Topic 5 Hazards

The concept of hazard in a geographical context

Hazards are the outcome of the interaction between natural environments and phenomena, on the one hand, and human environments, on the other. The hazards can be geophysical (volcanoes and earthquakes), atmospheric (storms and drought) or human-induced (some wildfires).

The way in which a hazard is perceived often depends upon the economic circumstances and cultural background of those experiencing the impacts of the hazard. Overall, hazards have social, economic and political impacts with both short- and long-term consequences.

A number of factors influence the nature of the human responses to a hazard. Possible responses are:

- fatalism
- adjustment/adaptation
- management
- prediction
- mitigation
- risk sharing

Clearly, responses are also linked to aspects of the hazard itself. These include the hazard's frequency, intensity, magnitude and distribution.

All of the above are linked to the level of development of the area in which the hazard occurs.

The Park model of human responses to a hazard sketches the phases following a hazard event, while the hazard management cycle takes into account the recurring nature of natural hazards.

Practice questions

1 Define the term 'natural hazard'.

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2 Study Figure 5.1. Outline the activities that might take place during the relief phase.

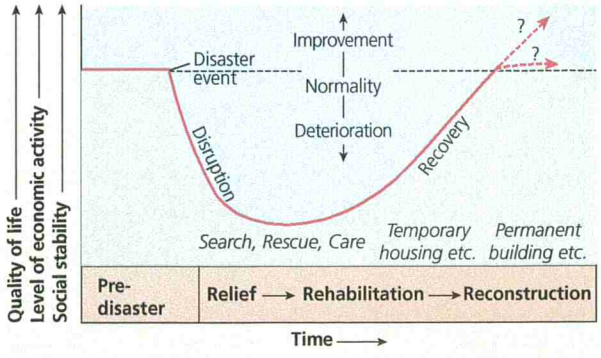

Figure 5.1 The Park model of human responses to a hazard

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3 Complete Table 5.1.

Table 5.1

Human response to a hazard	Definition	Example
Fatalism		
Prediction		
Adjustment/adaptation		
Mitigation		
Management		
Risk sharing		

4 Using Figure 5.2 and examples from your studies, explain the extent to which the time interval between disasters impacts on an area's response to those disasters.

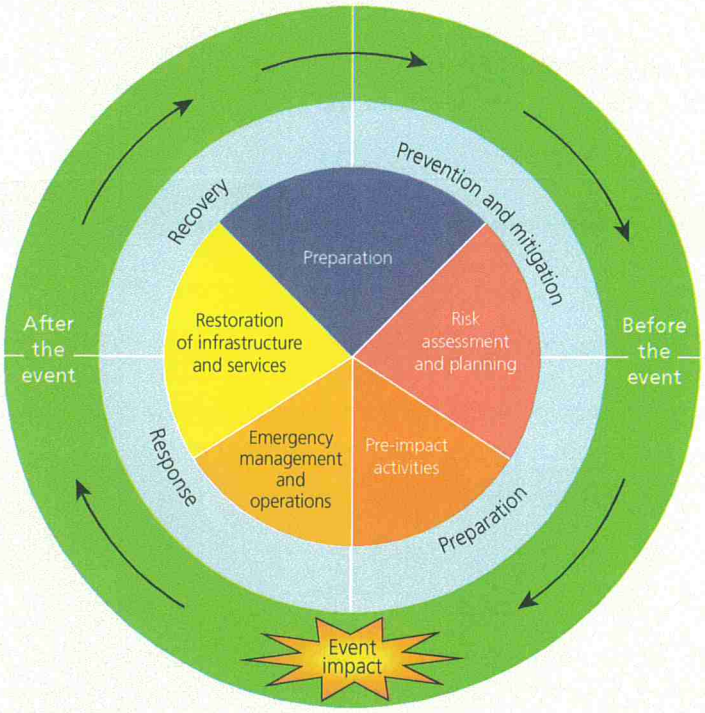

Figure 5.2 The hazard management cycle

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Plate tectonics

Plate tectonics is the theory that the Earth's outer shell is divided into several rigid plates that glide over a rocky inner layer. These plates vary in shape and size and move relative to one another. There are nine major plates and several smaller ones.

Most of the boundaries between these plates are geologically active.

- Constructive plate boundaries occur where plates move away from each other and fresh magma wells up to create new crust (e.g. the Mid-Atlantic Ridge).
- Destructive plate boundaries are where crust sinks into the mantle and melts (e.g. the Pacific 'Ring of Fire').
- Conservative plate boundaries occur where crust is neither destroyed nor created as plates pass one another (e.g. the San Andreas Fault).

Localised heating at the core–mantle boundary causes a plume of magma to rise through the mantle and eat into the plate above at what is called a 'hot spot'. When this lava breaks through to the surface, active volcanoes form above the spot.

Practice questions ?

5 Describe the main features (location, temperature, chemistry etc.) of the following:

a The oceanic crust

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b The continental crust

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c The asthenosphere

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d The mantle

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e The core

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6 Using Figure 5.3 and your own knowledge, outline how each of the two theories (ridge push and slab pull) explains how crustal plates move.

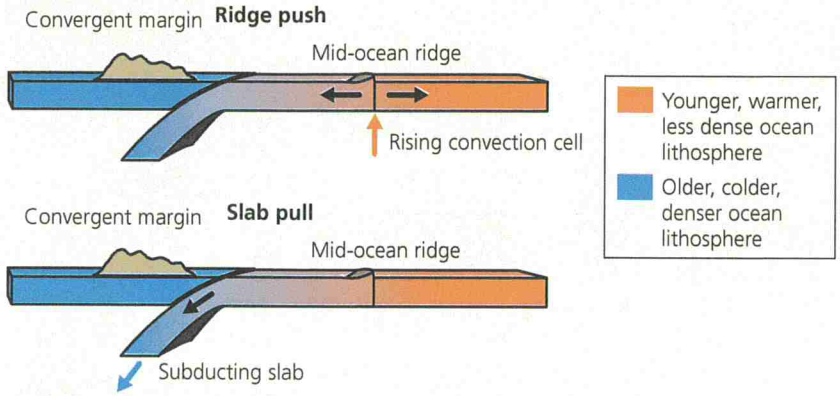

Figure 5.3 Ridge push and slab pull theories of crustal movement

Source: adapted from British Geological Survey

Worked example

One of the main differences between the theories is that they apply to different oceanic plate boundaries.

Application (AO2): Shows understanding straight away. Shows that there is a comparison being made.

In the ridge push theory, molten magma that rises at a mid-ocean ridge is hot, heating the rocks around it. As the rocks at the ridge are heated, they expand and become elevated above the surrounding sea floor. This elevation produces a slope down and away from the ridge. As the newly formed rock ages and cools, it becomes denser. Gravity then causes this older, denser lithosphere to slide away from the ridge, down the sloping asthenosphere. As the older, denser lithosphere slides away, new molten magma wells up at the mid-ocean ridge, as shown in Figure 5.3, eventually becoming new lithosphere. It is thought that the cooling, subsiding rock exerts a force on spreading lithospheric plates, driving their movements.

Knowledge (AO1) and application (AO2): Good knowledge and understanding of one side of the comparison.

The slab pull theory concentrates on subduction boundaries. One plate is denser and heavier than the other plate. The denser, heavier plate begins to subduct beneath the plate that is less dense. The edge of the subducting plate is much colder and heavier than the mantle, so it continues to sink, pulling the rest of the plate along with it. The force that the sinking edge of the plate exerts on the rest of the plate is called slab pull. Currently, many scientists consider slab pull to be a much stronger factor than ridge push in the movement of tectonic plates.

Knowledge (AO1) and application (AO2): Good knowledge and understanding of the other side of the comparison.

7 What do you understand by the term 'sea floor spreading'?

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8 To what extent does the mantle convection hypothesis explain plate movements at destructive boundaries and constructive plate margins?

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9 Use plate tectonic theory to account for the evolution of oceans as shown in Figure 5.4.

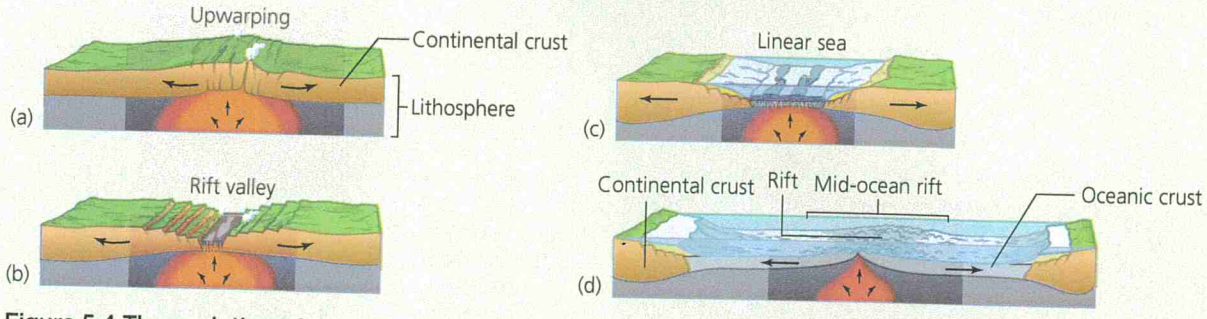

Figure 5.4 The evolution of a constructive plate margin

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10 Explain why earthquakes found at constructive margins:

a have shallow foci

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b cause little damage

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11 The magma and lavas produced at constructive plate margins are low in silica content. To what extent does this affect the nature of the volcanic eruptions found at this type of boundary?

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12 Study Figures 5.5 and 5.6. Account for the fact that earthquakes occur at these two types of boundary.

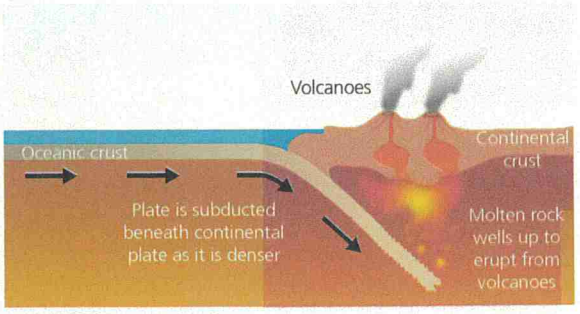

Figure 5.5 An ocean–continent destructive plate boundary

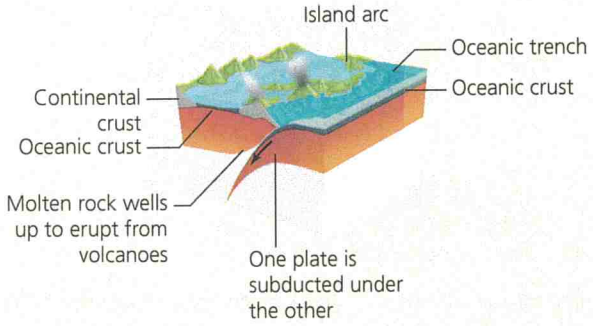

Figure 5.6 An ocean–ocean destructive plate boundary (an island arc)

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13 Describe the nature of the volcanic eruptions at the two types of boundary shown in Figures 5.5 and 5.6.

14 Explain why collision boundaries such as that between the Indo-Australian plate and the Eurasian plate produce many earthquakes.

15 Explain why earthquakes at conservative plate boundaries are potentially so destructive.

16 Complete Table 5.2 with examples and details of tectonic landforms.

Table 5.2

Landform	Named example	Location	Description	Tectonic context
Ocean ridge				
Rift valley				
Young fold mountains				
Deep sea trench				
Island arc				

17 Using Figure 5.7, explain how the moving Pacific plate and the magma plume work together to form a chain of islands.

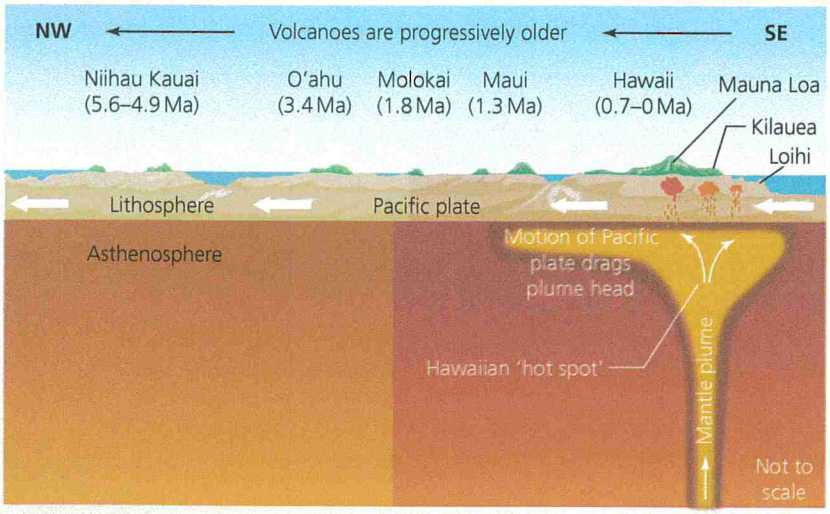

Figure 5.7 A chain of 'hot-spot' volcanoes in the Hawaiian Islands

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Volcanic hazards

Volcanoes are mainly found along tectonic plate boundaries and above hot spots. Those found along constructive plate boundaries often have:

- low-viscosity basaltic lava that flows easily
- volcanic ash eruptions

Those found along destructive margins often have:

- more viscous acidic lava
- violent eruptions, with lots of steam, gas, and ash

Hot-spot volcanoes have very runny lava and form shield volcanoes.

A volcanic hazard refers to any potentially dangerous volcanic process which impacts on people and/or property or which negatively impacts the productive capacity or sustainability of a population. Such hazards include:

- nuées ardentes (pyroclastic flows)
- lava flows
- mudflows (lahars)
- volcanic ash and bombs (tephra)
- gas and acidic rainfall

Although it is impossible to prevent volcanic eruptions, it is possible to reduce their impact by proper management, both in preparation for and in response to volcanic risk.

Practice questions

18 Describe the distribution of volcanic activity as shown in Figure 5.8 and relate it to the theory of plate tectonics.

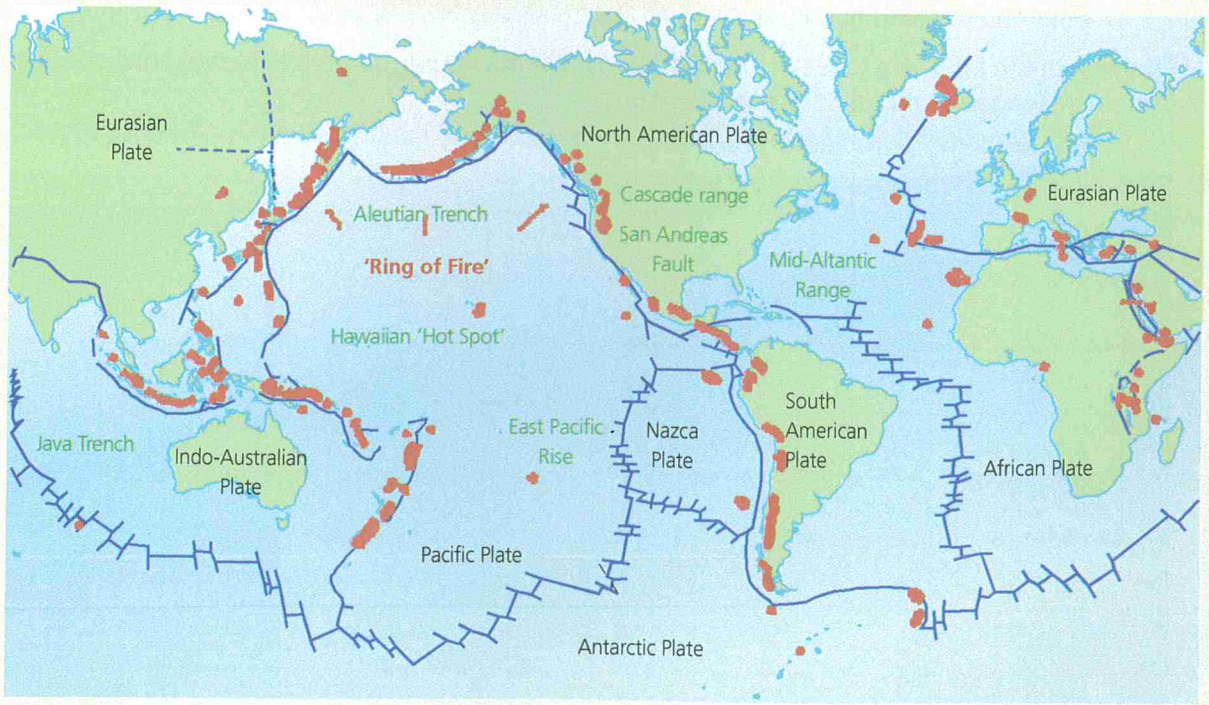

Figure 5.8 Location map of active volcanoes

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19 Figure 5.9 shows a number of different volcanic hazards.

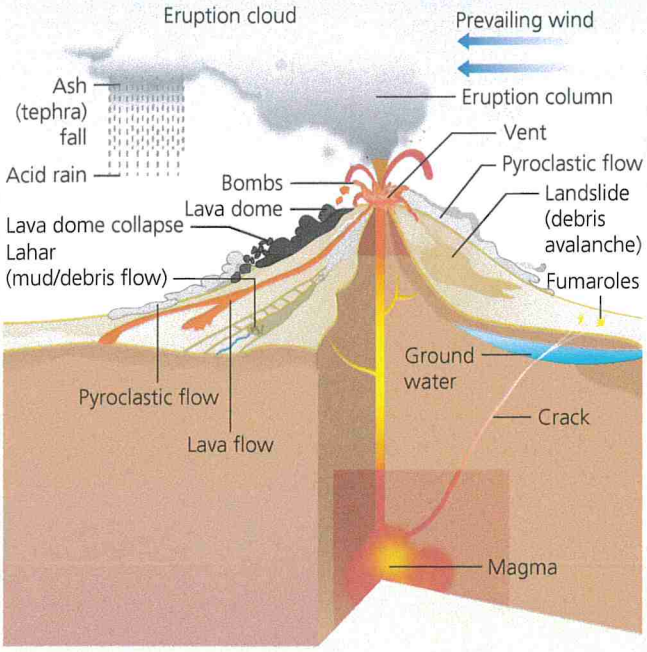

Figure 5.9 A simplified diagram showing some of the most common forms of volcanic hazard

For each of the following volcanic hazards (shown in the figure), name and locate an example, explain the cause(s) and describe the effects.

a Nuées ardentes (pyroclastic flows)

b Lava flows

c Mudflows (lahars)

d Pyroclastic and ash fallout (tephra)

e Gases/acid rain

20 Outline **two** pieces of evidence that scientists use to predict forthcoming volcanic hazards.

21 What steps can be taken by individuals and organisations to reduce the impact of volcanic hazards?

22 For **one** recent hazardous volcanic event, do the following:

a Name and locate the event.

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b Briefly describe the hazardous nature of the event.

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c Outline the social, economic and environmental impacts of the event.

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d Describe the human responses to the event.

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Seismic hazards

Seismicity refers to the geographic and historical distribution of earthquakes. Seismic hazards occur when the physical results of an earthquake impact on people and/or property or negatively impact the productive capacity or sustainability of a population.

Almost all earthquakes occur within the crust in bands along:

- oceanic ridges and associated transform faults
- conservative plate margins
- broad zones below and behind destructive plate boundaries

Earthquakes are produced because the crust is constantly moving, causing a build-up of stress within rocks. When this pressure is released, shock waves travel out in all directions. Those that reach the surface radiate from the epicentre in an intense shaking motion.

When the earthquakes occur close to or under dry land, the surface waves damage human-made structures, which can cause people to be:

- crushed in a collapsing building
- drowned in a flood caused by a broken dam or levee
- buried under a landslide
- burned in a fire

Rocks with high water content can be liquefied and flow, causing mudflows or building collapse.

Sometimes when earthquakes occur under oceans, the shock creates fast-moving, long-wavelength sea waves that travel far from the epicentre. They pile up on coastlines, causing immense damage.

Although scientists know most of the global locations where earthquakes are likely to occur, they still have great difficulty in predicting when they may occur. This makes planning and preparation difficult.

Practice questions

23 Describe the distribution of seismic activity as shown in Figure 5.10 and relate it to the theory of plate tectonics.

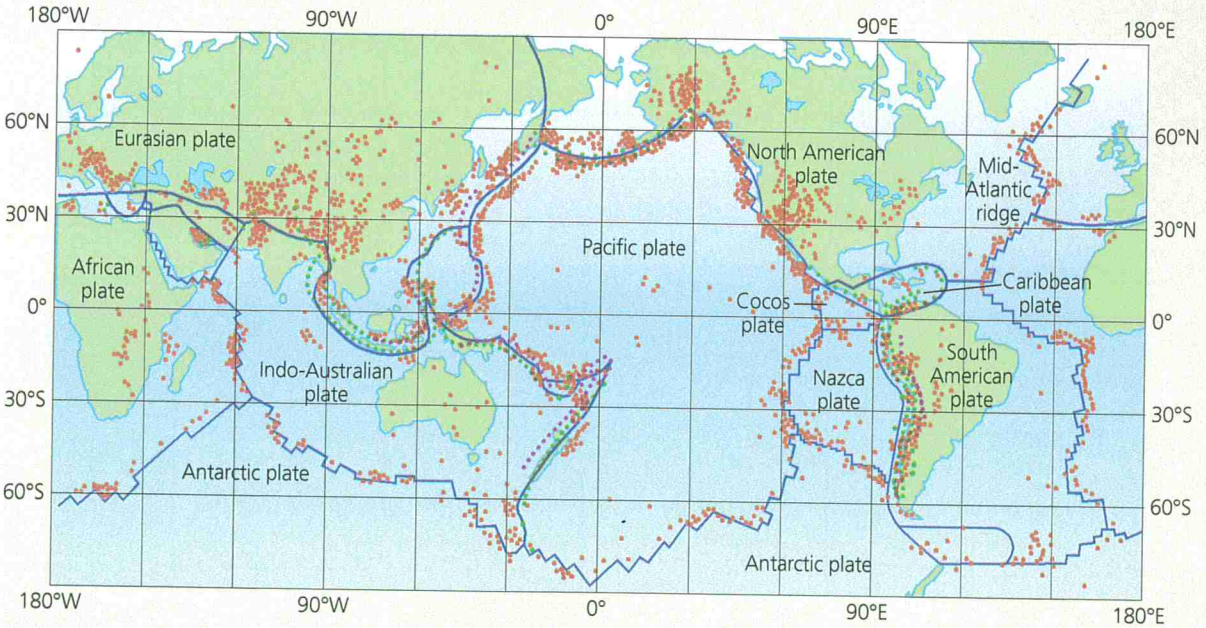

Figure 5.10 Earthquake locations for events between 1965 and 1995. The red dots are shallow earthquakes, the green are of intermediate depth, and the purple are deep

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24 For each of the following seismic hazards, name and locate an example, explain the cause and describe the effects.

a Earthquakes/shock waves

b Liquefaction

c Landslide

d Tsunamis

25 Describe how the 'seismic gap theory' can help predict the location and timing of earthquakes.

26 What steps can be taken by individuals and organisations to reduce the impact of seismic hazards?

27 For **one** recent hazardous seismic event, do the following:

a Name and locate the event.

b Briefly describe the hazardous nature of the event.

c Outline the social, economic and environmental impacts of the event.

d Describe the human responses to the event.

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Storm hazards

A tropical storm (or cyclone) is the generic term for a low-pressure system over tropical or subtropical waters, with organised convection (i.e. thunderstorm activity) and winds at low levels circulating either anticlockwise (in the northern hemisphere) or clockwise (in the southern hemisphere). The whole storm system may be 8,000 to 9,500m high and 200 to 700km wide, although it can sometimes be even bigger. It typically moves forward at speeds of 16–20 $km\,h^{-1}$ but can travel as fast as 60 $km\,h^{-1}$.

Tropical storms require a certain set of environmental conditions to develop. Once they have been triggered, they move westwards and northwards (southwards in the southern hemisphere) until they come under the influence of westerly winds. They then start to reverse their direction into an easterly path.

Tropical storms pose threats to coastal communities in the form of high winds, storm surges, coastal flooding and landslides. Their impact is huge. Between 1980 and 2009, 466 million people were affected, including 412,644 deaths and 290,654 injuries. The primary cause of cyclone-related mortality in both developed and less developed countries was storm surge drowning.

Practice questions

28 With the help of Figure 5.11, describe the structure of a typical tropical revolving storm.

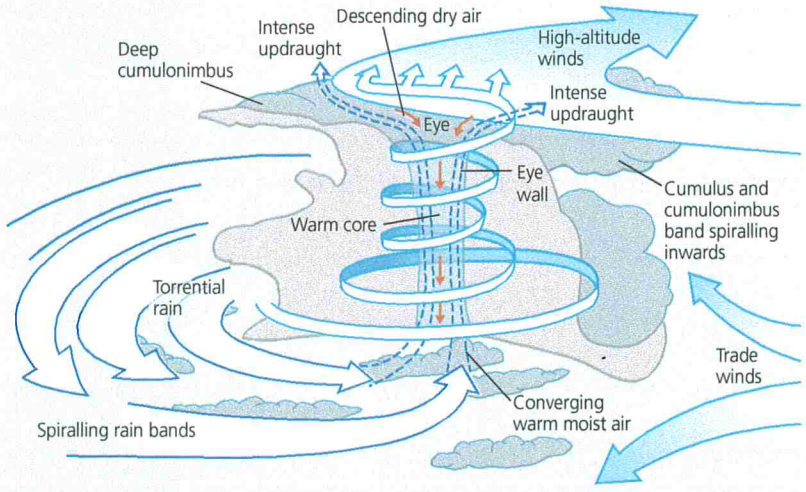

Figure 5.11 The structure of a tropical revolving storm

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29 Describe the processes involved in the formation of a tropical storm.

30 Using Figure 5.12, describe and account for the global distribution of tropical storms and the time of their occurrence.

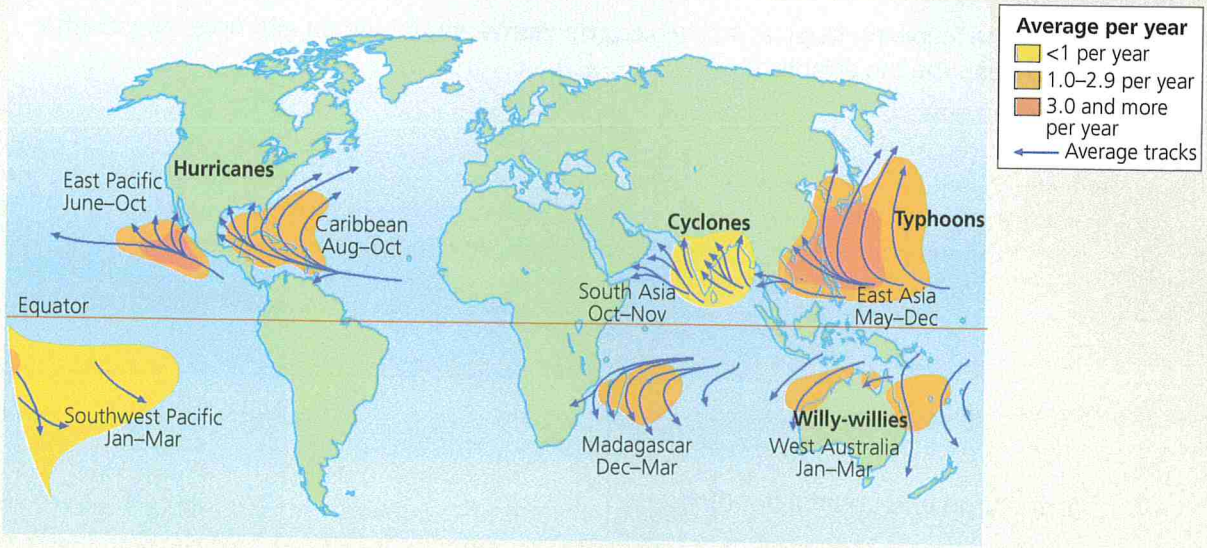

Figure 5.12 Global distribution and seasons of tropical storms

31 Outline **two** ways in which meteorologists can predict both the track and the intensity of a tropical storm.

Worked example

The most sophisticated hurricane forecasting system is based at the National Hurricane Center in the USA.

The first tools the meteorologists use are observations. These can be from ships, buoys, radar and, most importantly, satellites. Satellite data can be used to locate the storm centre and measure its movement and intensity. If a hurricane looks as though it may hit land, then aircraft and parachute probes are deployed to follow its track and measure the air temperatures and windspeeds. Finally, land-based radar observations are used.

Knowledge (AO1): Clear description of the ways in which tropical storms can be observed. The answer looks at a variety of ways, but it could alternatively have concentrated on one observation method in detail.

Once the observations are collated, they are put into computer modelling programs where a series of predictions about the path and intensity of the hurricane are produced, based on comparisons with historical data. The predictions are then considered by experienced forecasters who use experience and judgement to provide the best possible forecast.

Knowledge (AO1): Second method outlined. Note that the question asks for outline, not detailed description.

32 For each of the following tropical storm hazards, name and locate an example, explain the cause and describe the effects.

a High wind speeds

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b Storm surge and coastal flooding

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c Intense rainfall and river flooding

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d Landslides

33 What steps can be taken by organisations and individuals to reduce the impact of storm hazards?

34 Why might a decreased proportion of deaths and injuries be observed in the aftermath of tropical storms as a result of improved early warning systems and evacuation?

35 To what extent do the impacts of tropical storms and the human responses depend on both the physical nature of the environment and the level of economic development?

36 For **one** recent tropical storm, do the following:

a Name and locate the event.

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b Briefly describe the hazardous nature of the storm.

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c Outline the social, economic and environmental impacts of the storm.

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d Describe the human responses to the event.

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Fires in nature

A wildfire is an unplanned fire found in a natural area such as a forest, grassland or moorland. Such fires are often caused by human activity (abandoned barbecues, cigarette ends and so on) or natural lightning. The risk of wildfires increases in extremely dry conditions, such as drought, and during high winds.

The impacts of wildfires on the human environment include disruption or destruction of infrastructure (electricity, gas, water, telecommunications), housing, transport links (roads, railways) and agriculture.

Wildfires also destroy natural environments with a consequent loss of forest and other vegetation, as well as wild animal habitats.

Wildfires also impact weather and the climate by releasing large quantities of carbon and particulate matter into the atmosphere. This exacerbates climate change and can cause a range of health issues, including respiratory and cardiovascular problems.

Despite recent news coverage of wildfires in the USA and Australia, it is important to note that fatalities are relatively few and extensive wildfires have been around for millennia. Research has found a significant increase in burn severity in US forests and it is believed that outdated management practices (e.g. fire suppression) rather than climate change have led to major changes in the forests and resulting fires.

It is important to note that there are marked differences between wildfires and other natural hazards.

Practice questions

37 Complete Table 5.3.

Table 5.3 Conditions favouring wildfires

Factor	Impact on wildfire
Vegetation type	
Fuel characteristics	
Climate	
Recent weather conditions	
Fire behaviour	

38 Outline how wildfires can be started.

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39 What factors need to be taken into account when producing a wildfire risk assessment strategy?

40 Explain how outdated fire management practices may be contributing to the severity of wildfire hazards.

41 For a recent wildfire event you have studied, describe the impacts of that fire in terms of the following:

a Environmental impacts

b Social impacts

c Economic impacts

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d Political impacts

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Exam-style questions

Exam-style set 1

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1 Outline how risk management can reduce the impacts of wildfires. (AO1) 4 marks

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2 The United Nations Office for Disaster Risk Reduction has produced statistics regarding the number of natural disasters and the total costs of the damage incurred.

Table 5.4 shows the figures for the ten countries with the most disasters between 2005 and 2014.

Table 5.4

Country	Number of natural disasters	Rank	Total damage ($ billion)	Rank	d	d^2
China	286	1	265	2	−1	1
USA	212	2	443	1	+1	1
Philippines	181	3	16	7	−4	16
India	167	4	47	4	0	0
Indonesia	141	5	11	8	−3	9
Vietnam	73	6	7	9	−3	9
Afghanistan	72	7	0.16	10		
Mexico	64	8	26	5	3	9
Japan	62	9	239	3		
Pakistan	59	10	25	6	4	16

Calculate the Spearman's rank correlation coefficient for the two sets of data by completing Table 5.4 and using the formula:

$$R_s = 1 - \left(\frac{6\sum d^2}{n^3 - n} \right)$$

where:

R_s is the Spearman's rank correlation coefficient

n is the number of pairs of variables

$\sum d^2$ is the sum of the differences in rank squared.

Critical values for Spearman's rank where $n = 10$:

n	Significance level	
	0.05	0.01
10	±0.564	±0.746

Complete Table 5.4 and interpret your Spearman's rank result using the critical values above. (AO3) 6 marks 7

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3 Using Table 5.5 and your own knowledge, assess the usefulness of the volcanic explosivity index (VEI) when considering the impacts of a volcanic eruption. (AO1, AO2) 9 marks 10

Table 5.5 The volcanic explosivity index

Volcanic explosivity index (VEI)	Eruption rate/ kg s^{-1}	Volume of ejecta/ m^3	Eruption column height/ km	Duration of continuous blasts/h	Troposphere/ stratosphere injection	Qualitative description	Example
0 Non-explosive	10^2–10^3	<10^4	0.8–1.5	<1	Negligible/ none	Effusive	Kilauea, erupts continuously
1 Small	10^3–10^4	10^4–10^6	1.5–2.8	<1	Minor/none	Gentle	Nyiragongo, 2002
2 Moderate	10^4–10^5	10^6–10^7	2.8–5.5	1–6	Moderate/ none	Explosive	Galeras, Colombia, 1993
3 Moderate–large	10^5–10^6	10^7–10^8	5.5–10.5	1–12	Great/ possible	Severe	Nevado del Ruiz, 1985
4 Large	10^6–10^7	10^8–10^9	10.5–17.0	1–>12	Great/ definite	Violent	Mayon, 1895 Eyjafjallajökull, 2010
5 Very large	10^7–10^8	10^9–10^{10}	17.0–28.0	6–>12	Great/ significant	Cataclysmic	Vesuvius, AD 79 Mt St Helens, 1980
6 Very large	10^8–10^9	10^{10}–10^{11}	28.0–47.0	>12	Great/ significant	Paroxysmal	Mt Pinatubo, 1991
7 Very large	>10^9	10^{11}–10^{12}	>47.0	>12	Great/ significant	Colossal	Tambora, 1815
8 Very large	–	>10^{12}	–	>12	Great/ significant	Terrific	Yellowstone, millions of years ago

4 With reference to **one or more** seismic events that you have studied, assess the extent to which the hazards created can be managed effectively. (AO1, AO2) 9 marks

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5 Using a named example of a place that has suffered a recent hazardous event, assess the extent to which people's lived experience of that place has been affected by the hazardous event. (AO1, AO2) 20 marks

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Plan and write your answer on a separate sheet of paper and keep it with your workbook.

Exam-style set 2

1 Describe **two** forms of storm hazard. (AO1) 4 marks

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2 Analyse the data shown in Figure 5.13. (AO3) **6 marks**

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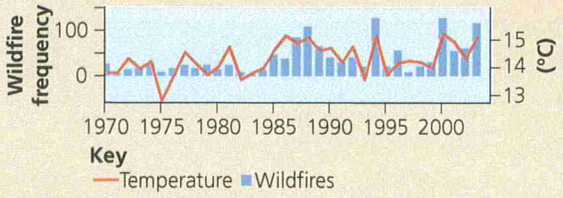
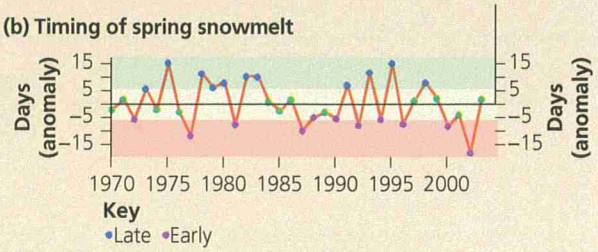
(a) Western US forest wildfires and spring–summer temperatures



(b) Timing of spring snowmelt



(c) Fire season length

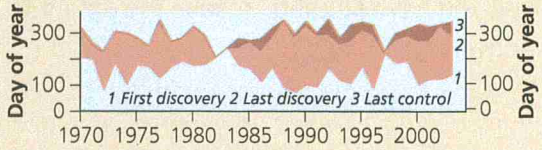


Figure 5.13 Annual frequency of large (> 400 ha) western US forest wildfires (bars) and mean March–August temperatures (a); timing of spring snowmelt for western USA (b); and fire season length (c)

3 Using Figure 5.14 and your own knowledge, assess the extent to which destructive plate boundaries could be viewed as very susceptible to earthquake hazards. (AO1, AO2)

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9 marks

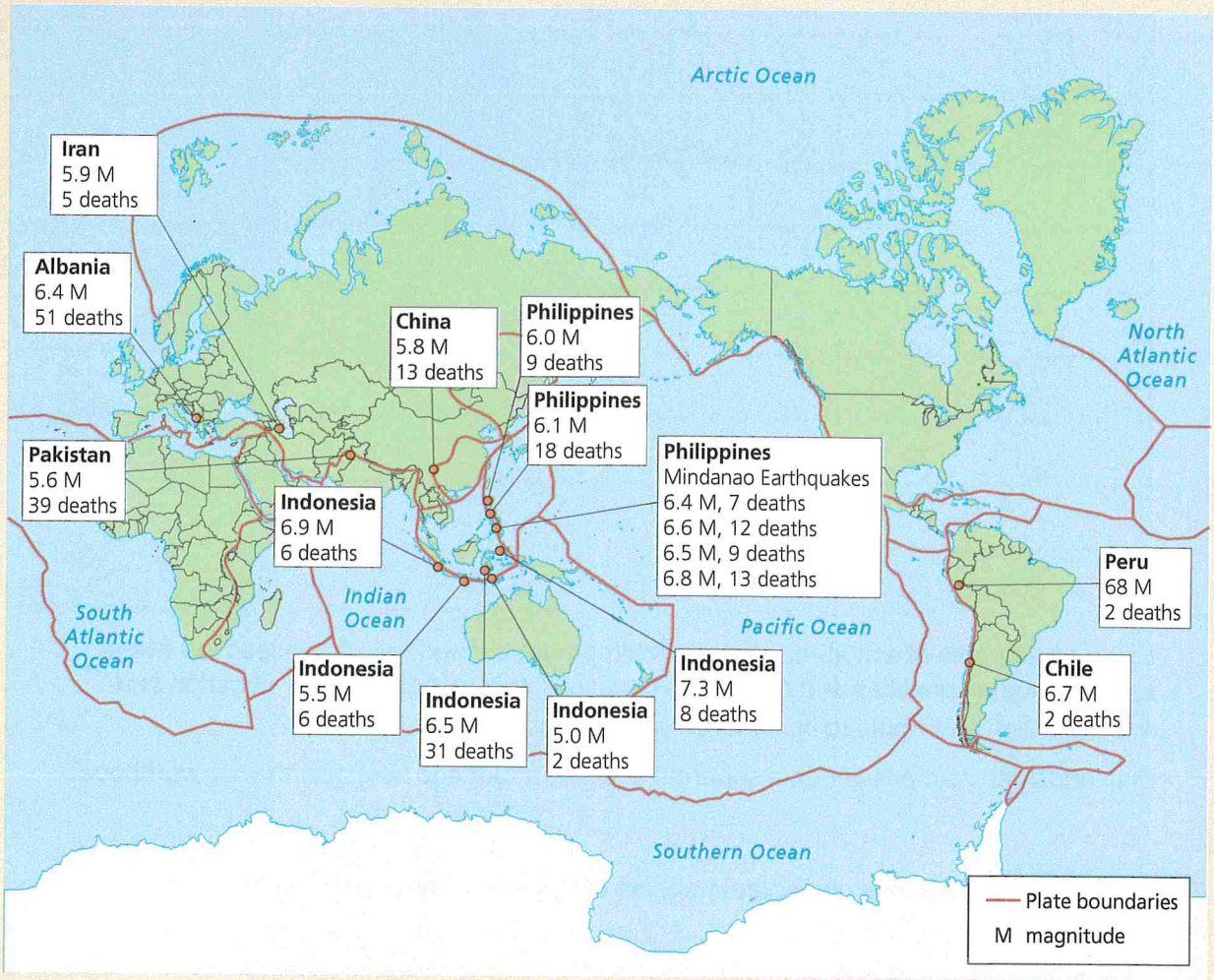

Figure 5.14 Global overview of 2019 earthquakes, showing events with a magnitude of 5.0 M or greater and more than one fatality

Source: adapted from Emergency Response Coordination Centre, European Commission

4 Assess the extent to which the positions of young fold mountains, rift valleys, ocean ridges, volcanoes, deep sea trenches and island arcs support the theory of plate tectonics. (AO1, AO2) 9 marks 10

5 Using an example of a multi-hazardous environment beyond the UK, assess the extent to which human qualities and responses (such as fatalism, adaptation, mitigation and management) contribute to its continuing human occupation. (AO1, AO2) 20 marks 25

Plan and write your answer on a separate sheet of paper and keep it with your workbook.

Additional extended prose questions

Plan and write your answers on separate sheets of paper and keep them with your workbook.

1 'The economic, social and political character of a local community reflects the presence and impacts of hazard risk and the community's responses to that hazard.'

For a place at a local scale that you have studied, assess the extent to which you support this view. (AO1) (AO2) 20 marks 25

2 To what extent do the human responses to a hazard/s depend on the character of the place affected by that hazard/s? (AO1) (AO2) 20 marks 25