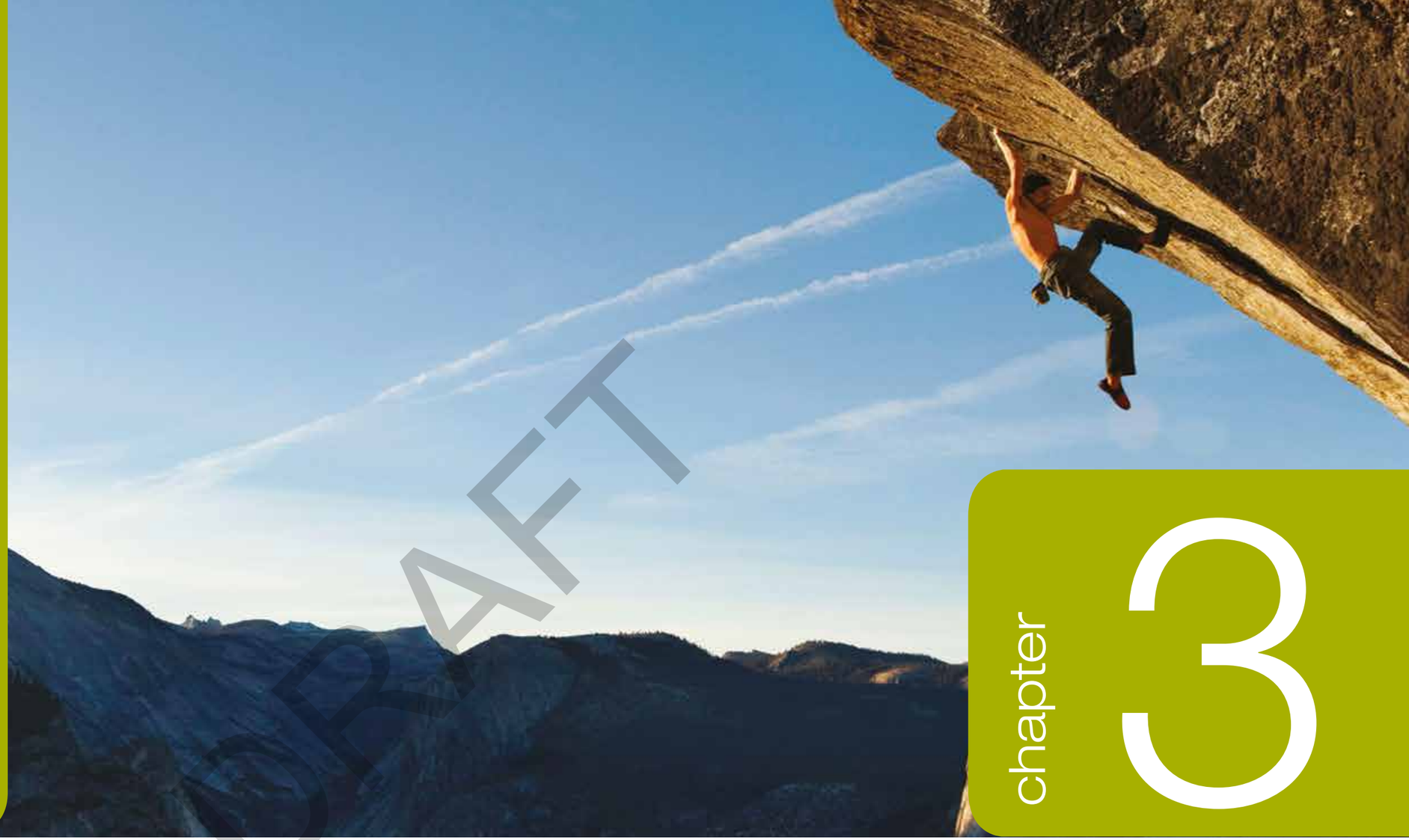
Mountain landscapes

A mountain is an elevated landform that rises above the surrounding landscape. Mountain landscapes appear on every continent on Earth. Mountains are created by the movement of the Earth's **tectonic plates**.

The imposing form of a mountain in a landscape has made mountains significant in the spiritual and cultural lives of many groups, including Indigenous Australians.

Weather conditions at high elevations are harsh and changeable. Humans and animals that live in the mountains have adapted their lifestyles to suit these extreme conditions. For those living close to mountains, there are also risks from volcanic eruptions, landslides and avalanches. In this chapter we will explore these mountain landscapes in detail.

chapter 3



Source 1 A rock climber in Yosemite National Park, California, United States. This type of climbing — without ropes — is known as free climbing.Mountain landscapes

3A

What processes shape mountain landscapes?

1 Yosemite National Park is one of the world's most popular rock-climbing destinations because of the type of rock found there. What features of the rock do you think might be important to this climber?

3B

How are mountain landscapes used and managed?

1 This climber has no safety ropes. Do you think this type of climbing should be allowed?

2 What effect does the presence of Yosemite National Park have on the region in which it is located? Name some Australian national parks.

3C

Are mountain landscapes hazardous places?

1 Which natural hazards do you think might be common in mountainous regions?

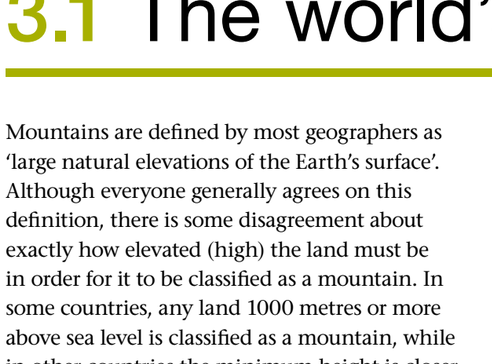
2 Do you think some of the mountains in this region are likely to be active volcanoes? Give some reasons for your answer.

3.1 The world's mountains

Mountains are defined by most geographers as 'large natural elevations of the Earth's surface'. Although everyone generally agrees on this definition, there is some disagreement about exactly how elevated (high) the land must be in order for it to be classified as a mountain. In some countries, any land 1000 metres or more above sea level is classified as a mountain, while in other countries the minimum height is closer to 2500 metres. If we go by this second definition, Australia's highest mountain, Mount Kosciuszko, at 2228 metres, is not really a mountain at all.

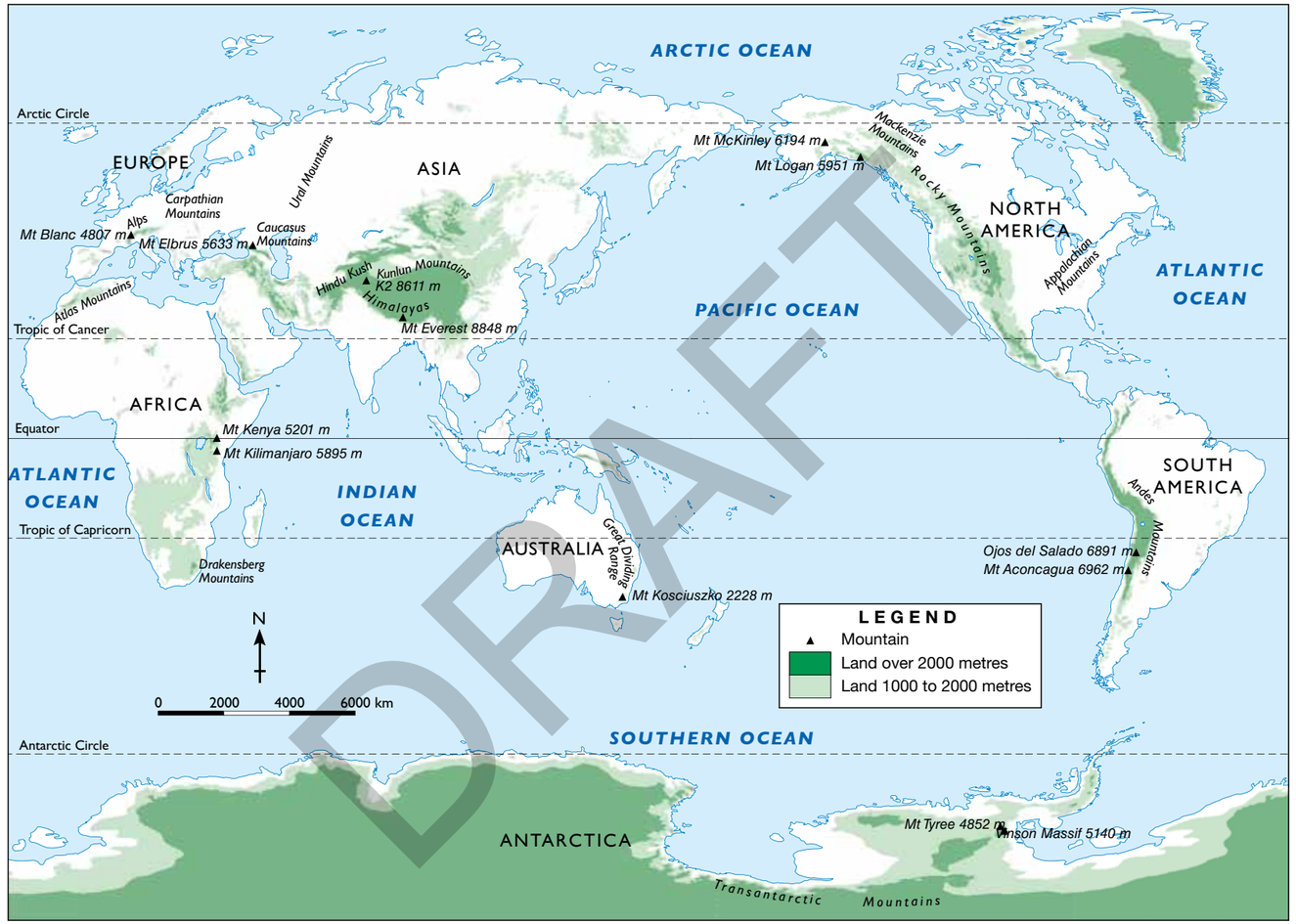
Some countries, such as Nepal and Lesotho, are very mountainous, while others, such as Australia and Egypt, are relatively flat. Lesotho (in southern Africa) is the only country in the world that is entirely more than 1 kilometre above sea level.

The Transantarctic Mountains (in Antarctica) make up one of the world's longest mountain ranges. Due to the huge volume of ice covering the land, Antarctica holds the record for the greatest average height above sea level of any continent (as shown in Source 2).



Source 1 The Himalayas contains nine of the world's ten highest mountains, including the highest, Mount Everest.

WORLD: MAJOR MOUNTAINS AND MOUNTAIN RANGES



Source 2

Source: Oxford University Press

Source 3 The Sierra Nevada Mountains in the United States. Their sheer sides are a result of parts of the Earth's crust lifting and dropping away steeply.

Source 4 The Blue Mountains in New South Wales are the worn away remains of a much larger and higher plateau. This plateau was lifted up by forces within the Earth's crust.

Check your learning 3.1

Remember and understand

1 Study Source 2. There are seven continents. Can you find the highest mountain in each? Which continent has the highest mountain of all? Which has the lowest?

2 What is the highest mountain in the world that is not part of a mountain range (a long line of mountains)? Where is it?

Apply and analyse

3 Mountains are often part of a mountain range. Why do you think this is the case?

4 Why do you think some places are mountainous and others are not?

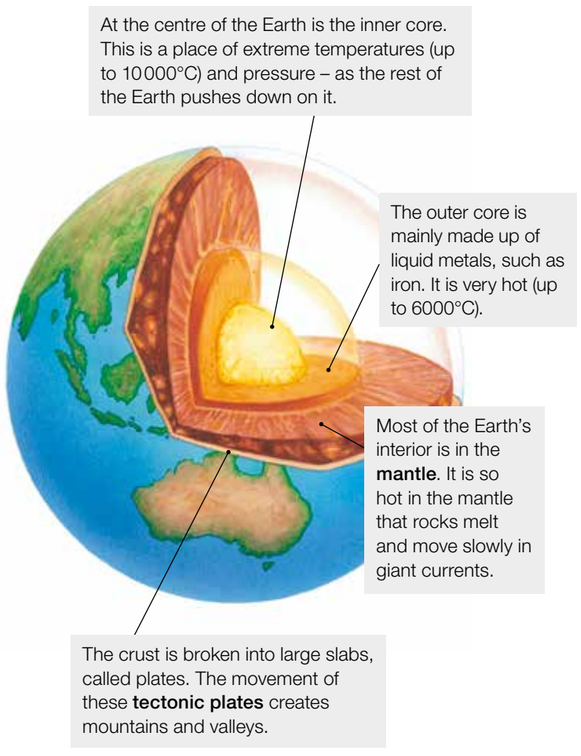
5 Study Source 2. Select a continent other than South America or Antarctica. Describe the distribution of mountains on this continent using this description of South America as an example: 'Most of South America is relatively flat. However, a long, high mountain range – the Andes Mountains – extends along the western edge of the continent, from the very north to the very south.'

Source 5 Mount Kilimanjaro is Africa's highest mountain. It is also the highest mountain in the world that stands alone, rather than being part of a mountain range.

3.2 How mountains are formed

Mountains are formed where the surface of the Earth has been pushed upwards. Tremendous forces inside the Earth can crumple the surface into long mountain chains, such as the Andes or Himalayas, or punch right through the surface to create volcanoes, such as Kilauea on the island of Hawai'i and Mount Kilimanjaro in Tanzania. To understand how this happens you need to know about the world beneath your feet.

You may be used to thinking of the Earth as a solid ball like a giant shot-put, but this is far from the reality. The Earth is more like a giant peach with a thin skin and a core at the centre surrounded by soft flesh. Scientists believe that the Earth is made up of four layers (see Source 1).



Source 1 The Earth's layers

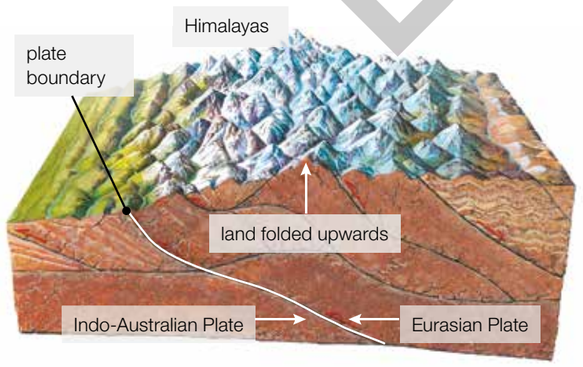
Tectonic plates

The outer layer of the Earth's surface (known as the crust) is broken into large pieces called **tectonic plates**. These plates are around 100 kilometres thick and fit together like enormous pieces of a jigsaw puzzle. Currents in the red-hot molten material (**magma**) under these tectonic plates cause them to move about (see Source 1).

In some places, they are being pushed into one another (converging). This process creates mountain ranges. The world's highest mountain ranges such as the Himalayas and the Andes are located along a converging plate boundary.

In other places, tectonic plates are being pulled apart from one another (diverging). This process creates rifts in the Earth's surface that allow hot magma to ooze to the surface and create new land. The world's longest mountain range, the mid-Atlantic Ridge, is an undersea mountain range formed along a diverging plate boundary.

The movement of tectonic plates is also responsible for many other features and natural events on the Earth's surface, such as volcanoes and earthquakes. Volcanoes are formed when magma is pushed through an opening in the Earth's crust. Earthquakes are caused when the edges of tectonic plates push and grind against one other.



Source 2 The collision of tectonic plates caused the formation of the Himalayas.

Types of mountains

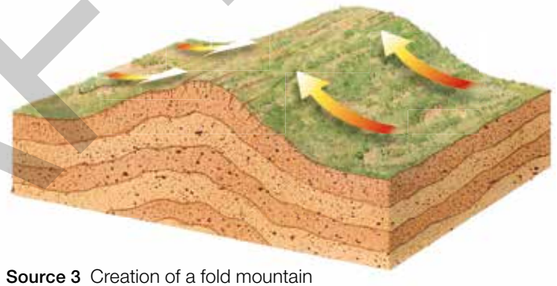
Mountains are classified according to how they were formed. There are three main types of mountains:

1 fold mountains
2 block mountains
3 volcanic mountains.

1 Fold mountains

Fold mountains are created by upward pressure where two tectonic plates collide. As the plates converge, layers of rock are buckled and pushed upwards creating fold mountains. Most of the world's highest mountain ranges are fold mountains.

The world's largest fold mountains are the Himalayas, which separate southern Asia from central Asia. They have been formed by the collision between the Indo-Australian plate and the Eurasian plate over the last 55 million years. Currents within the mantle are moving the Indo-Australian plate northwards, and its front edge is bulldozing into the Eurasian plate, folding the edges of both plates upwards.

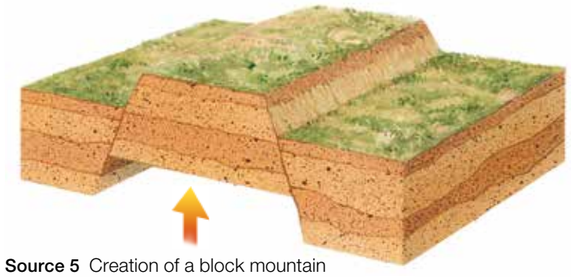


Source 3 Creation of a fold mountain

Source 4 These mountains on the edge of the Zanskar Valley in Ladakh, India, are clearly distinguishable as fold mountains.

2 Block mountains

Block mountains are created when cracks in the Earth's crust known as faults force blocks of land upwards. Rocks that are cooler because they are close to the surface tend to crack and break apart when compressed from the sides. Rather than folding, they are often lifted up in giant blocks along fault lines to create block mountains. Geologists refer to this mountain-building process as faulting.



Source 5 Creation of a block mountain

Source 6 Block mountains in the Arctic region of Norway

3 Volcanic mountains

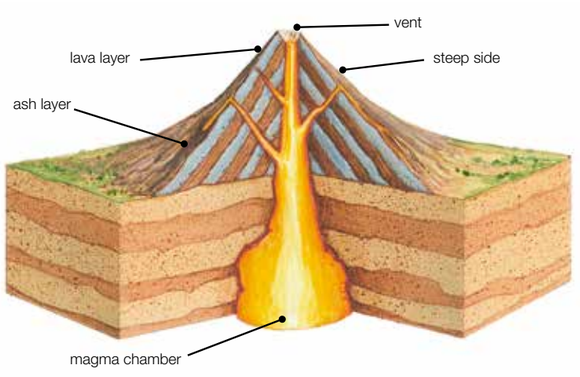
Volcanic mountains are created by volcanoes, as the name suggests. They are created when magma pushes its way from beneath the Earth to the crust. The material that comes out of a volcano builds up the Earth's surface, creating new land and new landforms.

Each eruption brings new material to the surface, as ash or **lava** or both. As lava flows across the surface it covers the rocks from previous eruptions and builds up the height of the land in layers. Runny lava can travel many kilometres from the crater and leave behind a shallow layer of new rocks over a wide area. These types of volcanoes are known as **shield volcanoes** (see Source 8).

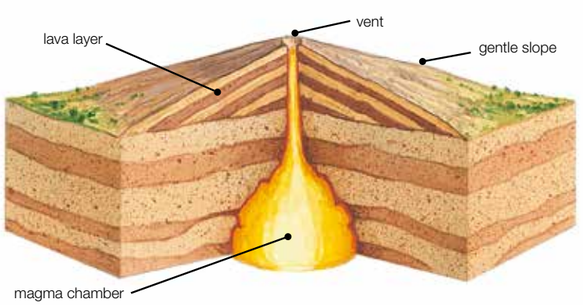
The Hawaiian volcanoes and Mount Kilimanjaro in Tanzania are examples of shield volcanoes. The more familiar steep-sided volcanic cones (see Source 7), such as New Zealand's Mount Taranaki and Mount Fuji in Japan, are formed when lava and ash do not travel far from the crater. These materials are then left as a new layer on the sides of the cone, building it higher.

Most of the world's volcanoes are located on or near plate boundaries where plates collide and one plate is forced downwards into the mantle. This causes pressure to build up and molten rocks, called magma, to rise to the surface and force their way out through a weakness in the crust. This is what we see as an eruption. Other volcanoes are located in **hot spots**, which are areas that are often in the centre of a plate where the mantle is particularly hot. In these places molten rock from the mantle is forced upwards through the moving crust.

The Hawaiian Islands have been formed above a hot spot. As the Pacific Plate moves over the hot spot a line of volcanoes has been created. The oldest volcanoes have been eroded so that little remains above sea level. The newest island, Hawai'i, has many active volcanoes and is increasing in size every year.



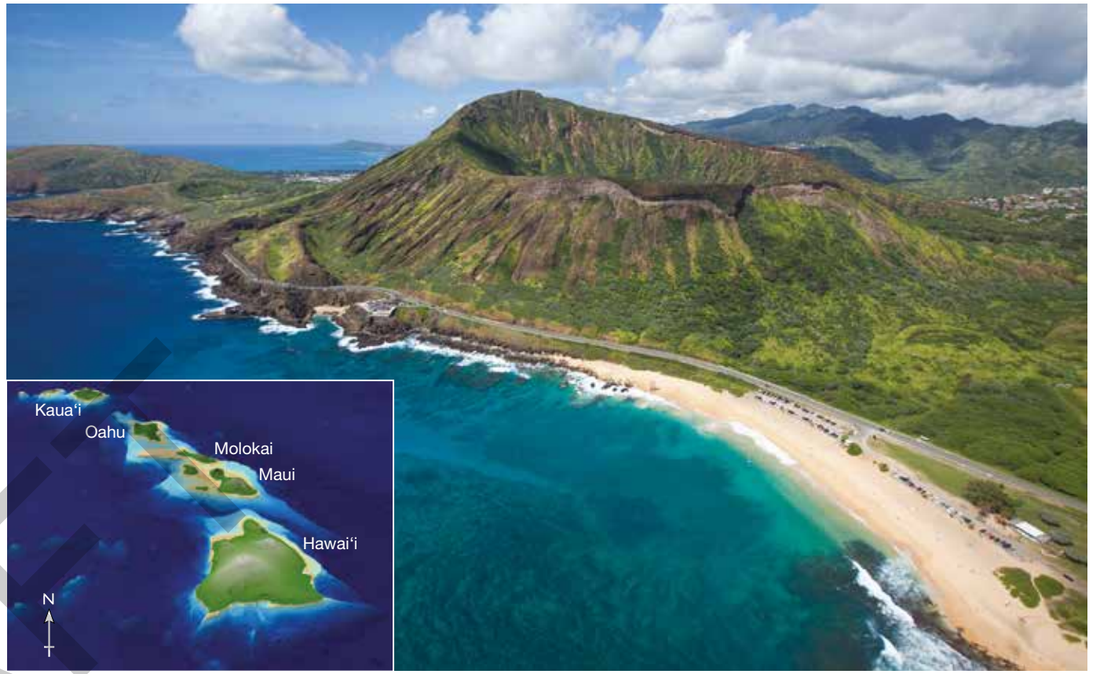
Source 7 A cutaway diagram of a volcanic cone



Source 8 A cutaway diagram of a shield volcano

Source 9 Mount Fuji in Japan is an example of a volcanic cone.

Source 10 Rangitoto Island in Auckland, New Zealand, is an example of a shield volcano.



Source 11 The Koko Crater on Oahu (main) and a digital terrain model of the Hawaiian Islands showing them sitting on top of a chain of massive volcanoes (inset)

Check your learning 3.2

Remember and understand

1 What are the four layers of the Earth?
2 In this section, the Earth is described as being more like a peach than a shot-put. In what ways is the Earth like each of these objects: an inflated balloon, an apple and an egg?
3 How do the Earth's tectonic plates move?
4 Describe the process of folding.
5 How does a volcanic eruption change the shape of the land?

Apply and analyse

6 What are the similarities between folding and faulting? What are the important differences?
7 Sketch and label a diagram of the block mountains in Norway (Source 6) to show how they are formed.
8 Explain why some volcanoes are steep-sided cones and some are not.
9 Why is every volcano in the world a different shape?

Evaluate and create

10 Scientists have been able to work out the age of the lava flows on each of the Hawaiian Islands. Here is their data with the age of lava in millions of years.

Island name	Age of lava (million years)
Kaua'i	3.8–5.6
Oahu	2.2–3.4
Molokai	1.3–1.8
Maui	0.8–1.3
Hawai'i	0.7

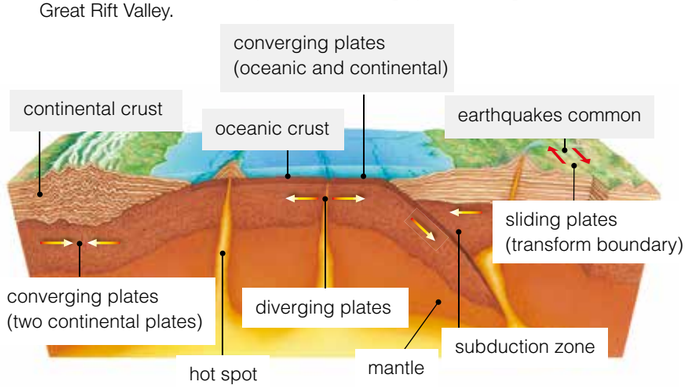
a On which island is the oldest lava found?
b On which island is the newest lava found?
c How does this data support the theory that the islands formed as they passed north over a hot spot?
d Which of these islands is the smallest?
e Which of these islands is the largest?
f Suggest a possible reason for this difference.

3.3 Tectonic plate boundaries

Source 5 shows the Earth's tectonic plates. The plate boundaries are shown to be either pushing into each other, (converging), pulling apart (diverging) or sliding against one another (transform boundary). This activity on the boundaries has a number of effects on the Earth's surface.

Source 2 In South America, four plates are colliding with each other creating the Andes.

Source 3 In Africa, three plates are moving apart creating the Great Rift Valley.



Source 4 Tectonic plate movement

Source 1 In North America, two plates are sliding past each other creating the San Andreas Fault.

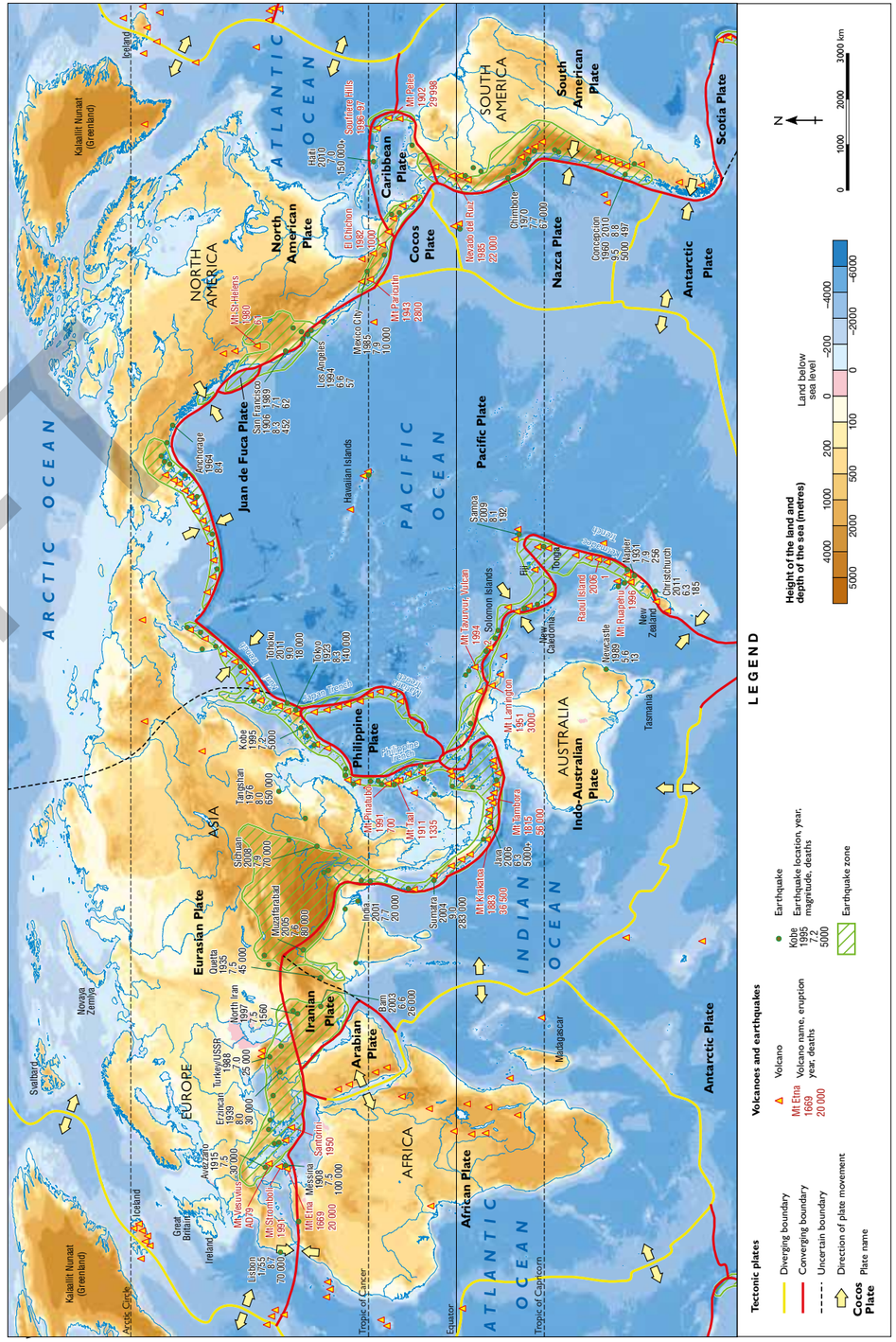
Check your learning 3.3

Remember and understand

1 Look at Source 5. Which of these statements are true and which are false?
   - **a** Africa is moving away from Europe.
   - **b** Australia is moving closer to Antarctica.
   - **c** South America and Africa are moving further apart.

Apply and analyse

1 Carefully examine Source 5.
   - **a** On which plate is Australia located?
   - **b** In which direction is this plate moving?
   - **c** What is the main difference in terms of plate boundaries between the location of New Zealand and the location of Australia?
   - **d** Identify any possible links you notice between plate boundaries and:
     - **i** mountain ranges
     - **ii** volcanoes
     - **iii** earthquakes.



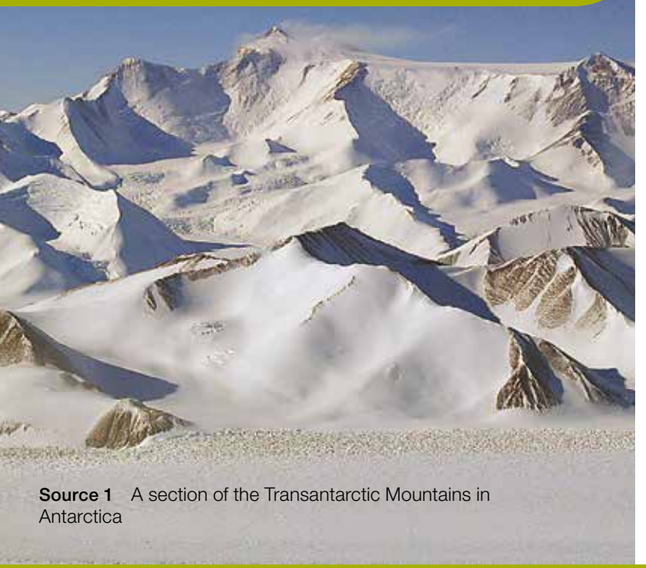
Source 5

Source: Oxford University Press

3A rich task

The mountains of Antarctica

Antarctica is the world's highest continent. Its average height above sea level is 2500 metres whereas Australia's is about 340 metres. Antarctica's great height is largely due to the two enormous ice sheets that cover virtually the whole continent. Up to 4 kilometres thick, these ice sheets hold 90 per cent of the world's ice and 70 per cent of its fresh water. Antarctica is also home to vast mountain ranges. Most of its mountains lie hidden beneath the ice, but some are tall enough to poke through the ice. One range, the Transantarctic Mountains, is over 3000 kilometres long and tall enough to hold back the world's largest ice sheet.



Source 1 A section of the Transantarctic Mountains in Antarctica

skilldrill

Interpreting a cross-section

Maps are useful tools for showing where places are located, but they don't usually show the height of the land. This is because they show a view from above, rather than from the side. Some maps, such as Source 3, show the height of the land through contour lines. These lines help us to visualise the shape of the land. One of the most useful tools that geographers use to see a landscape from the side are cross-sections.

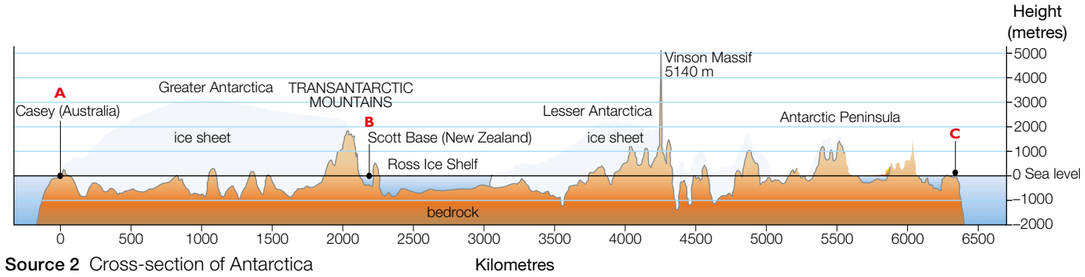
- **Step 1** Look at the map of Antarctica in Source 2.31. Find the line that runs from A to B on the map. This identifies the section of land to be shown as a cross-section.
- **Step 2** Look at the cross-section of Antarctica shown in Source 2. This shows the section running A – B – C as a cross-section.
- **Step 3** Use the cross-section to estimate the height of the mountains and the thickness of the ice that covers them.

Apply the skill

1 Why can't we see most of Antarctica's mountains?
2 Which of Antarctica's two ice sheets is the highest?
3 Describe the shape of the landforms beneath Antarctica's ice sheet.
4 How high above sea level is the Ross Ice Shelf?
5 When explorers first began to try to reach the South Pole they used the Ross Ice Shelf as a way to access the interior of Antarctica. Use the cross-section to explain why this was both a good idea and a bad idea.

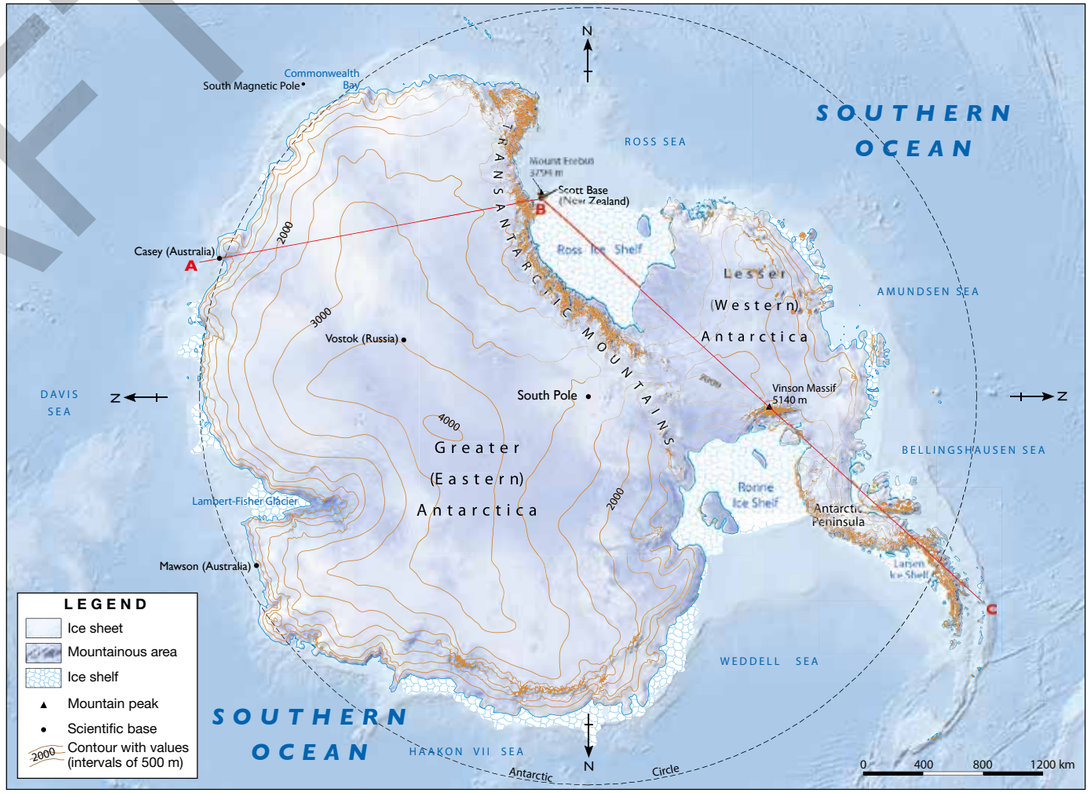
Extend your understanding

1 Use the map of Antarctica (3) to describe the distribution of mountains on that continent.
2 How do you think the Transantarctic Mountains were formed? Give some reasons for your answer.
3 Mount Erebus, located on the edge of the Ross Ice Shelf, is an active volcano. Do you think it is located over a hot spot? Give some reasons for your answer.



Source 2 Cross-section of Antarctica

ANTARCTICA



Source 3

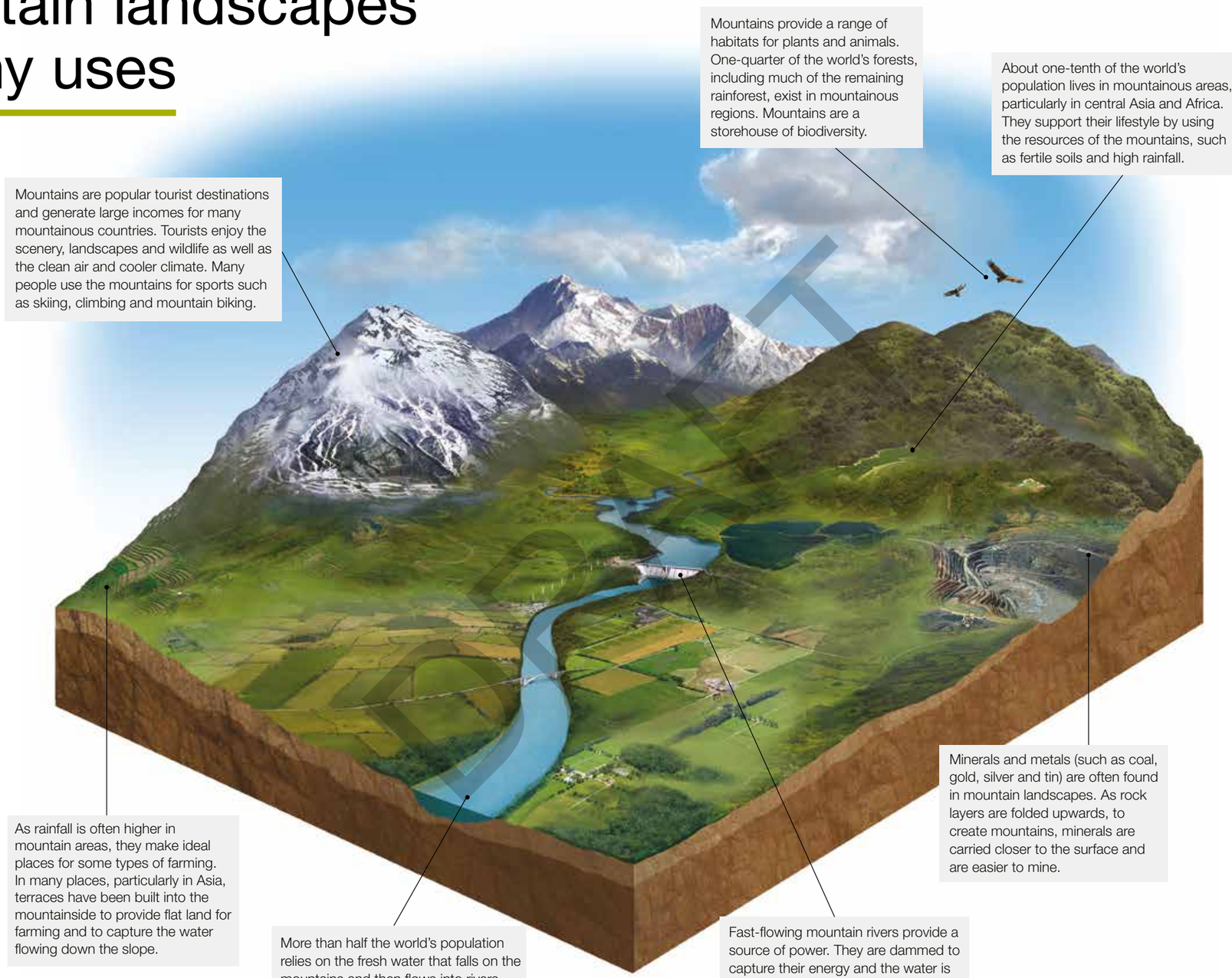
Source: Oxford University Press

3.4 Mountain landscapes have many uses

Like many of the world's landscapes, mountains are used by people as a resource. Billions of people rely on them to satisfy certain needs and wants. Some of the ways in which we use mountains do not change them at all, while others can affect them dramatically.

Mountain landscapes are often fragile. Small changes caused by human activities can greatly affect the plants and animals, soil and even the climate in these areas.

Depending on the society and culture into which people are born, and their personal circumstances, they will view and value different parts of the natural world in very different ways. For example, a tribesman from the highlands of Papua New Guinea may value mountains as a place to live and grow crops; an Indian farmer may value mountains as a source of fresh water for irrigation; and an Australian city-dweller may value mountains as a holiday destination for skiing and snowboarding.



Source 1 Mountain landscapes provide many resources.

Check your learning 3.4

Remember and understand

1. Which use of mountain landscapes shown in Source 1 do you think has the greatest impact on the natural environment? Justify your answer.
2. List three uses that have little or no impact on the natural environment.
3. In what ways do you use mountains as a resource?
4. Can you think of any other uses of the mountains not shown in Source 1?

Apply and analyse

5. In what ways does tourism change the natural environment?
6. How might tourism benefit people who live in mountainous places?

Evaluate and create

7. Select two uses of mountains that can co-exist without affecting each other. Explain why there is no conflict in these uses.
8. Select two uses that conflict or compete with each other. Explain why there is this conflict. Can you think of any real-life examples of this type of conflict?
9. In small groups, rank the uses of mountain landscapes shown from most to least harmful to the environment. When you have decided on the most harmful, brainstorm exactly what these impacts might be. Share your brainstorm with the rest of the class and be prepared to add to your list of potential impacts.

3.5 Traditional Aboriginal land use and mountains

Aboriginal people have a special connection with the land. They see themselves as being responsible for looking after the stories, places, resources and culture of their land. In this way, they seek to live sustainably. This concept is sometimes called Caring for Country and applies to all landscapes, including the forests, deserts, wetlands and mountains.

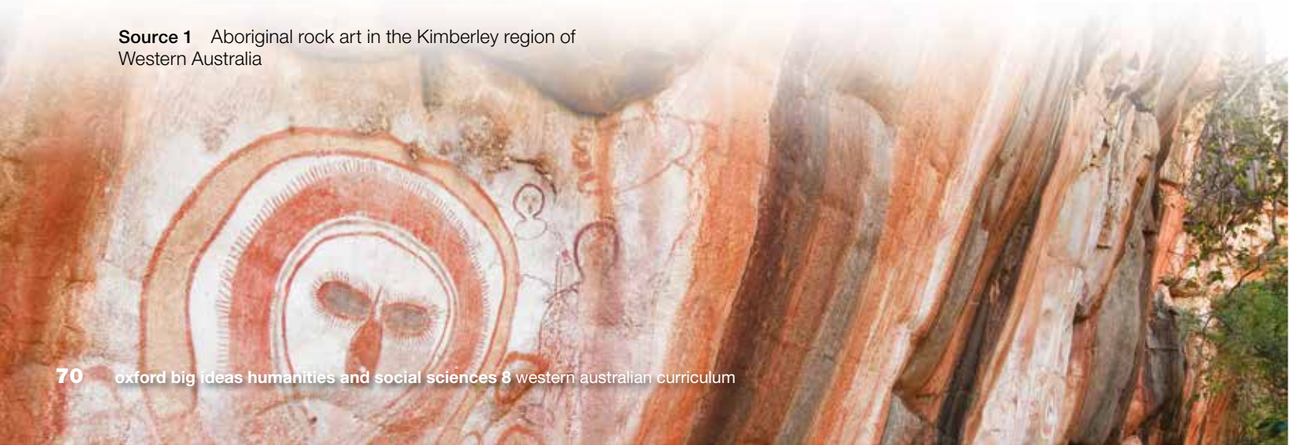
> The Mountains are very old and an ongoing life force that strengthens the ancestral link of our people. We have a living, spiritual connection with the mountains. We retain family stories and memories of the mountains, which makes them spiritually and culturally significant to us. Our traditional knowledge and cultural practices still exist and need to be maintained.
>
> Kosciuszko Aboriginal Working Group

The Bogong moth, a prized food source, can be found in great abundance in the Australian Alps. In early summer, tribes would travel great distances into neighbouring tribal areas to feast on the moth. Rich in fat content, they also provide an important food source for alpine animals, such as the mountain pygmy possum, lizards, birds and fish. Each year millions of these brown moths migrate up to 1000 kilometres to the mountain tops of the Great Dividing Range. As the moths sleep in huge colonies during summer they are easy to catch. Thrown into the ashes of a fire to burn off their wings and legs, they were then roasted and eaten.

Source 2 A Bogong moth

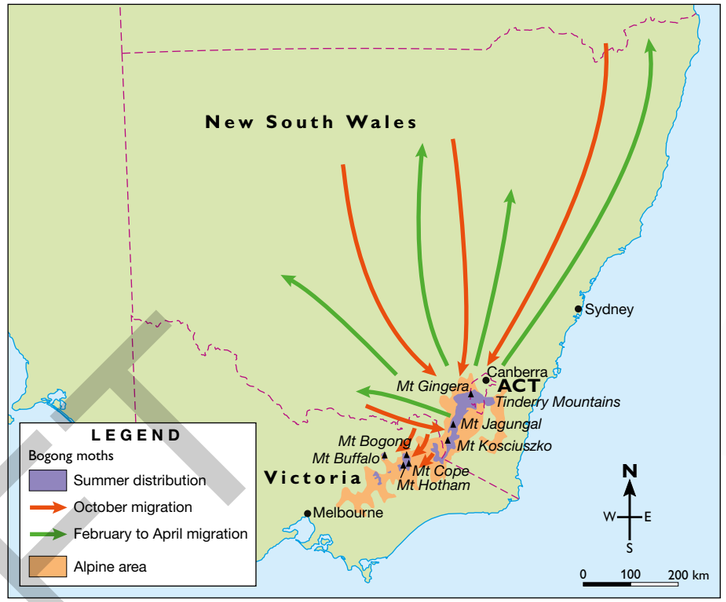
Important as food, the moths also served an important social purpose. As hundreds of people met at each nesting site, links between tribes and language groups were made and strengthened. Up to 1000 people may have converged at some sites, representing some of the largest gatherings of Aboriginal people. These feasts were an opportunity for people to share or swap food and other resources from their own Country and to learn more about the customs and languages of other tribal groups.

As well as providing food, the mountains provided traditional Indigenous people with other resources. Some alpine plants, for example, were used in medicine and others were used in important ceremonies. The Bangalow palm, which grows in the rainforests of the eastern Australian coastal mountains, was used for thatching roofs and making water carriers.



Source 1 Aboriginal rock art in the Kimberley region of Western Australia

BOGONG MOTH MIGRATION ROUTES



Source 3 Source: Oxford University Press

The rocks of the mountains also had their uses, and Indigenous tribes would travel to particular stone quarries to collect rocks for tools such as axes and hatchets. Often they would trade other goods for these rocks and this strengthened the ties between and within tribal groups. One of the most important of these quarries was Mount William in central Victoria, which was the source of greatly prized greenstone hatchet heads.

Source 4 Stone tools made using greenstone from Mount William in central Victoria

Check your learning 3.5

Remember and understand

1. Why was the Bogong moth an important resource for Indigenous Australians?
2. Why did people travel to Mount William?
3. How do you think the tools shown in Source 4 were used?

Apply and analyse

4. Examine Source 3.
   - a. Describe the migration patterns of the Bogong moth. Include compass directions, distances and times of the year in your description.
   - b. How did these migration patterns influence the movement of some Indigenous people?
5. Imagine that you are an Indigenous Australian and have travelled hundreds of kilometres to reach the nesting site of the Bogong moths. When you arrive the harvest is well under way.
   - a. Describe what you see, smell and hear as you arrive.
   - b. What would you bring with you?
   - c. Explain why your trip is an important annual event for you and your tribe.

Evaluate and create

6. Was the harvesting of the Bogong moth a sustainable use of this resource?
7. What questions could you ask to help you decide if the quarrying of stone at Mount William was a sustainable use of this resource?

3.6 The impacts of living and farming on mountains

Source 1 Lhasa is located on a flat area in the bend of the Kyi River.

Liveable places

One of the world's highest cities is Lhasa in the region of China known as Tibet. Lhasa is located high up in the Himalayas at an altitude of 3.5 kilometres above sea level. This is more than 1 kilometre higher than the top of Mount Kosciuszko — Australia's highest mountain. The city is located in a small river basin and is surrounded by high mountains. This meant that for centuries the people who lived in the city had very little contact with people from other places. Due to their isolation, the people of Lhasa have developed a unique way of life.

Most people who live in Lhasa are ethnic Tibetans. Virtually all Tibetans are Buddhists and recognise the Dalai Lama as their spiritual leader. For hundreds of years the region of Tibet has been a 'disputed territory'. At times the Chinese have ruled the region, at other times the Tibetans have ruled the region under the leadership of the Dalai Lama. At present, Tibet is officially recognised as part of China.

Living in the mountains can have its advantages and disadvantages. Some cultures enjoy the lifestyle of mountain living, away from the busy cities. In Switzerland around 60 per cent of people live in mountainous areas, where people can take advantage of tourism and the possibility of snow and skiing. On the other hand, for some communities, living in the mountains can be isolating, especially in regions where there is less infrastructure, such as reliable roads to support their needs. It can also be much colder at higher altitudes and people are at risk in areas prone to landslides or avalanches.

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Farming

Farming in mountainous areas has many advantages, such as reliable rainfall and fertile soils, but it also brings many challenges. These difficulties include accessing raw materials (such as grain for planting) and getting crops to market for sale. There are also many natural hazards to overcome, such as landslides and earthquakes. Despite all these obstacles, a lack of flat land is perhaps the greatest challenge for many mountain-dwelling farmers. Flat land allows farmers to irrigate their fields without water draining away and also makes it easier to use animals or tractors for tasks such as ploughing.

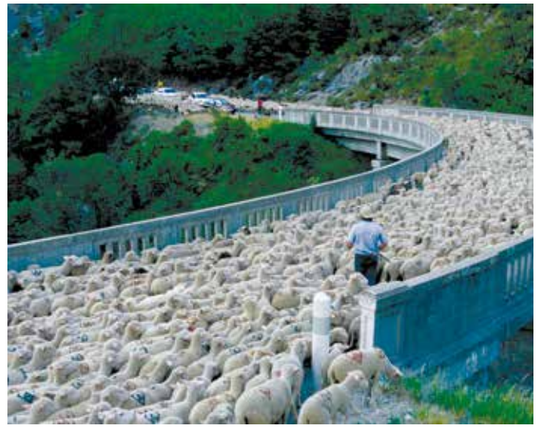
Herding

In mountainous areas there can be dramatic differences between summer and winter. In winter, snow blankets the grass on the ground and animals (including farm animals such as sheep, goats and cows) cannot feed. As temperatures rise in spring, the snow melts and grass recovers. The warmer temperatures also allow moss, lichens (fungi) and wildflowers to flourish, providing food for grazing animals. Farmers respond to these seasonal changes by moving their herds between summer pastures in mountain valleys and plains below.

In some parts of Asia and Europe, including the French Alps (see Sources 2 and 3), this type of farming is centuries old. An Australian equivalent is the summer movement of cattle into the Australian Alps in parts of Victoria and New South Wales, a practice that has now been largely stopped because of the damaging effects it can have on the landscape.

Month	Average low temperature (°C)	Rainfall (mm)
A	–3	164
M	–3	100
M	–2	84
A	0	125
M	5	127
J	8	72
J	10	42
A	11	52
S	7	153
O	4	232
N	–1	225
D	–3	167

Source 3 Climate data for the town of Mende in the French Alps



Source 2 A shepherd takes his flock of sheep into the French Alps for summer.

Check your learning 3.6

Remember and understand

1 What are some of the problems faced by people who live in mountainous regions?
2 What difficulties do people face in Lhasa?
3 Why do many farmers in Asia and Europe move their herds to live for some of the year in the mountains and some of the year on the plains below?

Apply and analyse

4 Look closely at Source 1.
   a Why do you think Lhasa was built in this place?
   b In what ways do you think the people of Lhasa use the river shown in the foreground?
   c How do you think these mountains were formed?
   d How are natural and human forces changing these mountains?

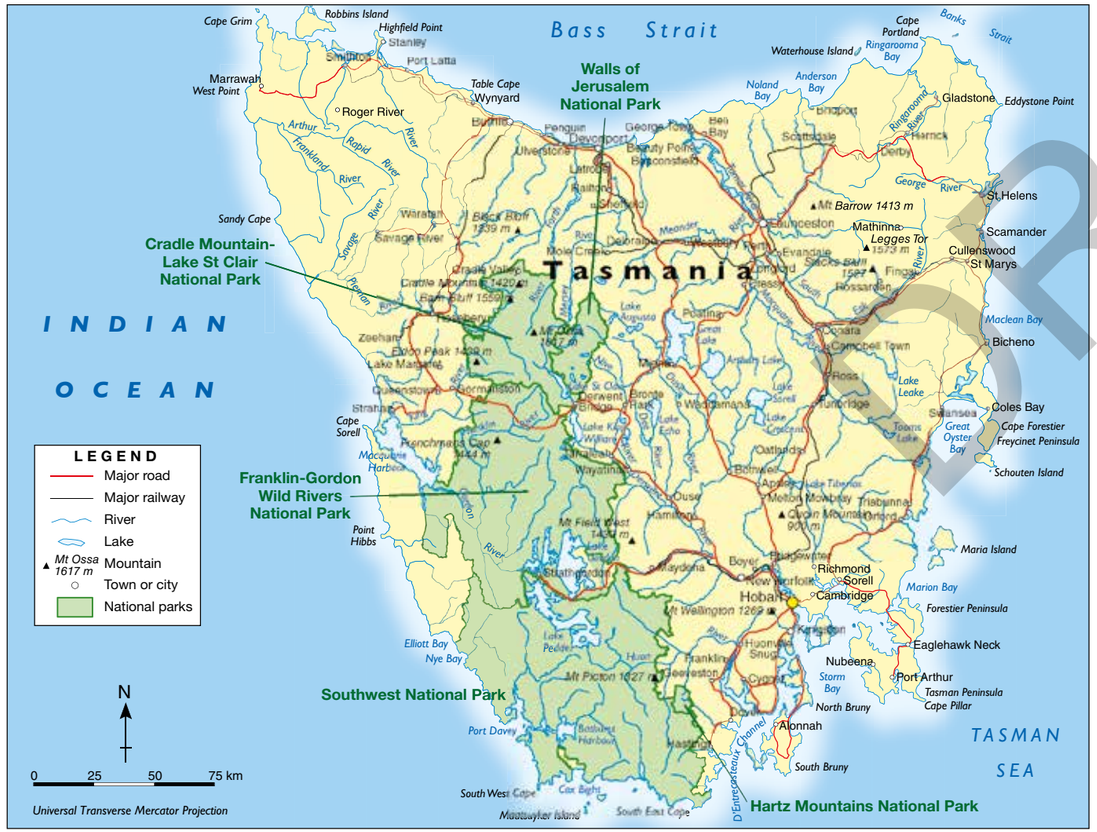
Evaluate and create

5 Study the climate date for the town of Mende in the French Alps in Source 3. This town is located near some of the summer pastures used by French farmers. Complete a climate graph for the town of Mende and answer the question that follow.
   a In which month do you think farmers bring their herds to the meadows near Mende?
   b In which month do you think they leave?
   c What would this mean for shop owners in Mende?

3.7 Sustainably managing mountains

In many places, mountain landscapes are under threat from human activities such as tourism, mining, river damming and wars and other conflicts. Some countries protect their mountains by declaring them to be national parks or nature reserves. Some of these are given further protection by being included on the United Nations World Heritage list. One of these special places is the Tasmanian Wilderness World Heritage Area in south-west Tasmania.

TASMANIA: TASMANIAN WILDERNESS WORLD HERITAGE AREA



Source 1

Source: Oxford University Press

One-fifth of Tasmania is included in this World Heritage area. The Tasmanian Parks and Wildlife Service claims that the area 'protects one of the last true wilderness regions on Earth and encompasses a greater range of natural and cultural values than any other region on Earth'. While fold mountains dominate in the east of the Tasmanian Wilderness, rugged block mountains dominate the west. Much of the area has been eroded by glaciers and this has led to some spectacular landforms. Most of the area is blanketed by rainforest but there are also areas of mountain vegetation and wetlands. Nineteen endangered animal species are found in the World Heritage area, including the Tasmanian devil.

The World Heritage list

The World Heritage list is administered by the United Nations. It is a list of the world's most important natural and human features. Individual countries are able to nominate their most special places for inclusion on the list. If a nominated place meets certain criteria then it can be given World Heritage status. Once the site is listed, the nominating country then has the responsibility to protect and preserve that place for future generations. The United Nations seeks to help countries to protect and preserve their sites by providing technical and emergency assistance, particularly for conservation of the site. There are currently more than 960 World Heritage sites, 19 of which are in Australia.

Many of the world's mountain landscapes have been given this special status. They include the volcanoes of New Zealand, the Blue Mountains, Yosemite National Park and Mount Everest. The United Nations also has a list of World Heritage sites where the special features of the place are threatened by natural disasters or human activities, such as war or tourism. The home of the mountain gorillas, the Virunga Mountains, is on this list, as are rainforests in the mountains of Madagascar and Indonesia.

Source 2 Frenchmans Cap in the Tasmanian Wilderness World Heritage Area was carved by glaciers thousands of years ago.

Check your learning 3.7

Remember and understand

1 What is the World Heritage list?
2 Name some mountain areas that have been included on the World Heritage list.
3 Why do you think the Tasmanian Wilderness area has been included on the list?

Apply and analyse

4 Look carefully at Source 1.
   a How many national parks are shown on this map?
   b Using the scale provided in Source 1, estimate the total area of the Tasmanian Wilderness World Heritage Area.
   c Conduct some Internet research to determine the actual area of the Tasmanian Wilderness World Heritage Area. Is this figure more or less than your estimate? Give possible reasons for this difference.

Evaluate and create

5 Research the Virunga Mountains, the Atsinanana region of Madagascar or the rainforests of Sumatra to find out why these mountain areas are in danger. Do you think the Tasmanian Wilderness area faces the same threats as these places?

3B rich task

Wolong National Nature Reserve, China

Mountain landscapes are home to some of the world's most endangered animals, including one of the most well known – the giant panda. Once widespread throughout the mountains of southern China, they are now limited to a few bamboo forest reserves. The largest of these reserves is the Wolong National Nature Reserve in Sichuan Province, which is home to about 150 pandas as well as other endangered animals, such as the red panda and the golden monkey.

Source 1 A giant panda cub in the Wolong National Nature Reserve

skilldrill

Six-figure grid references (GR)

In order to communicate the location of different features on topographic maps with pin-point accuracy, geographers use a system known as six-figure grid referencing (GR).

The lines than run from top to bottom (i.e. vertically) across a map are known as **eastings**. The lines that run from left to right (i.e. horizontally) are known as **northings**. In order to create a six-figure grid reference, the area between each easting is divided up into 10 equal parts (i.e. tenths). The area between each northing is also divided up into tenths. This is just like adding a finer set of gridlines over the existing gridlines, allowing you to be very specific about where things are within each grid square.

In order to create a six-figure grid reference, follow these steps:

- **Step 1** Find any point on the map that you want to communicate the exact location of. Mark this point on the map.
- **Step 2** Run your finger from this point to the left until you hit the first easting. Record the number of that easting. This will be the first two numbers in your six-figure reference. Now work out how many tenths from the easting your point is. This will give you the third number in your six-figure grid reference.
- **Step 3** Now, run your finger from the same point down until you hit the first northing. Record the number of that northing. This will be the fourth and fifth numbers in your six-figure reference. Now work out how many tenths from the northing your point is. This will give you the final number in your six-figure grid reference.

Apply the skill

1 What is the name of the river at GR 992137?

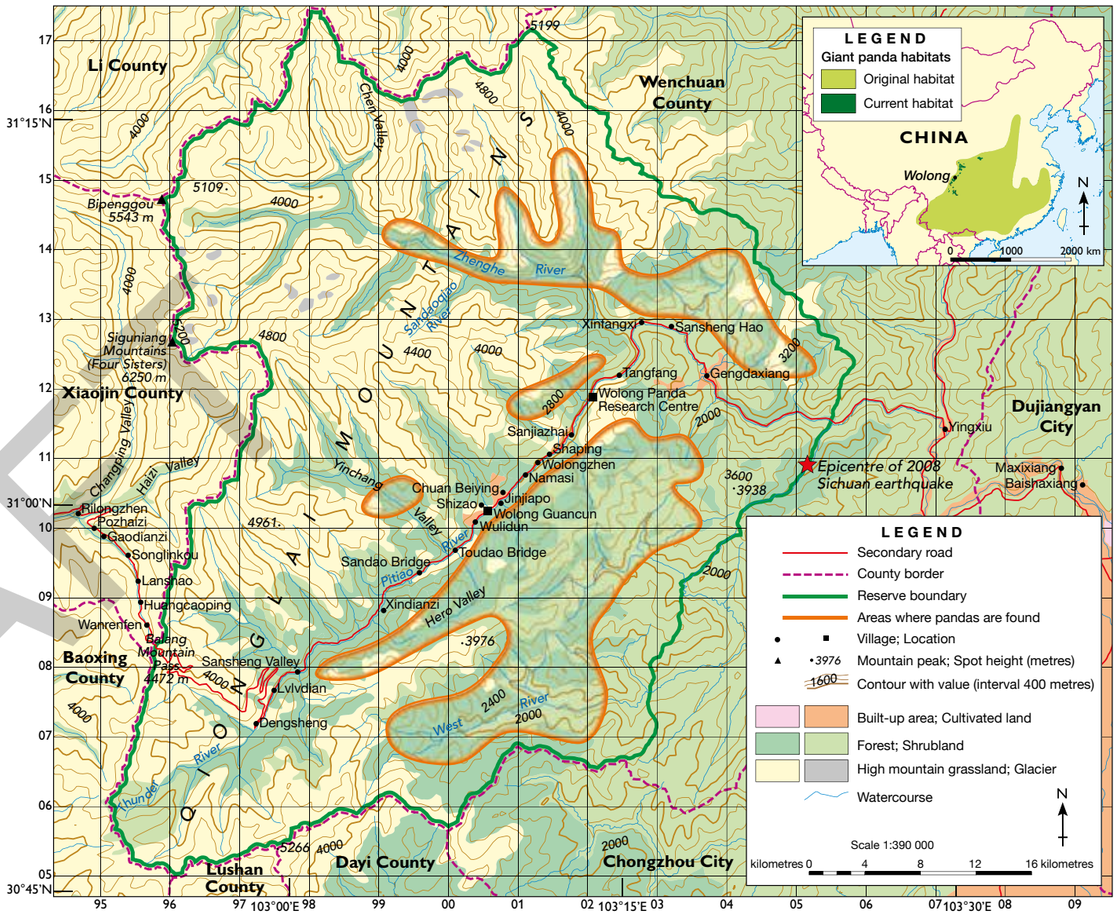
2 Give the six-figure grid reference for the epicentre of the 2008 Sichuan earthquake.

3 Give the six-figure grid reference for the Wolong Panda Research Centre.

4 Complete the following table:

Grid reference	Name of village
072114	
	Xindianzi
	Dengsheng

WOLONG NATIONAL NATURE RESERVE, CHINA



Source 2 Source: Oxford University Press

CHANGE IN PANDA HABITAT IN CHINA OVER TIME

Source 3 Source: Oxford University Press

Extend your understanding

1 What is the main type of vegetation found inside the area where pandas are found?

2 How many towns are located in the these areas?

3 How much cultivated land is found in the panda areas?

4 Study Source 3. Describe the change over time between the giant pandas' original and current habitats. Give a possible reason for it.

5 Do you think that reserves like Wolong will save the panda from extinction? Give some reasons for your answer.

3.8 Mountain hazards

Mountains can be hazardous places. The obvious danger in a volcanic area is an eruption, but there are other dangers too. The steep hillsides and unpredictable weather in mountainous regions can contribute to landslides and avalanches which can sweep with terrifying speed and force down the mountain slopes. Earthquakes are also a common hazard in mountainous places as sudden plate movements cause the ground to shake, dislodging rocks and even entire hillsides.

Volcanic eruptions

Volcanoes are dangerous natural features and can erupt without warning, devastating local environments. Lava can flow like a molten river or rain down like bombs many kilometres from the eruption site. Ash can cover the sky and blanket the landscape in a cloud that can kill people and animals alike. Humans are generally powerless in the face of such power and many thousands have died from hazards caused by eruptions. They include ash clouds, lava flows, mudslides, floods and **tsunamis**.

Perhaps the biggest danger in an eruption is the huge clouds of volcanic ash that can be produced. These clouds result from the sudden release of enormous pressure from within the Earth's mantle and crust. When Italy's Mount Vesuvius erupted in 79 CE it covered the nearby town of Pompeii in a thick layer of ash, killing 2000 people. The town lay forgotten beneath the ash for almost 1600 years before being discovered by workmen digging a canal.

The ash produced in an eruption can travel straight up (vertical) and then fall on the surrounding landscape, as in the case of Mount Vesuvius, or it can travel sideways (horizontal). Horizontal eruptions are perhaps the most dangerous as the ash – along with rocks, boulders and gases – can travel at speeds of 700 kilometres per hour and carry material heated to 1000 degrees Celsius. These are called **pyroclastic flows** and are responsible for many of the most devastating volcanic eruptions.

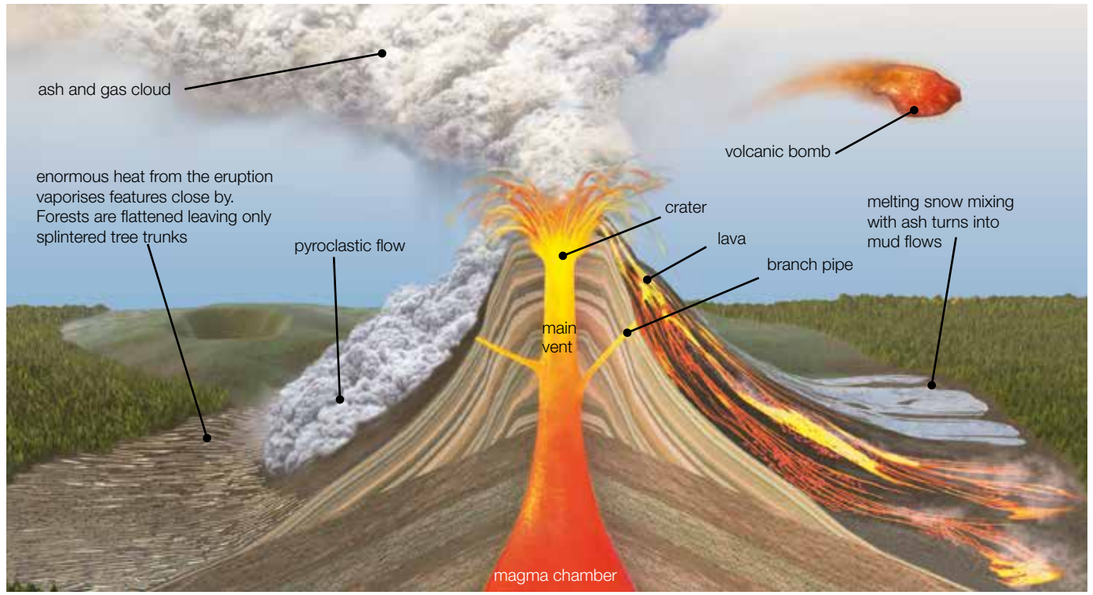
Another danger can be the sudden melting of the snow and ice on the sides of the volcano or the release of water from a crater lake in an eruption. These events can cause huge mudslides called **lahars** up to 50 metres thick to sweep down the sides of mountains. The eruption of Colombia's Nevado del Ruiz volcano in 1985 covered whole villages with thick mud and ash, killing 23000 people. This makes it the deadliest volcanic eruption of the last 100 years.

Source 1 Lava from Hawai'i's Kilauea volcano rolls downhill to the ocean

Tambora: the world's deadliest eruption

The deadliest volcanic eruption in history took place in 1815 in Indonesia, when Mount Tambora erupted. About 92000 people were killed by the pyroclastic flow from the eruption and the tsunami that was triggered by the eruption. More than 50 square kilometres of new material (ash and lava) was produced by the eruption and deposited on the Earth's surface.

Located where the Indo-Australian tectonic plate **subducts** (moves down) below the Eurasian plate, Indonesia has been home to more active volcanoes than any other nation over time. Vulcanologists estimate that Indonesia's 76 active volcanoes have produced more than 1000 eruptions.



Source 2 Features of a volcano and the hazards caused by eruptions

Check your learning 3.8

Remember and understand

1. Make a list of the dangers faced by communities living close to volcanic eruptions.
2. Why is a sideways eruption more dangerous than a vertical one?
3. What is a volcanic bomb?
4. Name two countries close to Australia that experience many tectonic disasters.

Apply and analyse

5. Use Source 2 to explain how volcanic eruptions take place.
6. Almost every resident of Tambora died in the eruption of Mount Tambora. Why do you think that was the case?

Evaluate and create

7. Conduct some research on the Internet to find out what people who live near Mount Tambora today could do to protect themselves from the effects of another eruption.

3.9 Vesuvius: studying a killer volcano

Location

Mount Vesuvius, near the Italian port city of Naples, is one of the world's most dangerous volcanoes. Over the course of human history it has erupted many times, most notably in 79 CE when an eruption buried the Roman towns of Pompeii and Herculaneum.

Type and extent of damage

Mount Vesuvius erupted releasing a deadly cloud of stones, ash and fumes up to 33 kilometres into the air. With molten rock and pumice coming down at the rate of 1.5 million tons per second, the towns of Pompeii and Herculaneum were quickly buried and few in the towns managed to escape. An estimated 16 000 people died from the eruption, most being killed by the heat of the eruption and ash suffocation.

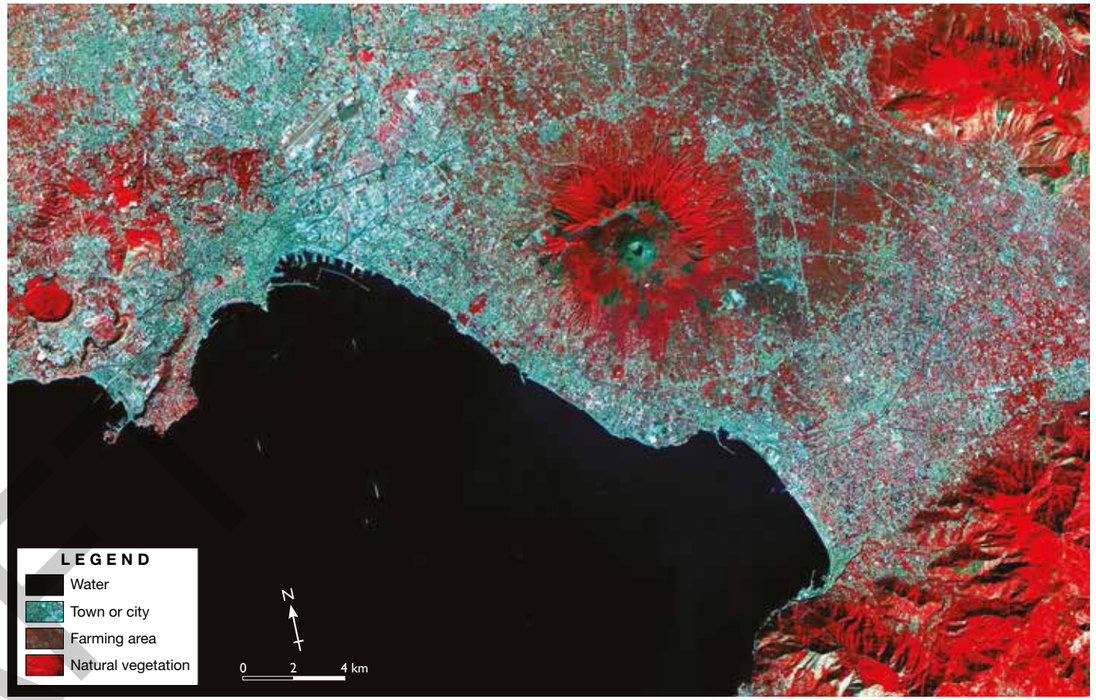
Living with volcanoes

Since this date, Mount Vesuvius has erupted more than 30 times, with the last eruption taking place in 1944. This eruption destroyed the surrounding villages of San Sebastiano al Vesuvio, Massa di Somma, Ottaviano and part of San Giorgio a Cremano. For the last 70 years it has laid quiet but many experts believe that it is once again due to erupt.

Over time, the city of Naples has grown at the foot of Vesuvius. There are also many other **urban** centres in the area surrounding Vesuvius. Some of these areas have a **population density** greater than 15 000 people per square kilometre, making them some of the most densely populated places on Earth. With more than 4 million people living near Vesuvius, it has the greatest population density of any volcanic region in the world.

Source 1 A sensor on the slopes of Mount Vesuvius

Source 2 Mount Vesuvius erupting in 1944. The ash cloud viewed from the nearby city of Naples



Source 3 A false colour satellite image of Mount Vesuvius and the Italian city of Naples highlights the key features of the region.

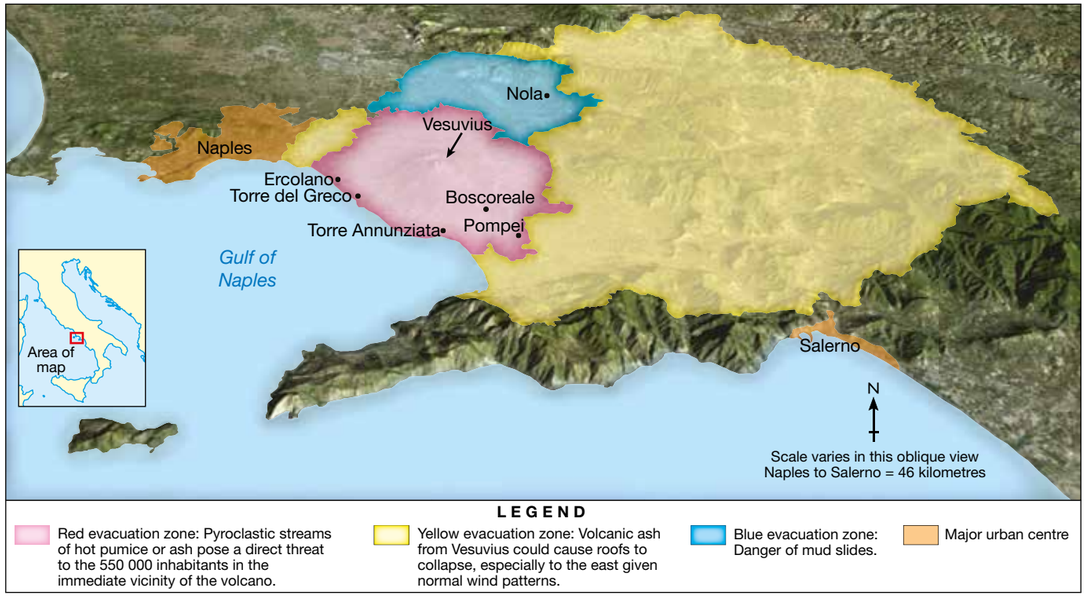
Like many volcanoes around the world, Vesuvius is being carefully monitored. It is studied from the ground, from underground, and even from space. **Vulcanologists** are watching for changes in the shape and internal chemistry of the volcano that will reveal when an eruption is about to happen so they can warn people to leave the area.

Preparing for an eruption

A number of measures have been implemented to help reduce the effects of another eruption of Vesuvius:

- An evacuation plan has been developed so that residents can more easily understand the risks faced in the region where they live (see Source 4). This will also help authorities to evacuate the area. Experts estimate that 600 000 people now live in the red evacuation zone.
- People living on the side of the mountain have been offered up to 30 000 Euros to move to safer areas. Their houses will be demolished and no new ones can be built in the same area.
- A national park has been established on the upper slopes so that authorities can stop any further building of homes and other structures. Authorities estimate that 800 structures have been illegally built in the park and will need to be demolished.
- On the side of Vesuvius there are dozens of sensors, such as the one shown in Source 1. These record earthquakes, gas temperatures and changes in the shape of the volcano. All these measurements can help vulcanologists predict an eruption. Monitoring the changing shape of a volcano, for example, can tell scientists if the mountain is bulging outwards. A bulge is a clue that lava is rising and may erupt. Signals from these sensors are sent automatically to a volcano observatory in Naples where there are always at least two scientists on duty to analyse the data.
- A satellite from the European Space Agency measures the temperature and shape of the crater and mountain slopes as it passes overhead. Analysis of data showed that an area south-west of Vesuvius had risen by more than 2 centimetres in a year. Satellites are also useful in tracking the movement of ash clouds following an eruption.

NAPLES REGION: MOUNT VESUVIUS EVACUATION ZONES



Source 4

Source: Oxford University Press

Check your learning 3.9

Remember and understand

1 Examine Source 4.
   - **a** List the dangers that people could face in the event of a volcanic eruption.
   - **b** How would the wind direction affect ash movement?
   - **c** What would happen if the wind was blowing to the west during an eruption?

2 Why has a national park been established on Mount Vesuvius?

3 Why do vulcanologists monitor the shape of the volcano?

Apply and analyse

4 Describe the pattern of human settlement around this volcano.

5 What makes this mountain so dangerous? Consider both natural and human factors in your answer.

6 Study Source 1. What do you think the object sticking out from the side of the white box is used for?

Evaluate and create

7 Despite authorities offering up to 30 000 Euros to thousands of residents in order to move only a few have done so. Why do you think this is the case?

8 Surveys have shown that residents of Naples are largely unaware of the danger posed by Mount Vesuvius and most have never heard of the evacuation plan.
   - **a** Why do you think this is the case?
   - **b** What is the greatest natural hazard you face?
   - **c** What preparations have you made in the event of a natural disaster?

9 Design a pamphlet that will be distributed to all Naples residents outlining the risks posed by a volcanic eruption. Your pamphlet must include some of the actions that individuals can take to prepare for an eruption, including having an evacuation plan.

3.10 Landslides

Landslides are one of the most common types of hazard affecting mountain landscapes. The term landslide is used to describe any type of large-scale movement of soil, mud, rocks or snow carried by the force of gravity downhill. The movement can be as slow as a few centimetres a year or very rapid. Large, rapid landslides have the potential to destroy towns, roads and bridges, block rivers and take human lives. They are among the most dangerous of all hazards in mountain landscapes.

Landslides are often caused by a combination of natural processes and human factors. Natural factors include heavy rain, unstable slopes, an earthquake or volcanic eruption, and erosion by rivers or waves. The likelihood of a landslide happening is often increased by human activities, such as vegetation clearing, road or mine construction that requires cutting into a slope, leaking pipes and vibrations caused by rock blasting or heavy traffic.

Types of landslides

There are five main types of landslides that can affect different mountain landscapes. These include:

Soil creep

Soil creep is the gradual movement of soil, rocks and earth down a gentle slope. This is the slowest-moving type of landslide and can take place over many years. As a result, it is often unnoticeable to people living in the area. Areas affected by soil creep can be identified by features such as leaning telegraph poles and fences, cracked walls and bowed trees.

Slumping

Slumping is the movement of larger sections of soil and rocks down a steep, curved slope. These sections slip down the surface of the slope to different degrees, often creating a number of different levels (called scarps). Slumping is usually triggered by earthquakes, excessive rain, or freezing or thawing of the land.

Mudslides

Mudslides (also known as lahars) are often triggered by heavy rain, quick thawing earth, earthquakes or volcanic activity. For example, snow on the sides of active volcanoes is caused to melt quickly and combine with soil and rocks to create mud slurry that travels downhill. The mud can be up to 50 metres thick and travel at speeds of up to 80 kilometres an hour, burying entire villages and killing many people.

Avalanches

Avalanches are the rapid movement of snow down steep mountain slopes. They are the fastest-moving type of landslide. Avalanches are triggered by natural movements of the Earth (such as earthquakes and weather events) and human movements (such as skiers and snowboarders).

When landslides strike: Venezuela

As with many natural disasters, people in poorer countries are more at risk. There, homes and other buildings are often poorly made and hillsides are often cleared of trees as timber is needed for fuel and building. With few planning restrictions in place people often live in landslide danger zones, with devastating results.

When heavy rains hit the South American country of Venezuela in late December 1999 they triggered the world's deadliest landslide. The rains were heaviest in the mountainous area in the north of the country. As the swollen rivers swept down from the mountains, they eroded their banks, turning the rivers into raging torrents of mud. Charging towards the coast, the rivers swept through towns and cities perched between the mountains and the ocean, covering them in a sea of mud. Hardest hit were the poorer residents of the country who had built their homes in shanty towns on cheap land on the steep mountain slopes. The mud quickly engulfed the streets and homes of these shanty towns, sweeping them away or burying them.

To try to avoid the danger of disease the dead were quickly buried and so the scale of the disaster will never be fully known. It is believed that more than 30 000 people lost their lives in these floods, but some estimates have placed the final figure closer to 50 000.

Source 1 An oblique aerial image of a mudslide in Vargas, Venezuela, 1999

Source 2 An annotated sketch of Source 1

Managing landslide risk

Although landslides can strike with great speed and little warning there are some measures that communities can implement to prepare for them and reduce their effects. Perhaps, most importantly, they can recognise that some human activities make landslides more likely. Careful planning is needed before cutting a road into the side of a hill, for example, as it makes the slope less stable.

Prevention and mitigation

There are a number of ways a community can prevent or mitigate (reduce) the damage caused by a natural disaster before it happens. In the case of a mountain hazard such as a landslide this might include:

- Improving the drainage of the slope or redirecting water, so that heavy rainfall does not trigger a landslide.
- Constructing retaining walls and piles (beams deep into the ground) to hold the soil together or resist landslide movement.
- Planting or maintaining plants and trees. Removing vegetation can start a landslide, while more vegetation can hold the soil together through root systems.

Preparedness

In order for a community to be prepared for a natural hazard such as a landslide, they need to be ready before the disaster happens. Communities can do this a number of ways, but it is most important for them to be aware of the potential hazard so they can plan for it. In a case like the Vargas mudslide, residents of the community could have prepared for the disaster by having warning systems and plans of action in place.

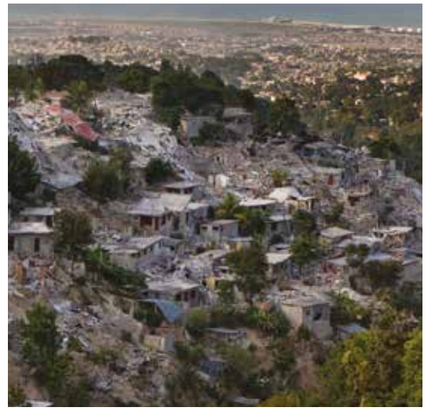
key concept: Scale

Landslide prediction

There are landslides in many mountainous areas around the world but the reasons for them differ from place to place. Geographers who try to predict where there will be a landslide need to study factors at a range of scales:

- At the local scale they need to consider steepness of the slope, soil type and changes made by people.
- At the regional scale they need to consider rainfall patterns and the likelihood of storms.
- At the global scale they need to consider the location of plate boundaries and tectonic movement.

For more information on the key concept of scale, refer to page xx of 'The geography toolkit'.



Source 3 A landslide in Haiti, triggered by an earthquake, killed thousands in 2010.

Check your learning 3.10

Remember and understand

1 What is a landslide?
2 Why are landslides more of a hazard in mountainous areas than in flatter places?
3 What can people do to reduce the likelihood of landslides?

Apply and analyse

4 Some landslides are so slow they are known as soil creep. How might a very slow landslide affect human activities and structures?
5 Which natural processes contributed to the landslides in Haiti? Which human activities contributed?
6 Use a series of sketches to explain why digging into a hillside for mining or road building can lead to a landslide.

Evaluate and create

7 Use Source 2 as a guide to create a geographical sketch of Source 3. Label your sketch with those factors that contributed to the landslide.
8 Do you think that natural factors or human factors were most responsible for the Venezuelan landslides? Give some reasons for your answer

3.11 The Tumbi landslide, Papua New Guinea

On the night of 24 January 2012 there was a massive landslide in the Southern Highlands of Papua New Guinea. The landslide buried whole villages and killed dozens of people. It was triggered by the collapse of a 150-metre wide section of hillside, and carved a 560-metre long path of destruction through the forests and villages below. More than 3 million cubic metres of rubble thundered downhill in the disaster. The Highland Highway, which runs through the area, was destroyed. Quarry workers and machinery were buried in debris up to 15 metres thick. Rescue efforts were hampered by heavy rain in the hours and days following the landslide. Landslides are a hazard in Papua New Guinea, particularly during the wet season from December to May.

Source 1 The landslide that engulfed the village of Tumbi in Papua New Guinea

key concept: Environment

Possible causes of the Tumbi Landslide

The ways in which humans use and change the natural world is an important part of the key concept of environment. By examining the possible causes of this landslide you will learn how environments are changed by a complex series of human activities and natural processes. As with many disasters such as this, the exact causes are unclear. Initial newspaper reports focused on a nearby natural gas plant under construction and some associated quarrying near the slip site, but the gas company denied any connection. Here are some of the possibilities and some of the evidence.

WAS IT HEAVY RAINFALL?

PNG is experiencing one of the worst wet seasons, which traditionally runs from December to May, ever, local authorities say.

United Nations report

The ground water level rose significantly above its historical levels … This caused the two minor, and one major, streams to combine, forcing water levels to rise beneath the limestone substructure of the hillside.

Papua New Guinea Government report

WAS IT THE TUMBI QUARRY?

Local people have blamed blasting from nearby quarries, which sent hundreds of tonnes of earth crashing down on the village of Tumbi.

Newspaper report, *Mail Online*, 26 January 2012

WAS IT THE SHAPE OF THE LAND?

[The land where the slip occurred is] characterised by high terrain and precipitous [steep] slopes.

United Nations report on the disaster

WAS IT AN EARTHQUAKE?

The Geophysical Observatory (PMGO) reported no seismic activity within the area in the past two weeks.

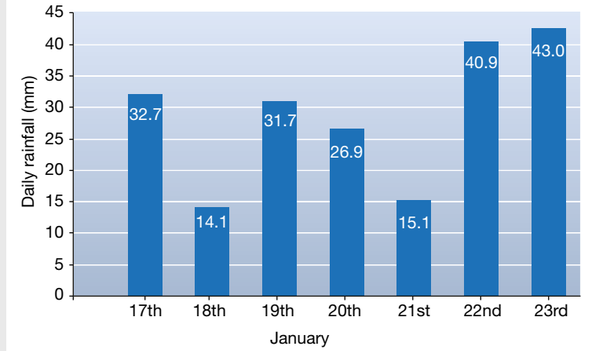
Papua New Guinea Government report

WAS IT THE FARMERS?

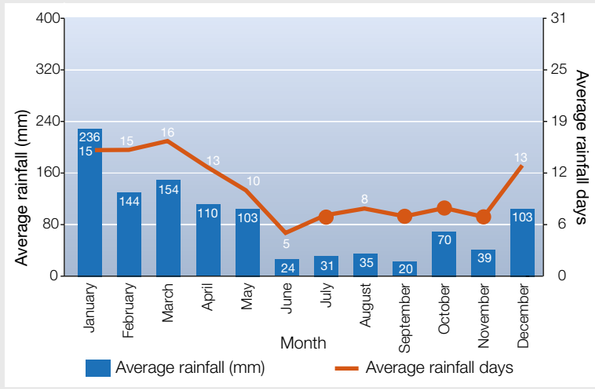
Intensive cultivation of the surrounding land may have also been a contributing factor by denying the ground of its natural vegetation.

Papua New Guinea Government report

For more information on the key concept of environment, refer to page xx of 'The geography toolkit'.



Source 2 Daily rainfall totals from 17 to 23 January 2012 in Komo, a town near the Tumbi Landslide site



Source 3 Average rainfall graph for Komo

Check your learning 3.11

Remember and understand

1 Describe the scene in Source 1.
2 On what date was there a landslide? Is this during the wet season?
3 Describe the shape of the land at the site of the landslide.

Apply and analyse

4 Study Source 2. How much rainfall was recorded in Komo in the seven days before the landslide? Compare this with the weekly average in January of 53.9 millimetres.
5 How does a quarry change the shape of a hillside? How might this contribute to a landslide?
6 Divide the possible causes of this landslide into two lists: natural processes and human activities.

Evaluate and create

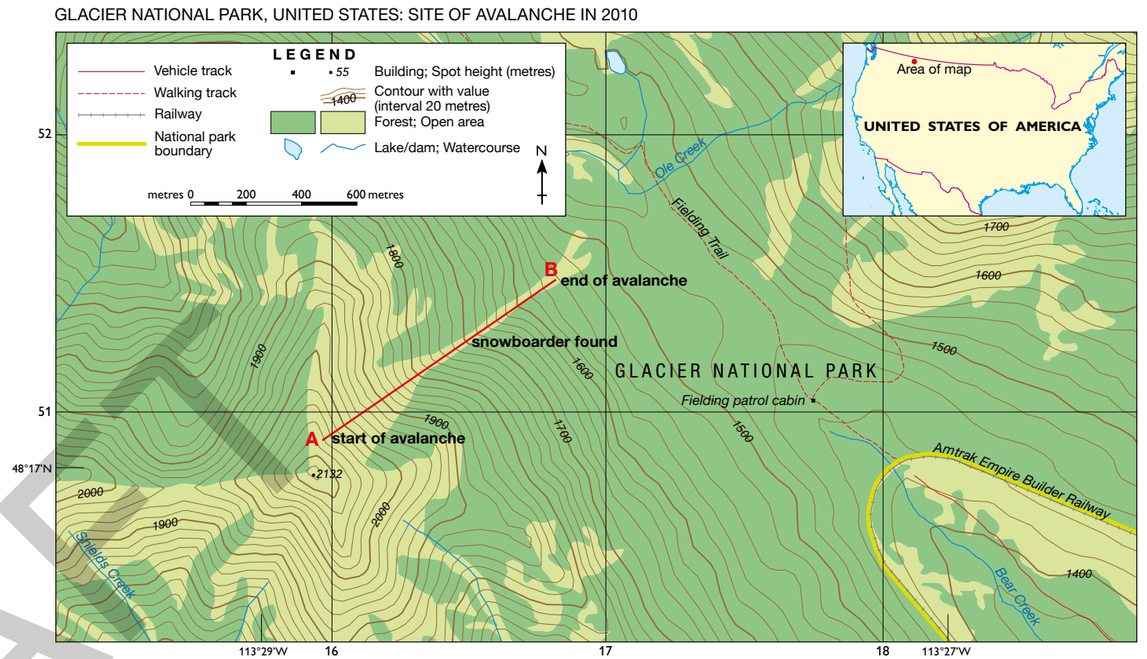
7 Rank the possible causes from those that you consider most responsible for the landslide to those that you consider had no influence. Write a few sentences explaining your choice of the top contributor.
8 Compare your ranked list with those of your classmates. Is there some general agreement about the leading cause? Why/Why not?
9 What further questions could you ask to help you work out the causes of this disaster?

3C rich task

Avalanches

More than 150 people a year, mostly skiers and snowboarders, are killed by avalanches. Avalanches are a type of landslide. They involve the rapid movement of snow down mountain slopes. Some slopes are more likely to produce an avalanche than others, mainly due to their steepness. Snow resting on a layer of slippery ice on a steep slope can easily collapse. The resulting avalanche can reach speeds of up to 130 kilometres per hour. In 2010, a lone snowboarder was killed by an avalanche in Glacier National Park in Montana in the United States. The site of the avalanche is shown in Source 2.

Source 1 A skier in the path of an avalanche



Source 2

Source: Oxford University Press

skill**drill**

Constructing a cross-section

Step 1 Identify the cross-section. Find the two points on the map that form the outer edges of your cross-section. In this case, these points are labelled A and B.

Step 2 Mark the outer edges. Place a straight-edged piece of paper across the map so that it crosses both points A and B. Mark these two points on your piece of paper. Be careful not to draw on the map.

Step 3 Mark the contour lines. Working from left to right, put a small mark on your piece of paper at every point that it crosses a contour line. You need to know the height of each of these lines so jot this down on the piece of paper as well.

Step 4 Draw the axes. On another piece of paper draw a set of axes for your cross-section. The horizontal axis is the same width as the distance between points A and B on the map. The vertical scale must begin below the lowest height on your cross-section and extend above your highest point. Put a vertical scale on both the left-hand side and right-hand side of your cross-section.

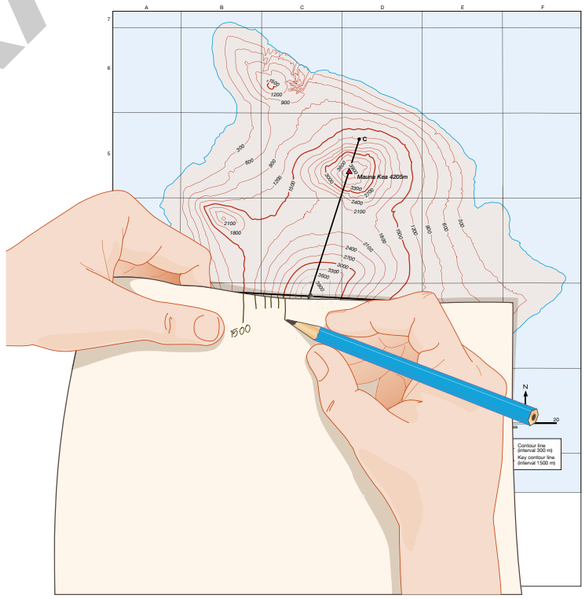
Step 5 Transfer the contour line heights. Lay your straight-edged piece of paper along your horizontal axis. For each contour height shown on your piece of paper, you must place a dot on your cross-section at the correct height according to your vertical scale.

Step 6 Join the dots. Join the points with a smooth line. Use a graphite pencil and take care to make your sketched line as 'natural' as possible. It should not be a series of short, straight lines but one long, smooth line.

Step 7 Add the finishing touches. Lightly shade the area below your line to show that this is solid land. Label both axes with their correct scales and give your cross-section a title.

Apply the skill

1 Construct a cross-section of the avalanche site along the line A–B marked on Source 2



Source 3 Marking contour lines

Extend your understanding

1 Study Source 2.
- **a** In which direction did the avalanche travel?
- **b** How far was the snowboarder carried?
- **c** Using your cross-section as a guide, describe the steepness of the slope at this place.
- **d** Did the avalanche travel down a gully or a ridge?

2 Rangers at Glacier National Park monitor snow conditions carefully and sometimes close dangerous areas such as this to skiers and snowboarders. What do you think they look for when they examine the snow conditions?

3 Study Source 2. On this map the beginning of the avalanche is labelled as A and the point at which it stopped is B.
- **a** How do you think the boarder accessed this slope?
- **b** What could the snowboarder have done to minimise the risks of an avalanche?
- **c** What could he have done to increase his chances of surviving an avalanche?