

Iceland: Living with Volcanoes

This is one of a series of five programmes produced by Pumpkin Interactive about natural hazard events. Each is suitable for GCSE and post-16 Geography courses, particularly AS, A2, Scottish Higher and pre-U.

This programme deals with volcanic eruptions and landscapes in Iceland, and the ways in which people have responded and tried to manage the threat of eruptions. The programme provides an excellent case study of volcanic eruptions, of volcanic landscapes, their primary and secondary effects, and the attempts to manage the risk from volcanoes for those living in Iceland and beyond. It also analyses some of the considerable economic benefits for Iceland's population from volcanic activity, such as geothermal energy.

PUMPKIN *Specialist producers of high quality DVDs.*

.....
Phone: + 44 (0) 1179 240 250

Fax: + 44 (0) 560 209 6668

Post: 22A Backfields, Lane, St Pauls, Bristol, BS2 8QW

Web: www.pumpkin-interactive.co.uk

Email: orders@pumpkin-interactive.co.uk
.....



Contents

p.3 Teachers' Notes

p.4 Teachers' Guidance 1. Exam course specification links

- This contains links to show how the programme matches different pre- and post-16 specifications

p.5 Teachers' Guidance 2. Using this DVD for active learning

- This consists of ideas to help students learn effectively while watching the programme.

p.6-8 Teachers' Guidance 3. The geological background to volcanic landscapes

- This provides background information about geological processes that have led to the development of volcanic activity in Iceland.

p.9 Teachers' Guidance 4. Background to Iceland

- This provides background information about Iceland, and its economic development.

p.10-12 Teachers' Guidance 5. Finding out about Iceland

- Guidance on setting up small group enquiries to guide students in getting to know Iceland before they see the programme

p.13 Student Resource 1. Detailed map of Iceland

- Basic atlas features of Iceland

p.14 Student Resource 2. Iceland: Map and key data

- Basic location and features of Iceland

p.15 Student Resource 3. Notes from the programme

- A framework for student notes on the programme

p.16-17 Student Resource 4. Remembering the programme

- Remembering basic details
- Remembering the numbers
- **Teacher answer sheet**

p.18-19 Student Resource 5. Understanding the programme

- Knowing the key terms and Understanding the key points

p.20 Student Resource 6. What causes Iceland's volcanoes?

- Developing an understanding of Iceland's formation along a constructive plate margin

p.21 Student Resource 7. The eruption in pictures

- A photo interpretation exercise of volcanic landscapes and eruptions

p.22 Student Resource 8. The benefits of living in a volcanic area

- A photo exercise on some of the benefits of living in a volcanic area

p.23 Student Resource 9. The primary and secondary effects of the eruption upon Iceland

- Analysing primary and secondary effects of the eruption

p.24 Student Resource 10. Managing the risk from volcanic activity in Iceland

- Assessing the effectiveness of strategies to reduce the impact of a volcanic eruption

p.25 Student Resource 11. Winners and losers from volcanic activity in Iceland

- Who have the winners and losers been from volcanic activity in Iceland?

Teachers' Notes

There are five Teachers' Guidance Sheets. These provide guidance and background information for teachers about:

- Links between this programme and GCSE and post-16 specifications (Teacher Guidance 1, p.4).
- Using video resources in classrooms (Teacher Guidance 2, p.5).
- The geological background to volcanic landscapes (Teacher Guidance 3, p.6-8).
- Iceland, its background, level of economic development, and issues that it faces (Teacher Guidance 4, p.9).
- Guidance on setting up small group enquiries to guide students in getting to know Iceland before they see the programme (Teachers' Guidance 5. p.10-12).

Teachers will find it especially helpful to read the introductory information about the geological background to volcanic landscapes (Teacher Guidance 3, p.6-8) and Iceland itself (Teacher Guidance 4, p.9), which together provide:

- The geological processes which have led to the formation and development of Iceland.
- Background information and data about levels of economic development in the country.

Each is critical to understanding the impacts of eruptions on the Icelandic landscape, and how the population of Iceland manages to respond to the challenges of living in such a landscape. The notes will also assist teachers in handling the follow-up activities.

The principles of the programme and these exercises are that students should:

- Know about the location of Iceland, the nature of its physical environment, its volcanic landscapes and those associated with landscapes along constructive plate margins.
- Understand the reasons why volcanic landscapes and eruptions in Iceland are markedly different from, for example, landscapes along destructive plate margins.
- Develop skills in analysing the impacts of eruptions upon Iceland and its landscapes.
- Be able to judge some of the issues in managing risk which face Iceland's population.

Student Resource pages are numbered 1 to 11.

Bob Digby
August 2013

Teacher Guidance 1. Exam course specification links

The following links show how this programme matches different GCSE and AS/A2 specifications.

1. Pre-16

AQA GCSE Geography A

- * Unit 1 Section A, Restless Earth
- * Unit 2 The Development Gap; a case study of a natural hazard in a developing country

AQA GCSE Geography B

- * Unit 2 Section A Living with natural hazards

Edexcel GCSE Geography A

- * Unit 2 Topic 3 A case study of a volcanic eruption

Edexcel GCSE Geography B

- * Unit 1 Topic 1 Restless Earth

Edexcel iGCSE

- * Section A Topic 3 Hazardous environments

OCR GCSE Geography B

- * Theme 3 Natural Hazards

WJEC GCSE Geography A

- * Unit 1 Core A Theme 3 Living in an Active Zone

2. Post-16

AQA A level Geography

- * Unit 3 A2 Plate tectonics and associated hazards

Edexcel A level Geography

- * Unit 1 AS World at risk (vulnerability, risk and hazards)
- * Unit 4 A2 Tectonic landscapes

OCR A level Geography

- * Unit 3 A2 Option A1: Earth hazards - volcanoes

WJEC A level Geography

- * Unit G1 Theme 2 AS Theme 2 – Investigating Tectonic and Hydrological change

IB Geography

- * Part 2 Optional Themes: Hazards and disasters— risk assessment and response

Pre-U Geography

- * Paper 1 Geographical Issues: Section A - Tectonic Hazards

Scottish Higher Geography

- * Unit A2 Option C: The Dynamic Earth

Teacher Guidance 2. Using this DVD for active learning

Watching a TV programme can often be interpreted by students as a passive experience. Jane Ferretti (2009) has followed Margaret Roberts' work (1986) on the attention given to narration rather than pictures on a DVD; asked to make notes, students more often than not make notes on what is said and not what they see. The strategies below help to engage students in different ways to help them make sense of the programme.

1 Describing

- Select scenes (e.g. scenes showing footage of volcanic eruptions) and ask students to describe in detail – e.g. '20 words to describe what is happening.'
- Ask students to describe a scene (e.g. the nature of an eruption, and ash cloud). This is especially effective if done without the sound.
- Reverse the process; ask students to predict what pictures are being shown, and details about these, by listening to the narration but with the screen picture turned off. This could be done for footage showing some of the impacts of the Heimaey eruption of 1973.

2 Understanding

- Before a clip, (e.g. the nature of the eruption) give students specific things to look for.
- Freeze-frame scenes and discuss students' understanding of what is being shown.
- Give students comprehension questions – but beware that they may be listening to the narration, with eyes down, rather than watching the picture.

3 Listening

- Give students a list of key words to listen out for, and then identify their meaning.
- Ask students to identify key words or phrases, and define these, based on the narration. Some ideas for these are given in Student Resource 5, 'Understanding the programme' (p18-19).

4 Creative follow-up

- **Role-play Interviews.** Here, students work in interview pairs. One acts as a journalist, devising questions for the second, who acts as the person being interviewed e.g. a resident of Iceland who believes that the volcanic landscape brings advantages to Iceland. A 5-minute interview follows which can either be done privately in pairs or by 'hot seating' in front of the class. Students then feed back about the interviews.
- **Information Gap.** You need two rooms for this. Half the class watches part of the programme without sound, while the other hears it without pictures. Each then discusses what they think will a) be in the script, and b) shown as pictures. Students then return to class, pair up, discuss the situation and characters, and put together sounds and pictures. The teacher then shows the complete part of the programme.
- **Fractured scenes.** Write parts of the dialogue (included in this DVD) on strips of paper; place these in random order in envelopes, and ask students to re-sequence. Or, distribute strips randomly among students, and ask them to describe the scene in which their script occurs.

Further reading

- Ferretti, Jane (2009) 'Effective use of visual resources in the classroom' in 'Teaching Geography', Autumn 2009.
- Roberts, Margaret (1986) 'Using video' in 'The Geography Teachers' Handbook', Geographical Association.

Teachers' Guidance 3.

The geological background to volcanic landscapes

Iceland is an example of one of the world's oceanic Large Igneous Provinces (LIP). These are past landscapes which have been formed over millions of years. Some are modern (e.g. Iceland), while others are ancient (e.g. the Columbia River Basalts in the western USA).

Many LIPs consist of flood basalts – areas of extensive basalt, whose most likely cause is probably a series of vast magma plumes that led to long outpourings of basalt on the earth's surface. These are the product of 'hotspots' – places on the earth's oceanic crust where the temperature of magma in the mantle beneath the crust is hotter than usual. Just as a saucepan on a stove or an oven have places where the temperature is higher, so too does the earth's mantle. At places where the temperature is highest, 'plumes' of magma are forced closer to the earth's surface, breaking out where the continental crust is thinnest, and causing outpourings of lava. The table below shows how these compare with other landscapes formed at, for example, destructive plate margins.

	Mid plate hotspots	Rift zones / constructive plate margins	Destructive plate margins	Conservative plate margins
Examples	Iceland, Hawaii	East African rift valley / Red Sea	Cascade Ranges in the USA's Pacific NW	San Andreas fault
On land	Continental calderas	Extensional tectonic landscapes (rift valleys)	Compressional tectonic landscapes (orogenic belts)	Strike-slip fault zones
Transitional	Volcanic islands	Proto-oceans (Red Sea)	Island arc systems	
Sub-marine	Volcanic 'swarms' on the ocean floor	Submarine ridges	Deep sea trenches	Transform faults

The physical and human impacts of volcanic eruptions are a result of magma viscosity, which is itself the product of its gas and silica content, and temperature. The clue to understanding volcanic eruptions and subsequent landscapes lies in the chemistry of the lavas.

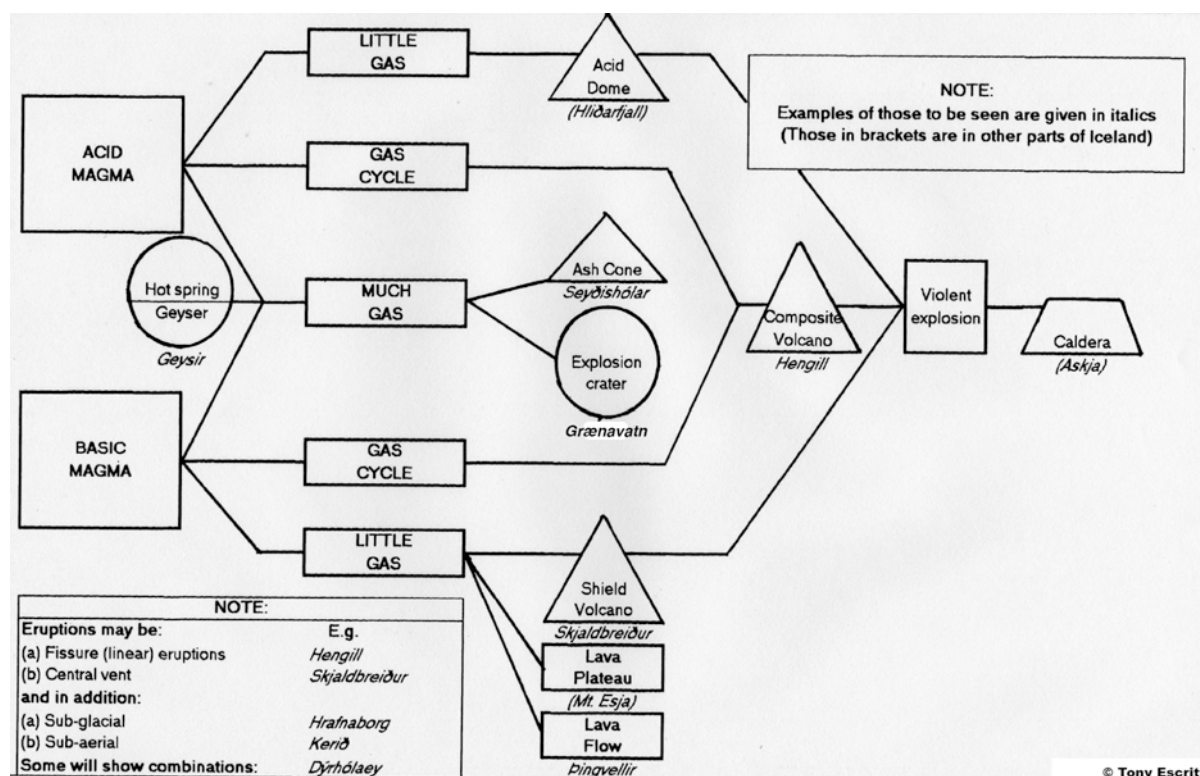
- The more viscous the magma, the rarer the eruption. Therefore, the rare eruptions on, for example, Montserrat, compare with the frequent – almost continuous – lava flows in locations such as the mid-Atlantic ridge (of which Iceland is a part) and Hawaii.
- Acidic lavas (see the table below) are rich in silica. Silica has a low melting point (about 600C) so its erupting lavas cool on exposure to the earth's atmosphere, solidifying close to the point of eruption. These produce steep-sided cones, such as the Soufriere Hills in Montserrat (about which Pumpkin Interactive has produced a further programme in this series).
- Basic lavas (see the table below) are lower in silica content. They are dominated more by metals, which have a higher melting point (about 1100C), so erupting lavas

are much hotter and cool less quickly on exposure to the earth's atmosphere. They often flow or spread a long distance from the point of eruption, and therefore produce shallow-sided shield volcanoes, such as many of the volcanic landscapes shown in this programme.

The table below summarises the differences.

Magma type and example	Eruption temperature	Gas content	Viscosity	SiO ₂ content
Basaltic lavas (basic) – mid-ocean plate spreading and hotspots e.g. Iceland	1100°C	Low	Low (Runny) – producing lava flows which extend over wide plateaus; also shallow-sloping shield volcanoes, lava swarms.	50%
Acidic lavas (rhyolitic, also known as felsic) – subduction zones where continental crust is destroyed e.g. Montserrat	800 °C	High	High (Sticky) – producing steep volcanic cones which have cooled rapidly, as well as explosive eruptions with pyroclastic flows	70%

Summary – understanding pattern and processes behind volcanic landforms



Provided with thanks to Tony Escritt.

A summary of the benefits of volcanic activity for people

The programme discusses many of the benefits of volcanic activity for people, the environment and the economy. Here is a summary of these.

USES OF VOLCANIC ACTIVITY	
Geothermal Power and Geothermal Heating Systems	<p>1: In Iceland the Geothermal Power Plant on the slopes of the Krafla volcano supplies the whole of North Iceland. It also supplies power to the National Grid when extra power is needed elsewhere.</p> <p>2: The 1973 lava on the island of Heimaey is still at 900 degrees C. and the heat has been harnessed for domestic heating.</p> <p>3: Most of Iceland's homes are now heated by geothermal heating.</p> <p>4: Other leading users of geothermal energy are New Zealand (Rotorua), USA (N. California) and Italy (Larderello).</p> <p>5: Theoretically any country has the potential for geothermal power.</p> <p>6: Even in Britain, where the last volcanic eruption was 50 million years ago we have tried to harness the deep, hot rocks in Cornwall.</p>
Tourism	<p>People are attracted by:</p> <p>1: Volcanoes and volcanic landscapes attract people - especially if active.</p> <p>2: Geysers, hot springs, warm rivers etc.</p>
Agriculture	<p>1: Glasshouse Cultivation: Iceland can grow bananas, tomatoes etc and is almost self-sufficient in horticultural produce inspite of its climate.</p> <p>2: Basaltic ash is potentially very fertile. On Mt. Vesuvius the high lime content has made the soils very fertile. Farms south of Eyjafjallajökull had their best crop yield immediately after the March/April eruption 2010.</p> <p>3: Icelanders have developed a way of using volcanic ash to speed up the growth of plants.</p>
Industry	<p>1: The building industry uses volcanic ash to make breeze blocks and stucco.</p> <p>2: Ash is used to make the foundations for roads and houses.</p> <p>3: Sulphur deposits can be quarried but hard to compete with huge, cheaper USA sulphur deposits.</p> <p>4: Diatomaceous Earth is extracted from the floor of Iceland's Lake Mývatn where the natural heat supplies minerals to the water, and prevents winter freezing so that diatoms live and die at a sediment accumulation rate of 1mm/yr. It is used for industrial filters, and gunpowder.</p> <p>5: Building: Ash can be used as a tough cement</p>
Other	<p>On the island of Heimaey the lava flow provided a protective harbour wall!</p>

© Tony Escritt: Volc-2

Provided with thanks to Tony Escritt

Teacher Guidance 4. Background to Iceland

Iceland is an island of about 103 000 km², about 40% of the size of the UK. It lies in the North Atlantic Ocean, about 65 degrees north, just short of the Arctic Circle. It lies along a constructive plate margin between the North American and Eurasian plates. Its location so far north of the Equator should give it a permanently cold climate, particularly during the almost continuous Arctic night between mid-November and early February, but it is warmed by the North Atlantic Drift. Its winters are therefore relatively mild and windy, while its summers are damp and cool; its mountains extend to over 1500 metres above sea level, and therefore experience cold mountain climates. Glaciers are extensive and cover 1/8th of the island. The exposure of recent volcanic lavas have given it some of the world's most spectacular tectonic landscapes, but the slow rates of weathering – combined with the cool, damp climate – means that arable farming takes place on just over 1% of the land area.

Located on a tectonic 'hotspot' (see Teacher Guidance 3, p.6-8), Iceland has frequent and severe volcanic activity. During Easter 2010, Eyjafjallajökull (1,666 m) erupted, causing rising plumes of ash high into the atmosphere, which seriously disrupted air traffic. Volcanologists monitor this and other nearby volcanoes such as Katla, which is likely to erupt in the near future, causing potentially the same levels of disruption. Grímsvötn and Hekla are its most active volcanoes.

It's a challenging environment in which to live. Iceland's rich cultural history is a result of its physical environment – witness, the existence of many ancient myths and legends – and, until recently, cultural isolation. Your students might well be interested in contemporary Icelandic music, so perhaps identify a few Icelandic artists such as Björk, Sigur Rós, and Of Monsters and Men. Imagery of ice, mountains, volcanism and the sea is used even in contemporary writing.

Development data for Iceland:

Population - 315,000 (2013 est.)

- Iceland's population growth is 0.66% per year (2013).
- Birth rate 13 per 1000, Death rate 7 per 1000, In-migration about 0.6 per 1000.
- Age structure: 0-14 years (19.8%), 15-64 years (66.9%), 65 years and over (13.2%)

Welfare data

- Infant mortality rate: 3.17 deaths/1,000 live births (2013).
- Life expectancy (2010): 81.1 years (19th in world rankings)
- Fertility rate: 1.88 children born/woman (2013 est.)
- Literacy: 99% (2003)
- Access to an improved drinking water source: 100%
- Access to improved sanitation facility: 100%

Economic data

Iceland's economy still relies heavily on fishing, which earns 40% of export earnings, 12% of GDP, and employs 5% of its workforce. Declining fish stocks are therefore critical to its future. It has sought to diversify its economy in manufacturing and service industries since 2000, including software production, biotechnology, and tourism. Its financial services industry boomed until a crash in 2008.

- GDP growth rate is recovering from the financial crisis in 2008 in which Iceland's banks collapsed. In 2012, growth was 1.6%.
- GDP - per capita (PPP in US\$): \$39,900 (2012 est.)
- GDP - composition by sector in 2012: agriculture 5.8%, industry 23.6% and services 70.7%
- Unemployment rate: 6% (2012 est.).

Teacher Guidance 5. Finding out about Iceland

Before seeing the programme, it is useful if students have some prior knowledge of Iceland, and of the nature of the landscape and landscape processes there.

Aim

This activity is designed for small groups of students who, together, can produce either a short PowerPoint or web page. Seven enquiry themes are given. With a class of 30, this should mean about 4 students per question, and if you wish you can split some of the questions. For each search, tell students to search for images and video clips as well as web sites for information and data. As a general introduction, the CIA Factbook has up-to-date data about all countries in the world.

Time allowed

To develop this enquiry, you need to allow two lessons as a minimum;

- a homework preparation with students doing their research
- one lesson in which groups get together to prepare presentations
- a final lesson in which each group is given about 5 minutes to present their findings

To develop this more fully, you could allow three one-hour lessons:

- one lesson's research time
- one lesson for the development of student presentations
- finally, one lesson for group presentations, with self-assessment of each presentation

Group Enquiries

1. Where is Iceland?

e.g. Which part of the world? Which latitude? Which other places have similar latitude? What is its capital? Who are its nearest neighbours? Does it have good links and relations with its neighbours? What is the official language there?

Guidance: Use sources such as atlases, Google Maps, CIA Factbook. To get to CIA Factbook, key 'CIA Factbook Iceland' into a search engine.

2. What is Iceland like?

e.g. is it big or small? Are there mountains, rivers; is it flat or hilly? Is it a mainly urban or rural country? What is its climate like? Is there 'summer' and 'winter' weather? What would it be like to live in as a country?

Guidance: Use sources such as atlases, Google Maps, Wikipedia. Key in 'Iceland' into a search engine; for an Icelandic view of the country try the 'Iceland Review' online newspaper – <http://icelandreview.com/>

3. How developed is Iceland?

e.g. what is Iceland's level of economic development? How do people make a living? Is its countryside (rural areas) developed? What are its cities like? What is the general standard of living like there?

Guidance

- Use the CIA Factbook on Iceland. Key 'CIA Factbook Iceland' into a search engine.
- Produce graphs of 4-5 development indicators to show how wealthy or poor Iceland is compared to (for example) the UK.
- Use the BBC news page, www.bbc.co.uk/news and search 'Iceland'.

4. What kind of work is there in Iceland?

e.g. What is Iceland's economy based on? What are the most common types of jobs done by people who live and work there? Is the economy changing? What threats are there to the economy? Is it industrialising? Who are the biggest employers in Iceland?

Guidance

- Use the CIA Factbook on Iceland. Key 'CIA Factbook Iceland' into a search engine
- Type 'Iceland economy' into a search engine; also Wikipedia (key in 'Iceland' into a search engine); use the CIA Factbook.
- For an Icelandic view of the country try the 'The Iceland Reporter' online newspaper – <http://www.theicelandreporter.com/>
- For job adverts, key 'Iceland jobs' into a search engine

5. What development problems does Iceland face?

e.g. are there any development projects that are currently taking place in Iceland? Who is funding these? How might these benefit the country?

Guidance

- You will need to do a general search using a search engine on phrases such as 'development projects in Iceland'. Clue – have a search for 'renewable energy in Iceland'

6. How do hazards affect Iceland?

e.g. What hazards does Iceland face? Why is this? Which parts of Iceland are most affected? Which years have been most affected by hazards? What landscape hazards are there?

Guidance

- Type 'hazards in Iceland' into a search engine, and find out what hazards are there, and why this is.
- What are the causes of so many hazards in Iceland? Are there any benefits for the country in living so close to these hazards?

7. What threats does Iceland face?

e.g. how is the country changing? What happened there in the 1970s and 2008? What opportunities and threats does it face? Are there any further environmental hazards that it faces?

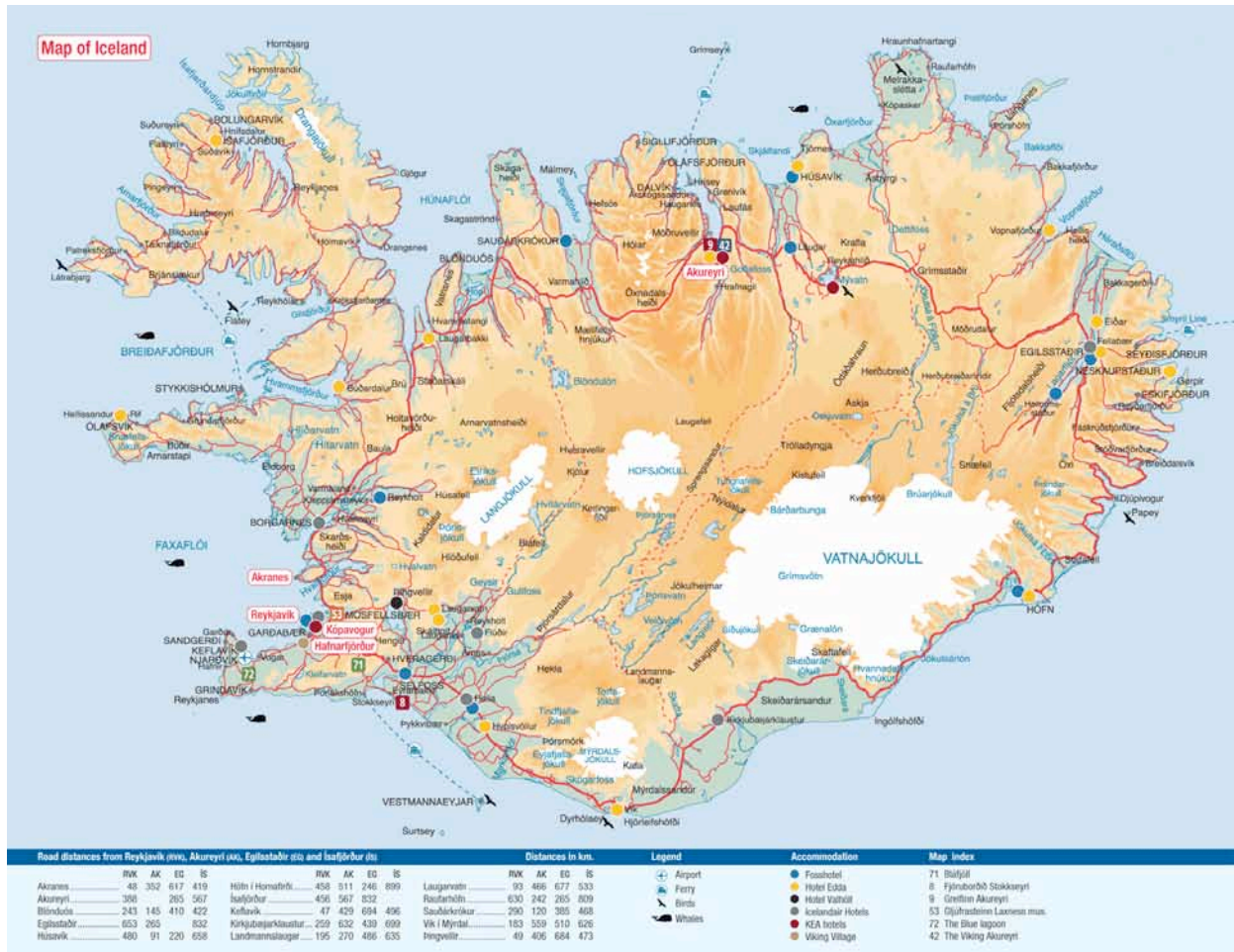
Guidance

- Type 'environmental threats to Iceland' into a search engine, also 'climate change Iceland'.
- Use the CIA Factbook to see what environmental problems and future threats the country faces.
- For an Icelandic view of the country try the 'The Iceland Reporter' online newspaper – <http://www.theicelandreporter.com/>

Student Resource 1. Detailed map of Iceland

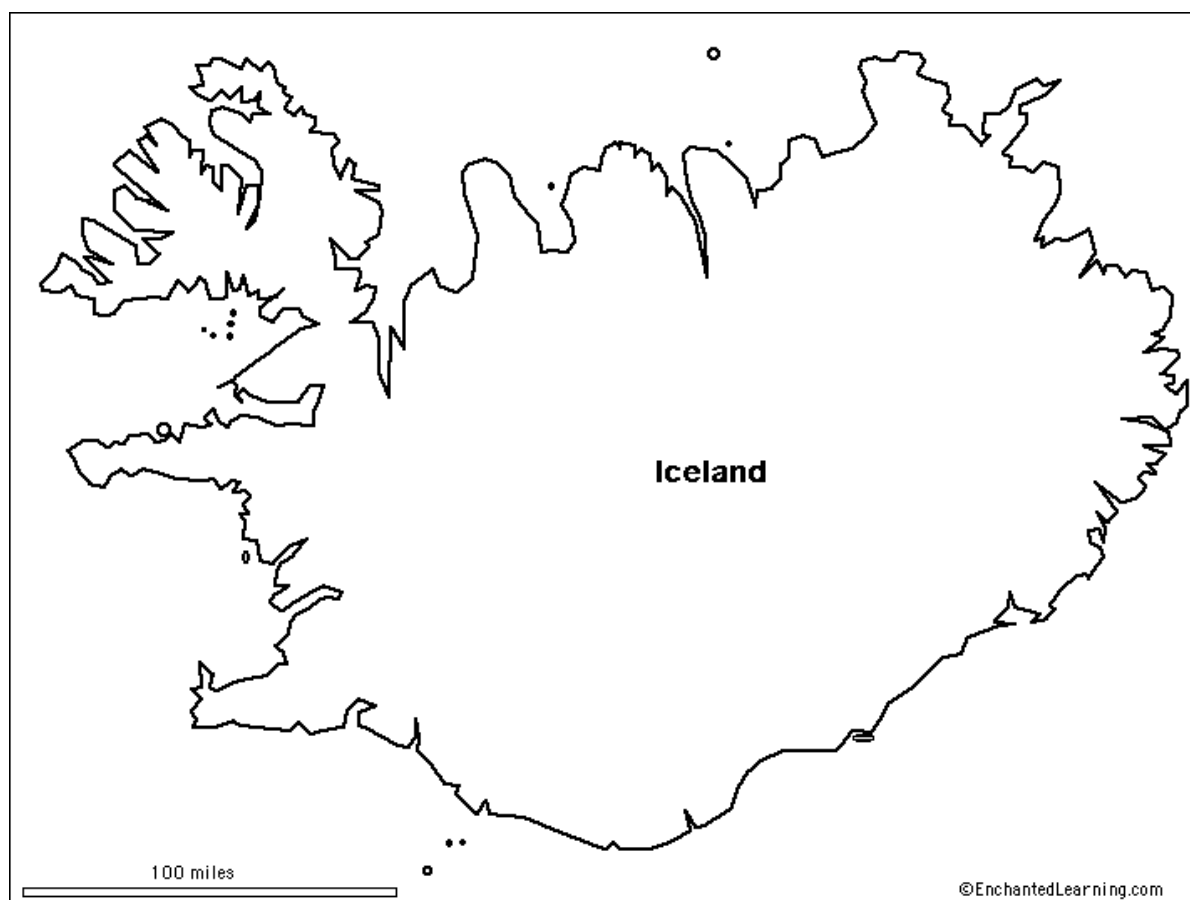
(source of outline:

http://www.visitorsguide.is/resources/Files/visitorsguide.is/Maps/Iceland_XL_1800x1400.gif)



Student Resource 2. Iceland: Map and key data

Source of map: <http://www.enchantedlearning.com/europe/iceland/outlinemap/>



1 On the map above, use a hard copy or online atlas to draw, locate and label the following:

- The Atlantic Ocean, and Greenland Sea
- The Arctic Circle
- The capital, Reykjavik, and any two other Icelandic towns or cities
- Its three highest peaks, and the area permanently covered in snow and ice
- A key to show the scale of this map

2 Use the CIA Factbook (<https://www.cia.gov/library/publications/the-world-factbook/geos/ic.html>) to complete the following factfile about Iceland:

- Its population and the population of its capital city
- Its birth and death rates, and how these compare with the UK
- Its GDP per capita and how far this compares with other countries
- Socio-economic data such as life expectancy, doctors per 1000 people, literacy
- Any changes to population and the economy

Student Resource 3.

Notes from the programme

Use this framework as an A3 sheet to make brief notes on the programme using a) the pictures, b) the commentary.

	Pictures	Commentary
Part 1. Introduction		
Part 2. Why live near volcanoes?		
Part 3. Impacts on Iceland		
Part 4. Reducing Impacts: Disaster preparedness		
Part 5. Building resilience against the volcano threat		
Part 6. Challenges and Opportunities		

Student Resource 4. Remembering the programme

A Remembering details; can you

1. remember the name of the capital?
2. say the name 'Eyjafjallajökull'?
3. remember the year in which Eyjafjallajökull erupted?
4. remember the name and year of another volcanic eruption?
5. name two benefits of tectonic activity for people who live in Iceland?
6. name two problems that tectonic activity causes there?

B Remembering the numbers

The following statements have a number missing. These numbers can be found at the foot of this page – but which number matches which statement?

Iceland's location in degrees north of the Equator	
The number of volcanic systems in Iceland	
The percentage of the country which is volcanically active	
Iceland's population	
The temperature in degrees C at which geothermal water comes out of the ground at Olafur's house	
The percentage cost of Iceland's energy compared to the UK's	
The number of visitors to the Blue Lagoon each year	
The depth in metres of the fissure that opened between Eyjafjallajökull and the neighbouring volcanic peak	
The year when Eyjafjallajökull erupted	
The year when Heimaey erupted	
The number of people evacuated from Heimaey when it erupted	
The number of flights cancelled or re-routed because of the eruption of Eyjafjallajökull	
The number of cubic metres of ice cap that could melt if Katla (Eyjafjallajökull's near neighbour) erupted	

Choose from these numbers

25	66	5400
30	500	100,000
33	1973	330,000
64	2010	500,000
		75 billion

B Remembering the numbers – teacher answer sheet

64	Iceland's location in degrees north of the equator
30	the number of volcanic systems in Iceland
25	the percentage of the country which is volcanically active
330 000	Iceland's population
66	the temperature in degrees centigrade at which geothermal water comes out of the ground at Olafur's house
33	the percentage cost of Iceland's energy compared to the UK's
500 000	the number of visitors to the Blue Lagoon each year
500	the depth in metres of the fissure that opened between Eyjafjallajökull and the neighbouring volcanic peak
2010	the year when Eyjafjallajökull erupted
1973	the year when Heimaey erupted
5400	the number of people evacuated from Heimaey when it erupted
100 000	the number of flights cancelled or re-routed because of the eruption of Eyjafjallajökull
75 billion	the number of cubic metres of ice cap that could melt if Katla (Eyjafjallajökull's near neighbour) erupted

Student Resource 5. Understanding the programme

A Knowing the key terms

Define these key terms from the programme:

- | | |
|------------------------------|-------------------------------|
| 1. Ballistics | 21. Hotspot / mantle plume |
| 2. Basic / Basaltic lava | 22. Hydro-electric power |
| 3. Bedrock | 23. Infrastructure |
| 4. Borehole | 24. Lava |
| 5. Caldera | 25. Lava flow |
| 6. Cone shaped peak | 26. Lava fountain |
| 7. Constructive plate margin | 27. Lava shield |
| 8. Crater | 28. Levée |
| 9. Divergent margin | 29. Magma |
| 10. Diversification | 30. Mantle plume |
| 11. Evacuation | 31. Meltwater |
| 12. Explosion pit | 32. Meteorologist |
| 13. Fissure | 33. Phreato-magmatic eruption |
| 14. Geologically active | 34. Prevailing winds |
| 15. Geothermal energy | 35. Rift valleys |
| 16. Geyser | 36. Rural depopulation |
| 17. Glacial outburst flood | 37. Tectonic plate |
| 18. Glacial outwash plain | 38. Volcanic ash |
| 19. GPS monitoring station | 39. Volcanologist |
| 20. Growing season | |

B Understanding the key points

Part 1 Introduction and causes

1. What is meant by the phrase 'Iceland is a geologically active region'?
2. What's the difference between magma and lava?
3. Why do volcanoes form along constructive plate boundaries?
4. Why are earthquakes commonly found together with volcanoes?

Part 2 Why live near volcanoes?

1. Why is the growing season in Iceland so short?
2. Why are soils in the south of Iceland so fertile?
3. Why are floods just as crucial to fertile soils in Iceland as the volcanoes themselves?
4. Outline the benefits for Ólafur's family of living in a geologically active region
5. Explain how geothermal energy is obtained
6. Why does Iceland's population enjoy low energy prices?
7. Why should tourists want to go to Iceland?
8. Explain how a geyser is formed
9. Why should Iceland be described as a 'young landscape'?

Part 3 Impacts on Iceland

1. How and why do the shapes and sizes of volcanoes vary in Iceland?
2. How and why do the impacts of Iceland's volcanoes vary?
3. What happened on 23rd March 2010? Why was this significant for i) Iceland, ii) places elsewhere?

4. What were the first signs that Eyjafjallajökull was erupting?
5. What happened in Heimaey, when, and with what effects?
6. What are 'basic / basaltic lavas'?
7. What kind of volcano shape result from these lavas? Why?
8. Why were so many people evacuated from Heimaey?
9. Why can glaciers be a greater threat to Icelandic people than volcanoes?
10. Why are volcanoes along constructive plate margins much less explosive than those found along destructive plate boundaries?
11. In what ways did erupted volcanic material negatively affect natural habitats and farmland on Iceland in 2010?
12. In what ways did erupted volcanic material positively affect natural habitats and farmland on Iceland in 2010?
13. Why was ash such a significant feature of Eyjafjallajökull's eruption? How did this form?
14. Why did ash from Eyjafjallajökull spread so far from Iceland?

Part 4 Disaster preparedness

1. What are 'safe zones', and why are these important in Iceland?
2. Outline two strategies that Iceland used to protect people when Eyjafjallajökull erupted.
3. How do volcanologists know when a volcano is likely to erupt?

Part 5 Reducing Impacts

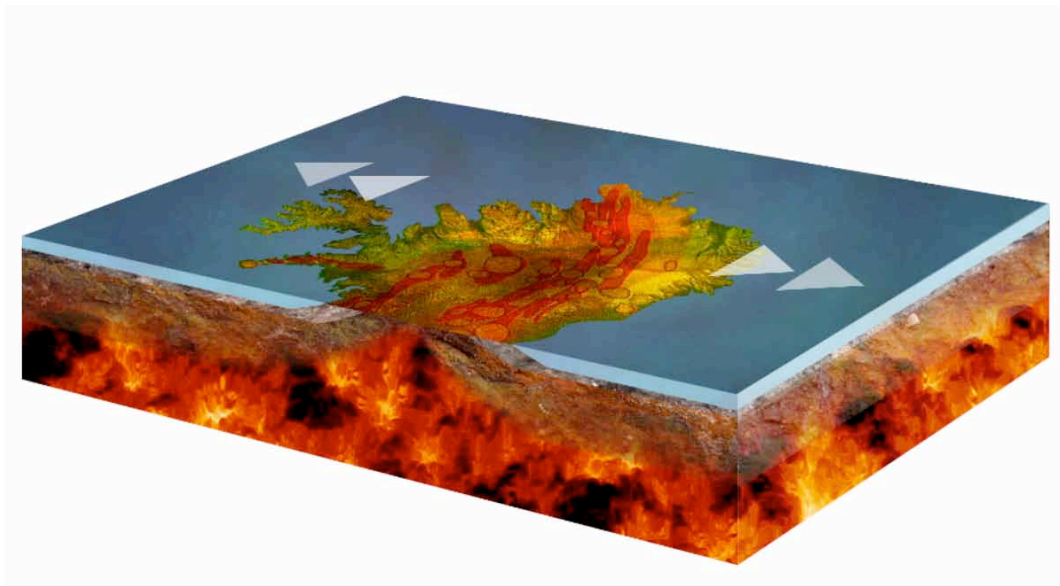
1. Why is Iceland's Meteorological Office involved in preparing for volcanic eruptions?
2. Why is disrupting air traffic such a big problem?
3. Why build levées to manage the impacts of a volcanic eruption in Iceland?
4. Why is it difficult to know how large the levées should be?
5. Is it worth spending so much money to protect the homes of 600-700 people?
6. In what ways was the eruption of Heimaey in 1973 different from that of Eyjafjallajökull in 2010?
7. What technique proved so effective in managing the eruption of Heimaey? Describe it, with diagrams to help you.
8. Why are hard engineering strategies needed as well as evacuation plans?

Part 6 Challenges and Opportunities

1. Briefly describe the difference that the eruption of Eyjafjallajökull made to farmers.
2. In what ways do volcanoes present opportunities for i) economic activity, ii) farmers to diversify?
3. How can volcanic activity lead to rural depopulation?
4. What's the 'Katla geopark'? Who and where might the market be to attract visitors to this park?
5. Why is there so much benefit to IT companies in locating some of their operations in Iceland?
6. How realistic is it that Iceland could supply countries in Western Europe with energy?

Student Resource 6. What causes Iceland's volcanoes?

1. Study the map which shows Iceland's position on a constructive plate margin. The image comes from the US Geological Survey (<http://pubs.usgs.gov/gip/dynamic/understanding.html>).



2. Annotate the map and diagram using these phrases, which have been jumbled:

Along the plate boundary is a chain of volcanoes.
The North American plate is moving away from the Eurasian plate
The Eurasian plate is moving eastwards (draw arrows to indicate this)
The North American plate is moving westwards (draw arrows to indicate this)
Heimaey is located here
This is the constructive plate boundary
Lava flows are most likely located here
This is a hotspot
This is a magma plume rising

Student Resource 7. The eruption in pictures

Study the six images and carry out the activities below:



Activity

- These images show the following – but not in this order. Match a title to each photo from the following list:

<ul style="list-style-type: none"> • Secondary cones • Lava flow • Cone and fissure eruption 	<ul style="list-style-type: none"> • Ash cloud • Lava eruption • Volcanic cone
---	---
- Annotate each photograph with labels to show what is happening in each case

Student Resource 8. The benefits of living in a volcanic area

1. Use these images from the programme to decide a) what is going on, and b) who benefits. Write notes beneath each photo.
2. Write 300-400 words on the title 'How volcanic activity can bring benefits to people'.



What is happening?
Who benefits from this?



What is happening?
Who benefits from this?



What is happening?
Who benefits from this?



What is happening?
Who benefits from this?



What is happening?
Who benefits from this?



What is happening?
Who benefits from this?

Student Resource 9. The primary and secondary effects of the eruption upon Iceland

The effects of a volcanic eruption can be classified as Primary and Secondary.

- Primary effects are caused directly by the eruption (e.g. landscape covered in ash, the acid rain produced by SO₂, or earthquakes linked to it).
- Secondary effects occur after the eruption. They include homelessness, or spread of disease caused by damage to water supply.

After watching the programme, summarise the impacts of recent volcanic eruptions upon Iceland (including Heimaey).

Impact	Primary effects	Secondary effects
Economic		
Social		
Environmental		

Summary: Now explain in about 500 words whether the main impacts of the eruption were **a)** social, economic or environmental, **b)** primary or secondary.

Student Resource 10. Managing the risk from volcanic activity in Iceland

Think about the attempts to manage the risks to people posed by a volcanic eruption in Iceland. For each of the following strategies in the left-hand column, complete the following table:

- In the second column, describe what each involves
- In the third and fourth columns, explain the advantages and disadvantages of each of these strategies

Actions taken to reduce risk	How it works	Its advantages	Its disadvantages
Establishing an exclusion zone			
Using Global Positioning Systems (GPS)			
Diverting lava flows using dams			
Cooling lava using sea water			
Developing an evacuation procedure			
Computer modelling of ash clouds by the Icelandic Met Office			
Educating the population			

Student Resource 11. Winners and losers from volcanic activity in Iceland

The eruption has brought a number of impacts – some people and groups win, whilst others lose.

Take each one of these, and develop a spider diagram below to show who has won and who has lost since the main volcanic eruption in 1973, and why?:

- | | | |
|--|---|--------------------------------------|
| a) Tourism | d) Young people in rural areas of Iceland | f) Geothermal power generation |
| b) The population of places affected, e.g. Heimaey | e) International airlines flying the North Atlantic | g) IT data centres |
| c) Iceland's dairy and arable farmers | | h) Iceland's fishing industry |
| | | i) Any other groups of your choosing |

