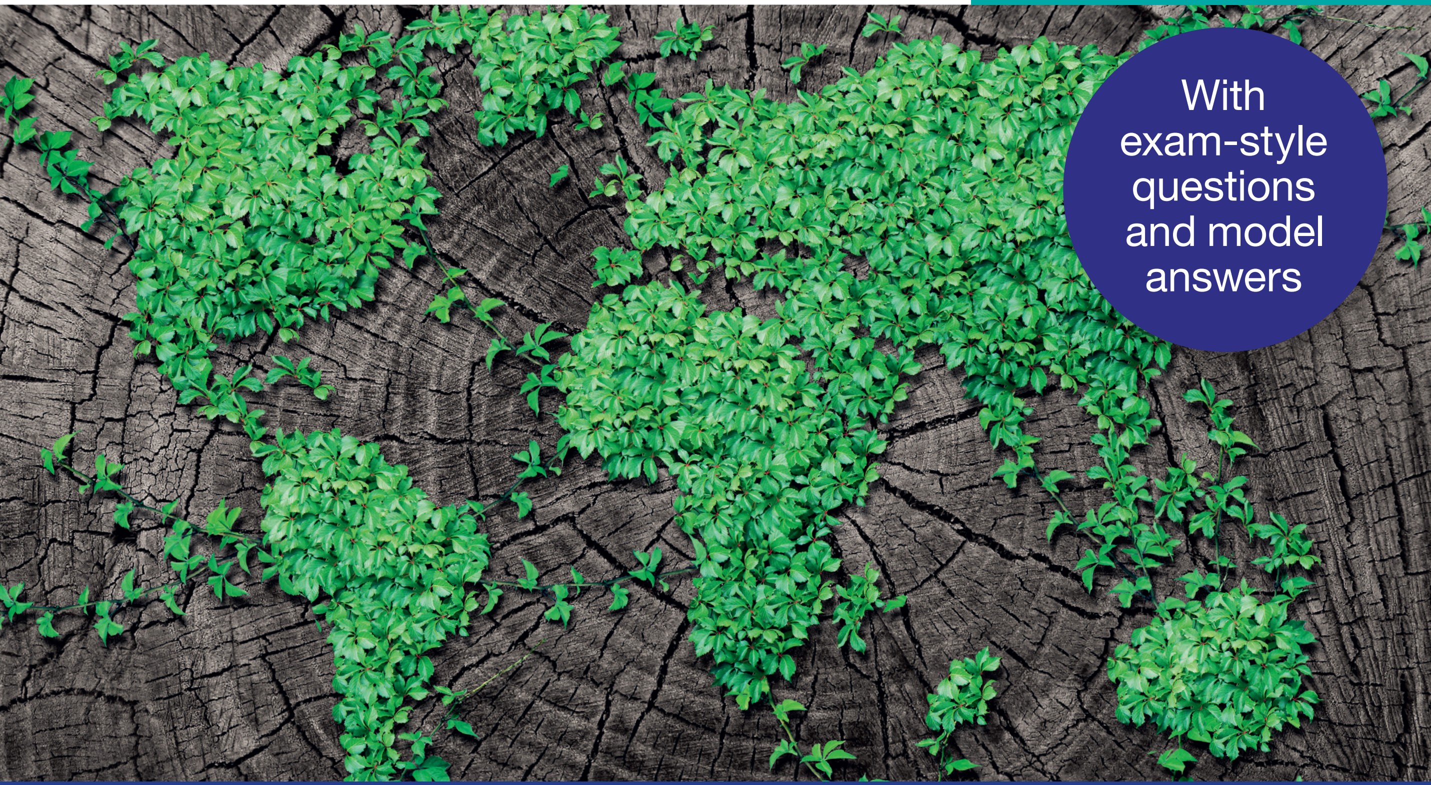
STUDENT GUIDE

NEW EDITION

With exam-style questions and model answers



AQA A-LEVEL

Geography

Physical geography

- Water and carbon cycles
- Hot desert systems and landscapes
- Coastal systems and landscapes
- Glacial systems and landscapes
- Hazards

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Questions & Answers

Volcanic hazards

Vulcanicity The process through which gases and molten rock are either extruded on the Earth's surface or intruded into the Earth's crust. It is clearly linked to the existence of plate margins.

The nature of vulcanicity and its relation to plate tectonics

Volcanoes are built by the accumulation of their own eruptive products: lava, bombs (crusted-over ash deposits), and tephra (airborne ash and dust). A common form of volcano is a conical hill or mountain built around a vent that connects with reservoirs of molten rock below the surface of the Earth. There are approximately 500 active volcanoes around the world. Only a few of them are erupting at any one time. An eruption is when a volcano gives off quantities of lava, ash or volcanic gas. A few volcanoes erupt more or less continuously (e.g. Mauna Loa, Hawaii), but others lie dormant between eruptions when they give out very little gas and lava. The type of volcano and volcanic activity depends upon the nature of the lava. This in turn depends upon the location of the volcano with regard to tectonic plate margins. If the lava is a thin fluid (not viscous), then gases may escape easily. But if the lava is thick and dense (highly viscous), the gases will not move freely but will build up tremendous pressure, and ultimately escape with explosive eruptions (see Tables 5 and 6).

Table 5 Variations in the type of volcanic activity in relation to types of plate margin

	Destructive margin	Hotspot	Constructive margin
Magma source	A mix of old oceanic plate, ocean sediments and continental fragments, often weathered by water	Deep in the asthenosphere (mantle)	Deep in the asthenosphere (mantle)
Rock name	Andesite/Rhyolite	Basalt/Gabbro	Basalt/Gabbro
Magma chemistry	Medium to high acidity, greater than 63% SiO_2 (silica) content	Quite basic (alkaline), sometimes relatively rich in sodium and potassium, low silica content (around 50%)	Very basic (alkaline), low silica content, typically high iron and magnesium content
Magma's physical character	Viscous (solidifies quickly), flows over short distances, solidifies even on steep slopes, allows gases to build up pressure – can explode violently	Quite non-viscous (fairly runny), flows over low-angled slopes or can erupt as an ash	Very non-viscous (runny), flows long distances over very low-angled slopes or can create a black ash (tephra) when exploding with water vapour (steam)

Knowledge check 40

Some geologists suggest Iceland sits on a hotspot. Investigate this theory.

Table 6 Variations in the type of volcanic activity in relation to lava type

	Basaltic lava	Andesitic lava	Rhyolitic lava
Silica content	45–50%	55–60%	65%
Eruption temperature	1,000°C+	800°C	700°C
Viscosity and gas content	Very runny, low gas	Sticky, intermediate gas	Very sticky, high gas
Volcanic products	Very hot, runny lava (shield volcanoes, low land or plateaux)	Sticky lava flows, tephra, ash, gas (composite volcanoes)	Pyroclastic flows, gas and volcanic ash (domes)
Eruption interval	Can be almost continuous, as on Hawaii	Decades or centuries	Millennia
Tectonic setting	Oceanic hotspots and constructive margins	Destructive plate margins (ocean/continental and ocean/ocean)	Continental hotspots and continental/continental margins
Processes	Dry partial melting of the upper mantle/lower lithosphere, basaltic magma is generally uncontaminated by water etc.	Wet partial melting of subducting oceanic crust contaminated by water and other material as magma rises.	In situ melting of lower continental crust, most rhyolitic (granitic) magmas cool before they reach the surface.
Hazardous?	Not really	Very	Very (but rare)

Form and impact of volcanic hazards

The impact of a volcano is only deemed hazardous when it has an effect on people. Figure 14 summarises the various forms of hazardous volcanic activity.

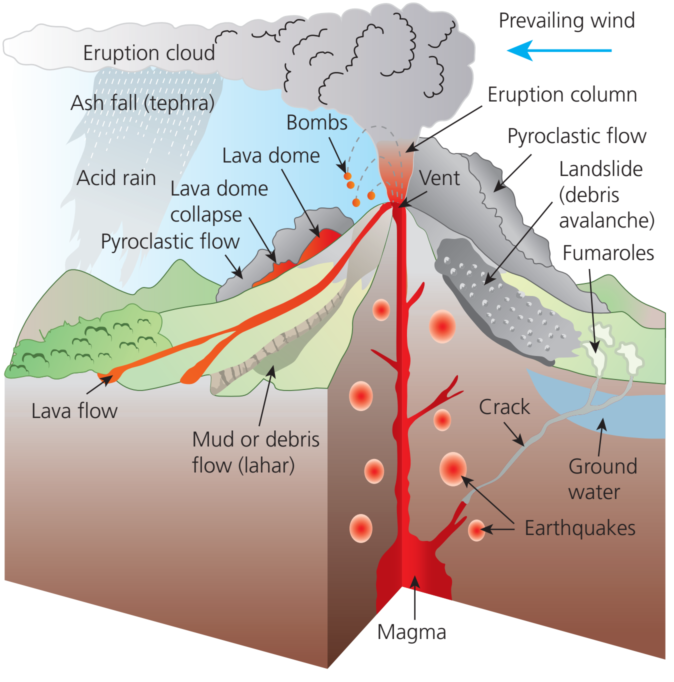

Figure 14 Forms of volcanic hazard

A volcanic event can produce a number of hazardous effects, the impact of which can range from the area immediately around the volcano to the entire planet. They include the following:

- **Tephra:** solid material of varying grain size (from fine ash up to volcanic bombs) ejected into the atmosphere. Buildings often collapse under the sheer weight of ash

Exam tip

The forms of hazard associated with a volcano will vary according to the individual volcano studied. When examining your chosen case study of a recent volcanic event (see page 71), make sure you note the forms of hazard for that volcano.

falling on to their roofs. Air, thick with ash, is very difficult to breathe, and can cause serious respiratory problems. Fine tephra can also contribute to acid rain.

- **Pyroclastic flows:** very hot (800°C), gas-charged, high-velocity flows (over 200 km/h) of a mixture of gases and tephra. These flows devastate everything in their path.
- **Nuée ardente:** a glowing cloud of hot gas, steam and dust, volcanic ash and larger pyroclasts produced during a violent eruption, which can descend the slopes of a volcano at high velocity.
- **Lava flows:** at the speed at which most lava flows, they do not usually pose a threat to life. Lava flows do, however, represent a threat to farmland, property and infrastructure.
- **Volcanic gases:** these include carbon dioxide, carbon monoxide, hydrogen sulfide, sulfur dioxide and chlorine.
- **Lahars:** volcanic mud flows such as the one that devastated the Colombian town of Armero after the eruption of Nevado del Ruiz in November 1985, which buried some people alive.
- **Flooding:** caused by the melting of ice caps and glaciers, such as glacial bursts (or **jökulhlaup**).
- **Tsunamis:** giant sea waves set off by huge explosions such as the one that devastated the island of Krakatoa in 1883.
- **Climatic change:** the ejection of vast amounts of volcanic debris into the atmosphere can reduce global temperatures and is believed to have been an agent in past and present climatic change.

One way of classifying a volcano's hazardous nature is by its explosivity, using the Volcanic Explosivity Index (VEI). A volcano's impact can be judged in terms of its primary and secondary effects, and the environmental, social, economic and political consequences, both short and long term.

Management and responses

The management and responses to volcanic events fall into two categories:

- Prediction:
  - Study the eruption history of the volcano.
  - Measure gas emissions, land swelling, groundwater levels (e.g. by using GIS).
  - Measure the shock waves generated by magma travelling upwards.
- Protection:
  - Assess the hazard, i.e. try to determine the areas of greatest risk that should influence land use planning.
  - Dig trenches to divert the lava.
  - Build barriers to slow down lava flows.
  - Administer explosive activity to try to divert a lava flow.
  - Pour water on the lava front to slow it down.

Exam tip

Although you have to study one case study of a recent volcanic event in detail, be aware of the **impacts** of other volcanic events (although this doesn't require quite as much detail).

Knowledge check 41

How can geologists determine the frequency of volcanic eruptions?

Exam tip

Although you have to consider one case study of a recent volcanic event in detail, be aware of the **management of and responses to** other volcanic events (although this does not require quite as much detail).

Case study requirement

You are required to study **one recent volcanic event**, its impacts and the human responses to it. Possible volcanoes include: Mt St Helens (Washington, USA), Mt Nyiragongo (DRC), Mt Etna (Italy), Soufrière Hills (Montserrat), Mt Merapi (Indonesia) and Eyjafjallajökull (Iceland). The framework in Table 7 may assist in this process.

Note: an example of a completed table (for an earthquake) is provided on pages 74–75.

Table 7 Case study disaster framework

Case study				
Location/Date				
Geographical context (e.g. plate boundary(ies))				
Description of event	**Magnitude**	**Duration**	**Linked events**	**Other features**
Impacts	**Primary**		**Secondary**	
Environmental				
Social				
Economic				
Political				
Risk management including preparedness and prevention				
Mitigation strategies				
Adaptation strategies				

Exam tip

Although you are encouraged to keep up-to-date with events, when undertaking these case studies it is recommended that you choose disasters that have run their course and are at least 2–3 years old. In this way all the requirements can be met.

Seismic hazards

The nature of seismicity and its relation to plate tectonics

Most earthquakes occur along plate boundaries or deep under continents. Their location can also be linked to the distribution of certain geological characteristics, such as conservative plate margins and associated transform faults (low frequency but high predictability), ocean trenches and beneath mountains (greater frequency and high predictability).

Seismicity The geographic and historical distribution of earthquakes. Again, their distribution is closely associated with plate margins.

As the Earth's crust is mobile, there can be a slow build-up of stress within the rocks where movement is taking place. When this stress is suddenly released, parts of the surface experience an intense shaking motion that lasts for just a few seconds. This is an earthquake.

Hazards

Question 1

Outline the causes of wildfires. (4 marks)

1 mark per valid point.

Student answer

For a wildfire to be created there needs to be two things: an ignition source and a fuel ✓. The former can be caused by lightning during an electrical storm ✓. Another cause is human carelessness, such as a discarded cigarette or a badly managed campfire ✓. The main fuel is timber in the form of trees. However, the initial fuel is often dry undergrowth, which can easily catch fire ✓.

4/4 marks awarded The student provides several valid statements.

Question 2

Figures 8a and 8b show information relating to Japan and the Tohoku earthquake 2011. Analyse the relationship between the two sets of information provided. (6 marks)

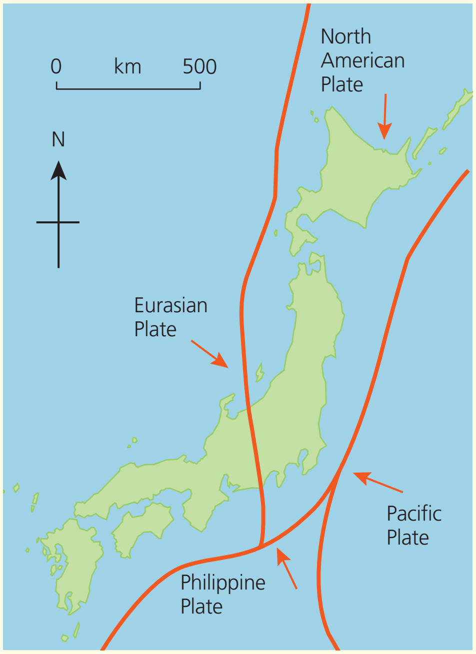

Figure 8a The plate tectonic setting of Japan

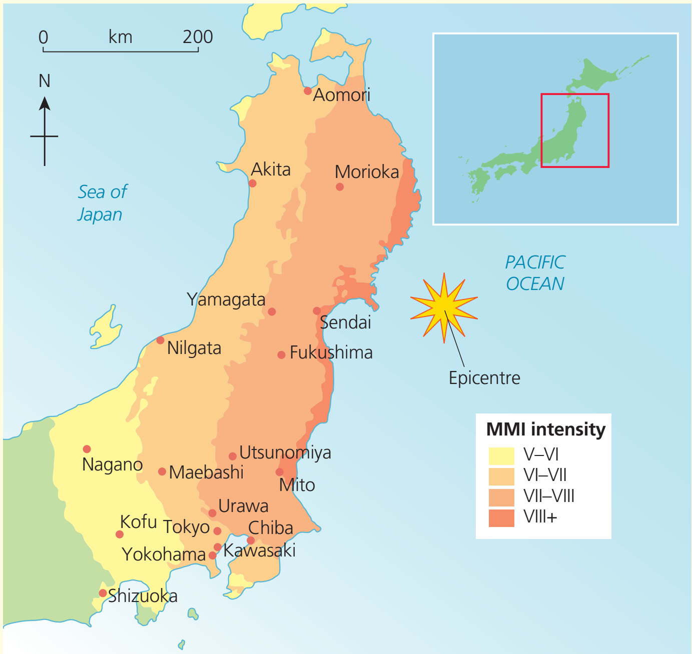

Figure 8b Estimated shaking intensity, Tohoku earthquake (2011)

Level 2 (4–6 marks)

A03 – Clear analysis of the qualitative evidence provided, which makes appropriate use of evidence in support. Clear connection(s) between different aspects of the evidence.

Level 1 (1–3 marks)

A03 – Basic analysis of the qualitative evidence provided, which makes limited use of evidence in support. Basic connection(s) between different aspects of the evidence.

Student answer

Japan sits on two continental plates – the northern part of the country lies on the North American Plate, while the south is on the Eurasian Plate. To the east of Japan are two oceanic plates – in the north is the Pacific Plate, and to the south lies the Philippine Plate. The two oceanic plates are both moving in a generally westward direction at a rate of a few centimetres per year. The zones at which the plates collide lie on the seabed to the east of Japan (Figure 8a) and are marked by deep ocean trenches. At this point subduction occurs and earthquakes can take place along such a tectonic boundary.

6/6 marks awarded The first paragraph gives a clear analysis of the tectonic setting, making use of plate names and directions of movement, and a clear link between the two maps is established.

The earthquake off Sendai in Tohoku in 2011 (Figure 8b) occurred on the fault that marks the boundary between the Pacific Plate to the east and the North American Plate to the west – 130 km to the east of the port of Sendai. The impact of the earthquake, as measured by the MMI scale on Figure 8b, was greatest all along the 400 km east coastline of Tohoku in a thin band parallel to the coast, north and south of Sendai. The intensity then reduced inland and to the west in a fairly uniform manner, and it also decreased to the southwest. There is, therefore, a strong relation of the intensity of the earthquake to the tectonic setting.

The second paragraph moves on to the second map by analysing the pattern of earthquake intensity. The last sentence in this paragraph makes clear that a link between the two maps exists, and therefore the question is addressed explicitly.

Finally, it is worth noting that the shaking intensity extends in a linear manner along the east coast, with high intensities some distance from the earthquake's epicentre. So, it is clear that the relationship between the two sets of information isn't entirely straightforward.

This brief paragraph challenges one aspect of this link – a valid point to make.