent plate boundaries**. You can find an example of a convergent plate boundary between the Indian Plate and the Eurasian Plate, around the location of the Himalaya **mountain range**. A mountain range is an area that contains a lot of mountains.

A convergent boundary between two continental plates is called a **collision zone**. In this zone the two plates push each other upwards, creating **fold mountains**. The mountains fold together like a piece of paper that is pushed at from two sides.

At a collision zone, large earthquakes can occur, such as the earthquake in Nepal in 2015.

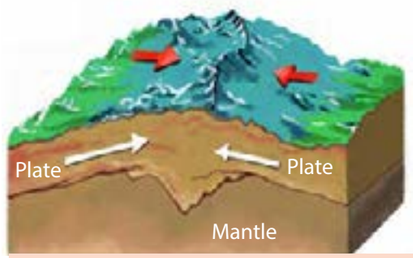


Figure 3.11 Collision between two continental plates creates fold mountains.

Around 10 million years ago, the Indian Plate started to collide with the Eurasian Plate. In some places, the Himalayas are still getting 10 mm higher every year.

Figure 3.12 Mount Everest in the Himalayas is formed by collision.

The Mariana Trench is the deepest oceanic trench. The most recent measurements estimated its depth at 10,994 m. This makes it deep enough to hold Mount Everest!

Convergent boundaries also occur between oceanic plates and continental plates. Because oceanic plate is heavier than continental plate, it dives under the lighter continental plate. This process is called **subduction.**

As oceanic plate subducts, the rock becomes part of the mantle. An example is the plate boundary between the Nazca Plate and the South American Plate. Here the heavy oceanic Nazca Plate subducts under the lighter continental South American Plate. When it subducts, it creates a **trench**: a deep and narrow gap on the ocean floor. Trenches are the deepest part of an ocean. Along the destructive type of convergent plate boundary, big earthquakes can happen and large volcanoes can be found. Near Ecuador you can find an example of this type of plate boundary.

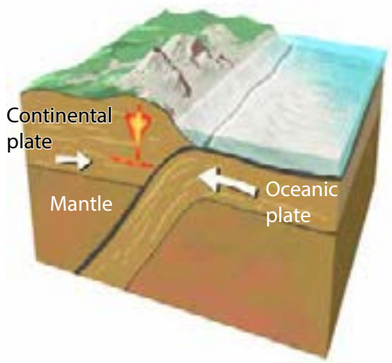


Figure 3.13 Subduction between an oceanic and a continental plate.

Plates sliding alongside each other

The last type of plate boundary that can be found in figure 3.6 is where two arrows are alongside each other (↑↓). This is a **transform plate boundary**, where one tectonic plate slides along another plate. An example is the plate boundary where the North American Plate slides alongside the Pacific Plate. There are no volcanoes or high mountains at a transform plate boundary, but there can be large earthquakes. The most famous example of a transform plate boundary is the San Andreas Fault, located close to San Francisco in the United States.

Figure 3.14 At a transform plate boundary two plates slide alongside each other.

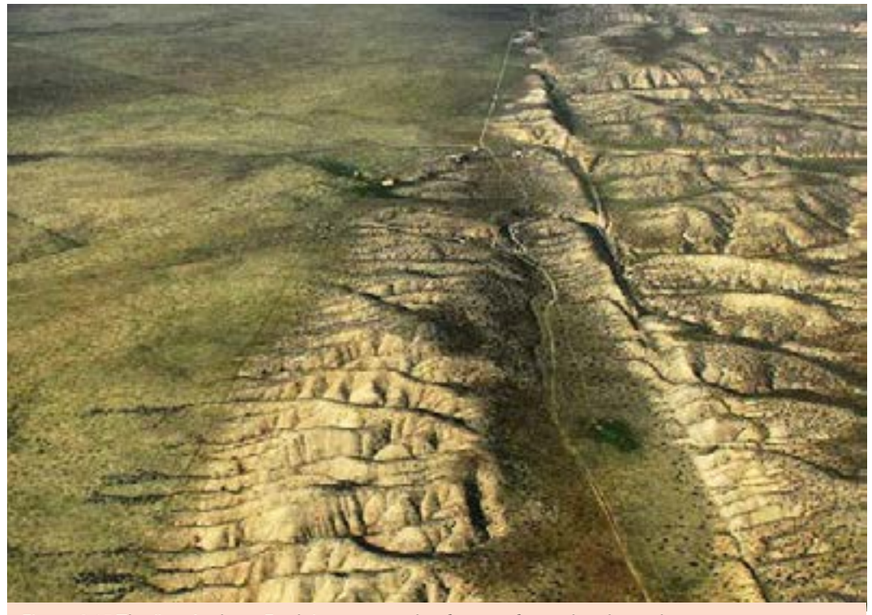


Figure 3.15 The San Andreas Fault is an example of a transform plate boundary.

Convection currents

The idea that tectonic plates move was brought up by Alfred Wegener, in 1912. But he could not imagine an **endogenous force** - a force that comes from within the earth - that was strong enough to move the tectonic plates. In 1929, the scientist Arthur Holmes suggested that the plates might move due to flows of mantle rock. It was only in the 1960s that this idea was accepted.

convection currents

Convection currents rise up from the heat in the earth's inner core. This heats up the rock in the mantle, which causes it to rise towards the crust. As it moves upwards, the rock cools. This colder rock sinks back into the mantle creating a circular movement. This circular movement moves two oceanic plates apart. At the other end the oceanic plate subducts under the continental plate. Here the rock is "recycled" into the mantle, until it is heated up enough to rise up again. But geologists still have a lot of debates about what precisely is happening in the mantle.

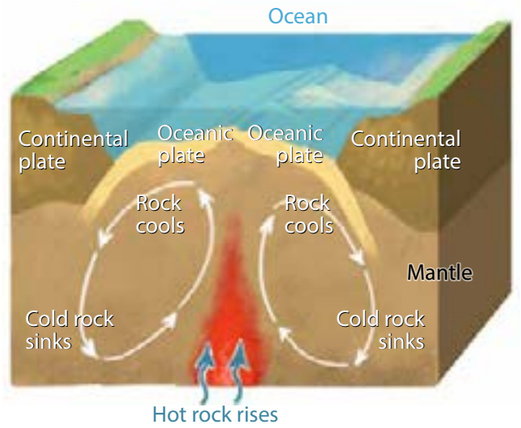


Figure 3.16 Convection currents move the oceanic plate.

Other theories of plate movement

Before the 1990s, geologists explained plate movement using ridge push. Scientists thought that the mid-ocean ridges - high mountain ranges on the ocean floor - pushed on the areas of the tectonic plates further away from the ridge. In this way, the ridges created a movement away from the mid-ocean ridge. After the 1990s, this idea was seen as a part of the answer, together with slab pull.
New technologies give new suggestions about the mechanism behind the moving plates. Many geologists now believe that plate tectonics is caused mostly by slab pull: according to this theory, rock at the subduction zone sinks into the mantle due to gravity. As it sinks, it pulls the rest of the oceanic plate with it.

Talking point
After over a century of research, scientists are still unsure why tectonic plates move. Why is it so difficult to study this?

Essence

There are three types of plate movement. Plates can move apart (diverge), they can move alongside each other (at a transform plate boundary) and they can move towards each other (converge). At a converging boundary between two continental plates, the plates collide, creating high mountains. At a converging boundary, between an oceanic plate and a continental plate, the oceanic plate will subduct. Tectonic plates move because convection currents carry them along.

3.3 Earthquakes

Getting started

It is the middle of the night. Suddenly Ana Paula wakes up. She hears a rumbling noise and then she feels everything shaking: it's as if her bed has suddenly been put on a small boat. A tremor! Since the earthquakes a few weeks ago, there have been several aftershocks. These shocks have been smaller than the original earthquake, but frightening nonetheless. When the movement stops, she hears her mum coming into her room to check if she is all right.

After studying this section, you will be able to:
- *Explain why an earthquake takes place*
- *Describe the effects of earthquakes*

Talking point
Would you like to live in an area which experiences earthquakes? Would you imagine it is exciting or scary, or both?

Shaking earth

Ecuador is close to the plate boundary between the continental South American Plate and the oceanic Nazca Plate. The Nazca Plate subducts under the South American Plate. This is not a smooth process: occasionally the plates get stuck. As the plates get stuck, tension builds up. When the tension has built up beyond breaking point, the energy that has been stored is released in the form of shockwaves: this is a bit like the ripples in a pond after you have thrown in a rock. These shockwaves are felt in the form of an **earthquake.**

earthquake

The movement of the earth's surface is registered on a **seismograph**. The size of an earthquake is measured on the **Richter scale**. Earthquakes of 1.0 or 2.0 on the Richter scale are very common. In places like Ecuador, they happen nearly every day. These earthquakes are so small that people cannot feel them. They are only registered by seismographs. When an earthquake has a **magnitude** (or: size) of 6.5 or higher, it is likely to cause damage to buildings and people. But as you will find out in section 3.4, magnitude is not the only factor that determines the amount of damage. On April 16th 2016, an earthquake with a magnitude of 7.8 struck Ecuador.

seismograph
Richter scale

magnitude

0-2:	Can be detected only by seismograph	6-7:	Damage to well-built structures, severe damage to poorly built ones
2-3:	Hanging objects may swing	7-8:	Buildings displaced from foundation; cracks in the earth; underground pipes broken
3-4:	Comparable to the vibrations of a passing truck	8-9:	Bridges destroyed, few structures left standing
4-5:	May break windows, cause small or unstable objects to fall	9 and over:	Near-total destruction, waves moving through the earth visible with naked eye
5-6:	Furniture moves, chunks of plaster may fall from walls		





Figure 3.17 Average damage based on the magnitude of the earthquake measured on the Richter scale.

The strongest earthquake ever measured took place in Chile in 1960. This earthquake had a magnitude of 9.5.

Hypocentre and epicentre

epicentre

hypocentre

After an earthquake happens, the **epicentre** is announced. This is the central point of the earthquake on the earth's surface. At the epicentre, the earthquake is felt the strongest and the damage to the buildings and people is the greatest. The epicentre is located exactly above the **hypocentre**. The hypocentre is the location inside the earth where the stress has been released. The depth of the hypocentre is important: If the hypocentre is close to the earth's surface, the damage is greater than when the hypocentre is located deep in the crust. In Ecuador, the epicentre was in the north-western part of the country, 170 kilometres from the capital Quito. The hypocentre was only 20 kilometres deep, which is quite shallow.

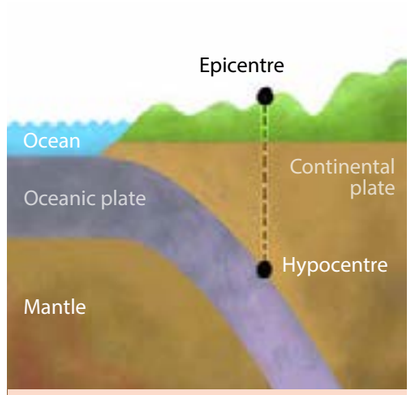


Figure 3.18 Hypocentre and epicentre of an earthquake.

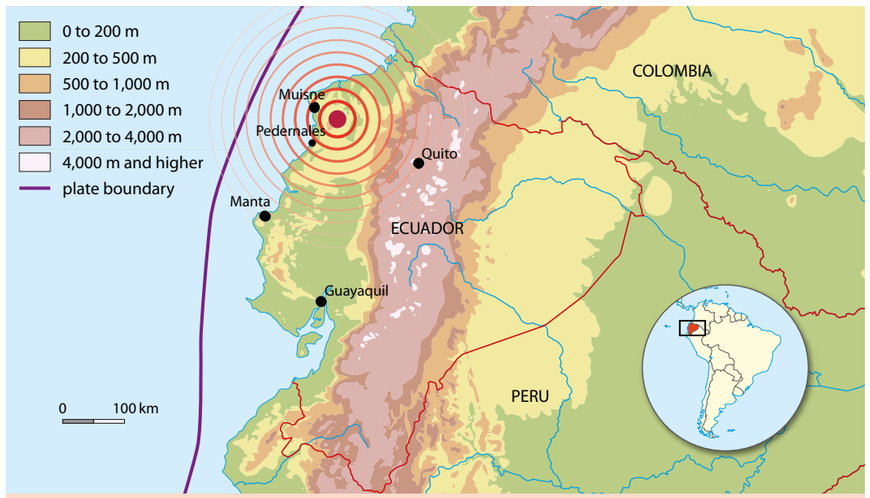


Figure 3.19 The epicentre of the earthquake in Ecuador in April 2016.

Effects of an earthquake

The obvious effect of an earthquake is the shaking of the earth. This shaking can cause buildings and infrastructure to collapse. **Aftershocks** are tremors that follow the main earthquakes. These aftershocks often cause the already weakened buildings to completely collapse. Within the first 24 hours after the earthquake in Ecuador, there were 55 aftershocks. The largest had a magnitude of 5.4 on the Richter scale.

The shaking can cause other effects on the ground as well: the movement can also trigger **landslides**. In a landslide, soil and rocks wiggle loose and slide down a hill. A landslide can cover or move houses, roads and other buildings.
If the soil contains a lot of water, **liquefaction** can occur: the soils start to behave like a liquid and buildings and cars can sink into it.

landslides

liquefaction

Figure 3.20 A landslide caused by an earthquake damaged the road.

Figure 3.21 Soil liquefaction after an earthquake in New Zealand.

The Mercalli scale is used to measure the effects of earthquakes. It is possible for earthquakes with a similar magnitude on the Richter scale to have a different number on the Mercalli scale. The range is from I (not felt) to X (extreme). The Ecuadorian earthquake had an intensity of VIII (severe) in the locations closest to the epicentre.

Earthquake or tremor?
To people living outside a major earthquake zone, every little shake of the earth is considered an earthquake. However, people who experience earthquakes on a more regular basis label them differently: a small shake without damage is called a tremor. Only when the shaking is bigger and there is a lot of damage, will they call it an earthquake.

Tsunamis

A **tsunami** can occur if an earthquake occurs underneath the ocean. The shockwaves can lift the seafloor by several metres. If the seafloor is lifted up, large waves are created. These waves move in all directions, including coastal areas. Once these waves reach the coast, they can cause flooding.

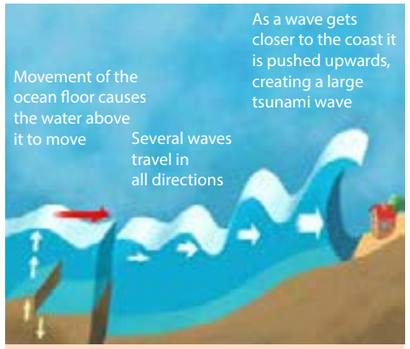


Figure 3.22 From an earthquake to a tsunami.

tsunami

Tsunami waves can travel very fast: up to 800 kilometres per hour. That's about as fast as an airplane!

Since the destructive tsunamis in the Indian Ocean in 2004 and in Japan in 2011, the world has become more alert to tsunamis. After the Ecuadorian earthquake, a tsunami alarm was given, because the epicentre was very close to the coast. After a few hours, it became clear that the earthquake had led to slightly higher waves than normal and that the threat had passed.

Figure 3.23 Houses were moved by a tsunami wave in Japan in 2011.

Earthquakes in the Netherlands

The Netherlands is located far away from plate boundaries, but occasionally there are earthquakes. In Limburg there is a **fault**, a fracture, in the Eurasian Plate, which can cause earthquakes. The last one was in 1992, and had a magnitude of 5.4. In Groningen, far away from any plate boundaries, there are tremors more often. These tremors are linked to the production of natural gas. So in a way, these tremors are caused by humans. Natural gas is a type of fossil fuel which is used for cooking and heating in the Netherlands. Since 1986 there have been about 50 tremors per year in Groningen. 14 of these tremors had a magnitude of 3.0 or higher. Even though these tremors are relatively small, they do cause damage to houses and some people have decided to move away.

fault

Essence

Earthquakes or tremors are sudden movements of the earth's crust. Occasionally the tectonic plates get stuck for a while. They build up tension. When this tension is released, the earth shakes.

The shockwaves of an earthquake are the strongest in the epicentre. The magnitude of an earthquake is measured on the Richter scale, using a seismograph. The shaking is not the only effect that does damage; landslides, liquefaction or tsunamis can happen, which cause problems as well.

3.4 Comparing the effects of earthquakes

In the days following the earthquake in Ecuador, the search and rescue teams were looking for survivors. Using sniffer dogs, they walked up and down the rubble. In the end, at least 673 people were killed and over 16,600 people were injured. Over the past few days, the number of deaths and injured seemed to go up every time Saskia checked the news app.

After studying this section, you will be able to:

- *Compare the effects of earthquakes in LEDCs and MEDCs*
- *Explain why the effects of earthquakes vary between LEDCs and MEDCs*

Earthquakes fact file

To compare two earthquakes, it is useful to look at some basic facts about the country, the earthquake itself and its effects. An overview can be found in the fact file below.

	New Zealand	Ecuador
HDI (2014)	0.913	0.732
Date	February 22nd, 2011	April 16th, 2016
Time	12:51 PM	18:58 PM
Magnitude	6.3	7.8
Hypocentre depth	5 km	20 km
Plate boundary	Subduction, between the Australian Plate and Pacific Plate	Subduction, between the Nazca Plate and the South American Plate
Location of the epicentre	Near Christchurch (367,700 people)	Near Muisne (5,925 people) and Pedernales (21,910 people)
Injuries	6,900 people	16,600 people
Deaths	185	673
Estimated cost	30 billion Euros	3 billion Euros

Figure 3.24 A fact file for the earthquakes in New Zealand and Ecuador.

Predicting the effects of earthquakes

Physical factors of an earthquake, like the magnitude, depth and duration, are not necessarily good predictors of the effects of an earthquake. The magnitude of the Ecuadorian earthquake was higher than the magnitude of the earthquake in New Zealand, but this only partially explains the difference in damage. Fewer people died or were injured during the earthquake in New Zealand then during the earthquake in Ecuador. Social and economic factors (together often called **socio-economic factors**), such as the level of development of a region, are much better predictors of earthquake damage.

Figure 3.25 Christchurch Cathedral was damaged by the earthquake.

socio-economic factors

Preparing for an earthquake

There are many things governments and individuals can do to limit the effects of earthquakes. Some of the actions can be taken before an earthquake actually happens. Governments can set up rules and inspections to check that buildings and roads are strong enough to survive earthquakes. They can set aside money to prepare search and rescue teams. Citizens can be asked to prepare an emergency backpack. Such a backpack contains food, water and other useful items which help people to survive after an earthquake.
All these measures are part of **hazard management**: the combination of measures to make populations more capable of surviving an earthquake. In MEDCs, such as New Zealand, more money is available for hazard management than in LEDCs. As a consequence, buildings and roads in MEDCs are less likely to collapse and search and rescue teams are better trained. All of this leads to fewer dead and injured people.

hazard management

The parliament building in New Zealand was refurbished to have rubber blocks underneath. These allow the building to shake without it getting damaged.

Damaged infrastructure

Not only roads and bridges, but also communication networks like phone lines and the internet, are likely to be damaged during an earthquake. Together, we call these systems **infrastructure**. Damaged infrastructure makes it difficult to get in and out of areas where the damage is greatest, or even to make a phone call from the damaged areas to ask for help.
Compared to New Zealand, Ecuador does not have a strong infrastructure**.** However, the lack of expensive infrastructure also means that rebuilding after an earthquake is cheaper in an LEDC than in an MEDC: It was ten times more expensive to rebuild the infrastructure in New Zealand compared to Ecuador.

Figure 3.26 Damaged phone lines after the earthquake in Ecuador.

infrastructure

Dogs are often used to find people buried by damaged buildings. The training to become a "sniffer dog" takes 1 to 1.5 years.

After the disaster

In the days and weeks after an earthquake, there can be chaos in the affected area. People search for survivors, but there might not be any hospitals to treat the injured.
In New Zealand, there are detailed plans on what to do after an earthquake. These plans were used by the rescue services, the police and doctors. The distribution of emergency aid, which includes search and rescue, ran smoothly. The New Zealand Red Cross collected money to help the victims of the earthquake.
In Ecuador, the situation was more chaotic: it was not clear to rescue services what they needed to do and the number of people hurt was higher. Besides search and rescue services, food, water, tents and blankets were needed. The World Food Programme provided emergency aid: 105,000 people received food for the first month after the earthquake. After the collapsed buildings were cleared and the dead were buried, people started to focus on rebuilding. In LEDCs, this often means **structural aid** is needed: aid over a longer time period, for example to help rebuild infrastructure.

Figure 3.27 Unloading emergency aid at the airport in Quito.

structural aid

Talking point
Would you donate money to an organisation that helps to rebuild a country after an earthquake? Would it make a difference whether that country is an LEDC or MEDC?

Natural disaster or just a disaster?
Some people argue that there is no such thing as a "natural disaster", even though you often find the term in newspapers. They say that the **hazard events**, such as earthquakes, are natural, but the consequences are not. Because what makes something a disaster depends on whether or not a society is prepared, rather than nature.

hazard events

Predicting an earthquake

Earthquakes are very unpredictable: there are few warning signs and the first earthquake often has the largest magnitude. Earthquake scientists study areas where earthquakes have happened before, to predict where an earthquake will probably happen next. But no one knows exactly when or how strong that earthquake will be. There are some stories that animals, such as bees and dogs, are able to predict earthquakes. But no scientific study has been able tell if this is true.

Essence

The effects of earthquakes do not only depend on physical factors. Socio-economic factors better explain the difference in the effects of earthquakes. LEDCs have less money to prepare themselves for earthquakes than MEDCs. This leads to weaker buildings and infrastructure networks. Damaged infrastructure makes it more difficult to distribute emergency aid after an earthquake takes place.

3.5 Volcanoes

Getting started

Saskia is working on a school project about European volcanoes. She has found information about volcanoes in Iceland, in Italy and even about ancient ones in Germany. But she has never seen a real-life volcano, so she asks Ana Paula about her volcano experiences. "Standing close to the volcano wasn't scary," Ana Paula replied, "it was beautiful. There was snow at the top. But now it is a bit scary: we cannot visit it, because it is active again."

After studying this section, you will be able to:

- *Describe what happens during a volcanic eruption*
- *Explain what the effects of volcanic eruptions are*

The word "volcano" comes from the name of the Roman god of fire and metalworking: Vulcan.

volcanoes

Finding and describing volcanoes

Volcanoes can be found near diverging boundaries, for example in Iceland. They can also be found near subduction boundaries, such as the volcano Cotapaxi in Ecuador. Volcanoes are formed in areas where magma is able to escape towards the earth's surface: in subduction zones, divergent plate boundaries and hot spots. When the magma exits the earth, this is called an **eruption**. The name changes from magma to lava. As the lava cools off, it forms rock.

eruption

Volcanoes come in many different shapes and sizes: in subduction zones, we can find **composite volcanoes**, which look like steep mountains. The eruptions of these volcanoes can be quite violent.

composite volcanoes

In Iceland, the volcanoes are not quite as spectacular looking: these are **shield volcanoes**, which look more like rolling hills. They are formed of thin, runny lava.

shield volcanoes

Figure 3.28 Mount Merapi on Indonesia is a composite volcano.

Figure 3.29 The area around the shield volcano Katla in Iceland.

Inside a volcano

Underneath a volcano, we will find the **magma chamber**. This is a pool where the magma is stored. When enough magma is collected in the magma chamber and the pressure has built up, the volcano will erupt. The magma is forced up the **main vent** (or central channel), towards the top of the volcano. If the top of the volcano is closed off, the force of the eruption will create a **crater**: a large hole at the top of the volcano.

magma chamber

main vent

crater

Not all of the magma will exit through the top of the volcano. Depending on the shape of the volcano and the thickness of the magma, some magma will find other pathways and exit through **side vents**.

side vents

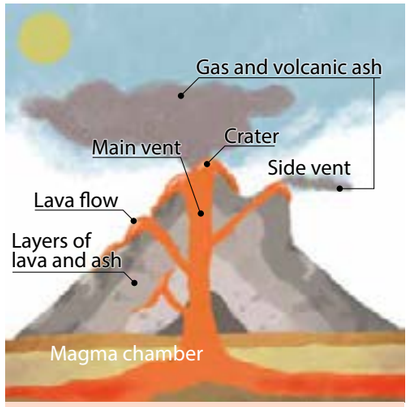


Figure 3.30 A cross-section of a volcano.

Volcanic eruptions

During a volcanic eruption, not only lava exits the volcano. If the eruption has a lot of power, pieces of rock called **volcanic bombs** can be thrown into the air. These cannot travel very far, but they can start fires because they are very hot. The toxic gasses that are part of an eruption are capable of killing people and animals close to the volcano, especially if the wind is blowing the gasses towards them.

volcanic bombs

The combination of gasses, ash, rocks and hot steam is called **pyroclastic flow**. Pyroclastic flow is particularly dangerous because it is extremely hot and it travels very fast down the slope of the volcano. This makes pyroclastic flow much more dangerous than the slow lava.

pyroclastic flow

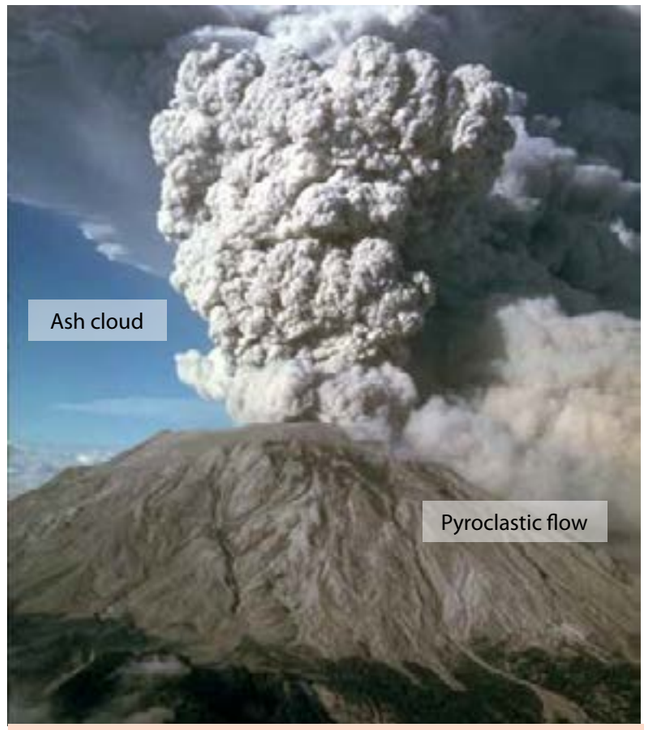


Figure 3.31 The ash cloud and pyroclastic flow from the eruption of Mount Saint Helens in 1980.

During the eruption of the Eyjafjallajökull volcano on Iceland in April 2010, a large ash cloud prevented airplanes from flying in Europe and Northwest America.

lahars

Secondary effects of volcanic eruptions

Besides the direct effects of volcanic eruptions, there are also secondary effects. The tops of volcanoes are sometimes covered in snow, like Cotapaxi. The hot ash and gas from the volcanic eruption can melt this snow and create mudflows, called **lahars.** These lahars travel quickly down the slope of the volcano and cover the landscape with a thick layer of mud, destroying settlements, forests and farmland.

Another secondary effect is on the global temperature. The largest volcanic eruptions send ash high into the air. This can make the earth cooler for a while because the ash reflects sunlight back into space.

Measuring the effects of volcanoes

To measure the magnitude of volcanic eruptions, we use the Volcano Explosivity Index (VEI), which runs from 0 (non explosive) to 8 (mega colossal). The magnitude is determined by observations such as: the amount of lava and size of rocks that erupt from the volcano, or the height of the gas cloud. For ancient eruptions, it is impossible to know how high the ash cloud was. Scientists use rocks in the area to find out how large the volcanic eruption must have been.

Scientists have been able to determine that one of the largest historic volcano eruptions took place in Yellowstone National Park, 630,000 years ago.

hot spots

Hot spots

Not all volcanoes occur at plate boundaries. Some can be found in the middle of tectonic plates. **Hot spots** occur at locations where the mantle is particularly hot. Both the Yellowstone Caldera and the island of Hawaii are examples of hotspots.

The islands of Hawaii were formed in the middle of the Pacific Plate. Here the magma is able to break through the crust. Volcanic eruptions have caused a chain of volcanic islands to appear. As the Pacific Plate moves at a speed of approximately 50 kilometres per million years, these eruptions have created a string of islands. The most recently formed Hawaiian island, Hawaii itself, is the only island that still has **active volcanoes**: these have erupted recently.

active volcanoes

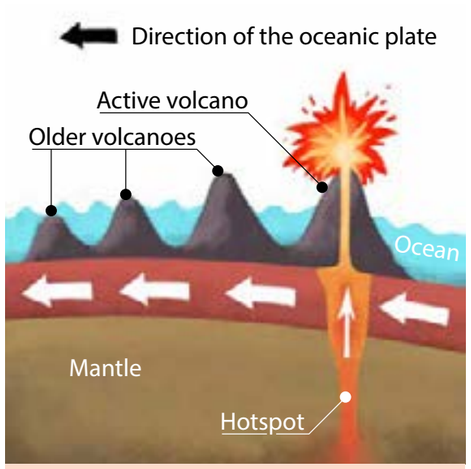


Figure 3.32 As an oceanic plate moves over a hotspot, new islands are created.

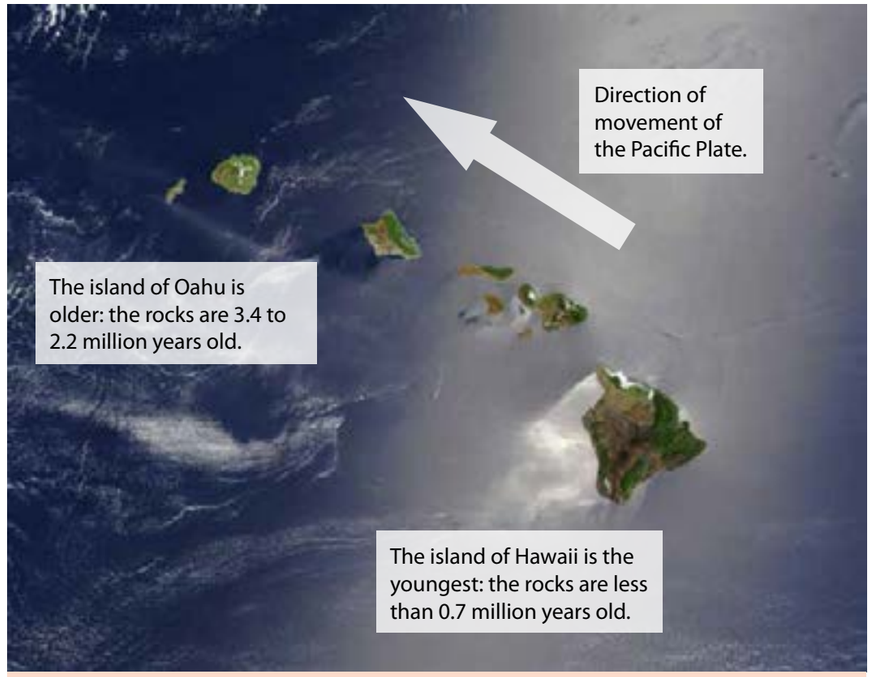


Figure 3.33 Satellite image of the Hawaiian Islands.

Predicting a volcanic eruption

Volcanic eruptions are easier to predict than earthquakes. Volcano scientists monitor volcanoes for warning signs that a volcano will become active. Warning signs include small earthquakes, temperature increases around the volcano and the release of gas (sulphur) clouds.

In 2015, the Cotopaxi volcano in Ecuador was showing signs of increased activity, which led the Ecuadorian government to announce a state of emergency. Inhabitants of the town close to the volcano left and tourists cancelled their bookings. In the end the feared eruption did not occur, and the volcano calmed down a bit.

Talking point
Evacuations are expensive: When should a government decide to evacuate?

Essence

Volcanoes occur at divergent and subduction plate boundaries and hot spots. Hot spots are areas where the mantle is extra hot.

During a volcanic eruption, the magma rises from the magma chamber through the main vent or side vents and exits the volcano. Besides lava, there can be ash, volcanic bombs, gas, or a combination (pyroclastic flow) exiting the volcano.

3.6 Living close to a volcano

Getting started

Saskia is thrilled! The students have worked hard to gather money and now they are going on a trip to Iceland! In Iceland, they will visit volcanoes and also the hot springs and famous Blue Lagoon. There seem to be many positive aspects to volcanoes, and the Icelanders make a living from them.

After studying this section, you will be able to:

- *Describe what the benefits of volcanoes are*
- *Explain why these benefits differ between LEDCs and MEDCs*

Minerals and rocks

After lava has become solid rock, it is useful for many things. Building materials, such as concrete, are made with volcanic rock. Furthermore, the magma, rising from the earth's mantle, carries some very valuable minerals with it: gold, silver and copper can all be found in solidified volcanic rocks. These minerals remain, even if the volcano stops being active. So, both in areas with active volcanoes as well as areas that used to have active volcanoes minerals can be found.

Mining these minerals or looking for gold and diamonds provides jobs to many people. This is particularly the case in LEDCs, where many more people work in the primary – mining – sector, than in MEDCs. In Ecuador, mining for gold is big business. This is why various foreign companies come into the country to make a profit. In Iceland, pumice is mined: a type of volcanic rock which is very coarse. It is used in soap or as scrubbing tool.

For many years, diamond was considered to be the hardest material known to man. But scientists have been able to make something that's 60% harder: Q-carbon.

Geothermal energy

"Geo" means earth and "thermal" means warmth. So, geothermal energy is energy created by the heat of the earth. The high temperatures inside the earth can be used to heat buildings and greenhouses directly, or to generate electricity. In both cases, water is pumped into the crust and heated up. The hot water is pumped up again and used for heating or to create steam. This steam spins a turbine which creates electricity.

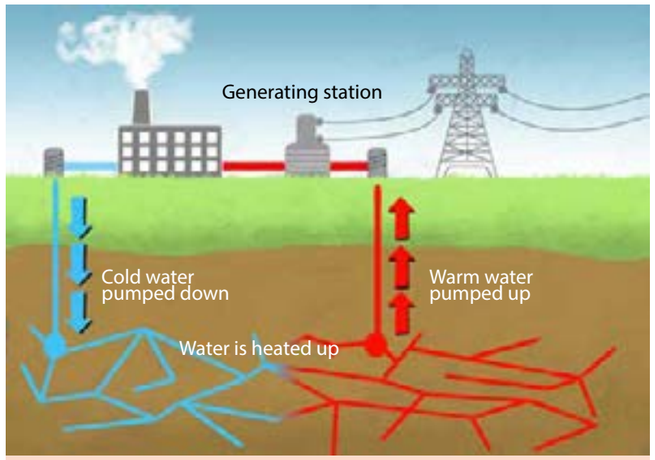


Figure 3.34 Generating geothermal energy.

Generating energy this way is environmentally friendly. But, unfortunately it is only possible on a large scale in areas where there are volcanoes and hot spots, and where the technique is available. Iceland, for example, heats 80% of its buildings and generates 25% of its electricity using geothermal energy.

The Ecuadorian government would really like to start using geothermal energy to create electricity as well. However, until now it has been too expensive, in comparison to other energy resources. Recently, the more common source of energy, fossil fuels, have become more expensive and have been linked to global warming. Therefore, the Ecuadorian government has started to look into geothermal energy as an alternative.

Agriculture

Volcanic ash contains many minerals that are beneficial for plants; so close to volcanoes many farmers work the land. The ash from a volcano eruption creates fertile soil. But over time the lava rocks are even better: over hundreds or thousands of years, they break apart and release their nutrients to form very fertile soil.

Around the Cotopaxi volcano, many people work in the agricultural sector. Usually they work on small farms where they grow food to feed themselves and their family. The farmers grow peaches, pears, apples, plums and also potatoes. Nevertheless, the eruption of the Cotopaxi volcano in 2015 was bad news: immediately after an eruption, the ash destroys the flowers on trees and blocks sunlight from reaching plants. Only after the rocks have broken apart can the farmers benefit from the fertile soil.

Figure 3.35 Farming near the erupting Tungurahua volcano in Ecuador.

Talking point
Would you like to live close to a volcano? Why or why not?

In Iceland, farming is a bit different: the Viking settlers found very fertile soil. They grew crops that are able to grow in cold climates, such as barley, rye and grains, using large fields. But the fertility decreased quickly, as soil did not regain used nutrients. Iceland is currently one of the most economically developed countries in the World. As the country developed, fewer and fewer of its citizens needed to work in agriculture. Most crops that are grown in Iceland, are grown in geothermal powered greenhouses.

Tourism

Both in Ecuador and Iceland, tourists come to visit the volcanoes and the landscapes volcanoes have created. Cotopaxi National Park has become the second most visited tourist attraction in Ecuador. Every weekend, approximately 100 climbers attempt to climb to the top of the Cotopaxi volcano. The number of tourists visiting the national park surrounding the volcano has increased over recent years. Towns around the national park organise markets where tourists can buy souvenirs.

Figure 3.36 Selling souvenirs to tourists in Ecuador.

In Iceland, tourism has increased quickly over the past 15 years. One of the most popular tourist attractions is the Blue Lagoon. This is a geothermal spa, where the water is heated due to heat in the earth's mantle. The water is at a constant temperature of 37°C to 39°C.

Figure 3.37 Number of tourists in Iceland 2002-2016.

Actually, the water in the blue lagoon has first been used to create geothermal power and then discharged into the spa's pools. Other attractions in Iceland include geysers and the volcanoes themselves.

Figure 3.38 The Blue Lagoon. In the background, you can see the geothermal power plant.

The colour of Blue Lagoon is caused by the great amount of minerals in the water. These minerals are said to be good for people who suffer from skin diseases.

Mining for gold

Although mining for gold brings jobs, money and profit to a region, there are many people who would rather see the mines go. Getting the gold out of the rock requires the use of many polluting chemicals, such as cyanide and mercury. After the chemicals have done their job, they stay behind and pollute the water, air and soil around the mine. Recycling is a way to obtain gold in a more environmentally-friendly way, for example, by recycling old jewellery or collecting the small pieces of gold from inside old phones.

1,000 kilograms of cell phones produce 300 grams of gold. 1,000 kilograms of mined gold ore will only produce 3 grams of gold.

Essence

Volcanoes bring benefits to many people: they can provide jobs in the mining industry and agriculture, particularly in LEDCs. But there are other benefits as well: tourists come to visit volcanoes and the landscapes around them. Geothermal energy is very useful as well, as it creates electricity which is very environmentally-friendly. At the moment, it is more common to find this type of technology in MEDCs rather than LEDCs.

What have I learnt?

In this chapter, you have learnt about the following topics:

Content

- What tectonic plates are and how plate tectonics works
- Why volcanoes and earthquakes happen at specific locations
- What the effects are of earthquakes and volcanic eruptions
- That the effects of earthquakes and volcanic eruptions can vary between LEDCs and MEDCs

Language

- To explain the steps in a process using keywords and linking words
- To compare the causes and effects of the different endogenous forces, using keywords and proper English phrases

You can answer the following questions:

3.1
1. Which layers make up planet earth?
2. What is a tectonic plate?
3. What is the difference between an oceanic and a continental tectonic plate?

3.2
1. What are the differences between a divergent, convergent and transform plate boundary?
2. Why do convergent plate boundaries sometimes cause collision and other times lead to subduction?
3. Why do tectonic plates move?

3.3
1. Why are there large earthquakes in Ecuador but not in the Netherlands?
2. How do we measure earthquakes?
3. What is the difference between the epicentre and the hypocentre?
4. How can earthquakes lead to tsunamis?

3.4
1. How can people prepare for an earthquake?
2. Why are earthquakes in MEDCs more expensive than in LEDCs?

3.5
1. Do all volcanoes look the same?
2. Why is lava not the most dangerous part of a volcanic eruption?
3. Why can volcanos sometimes be found in the middle of a tectonic plate?

3.6
1. What are the four benefits of living close to a volcano
2. What is geothermal energy?

Keywords and definitions

3.1 The earth's layers and plates

Inner core: The solid centre of the earth.
Outer core: The liquid layer around the inner core.
Mantle: The layer around the core. The thickest of the four layers.
Crust: The outer layer of the earth. The thinnest of the four layers.
Tectonic plates: Pieces of crust and upper mantle.
Ring of Fire: Area around the Pacific Plate where many earthquakes and volcanoes occur.
Plate tectonics: Movement of tectonic plates.
Plate boundaries: Place where two tectonic plates meet.
Oceanic plate: Tectonic plate underneath an ocean.
Continental plate: Tectonic plate that makes up the continents.
Pangea: An ancient supercontinent.

3.2 Moving plates

Divergent plate boundary: Two tectonic plates which move apart (←→).
Magma: Underground lava.
Oceanic ridge: Underwater mountains formed by a divergent plate boundary.
Convergent plate boundary: Two tectonic plates which move toward each other (→←).
Mountain range: An area which contains a lot of mountains.
Collision zone: A convergent boundary between two continental plates.
Fold mountains: Large mountains formed by the collision between two continental plates.
Subduction: Process where the oceanic plate dives under the continental plate.
Trench: Deep and narrow gap on the ocean floor. Formed by the subduction process.
Transform plate boundary: Where two tectonic plates slide alongside each other (↑↓).
Endogenous force: Force from within the earth, such as plate tectonics.
Convection currents: Currents that rise up due to the heat in the inner core of the earth. Process which moves the tectonic plates.

3.3 Earthquakes

Earthquake: Shockwaves which are observed after the earth's crust moves.
Seismograph: Device which registers the movement of the Earth's surface.
Richter scale: Scale to measure an earthquake's magnitude.
Magnitude: Size of the earthquake.
Epicentre: Central point of the earthquake on the earth's surface.
Hypocentre: Location of the earthquake inside the earth.
Aftershocks: Tremors or shocks that follow the main earthquake.
Landslide: Soil and rocks roll down a hill.
Liquifaction: A phenomenon where soil starts to act like a liquid: buildings and cars can sink into it.
Tsunami: A wave that can form if an earthquake occurred underneath an ocean.
Fault: A fracture in a tectonic plate.

3.4 Comparing the effects of earthquakes

Socio-economic factors: A combination of social and economic factors. Factors that have to do with both society and money.
Hazard management: The combination of measures to make populations less vulnerable to hazard events.
Infrastructure: Roads, bridges and communication networks.
Structural aid: Help that is provided over a longer period of time, to help with the rebuilding of society.
Hazard event: A natural phenomenon that has a negative effect on society (e.g. an earthquake, flood, or volcanic eruption).

3.5 Volcanoes

Volcano: A mountain or hill with a crater or vent through which lava, rocks and gasses have been erupted.
Eruption: When magma exits the volcano and changes into lava.
Composite volcano: A volcano that looks like a steep mountain, found in subduction zones.
Shield volcano: A volcano that looks like a rolling hill, found at a divergent plate boundary.
Magma chamber: A pool underneath the volcano, inside the earth's crust, where magma is stored.
Main vent: Central channel through the volcano.
Crater: A large hole at the top of the volcano.
Side vents: Smaller holes at the side of the volcano.
Volcanic bombs: Large pieces of volcanic rock.
Pyroclastic flow: A combination of gasses, ash, rock and hot steam.
Lahars: Mudflow created of molten snow from the top of the volcano.
Hot spot: Area in the mantle that is extra hot, causing volcanos to erupt away from the plate boundaries.
Active volcanoes: Volcanos that are erupting or have erupted recently.

3 Earthquakes and volcanoes

In this chapter, you will learn about earthquakes and volcanoes. You probably already know a lot about them. Create a pictogram for each of the following words; make a simple drawing in the box. Use the images to help you find more words: Add them to the list.

Earthquake		Emergency	
Volcano		_____	
Magma/lava		_____	

Skill	Assignment
	1.5, 1.6, 1.7, 1.8, 2.1, 2.2, 2.6, 2.7, 3.3, 3.8, 4.2, 5.2, 5.9
	1.1, 2.1, 2.3, 2.5, 2.6, 3.2, 3.8, 3.9, 4.1, 4.6, 4.8, 4.9, 4.10, 5.2, 5.8, 5.10, 6.1, 6.7, 6.9
	1.3, 1.4, 1.9, 2.9, 2.10, 3.1, 3.4, 3.6, 3.10, 4.11, 5.1, 5.5, 5.6, 5.11, 6.2, 6.4, 6.5, 6.6, 6.10
	1.1, 3.1, 3.9, 4.1, 4.10, 5.7, 6.1, 6.6, 6.8, 6.9, 6.10

3.1 The earth's layers and plates

Getting started

1 **a** Imagine you had a friend who told you she had recently experienced an earthquake. What sort of questions would you ask her? Think of at least three questions.

_____

_____

b Discuss your questions with your neighbour. Can you add any questions to your list? You can use the sentences and sentence starters on page 199.

_____

c Share your results with the class.

2 Read *The layers of the earth*. Which description fits which layer?

This layer is solid. It contains the centre of the earth (6,378 km from the surface). It is extremely hot (up to 6,200 °C). _____

It is solid and is the layer we live on. It is generally between 10 km and 75 km thick. _____

This is the thickest section of the earth with a diameter of about 2,900 km. _____

This layer is liquid. _____

3 **a** Fill in the missing words in the textbox below.

Geographers are most interested in the _____, because this is the layer where we live, work, and build. It is the _____ layer of the earth, and the _____ Moving deeper into the earth you find the _____ Like the crust, the mantle is _____ The layer that follows the mantle is the _____ Unlike any of the other layers this layer is _____ Fourthly you will find the _____, which unlike the layer above is _____ again.

Choose from:
solid, solid, outer core, inner core, liquid, mantle, outer, crust, thinnest

b Linking words are words that connect different parts of the text. For example:
Tectonic plates can be divided into two categories. The first type is oceanic plate. (sequence)
Normally you hardly notice the movement of the plates. But sometimes the movement can cause chaos. (contrast)

Take a look at the text in part **a**. Find four linking words that do the following:

Give a reason: _____ Give a contrast: _____

Give an addition: _____ Give a sequence: _____

4 **a** Read *The puzzle pieces of the crust*. Define the key word *tectonic plate* in your own words.

_____

b What is the name of the place where two tectonic plates meet?

_____

c In question 3b, you found linking words in the text. Circle the correct linking words in the following sentences.

The crust is made up of different pieces of rock, *fourthly/unlike* what you may think when you look at the ground below you. These pieces fit together *and/like* a puzzle. These tectonic plates come in different sizes. The boundaries of the Pacific Plate are called the Ring of Fire, *because/unlike* many volcanoes and earthquakes occur there. At some plate boundaries, you can find both earthquakes *and/unlike* volcanoes, at others earthquakes or volcanoes.

5 **a** In your textbook, take a look at fig. 3.6. Find the name or names of the tectonic plate(s) where you can find the following countries:

The Netherlands: _____

Ecuador: _____

New Zealand: _____

Iceland: _____

The United States: _____

b Take a look at the distribution of earthquakes and volcanoes in fig 3.6. What link can you find between them and plate boundaries?

_____

_____

_____

6 **a** In the text, it says that the Pacific Plate is the largest tectonic plate. Do you agree with this statement when you look at fig 3.6?

_____

b Can you think of a reason why the Pacific Plate appears smaller, even though it is actually the largest?

_____

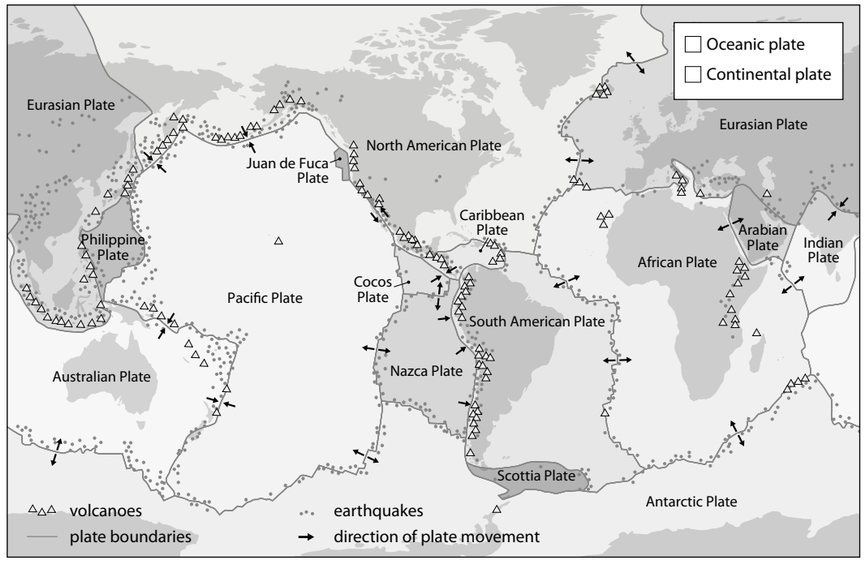
_____

_____

7 **a** Read *Tectonic plate types*. Fill in the following diagram.

Type of tectonic plate	Oceanic	
Weight		Light
Thickness		
Material		

b Use your colouring pencils. Give the oceanic plates and the continental plates a different colour. Add colours of your choice to the legend.



GB54 - 212-213
GB55 - 234-235

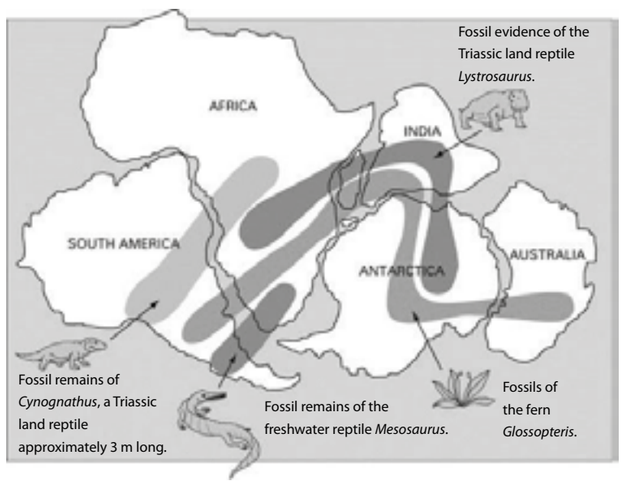
c The continental crust under mountains is very thick. Use the atlas to find three locations, besides the Himalayas, where you expect the continental plate to be thick.

_____

_____

8 **a** Read *Pangea*. Why are the fossils of the Mesosaurus important for the idea of plate tectonics?

b Take a look at the figure below. It shows the finding location of the fossils from four species which present evidence for plate tectonics. Pick one species (apart from the Mesosaurus). Explain how the fossils of this species help to explain plate tectonics.



c Find the map in your atlas. Pay attention to the arrows. These arrows show the direction of movement of the tectonic plates. If we waited long enough, what would you expect to happen with the Mediterranean Sea?

GB54 - 216B
GB55 - 238B

9 *Jeopardy!* is an American game show in which the participants have to give questions for a word that appears on the board. Most questions start with "Who is…? What is…?"
For example: "Inner core" – Where is the centre of the earth?
Give *Jeopardy!* style questions for the following keywords from section 3.1.

Looking back

Mantle

Crust

Plate boundary

Oceanic Plate

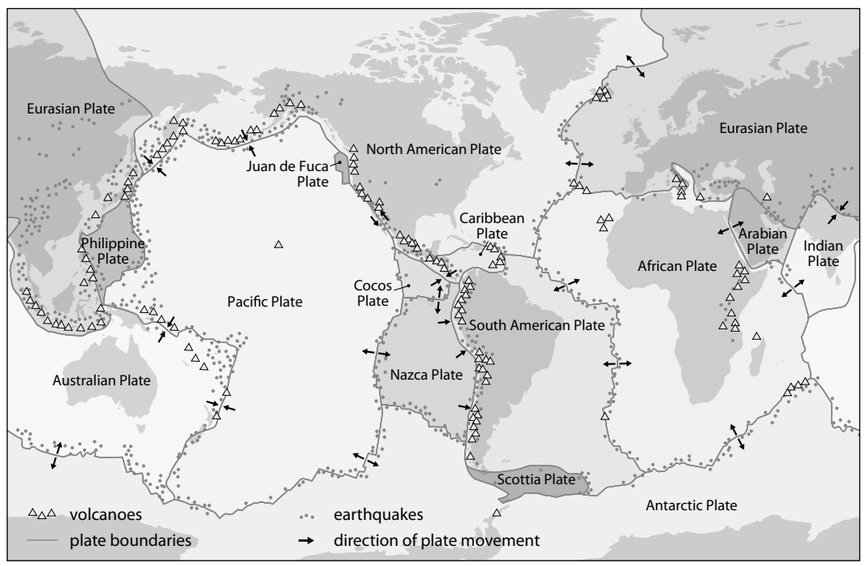
Move on! › Mindmap, page 100 › Extra assignment 1, page 97

3.2 Moving plates

Getting started

1 **a** Go to your digital BRICKS Geography and find the link to the USGS earthquake map. How many earthquakes were there in the past day?

b Where were these earthquakes located? Draw their locations on the map.



c What can you conclude based on the map you've just completed?

GB54 - 216B
GB55 - 238B

2 **a** Use the atlas. Take a look at the pink arrows. What combinations of arrows can you find? For each combination, give the names of two plates which have this plate boundary.

b Read *Plates moving apart, Plates moving towards each other* and *Plates sliding alongside each other*. What are the names for each of the boundaries you described in **2a**?

3 The woman in this photograph is standing at Thingvellir. Search on Google for Thingvellir.

a Where is Thingvellir located?

_____

_____

b Which two plates share a plate boundary at Thingvellir?

_____

c What is special about this tourist attraction?

_____

4 In the section *Plates moving towards each other,* you read about two different processes. Fill in the table with the details of these processes.

Name	**Collision**	**Subduction**
Type of plates		Oceanic - continental
Example		

5 **a** Draw a schematic overview for the collision process in four different steps and add the following captions on the lines underneath:

- Two continental plates move towards each other
- The plates push each other upwards
- The plates meet
- Fold mountains are created

b Share your workbook with a classmate. Does your drawing make sense to him or her? Should something be added to improve it? If your classmate has suggestions, add them to your drawings. You can use the sentences and sentence starters on page 199.

c Use the captions in question **a** to create a short text that explains the process of collision. Complete the following sentences, using words from the captions.

Firstly, two continental plates _____

Then _____

As these plates _____

This _____

6 **a** Draw a schematic overview for the other process mentioned in question 4 and add the following captions:

- *An oceanic plate and a continental plate move towards each other*
- *The heavier oceanic plate subducts under the continental plate*
- *Volcanoes form on the continental plate*

Don't forget to draw a trench and label it too.

b Share your workbook with a classmate. Does your drawing make sense to him or her? Should something be added to improve it? If your classmate has suggestions, add them to your drawings. You can use the sentences and sentence starters on page 199.

c In your atlas find the location of the Mariana Trench. Use the map to find which two tectonic plates are responsible for creating this trench. Circle the right answer to complete the sentences.
The Mariana Trench is located to the east of *the Phillipines / Indonesia* and north of *the Phillipines / Indonesia*. The trench was formed because the *Pacific Plate / Eurasian Plate* subducted under the *Eurasian Plate / Philippine Plate*.

GB54 - 216B
GB55 - 238B

7 **a** In your atlas, find the location of the Alps. Use the map to explain how these mountains have formed.

GB54 - 216B
GB55 - 238B

* **b** In your atlas, find the location of the Andes mountain range. Use the map to explain how these mountains have formed.

GB54 - 216B
GB55 - 238B

GB54 - 216D
GB55 - 238D

c Which of the two mountain ranges has volcanos? If needed use the atlas. Explain your answer.

8 The third type of plate boundary is the transform plate boundary. Complete the sentences to explain why there are no volcanoes and no high mountain ranges along this plate boundary.

There are no volcanoes along a transform plate boundary because

There are no high mountain ranges along a transform plate boundary because

9 Read *Convection currents.* Put the following sentences in the correct order:

_____ This heating causes the mantle rock to start rising towards the crust.
_____ The cooling rock starts to sink.
_____ They cause the crust above it to move.
_____ The mantle near the core is heated.
_____ As the hot rock comes closer to the crust, it starts to cool down.
_____ This process of hot rock rising and cold rock sinking creates circular currents in the mantle.
_____ These currents are called convection currents.

10 **a** Throughout this section, you've seen various verbs that have something do with plate tectonics. Find them and make a list. Example: move

b Pick three of the verbs and create a new sentence with it.

* 11 Read *Other theories of plate movement*. It is difficult for scientists to come up with one theory about why tectonic plates move. Explain why this is so difficult.

12 True or false? Change the false sentences to make them true.

Looking back

There are two ways tectonic plates move: apart and towards each other. *True / False*

When two plates move apart they can either subduct or collide. *True / False*

In the Alps, you can find many large volcanoes formed through collision. *True / False*

There are no large earthquakes at plate boundaries where plates move apart. *True / False*

Scientists are certain why tectonic plates move: there is one theory. *True / False*

Move on! › Mindmap, page 100 › Extra assignment 3, page 99

3.3 Earthquakes

Getting started

1 After the earthquake, Ana Paula sends an email to Saskia which describes her experiences during this event. Finish the email for her.

Hello Saskia,

How are _____

I hope everything is alright.

I found _____

The earth was _____

Sometimes these came during the night, sometimes _____

_____ in The Netherlands?

Hope to hear from you soon.

Greetings,
Ana Paula

Send

2 **a** Go to your digital BRICKS Geography and find the link to the USGS earthquake map. How many earthquakes were there over the past days?

_____

b Go to the settings and switch to "1 Day, All Magnitudes U.S." What happens to the number of earthquakes?

_____

c Go to the settings and switch to "30 Days, Significant Worldwide". Find the earthquake with the largest magnitude. Perform a Google search and gather the following information.

Location	
Tectonic plates involved	
Magnitude	
Number of casualties	

GB54 - 216B
GB55 - 238B

3 **a** Read *Shaking earth*. In Ecuador, you can find large earthquakes. Explain why. You may use the atlas if needed.

_____

_____

_____

b Would you expect to find large earthquakes in Iceland? Give an explanation for your answer.

_____

_____

c In the Netherlands, there are few large earthquakes. Use your atlas to give a reason for the small number of earthquakes in the Netherlands.

_____

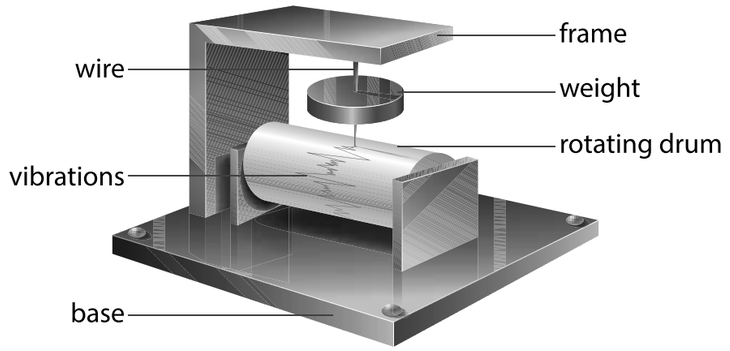
_____

4 Fill in the gaps. You can use the figure of the seismograph below.

A seismograph measures the _____ of an earthquake. It does so by measuring the _____ that have been produced by the earthquake. The seismograph is quite an _____ instrument: A _____ with a pen is hung from a frame. This is designed to hold still whilst the ground is _____ due to an earthquake. So the pen will draw the movement.

The paper on the drum slowly moves so that _____ can see when a movement occurred.

Choose from: *vibrations – scientists – magnitude – weight – ingenious - moving*



5 **a** Read *Hypocentre and epicentre*. In your own words, describe the difference between the hypocentre and the epicentre.

b Why do news broadcasts about earthquakes always include the depth of the hypocentre?

* **c** Explain why earthquakes with a deeper hypocentre will be felt less strongly than earthquakes that occur closer to the crust.

6 **a** Read *Effects of an earthquake*. Match the following effects with their definitions.

Aftershocks	Soil and rocks that come loose due to the movement and roll down the mountainside.
Landslides	Soil which acts like a liquid: Cars can sink into it.
Liquefaction	Tremors which follow the main earthquake.

b Which of the effects sound the most dangerous to you? Explain your answer.

7 **a** Earthquakes can be measured on both the Richter scale and the Mercalli scale. Complete the following sentences:

The Richter scale measures _____

The Mercalli scale measures _____

The Richter scale is reported _____

The Mercalli scale is reported _____

b Use the internet. For the following earthquakes, find out what they measured on the Richter and Mercalli scales and the depth of the hypocentre:

Earthquake	Richter scale	Mercalli Scale	Depth of the hypocentre
New Zealand February 22nd, 2011			
Nepal April 25th, 2015			
Italy August 24th, 2016			
Roermond, the Netherlands April 13th, 1992			

c Discuss with a classmate. What do you notice about the difference between the measurements on the Richter scale and the Mercalli scale in question **b**?
You can use the sentences and sentence starters on page 199.

8 **a** Read *Tsunamis*. Why can earthquakes that take place underneath oceans cause tsunamis?

b Use your atlas. Could the Netherlands be hit by a tsunami? Give a reason for your answer.

9 **a** Read *Earthquakes in the Netherlands*. Explain why it could be said that the earthquakes in Groningen are caused by humans.

b People in Groningen are protesting against the production of natural gas in their region, using posters like the one to the right. What do the protesters blame the natural gas production company for?

c It was only in 2014 and 2015 that a decision was taken to slowly decrease the production of natural gas. Why did it take so long? Write down two reasons and discuss them in class.
You can use the sentences and sentence starters on page 199 to have a proper conversation.

10 Look at the words below. These words have something in common, but one word stands out. Write a combined sentence about what they have in common and about what stands out.

Looking back

Mercalli – Richter – Seismograph

Liquefaction – landslides – tsunami

Earthquake – tremor - aftershock

Move on! › Mindmap, page 100 › Extra assignment 2, page 98

3.4 Comparing the effects of earthquakes

Getting started

1 **a** After a disaster occurs, one of the first groups of people on the scene are the search and rescue crew. Complete the sentences to describe the work of search and rescue teams.

The first thing that needs to be done is _____

_____

Then they start searching.

The search must be done very _____

Otherwise, people that have survived can still get _____

Everyone has to be very quiet otherwise they cannot hear _____

If the rescuers work hard, they may _____

The longer the search takes, the less likely it is that _____

b Sniffer dogs are often referred to as a K9 unit. Find out why.

2 Read *Earthquakes fact file* and take a look at figure 3.24. Compare the two earthquakes. Write down three things that you find strange.

3 **a** Read *Predicting the effects of earthquakes.* Name three physical factors of earthquakes.

b Are physical factors the best predictors for the effects of earthquakes? Answer in a full sentence.

4 What are socio-economic factors? Circle the factors below that you think are socio-economic factors. Explain why you think they are socio-economic factors.

GDP per capita

Magnitude

HDI index

Percentage of people with a high school diploma

Number of people living in an area

Depth of the hypocentre

5 **a** Read *Preparing for an earthquake.*
In the image you see various items that would fit in an emergency backpack. For the items mentioned underneath, explain why they would be useful in an emergency backpack.

Tent

Bottled water

Gloves

Battery-operated radio

Whistle

b Give the name of at least five other items you can see in the figure.

c Where should you keep your emergency backpack?

6 **a** Go to your digital BRICKS Geography and play the disaster management game. Choose the scenario "earthquake". Name four investments a region could make to prepare for earthquakes.

b Why is hazard management better organised in MEDCs than in LEDCs?

7 Read *Damaged infrastructure*.
Take a look at the photograph.

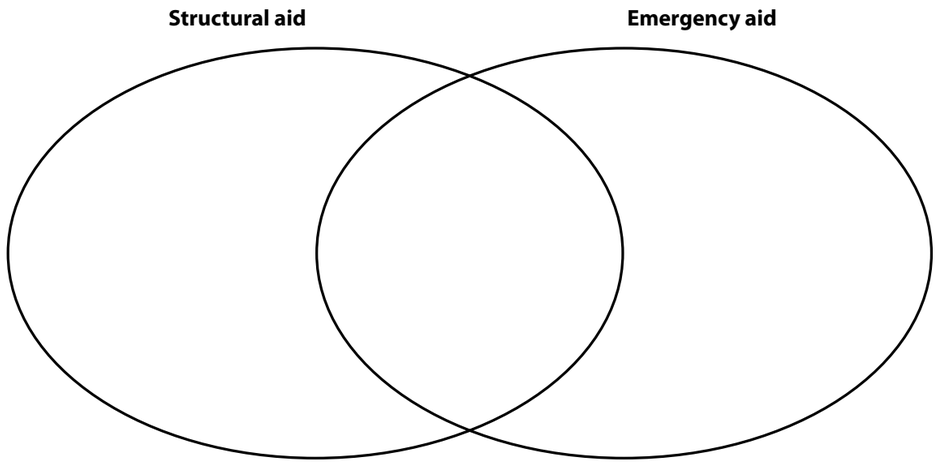
a What does this photograph show?

b During an earthquake these can break. What problems does this cause?

c It was more expensive to rebuild the infrastructure in New Zealand than in Ecuador. Explain why.

8 **a** Read *After the disaster*. Add the following words to the circles below. If you think a word can be both structural aid and emergency aid, add them to the middle.

food and water - rebuilding material for houses - blankets, tents - material for roads - doctors and nurses – medicine - new machines for farmers - earthquake lessons at schools - new school books



b Compare your results with those of a classmate. Do you agree on the division? If there is a difference between your results, discuss how you made your decisions and consider making adjustments. You can use the sentences and sentence starters on page 199 to have a proper conversation.

9 What is the difference between emergency aid and structural aid?

10 **a** Read *Predicting an earthquake*. Go to your digital BRICKS Geography and watch the video on Youtube. The presenter talks quite fast, so it might help to slow down the speed of the video to 0.75 in the settings.
Why were Italian earthquake scientists thrown in jail?

b What are some possible predictors of earthquakes?

c Do you think it is fair that these Italian scientists were thrown in jail? Explain your answer.

Looking back

11 Make the sentences complete.

1 Socio-economic factors are used _____

2 Having enough bottles of water _____

3 The infrastructure after an earthquake _____

4 Emergency aid is provided by the government _____

5 LEDCs often need emergency aid _____

6 The best thing to do is to predict earthquakes, _____

Choose from:
a is part of the so-called hazard management.
b and very often by other countries as well.
c but that has been very difficult up to this time.
d to indicate the damage of an earthquake.
e influences the search and rescue teams' work.
f as well as aid for a longer period of time.

Move on! › Mindmap, page 100

3.5 Volcanoes

Getting started

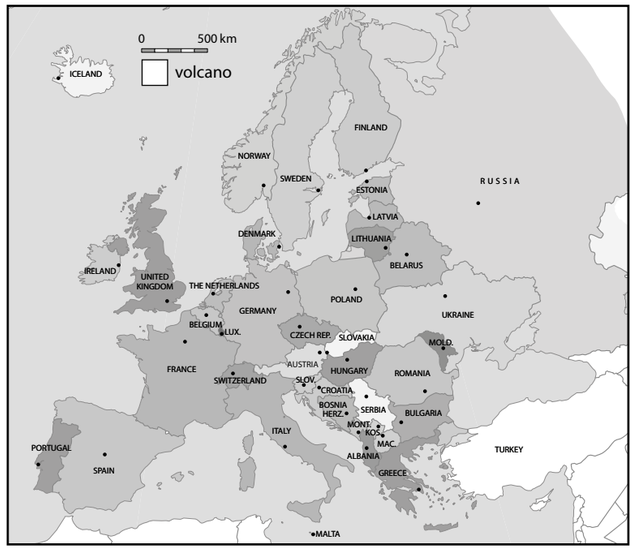
1 **a** Write down as many words you can think of to use when describing a volcanic eruption. One is given.

Smoke,

b Form at least four correct English sentences with your words. Relate the sentences to volcanoes.

GB54 - 76C
GB55 - 76C

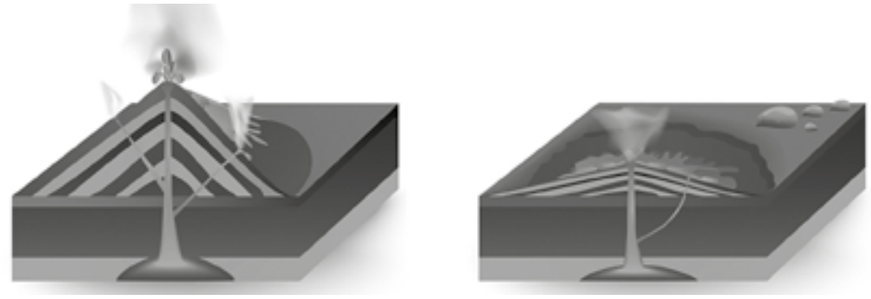
2 **a** There are quite a few volcanoes in Europe. Use the atlas. Draw the volcanoes on the map below. Add your symbol for a volcano to the legend.



b In which countries in Europe can you find volcanoes?

c Not all these volcanoes are active anymore; what does it mean when a volcano is non-active? In your answer use the words "dormant" and "extinct".

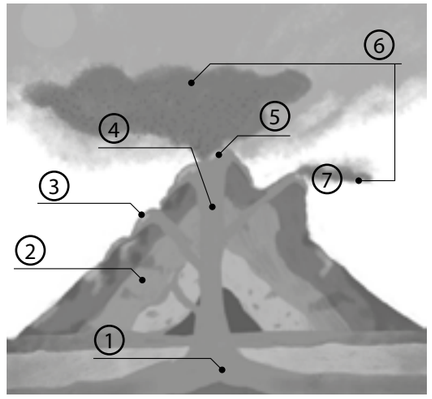
3 **a** Read *Finding and describing volcanoes*. Below are two diagrams of volcanoes. Which one is which type?



b Explain how shield volcanoes achieve their typical shape.

4 Magma is not the same as lava. What is the difference?

5 **a** Read *Inside a volcano*. Write down the words behind the numbers.



1 _____
2 _____
3 _____
4 _____
5 _____
6 _____
7 _____

b Complete the following sentences. Use words from *Inside a volcano*.

1 In the magma chamber _____

2 During a volcanic eruption _____

3 Not all magma exits through the main vent _____

4 A volcanic eruption can create _____

5 At the moment magma exits _____

6 Read *Volcanic eruptions.* Fill in the missing words.

1 When a volcano erupts, _____ are released from the mountain, causing a lot of damage _____

2 _____ can cause many deaths, if wind blows the gasses towards people

3 Much more dangerous than lava is _____

4 It is not only extremely hot, but _____

5 An eruption can even _____

6 Erupting material does not only need to escape _____

7 Magma can leave _____

Choose from (there is one too many): *through the top of the volcano - it travels downhill very fast - nearby - the pyroclastic flow - volcanic bombs - the volcano through side vents - toxic gasses - cause problems for air traffic - lava can kill a lot of living beings*

7 Read *Secondary effects of volcanic eruptions.* Read the following text and underline the effects. Use a different colour for the physical effects and socio-economic effects.

In April 2010, the Eyjafjallajökull volcano in Iceland erupted. The eruption started on 20th March. The eruption happened underneath a thick layer of ice: The gasses in the molten rock, along with the steam from the ice, created a large ash cloud. This had many effects, both inside Iceland and internationally. Country areas were flooded because of the melting ice which lay on top of the volcano, while ash falling from the ash cloud damaged farm land and poisoned farm animals. Some roads were destroyed, and people had to stay inside their houses due to the ash in the air. Across Europe, travel was disrupted because many flights were cancelled between 14th and 21st April 2010. This was problematic for many tourists, because the eruption happened around the Easter holidays. Not only were tourists affected, but businesses also lost trade and food that needed to be transported had to be thrown away. Airlines lost millions of Euros each day.

8 Read *Measuring the effects of volcanoes*. Take a look at the Volcanic Explosivity Index.

VEI	Volume of erupted material	Examples	Frequency	Thickness
0	0.0001 km^3		Frequent	0
1	0.001 km^3		Frequent	dusting
2	0.01 km^3	Cotopaxi, Ecuador (2015)	Tens per year	A few centimetres
3	0.1 km^3	Etna, Italy (2002)	Several per year	Several centimetres
4	1 km^3	Eyjafjallajökull, Iceland (2010); Mount St. Helens, USA (1980)	Tens per decade	A few tens of centimetres
5	10 km^3	Vesuvius, Italy (79AD); Pinatubo, The Philippines (1991)	One per decade	About 0.5 metre
6	100 km^3	Tambora, Indonesia (1815)	Several per century	About 3 metres
7	1000 km^3		Several per millennium	At least several metres
8		Yellowstone, the USA (630,000 years ago)	Two per 100,000 years	At least several metres

a Earlier in the section, you read about the eruption of the Eyjafjallajökull. Was this a big volcanic eruption? Explain your answer.

b The thickness of ash in the air increases when the eruption scores higher on the VEI. Why?

9 **a** Read *Hot spots.* Use your atlas to find the location of the Hawaiian islands. Describe the method you used to find them.

b What is the distance between the oldest and the newest island on the Hawaiian ridge?

10 Read *Predicting a volcanic eruption*. In March 2017, a group of journalists from the BBC were surprised by a small eruption from the volcano Mount Etna. Go to your digital BRICKS Geography and watch the video. It is rare for people to be surprised by volcanic eruptions. Explain why.

_____

_____

11 **a** Match the following terms with their definition.

Looking back

Hot spot	A combination of gasses, rocks and ash
Volcanic eruption	Magma outside the volcano
Magma chamber	A place in the mantle where the magma is extra hot
Lava	When magma exits the volcano
Pyroclastic flow	The storage for magma within the volcano

b For the following keywords give your own definition.

Main vent _____

Lahars _____

Active volcano _____

Composite volcano _____

Volcanic bomb _____

Move on! › Mindmap, page 100 › Extra assignment 4, page 99

3.6 Living close to a volcano

Getting started

1 Go to your digital BRICKS Geography and take a look at what Iceland has to offer for tourists. Would you like to visit Iceland? Give two reasons why or why not.

_____

_____

2 Read *Minerals and rocks*. Write down three reasons why people still return to a volcano after its eruption. Use the following groups of words to construct your sentences:
becomes solid - valuable minerals - After erupting - is made out of - make - You can find - volcanic rock - want to - a profit - the lava - Concrete - by mining the hills - Many large companies - like gold and silver

_____

_____

_____

_____

3 At which types of plate boundaries would you expect to find most volcanic minerals? Circle the right answer and explain your answer below.

A Transform plate boundaries and subduction plate boundaries
B Subduction plate boundaries and divergent plate boundaries
C Divergent plate boundaries and transform plate boundaries

_____

_____

4 Read *Geothermal energy*. Find the words with the following meaning:

1 Special construction to grow plants _____
2 To create _____
3 Turn _____
4 Concerning the surroundings _____
5 Being there _____
6 Heath _____

5 **a** Put the following sentences in the right order to explain the process of geothermal energy.

_____ The water sometimes reaches temperatures of up to 370°C.
_____ Water is pumped into the soil.
_____ The steam, or warm water is pumped up.
_____ The warm water is used to produce electricity.
_____ This water is heated up by the higher temperatures in the crust.

b Why does Ecuador use less geothermal energy than Iceland?

6 Read *Agriculture*. Then read the newspaper article below.

Volcano ash could be good for gardens

The ash cloud that is causing chaos for travellers could be good for gardens, according to horticulturalists.

The ash would not only fertilise plants but help the soil hold water and encourage bacteria. However, volcanoes can also spew out poisonous ash and government officials are following the situation because of the risk to agriculture. Colin Dale, a plant specialist, said ash is a good source of nutrients and pests do not like it.

"Volcanic ash can be a great help to your garden in more ways than one. The ash holds air and the air spaces it creates in soil can insulate plants against temperature change. It can also allow your soil to hold water for longer encouraging both soil bacteria and seed germination, both of which are great for plant growth."

Professor Jon Davidson said fertile areas like Indonesia have benefited from ash in the past. "In general, volcanic ash is good because it is full of all kinds of elements and nutrients that restore the soil," he added.

The government is keeping a close eye on the ash situation because of the effect it could have on agriculture and food supplies. Depending on the type of ash, it could be good or bad for farmers.

Adapted from the Telegraph

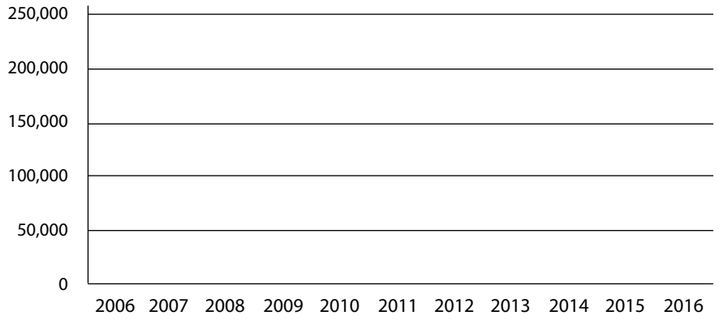
a The article mentions several reasons why volcanic ash is good for plants. Give three reasons. Start every sentence with "volcanic ash".

b Would you encourage a farmer to live close to a volcano? Explain your answer.

7 **a** Read *Tourism*. Take a look at figure 3.37. Describe the trend in tourist visits to Iceland.

b Use the data in the table below to create a bar graph for tourist visits to Cotopaxi.

Year	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Tourist visits	90,529	97,110	93,010	101,882	95,972	153,611	168,499	223,836	178,653	142,116	121,092



c Describe the trend in tourist visits to Cotopaxi.

8 Why are tourist visits important for Ecuador and Iceland?

9 **a** Read *Mining for gold*. Identify a positive aspect of gold mining.

b Go to your digital BRICKS Geography and watch the video on gold mining. Note down three negative consequences of gold mining.

Looking back

10 Imagine you live near a volcano that has just erupted. The government has asked you to write a short newspaper article in which you convince the inhabitants not to move away from this area. What would you write?
Use and underline the following words (or a word that comes from them) in your text:
benefits – minerals – mining – energy – agriculture - tourist
You can use the linking words on pages 200 and 201.

Section 1

The news broadcast

Extra assignment 1

You and your group members are journalists. You work for a big news company. You have just heard a large earthquake has taken place. You need to learn as much as you can about this earthquake, so that you can make a news broadcast.
A news broadcast is a short film. As journalists, you need to share as many facts about the recent earthquake as possible with the world. The maximum length for your news broadcast is 5 minutes. Ask your teacher which earthquake to use as your subject.

1 Decide which news company you work for. This can be a real company – like the NOS, BBC or Aljazeera. It can also be an imagined company. What is the name of your news company?

2 Ask your teacher, which earthquake you should use for your news broadcast. Write it down.

3 Gather as much information about the earthquake as possible. You can use news articles to gather information. It might be a good idea to collect the information you have gathered in a mind map.
Questions you might like to answer in your news broadcast:
- What was the size of the earthquake?
- Which tectonic plates where involved?
- How many people were killed?
- Were there any other immediate consequences of the earthquake?
- Will it be necessary to help the area with the rebuilding after the earthquake?

4 Did the earthquake happen a while ago? Then you might also be able to mention something about rebuilding in the area. If you decided to make a mind map, you can add this information to it.

5 Interview an imaginary witness of the earthquake. Maybe you can "fly" a colleague to the affected area and get first-hand experiences of a witness in your news broadcast?

6 On a separate piece of paper, write a script for your news broadcast. Decide which information fits best where.

7 Record the news broadcast.

8 Show the news broadcasts in class. You will be graded for the accuracy of facts, use of English, and creativity.

Section 3

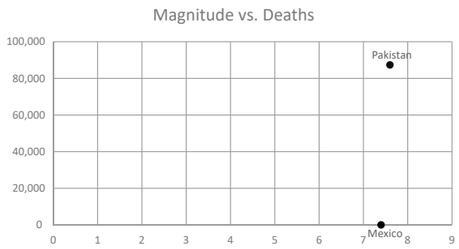
Geography and mathematics — Extra assignment 2

Some questions are easily answered when you deal with numbers: what happens to ice cream cone sales when the temperature increases? Or, what happens to your exam results if you study longer? These questions can be answered using scatter plots, a type of diagram which shows the relationship between two variables: for example, the number of ice cream cones sold and temperature or exam results and time spent studying. For both of these examples, it seems obvious that if one is higher, the other will also be raised: if the temperature is higher, more ice cream is sold and if you study longer, you are more likely to obtain a good grade.
What if we use this technique to find out how a physical factor such as magnitude, or a socio-economic factor such as the Human Development Index (HDI), impacts on the number of victims of an earthquake?

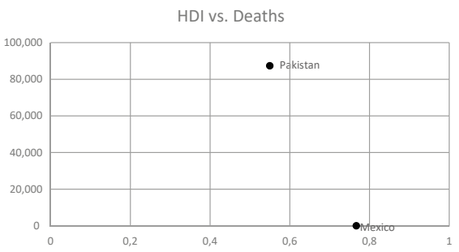
Country	Magnitude	HDI	Deaths
Mexico	7.4	0.762	15
Turkey	6	0.767	6
India	7.6	0.624	20,000
Italy	5.7	0.887	29
Iran	6.6	0.774	31,000
Japan	6.6	0.903	40

Country	Magnitude	HDI	Deaths
Pakistan	7.6	0.550	87,350
Indonesia	6.4	0.689	5,750
New Zealand	6.3	0.913	185
China	7.9	0.738	87,000
Italy	6.2	0.887	295
Ecuador	7.8	0.732	673

1 Create a scatterplot of Magnitude (x-axis) and number of deaths (y-axis). Label each point you plot with the name of the country. Mexico and Pakistan are given as examples.



2 Create a second scatterplot of HDI (x-axis) and number of deaths (y-axis). Once again, label each point on your graph with the name of a country.



3 Draw two straight lines through the points in each graph. This line is called a "line of best fit". For one graph this line goes upwards, for the other downwards. Explain what this means.

Section 2

Writing like Wegener — Extra assignment 3

Alfred Wegener has a problem. He has found several pieces of evidence that the earth's crust consists out of several different pieces, which must be moving. However, no one believes him! Overall, he has four main arguments:

1) Some continents fit together like puzzle pieces: for example, the east coast of South America and the west coast of Africa.
2) Fossils of similar animals have been found across different continents; fossils of the same fern have been found in South America, Antarctica, Africa, India and Australia.
3) Coal (which formed in tropical areas) can be found near the North Pole, while there is evidence of glaciers to be found in Africa.
4) Matching mountain ranges are found on different continents, particularly in South America and Africa.

Alfred Wegener (left) doing research on Greenland.

Imagine you are Alfred Wegener in 1912 and you are writing a letter to a friend. Explain to him, or her, your new idea and the arguments behind it. Your letter should try to convince your friend to believe your idea. You can use the linking words on pages 200 and 201.

Section 5

Volcano model — Extra assignment 4

1 In this assignment, you are going to make a 3D model of a volcano. As a group, select the volcano you choose to make:
- Mount Etna (Italy)
- Mauna Loa (Hawaii, USA)
- Soufiere Hills (Monserrat)
- Merapi (Indonesia)

2 Your model should show both the inside and outside of the volcano.

3 Decide which material you want to use for your model. Be creative: clay, paper-maché, cake, paper, wood, etc. You are welcome to think "outside the box"!

4 Don't forget to paint your volcano and add labels (see figure 3.30).

5 In a short presentation, show and explain your model, then answer the following questions about your volcano:
1 What is the name of the volcano?
2 How high is the volcano?
3 On which tectonic plate is your volcano located?
4 Is your volcano located in a subduction zone or at a hot spot?
5 Is the volcano active, dormant or extinct?
6 When was the most recent eruption of this volcano?

Mindmap

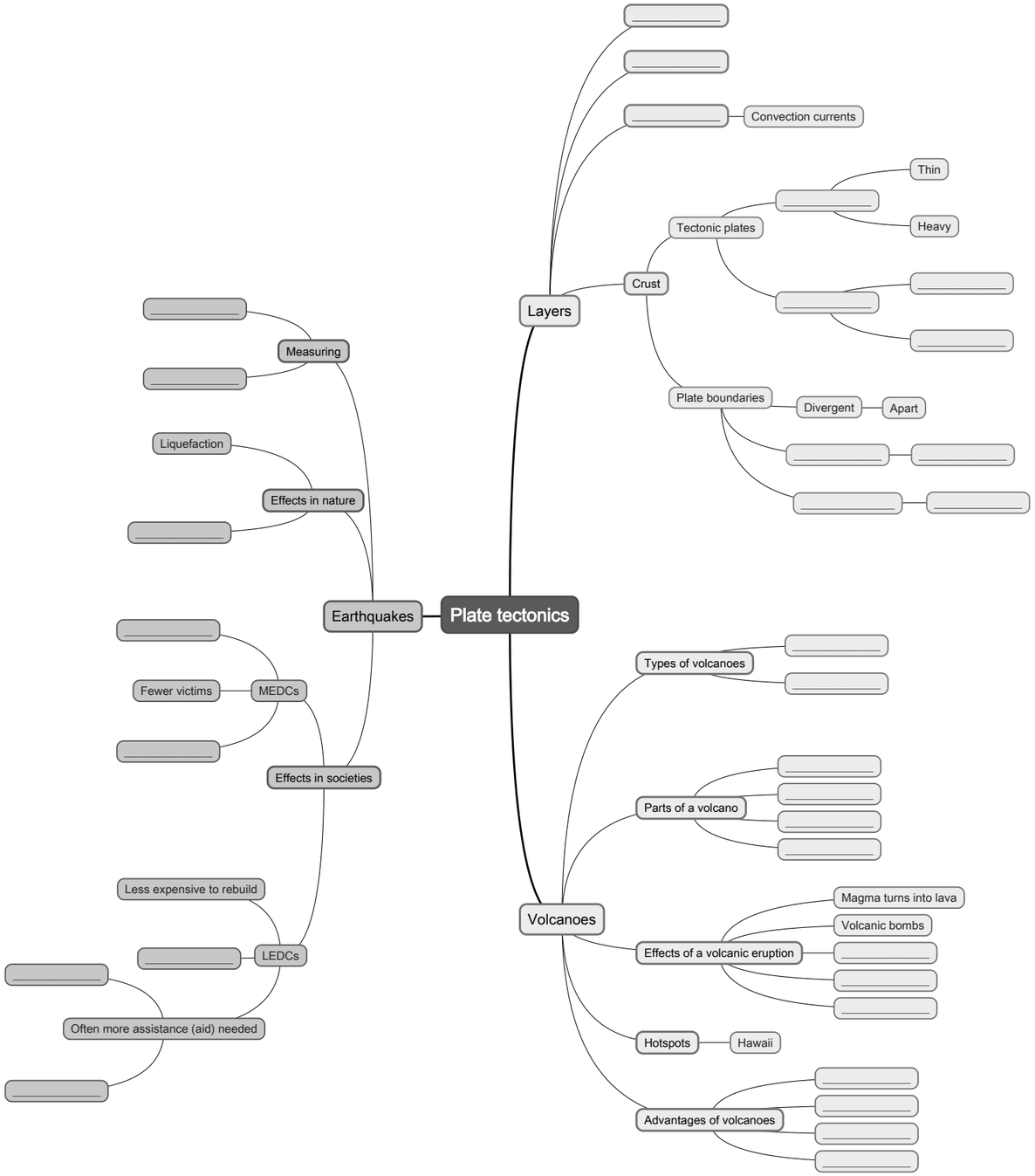


Plate tectonics
Earthquakes
Measuring
Liquefaction
Effects in nature
MEDCs
Fewer victims
Effects in societies
Less expensive to rebuild
LEDCs
Often more assistance (aid) needed
Layers
Crust
Convection currents
Tectonic plates
Thin
Heavy
Plate boundaries
Divergent
Apart
Volcanoes
Types of volcanoes
Parts of a volcano
Effects of a volcanic eruption
Magma turns into lava
Volcanic bombs
Hotspots
Hawaii
Advantages of volcanoes

Meer weten?

Kijk voor meer informatie op **www.brickstto.nl**.

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EduHint