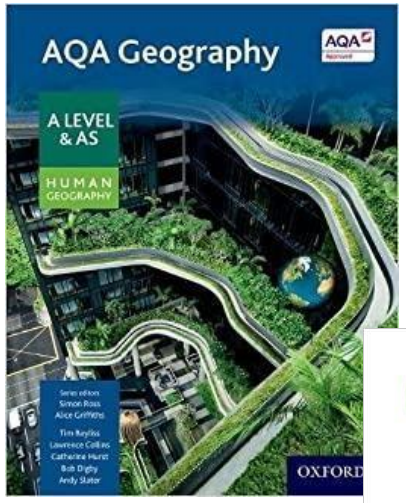
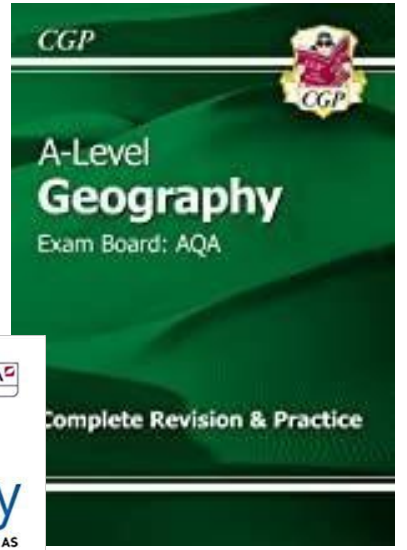
# Welcome to A Level Geography!

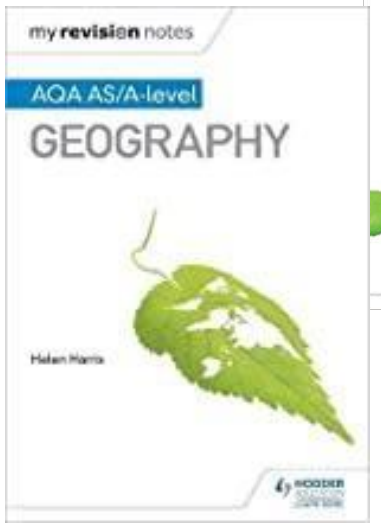
**AQA Geography – 7037**

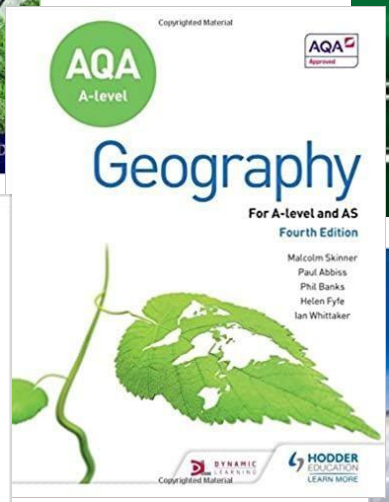
The AQA exam structure is broken into 3 components:

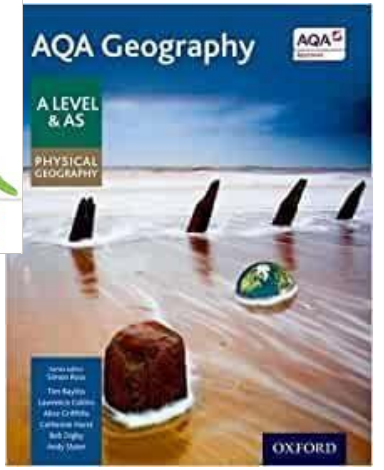
- Paper 1 - Physical Geography
- Paper 2 – Human Geography
- Geography fieldwork investigation NEA



# Paper 1 – Physical Geography

2 hours 30 minutes long and there are 120 marks (40% of A-Level grade)

You will complete 3 sections:

- Water and Carbon Cycles (36 marks)
- Coastal Systems and Landscapes (36 marks)
- Hazards (48 marks)

# Paper 2 – Human Geography

2 hours 30 minutes long and there are 120 marks (40% of A-Level grade)

You will complete 3 sections:

- Global Systems and Governance (36 marks)
- Changing Places (36 marks)
- Contemporary Urban Environments (48 marks)

# Hazards

**Research a range of landforms/hazards associated with the Earth.**

**For each one:**

1. Provide a clear description of what it is and include a diagram of what it looks like or how it forms.
2. Write down an example of where in the world one has happened or where one can be found.
3. You also have the work booklet to complete, using the complimentary resource booklet.

| Landforms / Hazards |
| --- |
| Transform Faults |
| Mid-ocean Ridges |
| Rift Valleys |
| Submarine Volcanoes |
| Horsts |
| Ocean Trenches |
| Fold Mountains |
| Nappes |
| Recumbent Folds |
| Island Arcs |
| Deep-focus Earthquakes |
| Shallow-focus Earthquakes |
| Calderas |
| Hot Spots |
| Basic Volcanoes |
| Acidic Volcanoes |

# Changing Places

**Create a glossary of key terminology for this unit.**

| | | |
|---|---|---|
| Location | Artistic representations of place | Continuity |
| Locale | Lived experience of place | Qualitative data |
| Sense of place | Market town | Quantitative data |
| Place | Gentrification | Meaning of place |
| Perception of place | Geospatial data | Representation of place |
| Attachment to place | Cultural character | Place memory |
| Placemaking | Oral sources of data | Perception of place |
| Localism | Dialect | Reimaging place |
| Tourist gaze | Topography | Rebranding place |
| Distant place | Built environment | Regeneration of places |
| Regionalism | Chloropleth map | Place marketing |
| Nationalism | International institutions | Crowdsourcing |
| Identity | Global institutions | Corporate body |
| Globalisation | National institutions | Objective |
| Placelessness | Heritage tourism | Infrastructure |
| Clone town | Deprivation | Agents of change |
| Homogenised place | Census | Function of a place |
| Glocalisation | Subjective | Multinational Corporation |
| Belonging | Community | Economic characteristics |
| Well being | Local group | Social characteristics |
| Transitional town movement | Residents associations | Inequalities |
| Near places | Counter mapping | International places |
| Far places | Mercator projection | Endogenous factors |
| Experienced Places | Biomapping | Exogenous factors |
| Media places | Textual source | Demographic characteristics |
| Positionality | Augmented place | Multiple Deprivation |
| Character of a place | Literary source | |

# Changing Places

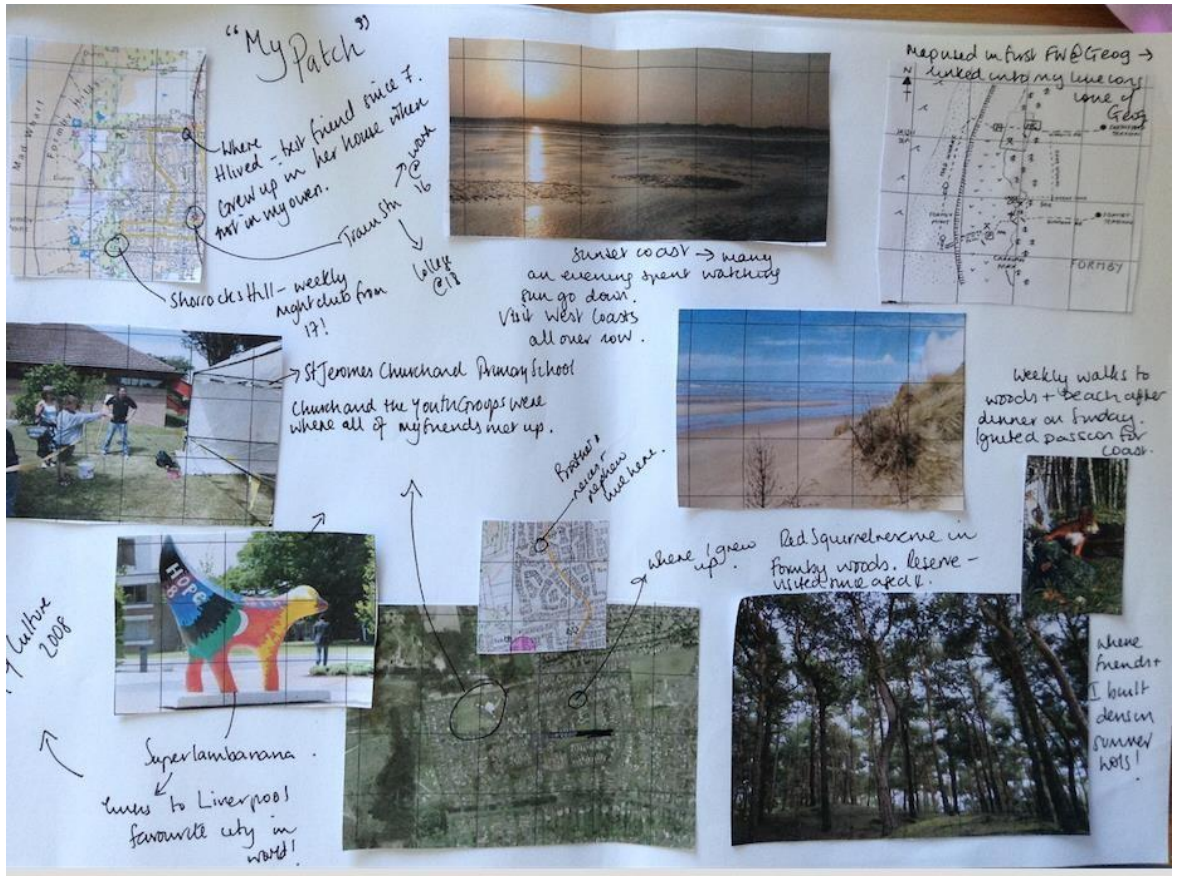
**Produce your very own sense of place piece.**

**This is an annotated collage of a range of places which you have a personal attachment to and that have built your identity. Places may include a special holiday destination, your home, where you go to meet your friends, your primary school…**

**SENSE OF PLACE** – ***the subjective (personal) and emotional attachment to place.***

**What to include:**

- Maps, photographs, images…
- Key terms (take these from your glossary – place, sense of place, locale, location…)
- Describe each place.
- Which place has had the greatest impact on your identity?
- Explain the emotional attachment.
- How have the places changed over time?



# Coastal Systems and Landscapes

**Create a glossary of key terminology for this unit.**

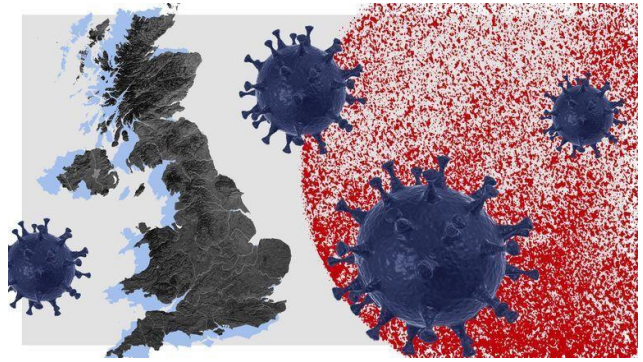
The emboldened words are higher level terms introduced at A-level the other words can be included in your glossary but are assumed to be known from GCSE.

Make sure your definitions are relevant to coasts. Previously students have found definitions which are linked to other areas of geography which is not helpful at all.

| *Introductory* | *Transportation* | *Depositional Features* |
|---|---|---|
| Coast | Load | Spit |
| **Coastal System** | Longshore Drift | **Cuspate Spit** |
| Impermeable Rock | Traction | **Baymouth Bar** |
| Permeable Rock | Saltation | **Offshore Bar** |
| **Dynamic Equilibrium** | Suspension | **Barrier Beach** |
| **Positive Feedback** | Solution | **Barrier Island** |
| **Negative Feedback** | | Lagoon |
| **Sediment Cell** | *Erosion* | Tombolo |
| **Sediment Budget** | Erosion | Salt Marsh |
| | Abrasion (Corrasion) | |
| *Waves & Tides* | Attrition | *Sand Dunes* |
| Constructive Waves | **Cavitation** | Sand Dunes |
| Destructive Waves | Hydraulic Action | **Embryo Dune** |
| Fetch | Corrosion | **Fore Dune** |
| Wavelength | **Wave Quarrying** | **Grey Dune** |
| Wave Crest | Differential Erosion | **Mature Dune** |
| Wave Trough | | **Dune Heath** |
| Swash | *Deposition* | **Blowout** |
| Backwash | Deposition | **Dune Slack** |
| **Neap Tide** | **Refraction** | |
| **Spring Tide** | | *Sea Level Change* |
| **Funneled Coast** | *Erosional Features* | **Eustatic** |
| **Tidal Bore** | **Concordant Coastline** | **Isostatic** |
| **Littoral Zone** | **Geo** | **Tectonic** |
| | **Cove** | **Thermal Expansion** |
| *Weathering* | **Discordant Coastline** | **IPCC** |
| Weathering | Bay | **Emergent Coastline** |
| **Exfoliation (Onion-skin)** | Headland | **Raised Beach** |
| Freeze-thaw Action | Fault | **Marine Terrace** |
| **Hydrolysis** | Cave | **Submergent Coastline** |
| **Hydration** | Arch | **Submerged Forest** |
| **Salt Crystallisation** | Stack | **Ria** |
| | Stump | **Fjord** |
| *Mass Movement* | Wave-cut Notch | **Dalmation Coastline** |
| Mass Movement | Wave-cut Platform | **Coral Reef Bleaching** |
| **Creep** | | |
| **Solifluction** | *Beach Features* | *Management* |
| **Mudflow** | Beach | Beach Nourishment |
| **Earthflow** | **Storm Beach** | **Cost-Benefit Analysis** |
| **Rotational Slip** | **Berms** | Gabions |
| **Landslide** | **Cusps** | Groyne |
| Scree Slope | **Runnels** | Hard Engineering |
| **Rockfall** | **Offshore Zone** | Managed Retreat |
| | **Breaker Zone** | **Polders** |
| | **Swash Zone** | Revetments |
| | **Inshore Zone** | Rip-rap |
| | **Onshore Zone** | Sea Walls |
| | **Backshore Zone** | Soft Engineering |
| | **Nearshore Zone** | **Dune Regeneration** |


# Global Systems and Global Governance

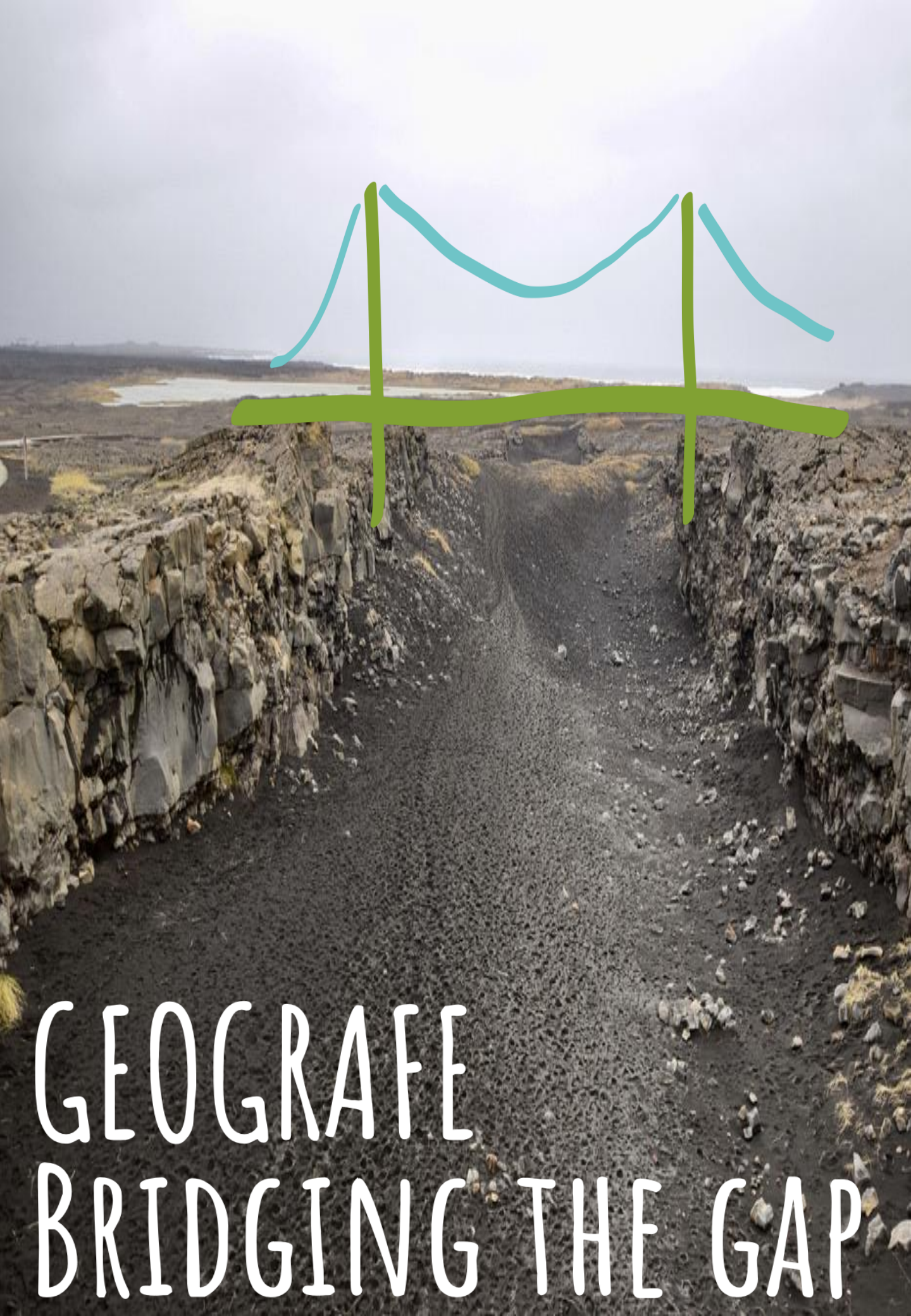
**In the Global Governance unit we study the role of the World Health Organisation in governing global issues.**



**Your task is to conduct research and create a fact file about how the WHO played its part in managing the COVID-19 pandemic.**

**What to include:**

- Background information on the WHO – *Who they are, what they do, where they work…*
- Description of the spread - *Using geographical terminology/maps.*
- Manipulation of data *e.g. Infection rate*
- How the WHO are working with government and non-governmental organisations during this pandemic.


GEOGRAFE
BRIDGING THE GAP

# IMPORTANT NOTICE

Please print this PPT off as a double sided document to complete activities and questions. You will hand this in when you start in September.

# Welcome to Team Geography

**Well done**, you made a great choice. Of course, as a geography graduate (yep I studied geography at Uni) I would say that wouldn't I!

Well, don't just take my word for it. According to the former president of the Royal Geographical Society, Michael Palin, "Geography is not only up-to-date and relevant, it is one of the most exciting, adventurous and valuable subjects to study today. So many of the world's current problems boil down to geography and need the geographers of the future to help us understand them."

Former US President, Barack Obama, recognises the importance of geography too! He said "The study of geography is about more than just memorizing places on a map. It's about understanding the complexity of our world, appreciating the diversity of cultures that exists across continents. And in the end, it's about using all that knowledge to help bridge divides and bring people together."

In our rapidly changing world, we need people like you to study geography more than ever. The adopted godfather of geography, David Attenborough agrees! He said "The truth is: the natural world is changing. And we are totally dependent on that world. It provides our food, water and air. It is the most precious thing we have, and we need to defend it."

An essential outcome of studying geography is being able to apply knowledge and understanding to new settings. Thinking like a geographer is an amazing ability as Dr Rita Gardner points out "Geography prepares young people with the knowledge, skills and understanding to make sense of their world and to face the challenges that will shape our societies and environments at the local, national and global scales."

With the skills and knowledge of a geographer **you** can make a difference to the world we live in. **Welcome to team geography.**

# I ♡ Geography

"One of the most exciting, adventurous and valuable subjects today"

"Helps bridge divides and brings people together"

"Geography prepares young people with the knowledge, skills and understanding to make sense of their world"

"(the world) is the most precious thing we have, and we need to defend it"

# Introduction



As a further education (FE) student you're going to find studying a little different to what you experienced at GCSE level. You are going to be expected to take more responsibility for your learning! Whether or not you're studying geography post-16 this project will help you to develop skills that can be used across FE courses (and you get to learn about two amazing volcanic eruptions that have happened lately!).


In this assignment you are going to research two volcanic eruptions that have occurred in 2021. To get started, take a look at the videos below to see what you're going to be studying.

## Volcano 1 – Fagradalsfjall, Iceland

https://tinyurl.com/fagrad1

https://tinyurl.com/fagrad2

## Volcano 2 – La Soufrière, St Vincent

https://tinyurl.com/lasouf1

https://tinyurl.com/lasouf2

**Human Geography**

Things that are to do with people.

population, urban environments, economic, development, culture, history

**Physical Geography**

Things that are to do with the natural environment.

geomorphology, hydrology, natural resources, ecosystems, relief, climate

# Challenge 1 – Cornell Notes



When studying at FE you will be expected to do wider reading. This means reading extra articles/books etc. in addition to your text books that link to your courses. Making organised notes when doing this can really help develop your knowledge and understanding. One really useful note taking technique is Cornell Notes.

You are going to use the Cornell Notes method of recording information from the volcano resource booklet you've been given. To do this, you are going to research how to use Cornell Notes using the resources below.

## Cornell Notes

1. Watch the two videos about taking Cornell Notes on Internet Geography: www.internetgeography.net/cornell-notes

Use the link above or scan the QR code

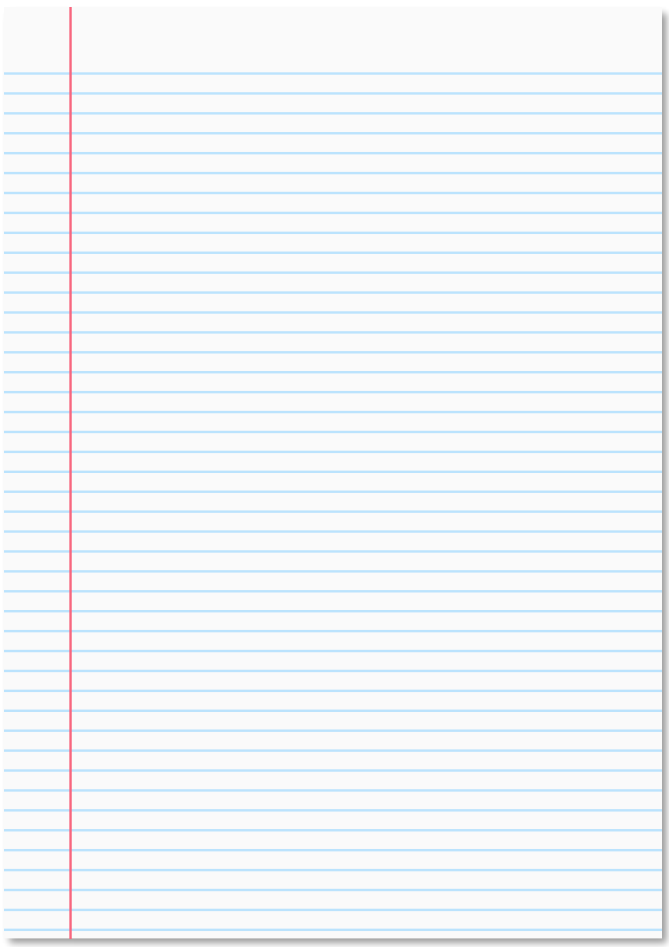
2. Divide up the page on the right to prepare it for recording Cornell Notes.

3. Annotate the page on the right to show how Cornell Notes should be completed.

4. Turn over the page and look at the example Cornell Notes that have been started. Using the webpage below complete the notes (I got up to paragraph 3 so start from 4).

www.alevelgeography.com/structure-of-the-earth

Use the link above or scan the QR code

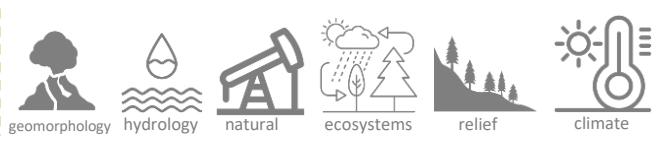


**Human Geography**

Things that are to do with people.


**Physical Geography**

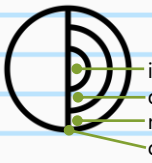
Things that are to do with the natural environment.



# Structure of the Earth

## Keywords

Continental crust
Mohorovicic Discontinuity (Moho)
Asthenosphere
Lithosphere




Crust – oceanic > around 5km
- continental > average around 100km large
30km (up to mountain ranges)

Moho – boundary between the crust and mantle

Mantle – dense (due to temp and pressure) – semi-solid rock – 2900km thick
- iron / magnesium / calcium

Upper Mantle – Asthenosphere

Lithosphere

100 to 300 km down

Semi molten (flows slowly)

Rigid layer between crust and asthenosphere

## Questions

What are the characteristics of the Moho?

## Summary

# Challenge 2 – Take Note



In recent months volcanoes have been in the news with the eruptions in Iceland, near Mount Fagradalssfjall and the La Soufrière volcano on the Caribbean island of Saint Vincent. Volcanoes are covered in most A level Geography specs, so it is really useful for you to keep up with the news and study these recent events.

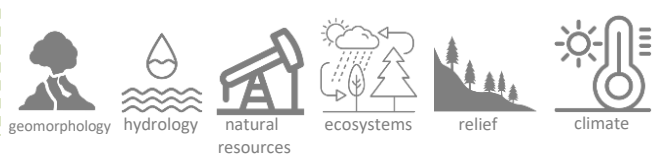
You have been provided with a resource booklet that discusses the eruption of the two volcanoes. Read the two articles and complete Cornell Notes for each article. Pages have been provided in this booklet for you to complete the activity.

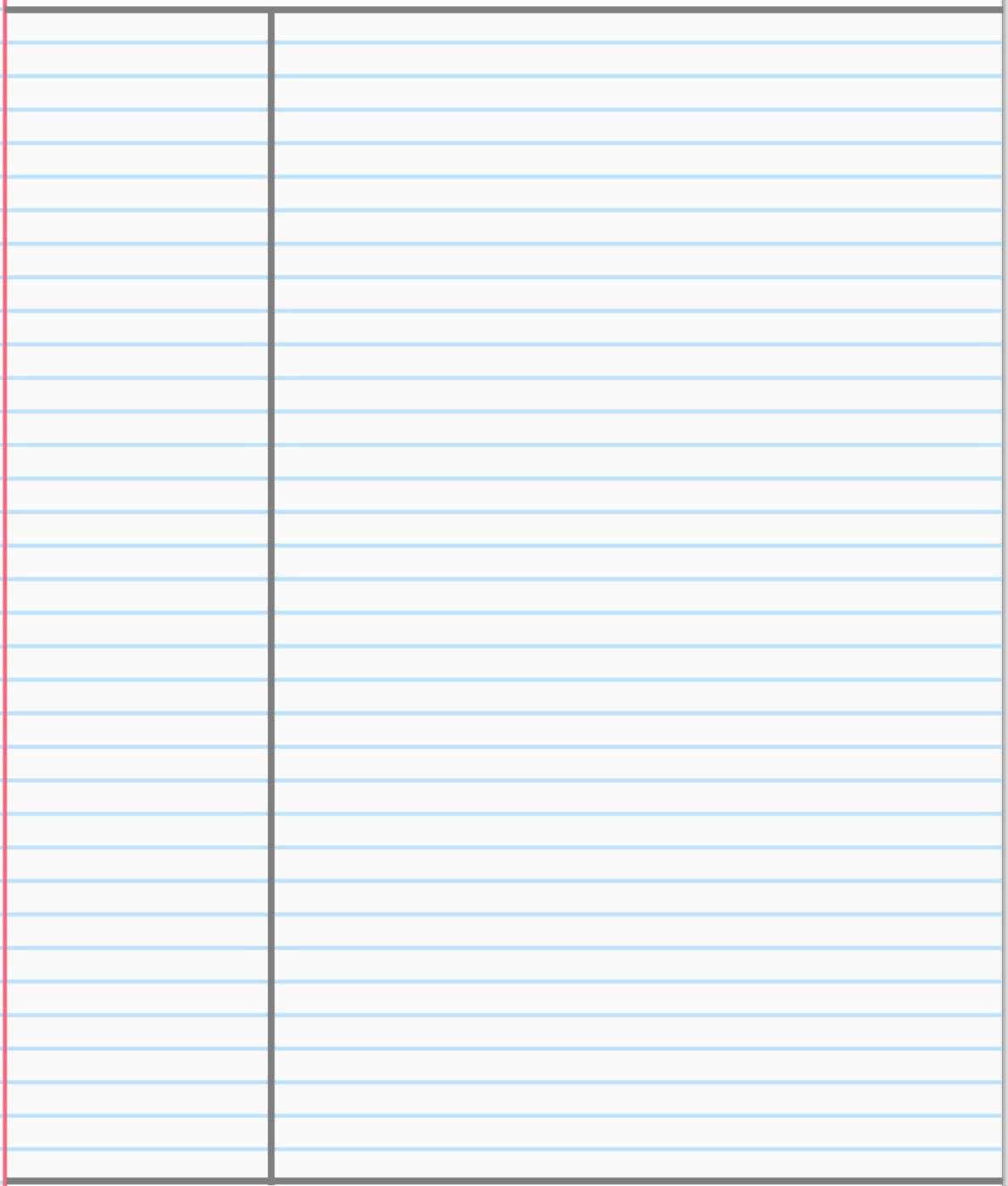
**Human Geography**

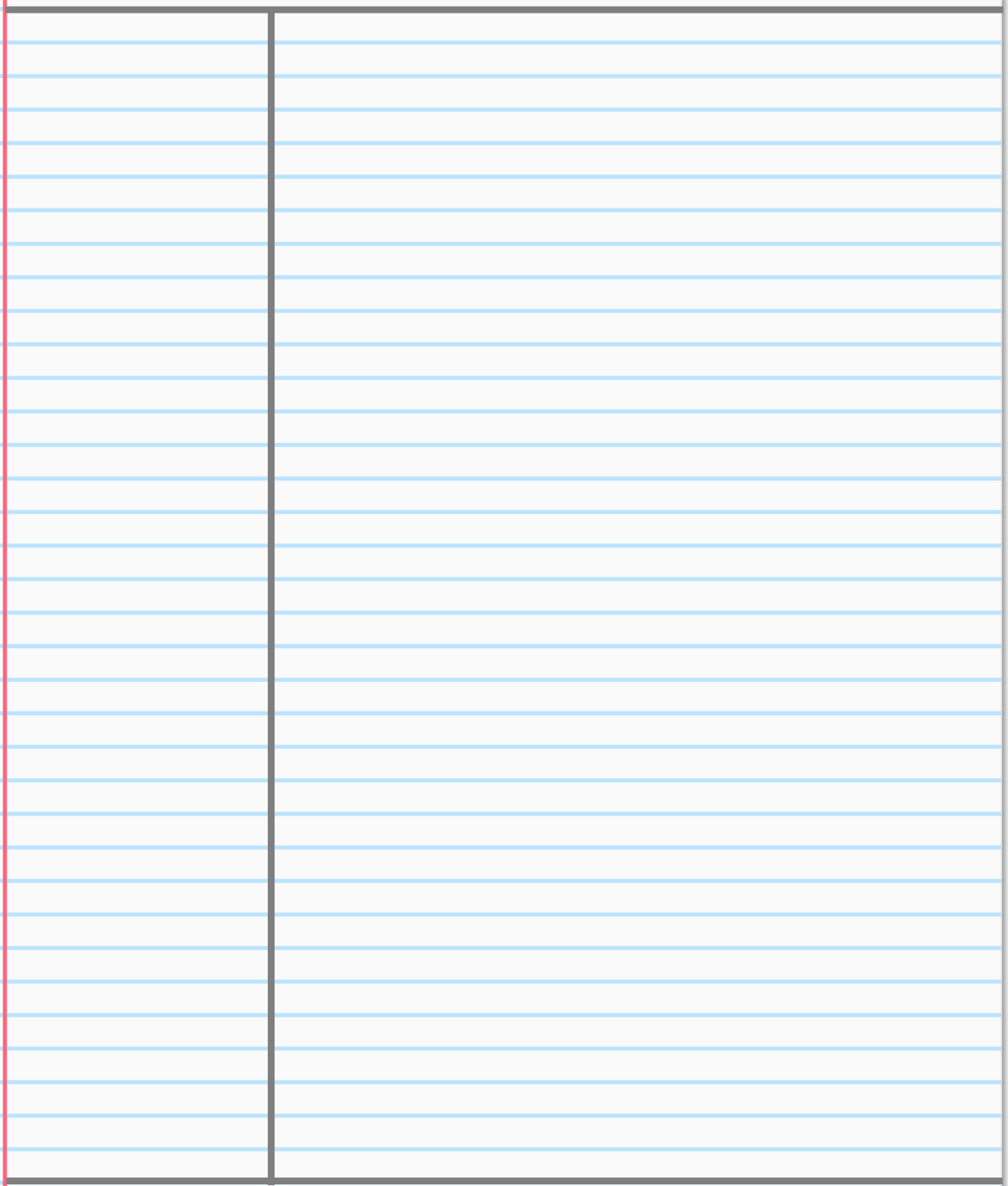
Things that are to do with people.

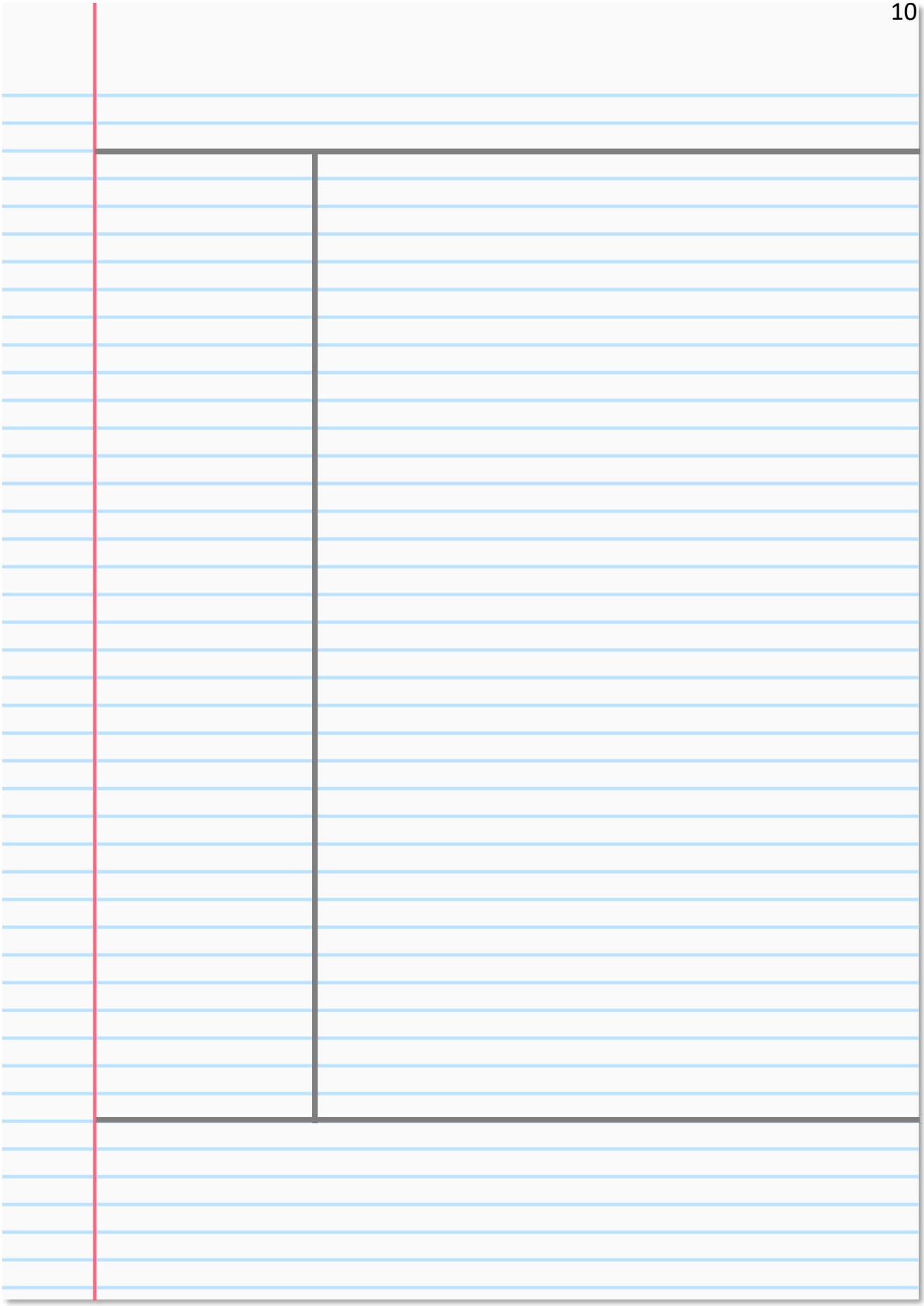

**Physical Geography**

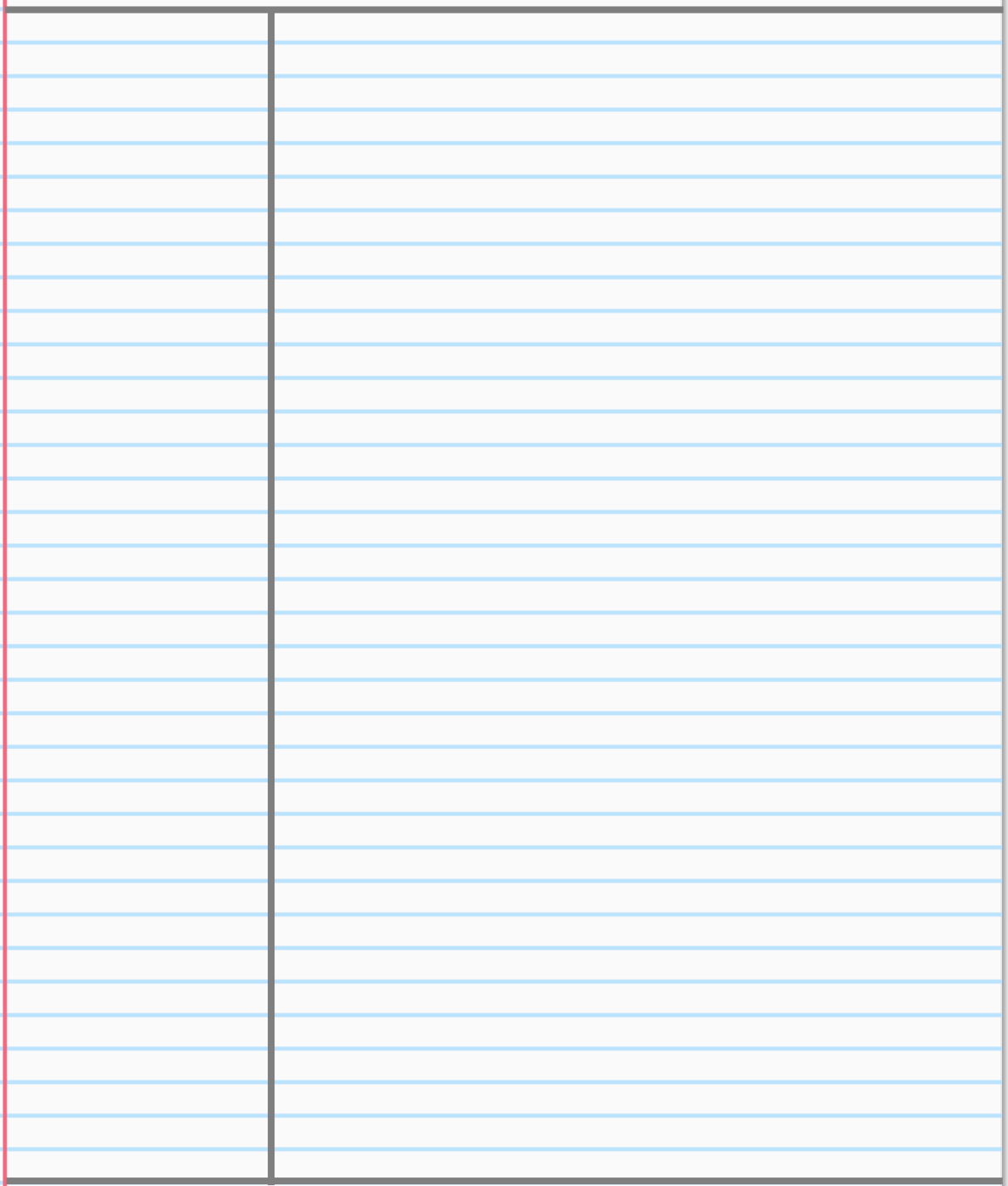
Things that are to do with the natural environment.









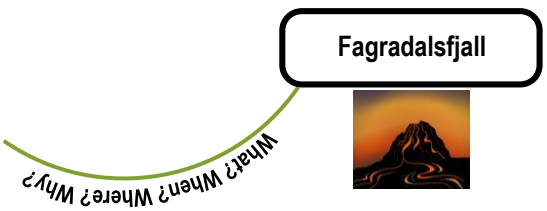


# Challenge 3 – Mind Mapping

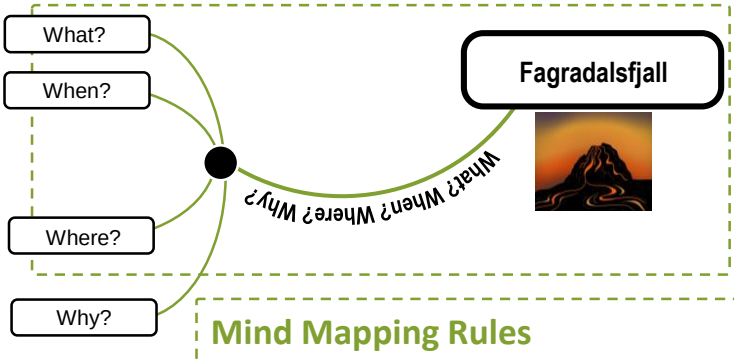
You should now be in the position of having several pages of notes covering each volcanic eruption. The challenge now is transforming the information you have gathered into knowledge. This is where mind maps can help! A mind map can help organise information and help illustrate how things are interrelated. The guide below illustrates how to create a mind map.


**Step 1**
Start with a central concept. Write this in the middle of a piece of plain paper that is orientated landscape.


**Step 2**
Draw a reasonably sized (coloured) memorable image that represents the topic you are going to be mapping.




**Step 3**
Draw branches from the central theme. Using a different colour for each branch is useful. Write key words along these branches that represent what information will be included on this branch.




**Step 4**
Draw additional branches that extend from your main branches. Add appropriate images where you can. Keep expanding the mind map.

## Mind Mapping Rules

Use symbols  Keywords on lines  Lines of different colour, size, styles

Upper and lower case to emphasise  Vary colours  Key headings  lists

Use the A3 templates you've been given to organise your information and produce a mind map to show the main features of each eruption.

**Human Geography**
Things that are to do with people.

population  urban environments  economic  development  culture  history

**Physical Geography**
Things that are to do with the natural environment.

geomorphology  hydrology  natural resources  ecosystems  relief  climate

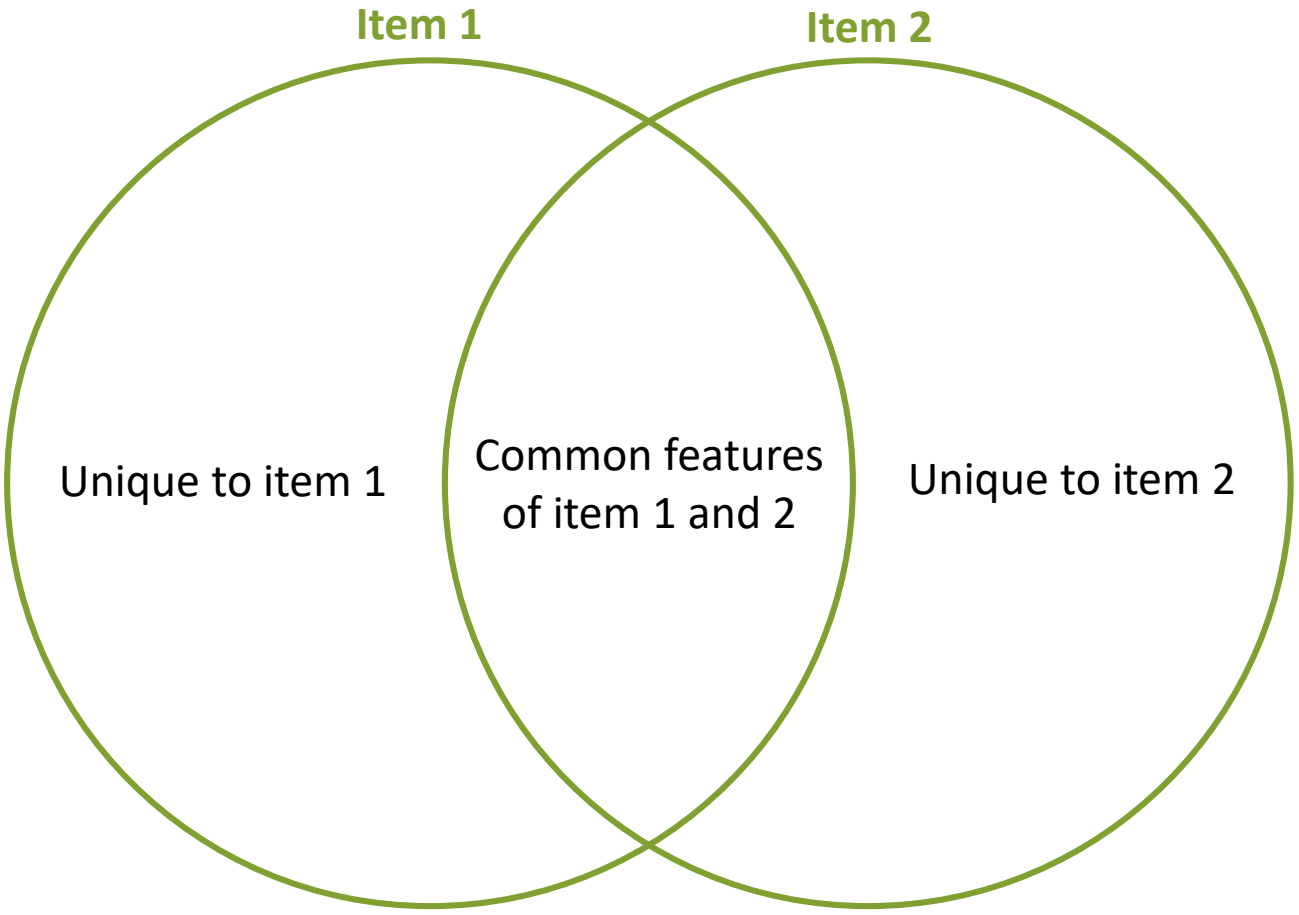
# Challenge 4 – Compare and Contrast



Being able to compare and contrast is a useful skill to have when studying at a higher level. A useful tool to do this is a Venn Diagram. Venn Diagrams show the relations between multiple sets of information. The guide below illustrates how to use a Venn Diagram to compare and contrast two things.

## Creating a Venn Diagram

1. Draw two circles that overlap (as shown below)
2. Identify the things you are comparing and contrasting
3. In the area below item one, identify everything that only applies to item one
4. In the area below item two, identify everything that only applies to item two.
5. In the area where the circles cross over, identify everything the two items have in common



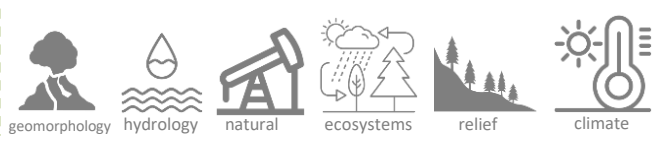

Use the A3 template you've been given to create a Venn Diagram to compare and contrast the two eruptions you have been studying.

**Human Geography**

Things that are to do with people.


**Physical Geography**

Things that are to do with the natural environment.



# Challenge 5 – Revise It

In preparation for completing some questions based on your learning, you are going to spend some time revising the two case studies. To do this, you are going to try a different approach to revision called the Leitner Box. The Leitner Box was developed by a German scientist called Sebastian Leitner and is a really effective, easy to develop practice and recall system. The approach involves using flash cards to learn and recall information. To begin with, you will need to develop a bank of flash cards covering the main aspects of the two volcanic case studies. Follow the guide below to create your flash cards. Flashcards should be used to test your knowledge, not just as a way to condense your notes further.

1. Ensure that the flashcards have a question or key term on one side and the answer or definition on the other.
   - The flashcard must work the memory.
   - If flashcards only contain notes then no retrieval practice will be happening.

2. Ensure the right questions and knowledge are on the cards.

3. Keep the information as short as possible. You are condensing the information you have.

4. Write clearly. You should be able to read what you wrote at a very quick glance.

Leitner recommends that when we have a large amount of information to learn on flash cards we tend to focus on those we already know and avoid the ones we find difficult. To avoid this, create four sections in your storage box (or what ever way you are storing your cards).

**Box 1**
Here you put the cards for frequent practice. This is the stuff that needs regular review because you're not remembering it. Spend around 40% of your time on these. When you are confident and fully recall a card, move it to box 2.

**Box 2**
Around 30% of your time is spent here. These are cards that have only just moved out of box 1, or cards containing information that still trips you up. If you're not remembering it, move it up to box 1 or down to box 3 if you've regularly recalling it.

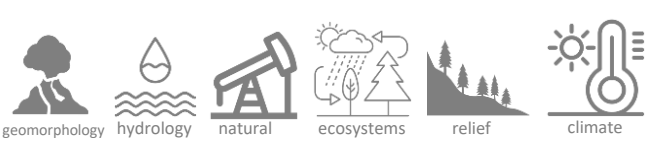
**Box 3**
Spend around 20% of your time here. These are the cards you can almost always recall. You feel confident about the content, even though some might be complex. If you make any mistakes in recall, move the card up to box 2.

**Box 4**
You'll start with only a few cards here. This is the material you feel is easy to recall. You always get it right, therefore you only spend 10% of your time checking the cards here. However, it is key that nothing ever leaves this box as you know it so well.

Test your self with the information on your cards. Have a friend or family member check your ability to recall the information on the cards. Repeat until all cards are in box 4.

**Human Geography**
Things that are to do with people.


**Physical Geography**
Things that are to do with the natural environment.



# Challenge 6 – Assess It



No one likes a test. However, completing practice questions can really help develop your knowledge as well as your ability to apply this to demonstrate understanding. Over the next couple of pages are a selection of A Level transition questions to have a go at.

1. State what is meant by the term tephra [2]

2. Use Figure 1 to describe how Iceland's location on the Mid-Atlantic Ridge constructive plate boundary had led to its distinctive tectonic landscape. [4]

3. Explain the process of subduction at the oceanic-oceanic crust convergent plate boundary, as shown in Figure 4. [4]

4. Outline the characteristics of an explosive eruption. [4]

5. Outline the main hazards from lava flows [4]

6. Suggest why pyroclastic flows can be so hazardous, making reference to the text on the La Soufrière eruption on page 7 of the resource booklet. [3]

7. Compare and contrast the tectonic settings for Iceland and St Vincent and the Grenadines. [4]

8. Suggest why vulnerability to tectonic hazards may vary between Iceland and St Vincent and the Grenadines. [4]

9. Outline the specific impacts experienced by people in Iceland and St Vincent and the Grenadines - use the following sub-headings: Social/political; Economic; Environmental. [8]

# Challenge 7 – Essay



You're going to be so excited by this! You will often be expected to write essays when studying at key stage 5. I know, exciting eh? To get you on the road to effective essay writing you're going to be guided through an A-level style essay question. The question we're going to have a go at is:

With reference to the Fagradalsfjall and La Soufrière eruptions, assess the extent to which economic development affects the ability to cope with exposure to tectonic risks. [15]

Exam questions at key stage 5 can be worth up to 20 marks.

## Essay Guide

1. Read the question and BUG it - BOX the command word; UNDERLINE the focus; GLANCE back to check you have answered it properly.
2. Remind yourself what the command word wants you to do - ASSESS wants you to make an informed judgement.
3. Start off with a brief introduction - open with your judgement as this then provides you with a focus to base the structure of the rest of your essay on - try to include some key vocabulary early on. If you demonstrate that you understand the key terms mentioned in the question and the command words you are off to a confident start!
4. Introduce the Fagradalsfjall eruption - discuss the impacts of the eruption along with the management, monitoring and response. You need to make multiple points to support your arguments - and refer back to the link to economic development throughout. Bring in examples from the text - but don't just copy extracts of information - you need to do something with that information to demonstrate your understanding. Make a counter argument if appropriate.
5. Then introduce the La Soufrière - and do the same as above, but this time introduce some comparative language such as 'whereas', 'on the other hand' to link it to the Fagradalsfjall eruption, as well as back to the question.
6. Remember 'PEEL - Point -> Evidence -> Explanation -> Link back to the question' throughout your discussion - this keeps your argument clear throughout, and ensures that you are answering the question.
7. Remember chains of reasoning - elaborate your explanations with phrases like ' this means that….', ' this leads to…', 'this results in….'
8. Finish off with a conclusion - draw together the different points you have made in your essay - make sure you summarise your arguments and reiterate your original judgement and link back to the question (which in this case is about the link between economic development and the ability to cope with tectonic hazards - specifically in the context of Iceland and St Vincent and the Grenadines).

Ready to give it a go? Using the following pages (and the guide above), have a go at writing your first essay. All that is expected is that you give it your best shot!

# Fagradalsfjall

## Introduction

1 On Friday 19th March 2021, a volcanic eruption began near the capital, Reykjavik, in southwest Iceland. The eruption near Mount Fagradalsfjall, about 20 miles southwest of Reykjavik, took place at 8:45 pm local time. Molten rock breached the surface in a valley near a flat-topped mountain named Fagradalsfjall (beautiful valley mountain), in the region of Geldingadalur (Dale of the Geldings), six miles from the nearest town.

## Context

2 Iceland is a Nordic island country in the North Atlantic Ocean, with a population of 356,991 and an area of 103,000 $km^2$ (40,000 sq. mi), making it the most sparsely populated country in Europe. The capital and largest city is Reykjavík. Reykjavík and the surrounding areas in the southwest of the country are home to over two-thirds of the population. Iceland is a **high-income country** with the world's eighth highest GNI per capita of $73 000. Iceland gained independence from Denmark in 1918 and founded a democratic republic in 1944. Iceland has a market economy with relatively low taxes, compared to other **OECD** countries. Iceland ranks high in economic, democratic, and social stability, as well as equality.

3 The country's economy is dominated by fishing, finance, biotechnology, and manufacturing. However, the tourist industry is expanding, aided by extensive marketing by the government. 1.7 million people visited Iceland in 2016, 3 times more than the number that came in 2010.

## Iceland's tectonic setting

4 Iceland frequently experiences earthquakes and volcanic eruptions because it is located on the **Mid-Atlantic Ridge** tectonic plate boundary, which separates the Eurasian and the North American plates, forming a **divergent** (constructive) **plate margin** (see figure 1). The ridge, an underwater mountain chain, extends about 16,000 km along the north-south axis of the Atlantic Ocean. Molten magma from beneath the Earth´s crust constantly wells up, cools, and is pushed away from the ridge´s flanks, widening the gap between the continents in the process.

5 Iceland formed by the coincidence of the spreading boundary of the North American and Eurasian plates and a hotspot or **mantle plume** - an upsurge of abnormally hot rock in the Earth´s mantle. As the plates moved apart, excessive eruptions of lava constructed volcanoes and filled **rift valleys**. Subsequent movement rifted these later lava fields, causing long, linear valleys bounded by parallel faults. The divergence of the ridge started in the north about 150 million years ago and 90 million years ago in the south. These movements continue today, accompanied by earthquakes, reactivation of old volcanoes, and the formation of new ones.

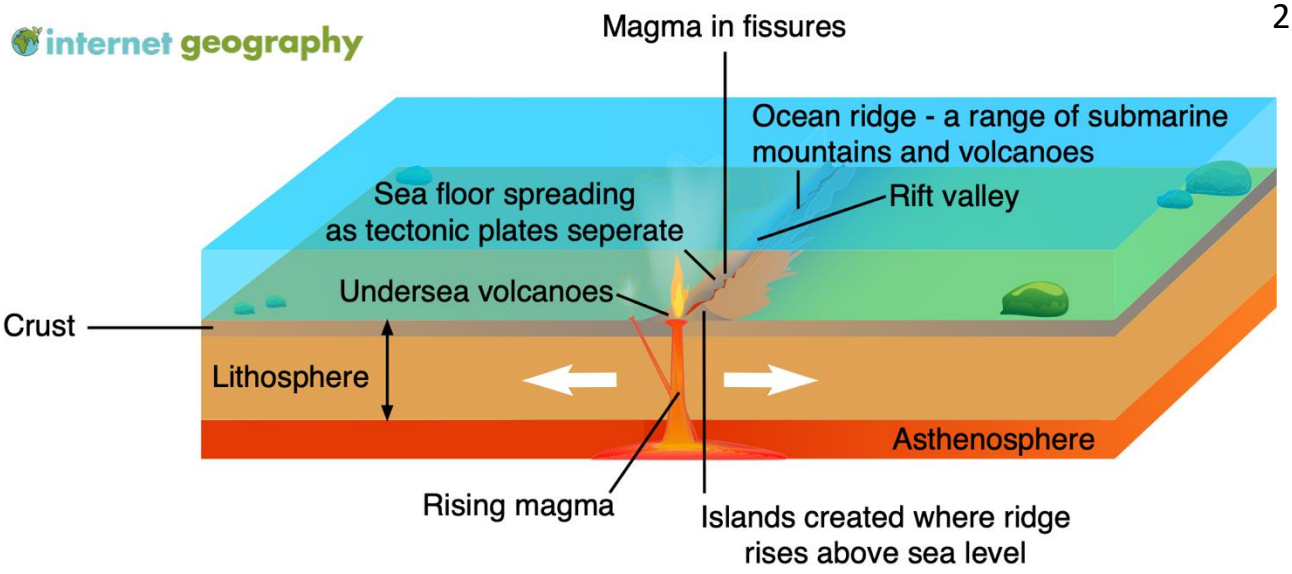



Figure 1 – A constructive plate boundary

6 Iceland is the largest island on the ridge because of the additional volcanism caused by the hotspot under the country, the Iceland plume. Eruptions occur about every 5-10 years and primarily consist of **basaltic lava** and **tephra**. The last major eruption on Iceland was in 2010.

### The eruption

7 In the four weeks leading to the eruption, more than 50,000 earthquakes occurred on the Reykjanes Peninsula in Geldingadalur valley, close to Fagradalsfjall, a mountain 20 miles southwest of the capital Reykjavik. The earthquakes were a significant increase from the 1,000-3,000 registered each year since 2014. Several of these earthquakes exceeded magnitude 5. The tremors are caused by rising magma and tectonic movement.

8 On at 8.45 pm (local time) on Friday 19th March 2021, a **fissure** (crack in the Earth's surface), approximately 200 m long, opened, releasing lava. Though considered minor, the eruption spewed more than 10 million square feet of lava, sometimes in fountains reaching heights of more than 90 m. Local people were alerted to the eruption when a series of small lava fountains turned the night sky red.

9 Meteorologists said the eruption was small. The area is uninhabited, so the eruption is not expected to present any danger. Following the initial eruption, lava was trapped within the Geldingadalur valley (which needed to fill with lava at least 25 to 30 metres thick before it pours out of the valley). However, the lava has now flowed beyond its boundaries.

10 The eruption is the first in the area, the Reykjanes Peninsula, in 781 years. It is the first time this particular volcano has erupted in about 6,000 years.

11 The initial eruption led to around 300,000 cubic metres (10.5 million cubic feet) of lava have poured out. However, experts deem the eruption to be relatively small and controlled.

12 Lava first poured out of a meandering fissure, however over the first weekend, the eruption focused its output on a single spot, building a steep, towering cauldron of freshly cooled rock. Smooth rivers of lava crept around blockier, rubble-like lava.

13 Vulcanologists describe the eruption as "**effusive**". Lava flows out of the volcano onto the ground instead of being "explosive", wherein magma, along with ash, is violently fragmented and rapidly expelled from a volcano.

14 Throughout the eruption, ejected molten lava has landed on the sides of the **vent** and solidified. Over time, this builds a cone around the vent. This is typical of effusive fissure eruptions of **low viscosity**, basaltic lava. The spatter cone is relatively weak and is susceptible to collapse. When this occurs, large volumes of lava flow rapidly out of the cone as unconfined lava. These events are unpredictable and can immediately change the direction and speed of a lava flow.

15 Scientists suggest the heightened volcanic activity represents a transition from a gradual opening of the Mid-Atlantic rift to a considerably more dramatic phase when both sides of the Reykjanes Peninsula rapidly separate. When a geologic rift quickly pulls the land apart like this, it creates a space, and magma rushes up to fill it in, causing Icelandic lava eruptions.

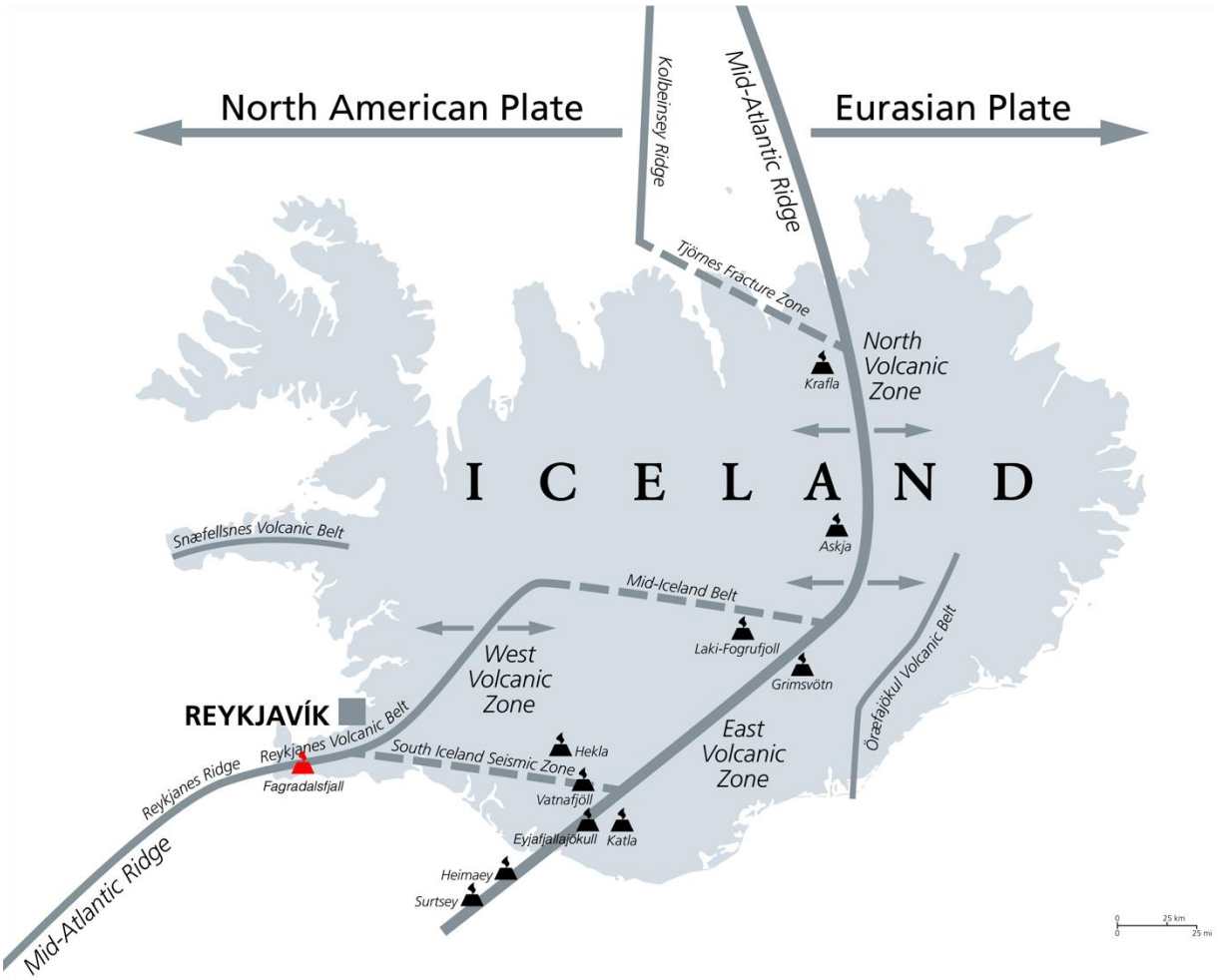



Figure 2 – Iceland's tectonic setting

16 Studies of the lava by vulcanologists indicate that the magma is a primitive basalt that originates from deep within the Earth's mantle.

### Hazards

17 The main hazard from the eruption is the potential danger of toxic sulphur dioxide gas. This gas can pose a deadly and silent threat to human populations. Acid rain is produced when $SO_2$ combines with atmospheric water, enhancing weathering and damaging crops and polluting surface water and soils.

18 Another hazard posed by the eruption is the collapse of the fragile volcanic cones formed from **lava spatter**. The failure of the delicate cones can lead to rapid lava flows along with avalanches of hot, volcanic rock.

19 As the area is very active, fissures can quickly form, presenting a risk to tourists visiting the site. Additionally, as the lava has a **low viscosity**, it can flow rapidly.

### Implications for people living in tectonically active areas

20 The site was initially closed to the public until officials had completed safety assessments. From the afternoon of Saturday 20th, March 2021, people were allowed to trek to the site. People made the difficult hike to the area over the weekend to witness the eruption up close, and local helicopter companies offered tours from Reykjavik.

21 By Monday, the site was closed again due to high gas pollution levels and poor weather conditions. Emergency services had to rescue several people from the area on Sunday night, following reports of missing people.

22 The earthquakes that preceded the eruption have mostly subsided now that magma has reached the surface.

23 The current volcanic activity is very different from the 2010 eruption of Eyjafjallajökull, a stratovolcano that led to the eruption of millions of ash and gas into the atmosphere, closing European airspace. It is not anticipated the current eruption will release significant quantities of ash or smoke into the atmosphere.

## Why do people live in tectonically active areas?

24 Iceland is a pioneer in the use of **geothermal energy** for space heating (see figure 3). Generating electricity with geothermal energy has increased significantly in recent years. Geothermal power facilities currently generate 25% of the country's total electricity production.

25 Since the eruption of Eyjafjallajökull in 2010, the government has promoted Iceland's unique volcanic environment leading to a boom in international tourism.

### Management, monitoring and response

26 The Icelandic Meteorological Office (IMO) is not only Iceland's national weather service, it is also responsible for monitoring volcanic and seismic activity. The IMO has an extensive network of seismic monitoring stations across the country. The IMO said the eruption of Fagradalsfjall began at about 20:45 GMT on Friday and was later confirmed via webcams and satellite images.

27 A coastguard helicopter was immediately sent to survey the area, about 30 km (19 miles) from Reykjavik.

28 Immediately following the eruption, Iceland's prime minister Katrín Jakobsdóttir announced on Twitter, "A volcanic eruption has begun in Fagradalsfjall on the Reykjanes peninsula. We are monitoring the situation closely, and as of now, it is not considered a threat to surrounding towns. We ask people to keep away from the immediate area and stay safe".

29 A coastguard helicopter was sent to survey the area, about 30 km (19 miles) from Reykjavik.

30 Following safety assessments, the government opened the eruption site to the public after several days. As the site is remote and difficult to access due to the uneven surface formed from previous lava flows and a 90-minute hike from the nearest main road, authorities marked out routes to access the site. The paths resolved the problems caused by people becoming lost in the dark in the early days of the eruption.

31 Monitoring equipment has been installed at the site, including devices to measure $CO_2$ levels and webcams to monitor the eruption.

32 Conditions at the site are continually monitored, with daily notices issued to the public regarding the site's safety. High $CO_2$ levels, dangerous weather conditions and volcanic activity have led to the area being temporarily closed to the public since the initial eruption.

Figure 3 – A geothermal energy plant in Iceland

# La Soufrière

## Introduction

33 On Friday 9th April 2010, the La Soufrière volcano erupted in the northern part of the Caribbean island of St Vincent (part of St Vincent and the Grenadines), about 20km north of the capital of Kingstown. An explosive eruption began at 8:41 am local time, sending an ash plume 8 km into the sky. La Soufrière is the highest peak on the island of St Vincent, and the highest point in the country, at 1,234 m above sea level (4,049 ft), and is the island's youngest and northernmost volcano.

## Context

34 The island of St Vincent is part of the island chain country of St Vincent and the Grenadines, located in the southeast Windward Islands, which form part of the West Indies, where the Caribbean Sea meets the Atlantic Ocean. St Vincent and the Grenadines has a population of 110,211 and an area of 369 $km^2$ (142 sq. mi). The country is made up of the main island of Saint Vincent and the northern two-thirds of the Grenadines. The Grenadines are a chain of 32 smaller islands - some of which are inhabited, whilst others are not. The capital and largest city is Kingstown in the south-west of the island of St Vincent, which is also the island's main port. St Vincent and the Grenadines is a **low-income country** with a GNI per capita of $7,460. Formerly a British colony, the country became the last of the Windward Islands to gain independence in 1979, although Queen Elizabeth II is still the Head of State. St Vincent and the Grenadines is a democratic country with no formal armed forces. The country's economy is dominated by agriculture, and in particular banana production, however, the tourist industry is growing rapidly, aided by improvements to the country's infrastructure.

## St Vincent's tectonic setting

35 La Soufrière (also known as Soufrière Saint Vincent) is an active **stratovolcano**. Stratovolcanoes are also known as composite volcanoes as they are built up of many layers of hardened lava and tephra, and have a steep profile with a **crater lake** at the summit. They are conical in shape as their highly **viscous lava** typically cools and hardens before spreading out too far. The magma below ground is often **felsic** (igneous rocks that are rich in the elements that form feldspar and quartz).

36 The island of St Vincent is vulnerable to volcanic eruptions because it is located on the **convergent** (destructive) **plate margin** separating the North American Plate from the Caribbean Plate. At this boundary the two plates are moving towards each other. The North American Plate, which is the denser of the two, sinks beneath the Caribbean Plate, which causes the North American Plate to melt, forming magma, which then rises to the surface when it can erupt forming a volcano. This process is called

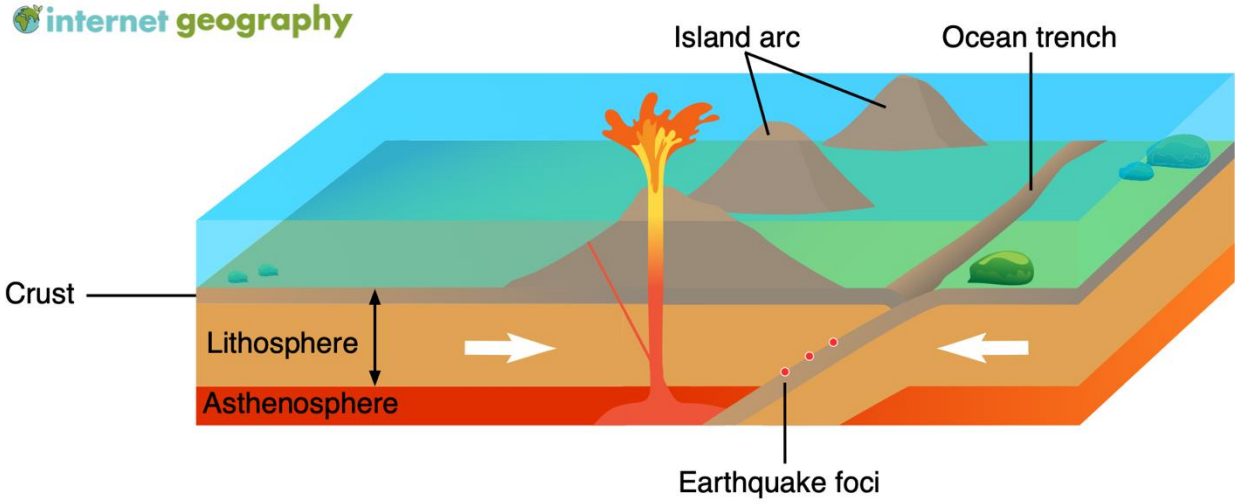



Figure 4 – An oceanic-oceanic crust convergent plate boundary

**subduction** and is what formed the volcanic islands, along with their steep-sided conical peaks, of the Eastern Caribbean.

37 La Soufrière has experienced five explosive eruptions since records began, in 1718, 1812, 1902, 1979 and 2021, with the most deadly event in 1902 which killed 1,680 and left a further 600 people badly burned, and another 4,000 homeless. It also wiped out the last of the **indigenous** Carib **population**. The crater lake had been reformed within five years of this eruption so the volcano was considered no longer active. The 1979 eruption had no confirmed casualties as the government put in place an effective evacuation plan, moving residents to the safety of nearby beaches.

### The eruption

38 La Soufrière had been dormant since 1979, but in late 2020 started showing signs of activity - rumbling and spewing steam and smoke. On 27th December a new lava dome had been formed by an **effusive eruption**, so the government began to review their evacuation plans throughout January 2021 in case the effusive eruption showed signs of becoming explosive. During this time the **lava dome** grew to 100m tall, 200m wide and 900m long, and continued to expand further throughout February, when it also began to emit gas and steam plumes from the summit, as well as small rock falls, and there were clear signs of damage to vegetation. By the end of March the lava dome measured 105m tall, 243m wide and 921m long. During early April monitoring observed a sustained increase in volcanic and seismic activity, including regular small earthquakes which were felt in the nearby communities of Fancy and Chateaubelair. On Thursday 8th April a lava dome was clearly visible, causing the government to declare a red alert, ordering 16,000 people to evacuate the area around La Soufrière as an explosive eruption was imminent. Residents of St Vincent were housed temporarily on the neighbouring islands of Antigua, Barbados, Grenada and St Lucia. However the evacuation effort was hampered by Covid-19 as the Prime Minister Ralph Gonsalves announced that people must be vaccinated in order to board the cruise ships or be granted refuge in other countries.

39 At 8:41 local time on Friday 9th April 2021, La Soufrière erupted in an explosive manner. The plume of volcanic ash reached approximately 8,000m into the sky and began to drift eastwards towards the Atlantic Ocean. Explosions were observed over the following days - a second explosion occurred that evening, with a third on 11th April. White-coloured dust covered buildings and roads around the island, including the capital of Kingstown. The presence of thick ash and smoke closed air space over the island, and caused power outages as well as disruptions to food and water supply. In the early hours of Monday 12th April, a huge eruption triggered **pyroclastic flows** down the volcano's south and south-west flanks.

### Hazards

40 Throughout both the effusive and explosive phases of La Soufrière's activity, a significant amount of toxic sulphur dioxide was released into the atmosphere - which poses a silent, yet deadly threat to people. Sulphur dioxide also combines with water in the atmosphere which produces acid rain, which causes an increase in

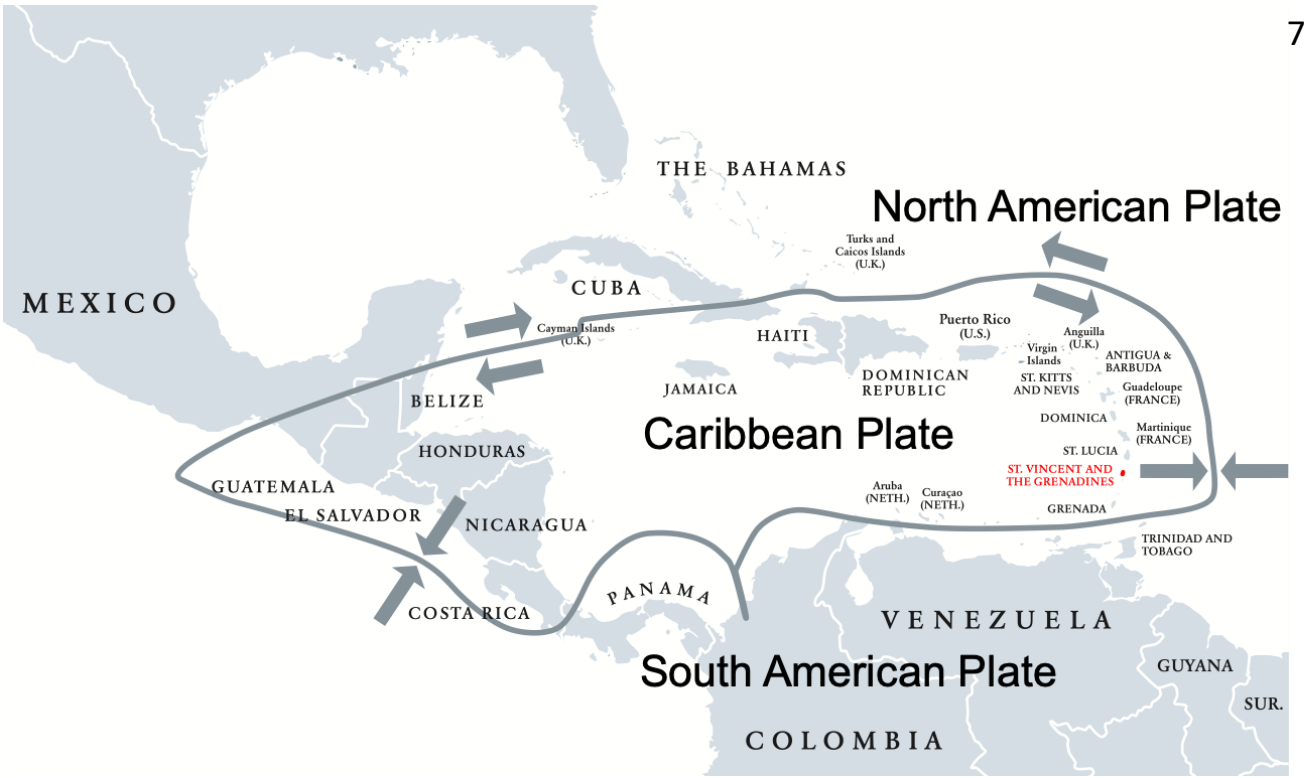



Figure 5 – St. Vincent and the Grenadines tectonic setting

**chemical weathering**, as well as contaminating water and causing extensive damage to crops. The impact on crops is particularly problematic in a low income country like St Vincent and the Grenadines, where farming provides the livelihood of a significant proportion of the population.

### Implications for people living in tectonically active areas

41 La Soufrière is located in the north of St Vincent, so the northern half of the island was most severely affected. Although 16,000 residents evacuated, 3,200 stayed in government shelters, with another 20,000 people needing shelter. Nearby countries sent emergency supplies, such as water, food and medicine. The UN warned of a **humanitarian crisis**, exacerbated by Covid-19 - with major concerns over the lack of water and positive cases being reported in the crowded shelters. The government has warned the 16,000 residents who have been evacuated that they may be displaced for 3-4 months.

42 The impact on agriculture is significant. Many people in low income countries, such as St Vincent and the Grenadines, choose to live around the slopes of volcanoes as lava and ash add nutrients to the soils, making them more fertile, and therefore increasing crop yields. However this eruption was so explosive that the blanket of ash destroyed all crops and killed livestock, which will take years to recover from. A number of houses also collapsed under the weight of the ash.

43 When La Soufrière erupted it released an ash plume of approximately 10,000m. Huge plumes of smoke reached the neighbouring island of Barbados, 190 km away, with residents being urged to stay indoors due to the harmful gases, and being warned of weeks of falling ash, which could make driving conditions hazardous. People on St Lucia, 76 km north of St Vincent, have also been warned to expect air quality to be affected, with harmful gases potentially causing breathing difficulties for people with asthma and other respiratory conditions.

### Why do people live in active regions?

44 St Vincent and the Grenadines is a low income country and its economy is dominated by agriculture, and in particular banana production. Because the majority of residents earn their living through farming they choose to live around the slopes of La Soufrière, as lava and ash historically have added nutrients to the soils, increasing fertility and thus crop yields. Volcanic rocks are extremely tough and resistant so also provide good building materials.

### Management, monitoring and response

45 In December 2020 volcanologists were on high alert after observing that La Soufrière was experiencing increased activity, with monitors reporting tremors, gas emissions, the formation of a new volcano dome and changes to its crater lake. During late December government officials communicated their concerns with residents and began to review evacuation plans in case an explosive eruption was imminent.

46 Throughout January and February 2021, scientists continued to monitor activity - measuring the dome and recording temperatures, as well as observing gas emissions and steam plumes. On 1st February sulphur dioxide emissions were detected, suggesting that groundwater was beginning to dry up. On 7th February the same group of scientists recorded a five degree increase in temperatures and detected hydrogen sulphide at the Willibou Hot Spring, prompting the National Emergency Management Organisation (NEMO) to warn the public to stay away from the volcano.

47 Throughout March the monitoring team continued to observe gas and steam emissions, and on 23rd March the Regional Monitoring Network detected a series of low-frequency seismic events, lasting approximately 45 minutes, caused by magma movement beneath the dome. These escalated into a number of small volcanic earthquakes felt in the neighbouring communities over the next few days. They also observed the continued growth of the lava dome, along with steam and gas emissions, and another series of volcanic earthquakes, which had increased in intensity.

48 On 8th April scientists deemed that an explosion was imminent, so the island was put on Red Alert, with an evacuation issued by the government to 16,000 people in the area surrounding the volcano. Neighbouring countries agreed to take in evacuees, however people were not allowed to the cruise ships used in the evacuation or be granted refuge on another island, without Covid-19 vaccine. Shortly after the explosion the International Volcanic Health Hazard Network warned residents of the risk from ash and sulphur dioxide to asthmatics and others with chronic health conditions.

49 From 11th April neighbouring countries stepped up their efforts to provide assistance. Venezuela sent humanitarian supplies to aid the relief effort, along with risk experts and the Barbados Defence Force was deployed to provide further humanitarian assistance and disaster response. Trinidad and Tobago sent 50 members of their defence force to provide medical, logistical and infantry support, Grenada pledged more than $1 million in emergency supplies, including food and water, and both Montserrat and St Kitts and Nevis offered aid packages including money and essential supplies. Caribbean mobile phone network Digicel, offered to donate £500,000 of essential items to NEMO.

50 Further afield, the UK announced a £200,000 package to immediate **humanitarian aid**, along with technical experts to help restore critical infrastructure like transport links and communications. The UN Environment Programme agreed to help remove debris and ash, and agreed to consider the request from PM Ralph Gonsalves, and the World Bank announced financial aid of $20 million from its Catastrophe Deferred Drawdown Option.

# Glossary

**Basaltic lava** – A thin, very fluid lava, that forms dense igneous rock when it cools.

**Chemical weathering** – The breakdown of rock in situ, caused by chemical reactions.

**Convergent plate margin -** A tectonic boundary where two plates are moving toward each other.

**Crater lake** - a lake in a crater formed by explosive activity or a collapse during an eruption.

**Effusive eruption** - a type of eruption where lava steadily flows out of the volcano onto the ground.

**Divergent plate margin** - A tectonic boundary where two plates are moving away from each other and new crust is forming from magma that rises to the Earth's surface between the two plates.

**Felsic** - describes igneous rocks that are rich in elements that form feldspar and quartz.

**Fissure** – A linear fracture on the Earth's surface through which lavas, pyroclastic flow and gas are erupted and effused.

**Geothermal energy** – Energy obtained by tapping underground reservoirs of heat, usually near volcano es or other hot spots on the surface of the Earth.

**High income country (HIC)** – A nation with a gross national income per capita of US$12,536 or more in 2019.

**Humanitarian aid** – Providing material and logistic assistance to people who need help.

**Humanitarian crisis** - An event or series of events that represents a critical threat to the health, safety, security, or wellbeing of a community or other large group of people, usually over a wide area.

**Indigenous population** - Communities that live within, or are attached to, geographically distinct traditional habitats or ancestral territories, and who identify themselves as being part of a distinct cultural group, descended from groups present in the area before modern states were created and current borders were defined.

**Lava dome** - circular mound shaped protrusion resulting from slow extrusions of viscous lava.

**Lava spatter** - Blobs of lava thrown a little ways into the air (by expanding gases) that is still molten when it lands.

**Low viscosity** - Substances that are thin and runny.

**Mantle plume** - An upwelling of abnormally hot rock within the Earth's mantle.
**Mid-Atlantic ridge** -

**Organisation for economic co-operation and development (OECD) -** intergovernmental economic organisation with 37 member countries, founded in 1961 to stimulate economic progress and world trade.

**Pyroclastic flow** – A dense, destructive mass of very hot ash, lava fragments, and gases ejected explosively from a volcano and typically flowing at great speed.

# Glossary

**Rift valley** - A steep-sided valley formed by the downward displacement of a block of the earth's surface between nearly parallel faults or fault systems.

**Stratovolcano** - steep conical volcano built up of many layers (strata) of hardened lava and tephra - also known as composite.

**Subduction** - The sideways and downward movement of the edge of a plate of the earth's crust into the mantle beneath another plate.

**Tephra** - fragmental material produced by a volcanic eruption.

**Vent – A hole or fissure in the ground from which lava and other volcanic products emerge.**

**Viscous lava** – Molten rock above the Earth’s surface with a high silica content that is thick.