Chapter 3: Hazardous environments

Introduction

This chapter is about three different natural hazards that threaten people in many parts of the world. They are earthquakes, volcanic eruptions and tropical revolving storms (hurricanes and typhoons). They have the power to cause great damage to settlements and to injure and kill many people. Is it possible to predict when and where they will occur? What can be done to minimise their destructive impacts, both before and immediately after the event?

For information about another hazard not covered in this chapter – flooding – see Chapter 1.8.

3.1 Different types of hazard

A **hazard** is defined as an event that threatens, or actually causes damage and destruction to people, their property and settlements. A **natural hazard** is one produced by environmental processes and involves events such as storms, floods, earthquakes and volcanic eruptions. There are also hazards that are created by people. These range from industrial explosions to nuclear warfare, from air and road crashes to fire and the collapse of buildings. Most of these are the outcome of mishaps to do with human technology. The important point to remember with is that, if there were no people, there would be no hazards because hazards in this context means hazards to people.

Geological	Climatic	Biological	Technological
Earthquakes	Storms	Fires	Nuclear explosion
Volcanic eruptions	Floods	Pests	Accidents
Landslides	Drought	Diseases	Pollution

Table 3.1: Four major categories of hazard with examples

Table 3.1 above classifies hazards into four main categories based on their causes and gives some examples of each. This may look neat and tidy, but we need to realise that some hazards have more than one cause and therefore do not fit easily into this classification. For example, floods are not only caused by heavy rainfall. A stream of volcanic lava running down into a valley can easily block the flow of a

Figure 3.1: *Malnourished children in a desertified area*

river and cause flooding upstream. Floods in coastal areas can be caused by the tidal waves (tsunamis) associated with **earthquakes**. Coastal flooding also results from storm surges caused by low atmospheric pressures and not from heavy rainfall (see Figure 3.13 on page 73).

Another point is that some **natural events** only become hazards in an indirect ways. For example, drought mainly becomes a hazard because of its effect on food production. Crops and livestock lacking water will not yield so much food. Food shortages mean malnutrition and possibly death by starvation (Figure 3.1).

Diseases are an interesting group of hazards. Are diseases natural events or are they caused by humans? Some are certainly natural hazards. For example, malaria is a 'vector' or biological hazard carried from one human to the next by a mosquito. In contrast, there are many contagious diseases associated with human pollution of the environment. Typhoid and cholera are just two examples. An interesting aspect of all diseases is that the hazard threat is very focused on people. The outcomes are illness and death for people.

In this chapter, we are going to focus on three natural hazards: tropical storms, earthquakes and volcanic eruptions (Figure 3.2). Tropical storms are a climatic hazard in which two weather elements, wind and rain, threaten human life and property. Earthquakes and volcanic eruptions are geological hazards.

Before we look more closely at these three hazards, a point needs to be made about hazards in general. An important aspect of all hazards is **risk**. Risk is about the probability of a particular event happening and the scale of its possible damage. Risk is also what people take knowing that they are 'exposed' to a natural event that might prove hazardous. The greater the probability of a natural event occurring in a particular location and causing damage, the greater is the risk that people are taking. This is particularly so if they remain in that location or do not take evasive (preventative) or precautionary actions, known as **adjustment** or **mitigation**.

So it is important to remember these three aspects of hazards:

- **distribution** – where do they occur on the Earth's surface?
- **frequency** – do they occur regularly?
- **scale** – do the events vary in their hazardousness?

To these, we might add a fourth and important question about **prediction**. Can we predict when these events will occur and their likely scale of damage?

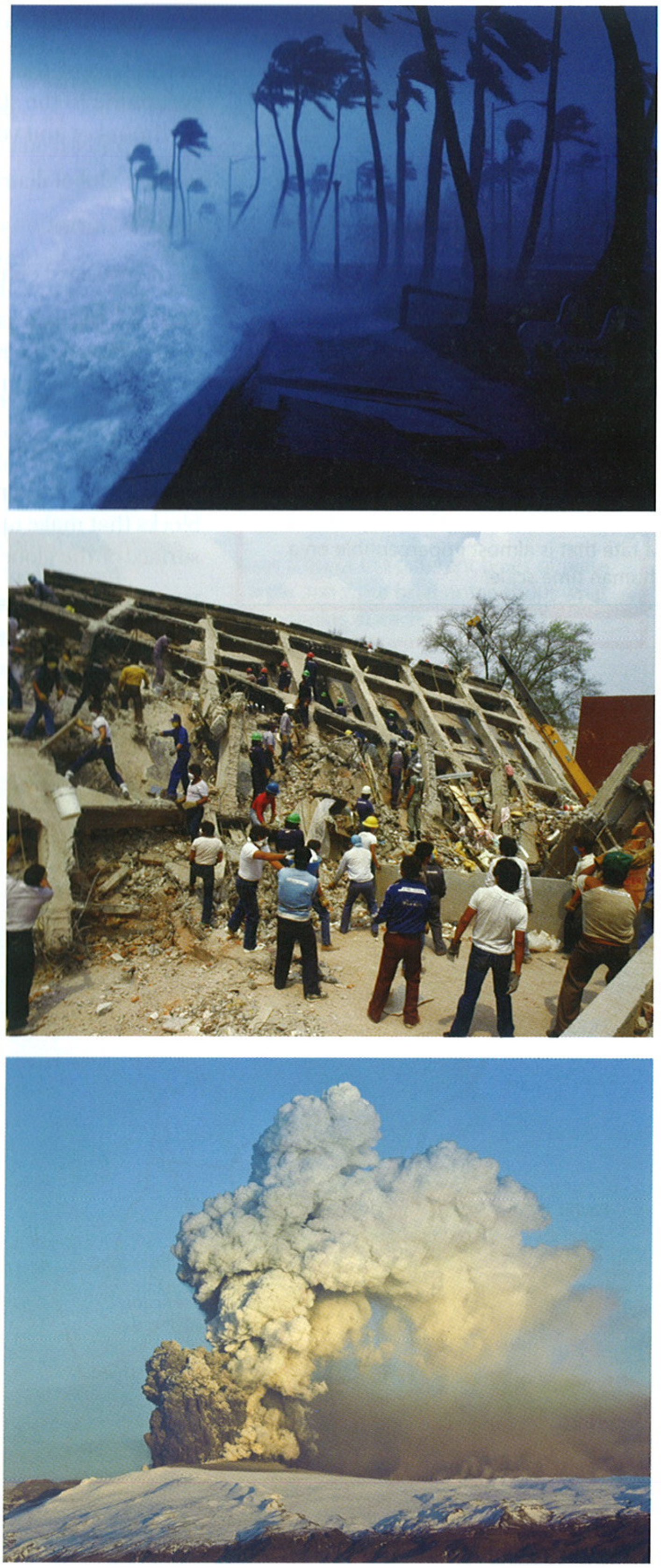

Figure 3.2: *Three natural hazards: tropical storms, earthquakes and volcanic eruptions*

3.2 Earthquakes and volcanic eruptions

In this part of the chapter, we look at three aspects of two tectonic (tectonic means pertaining to the structure and movement of the earth's crust) hazards, earthquakes and volcanic eruptions:

- their global distributions
- their causes
- their hazard characteristics.

Since earthquakes and volcanic eruptions both result from plate tectonics, they are closely linked in terms of both their distributions and causes. They differ, however, in terms of the sort of damage they do.

Tectonic plates

The tectonic plates shown in Figure 3.3 are constantly moving. But they do so at a rate that is almost imperceptible on a human time scale.

The crust of the Earth is made up of a number of **tectonic plates** which are the rigid blocks that make up the surface of the earth (Figure 3.3). These plates move over the surface of the globe. Their movements create four different types of plate margin.

When two plates are moving apart, for example in the oceans, the margin between them is called a **constructive** or **divergent plate margin**. It is called this because magma (molten rock) rises to the crust to fill the gap and create new crust through submarine volcanoes. This is happening, for example, along the mid-ocean ridge in the Atlantic Ocean.

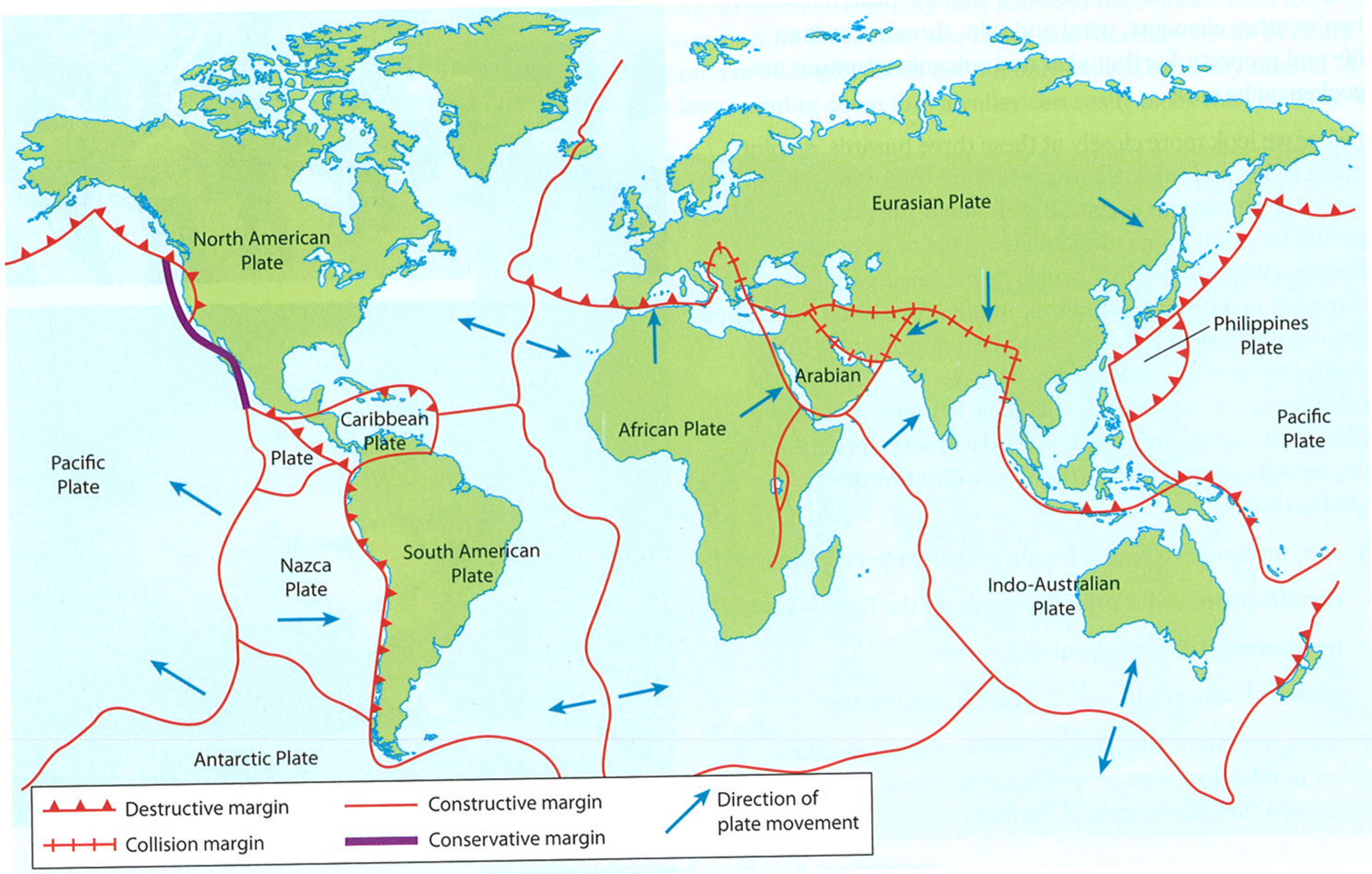

Figure 3.3: *The world's tectonic plates and their margins*

When two plates are moving towards each other, like the Nazca plate and the South American plate, the margin between them is called a **destructive** or **convergent plate margin**. The edge of one plate margin is being destroyed as it plunges beneath the other plate it is meeting head on. This is known as **subduction**. Molten rocks rises to the surface to form volcanoes. The friction between the two plates creates earthquakes.

A **collision plate margin** occurs where two plates meet head on and are of equal density and strength. The sediments between the two plates are squeezed upwards. The result is the formation of fold mountains, such as the Himalayas that were created by the collision between the Eurasian and Indo-Australian plates. Earthquakes are created by the pressure and friction.

There is a fourth type of plate margin referred to as a **conservative plate margin**. This occurs where two plates are sliding past each other. Since there is neither rising magma here nor subduction, there are no volcanoes. Instead the friction gives rise to earthquakes as in California between the Pacific and North American plates.

Tectonic plates shape the landscape by creating new rocks and forming mountains and rift valleys. They do this by the processes of volcanic activity, folding and faulting. These are the most powerful natural forces on the planet. It is not surprising that they should give rise to the most awesome natural hazards.

Make a list of the different types of plate margin and write brief notes about what is happening at each of them.

Distribution

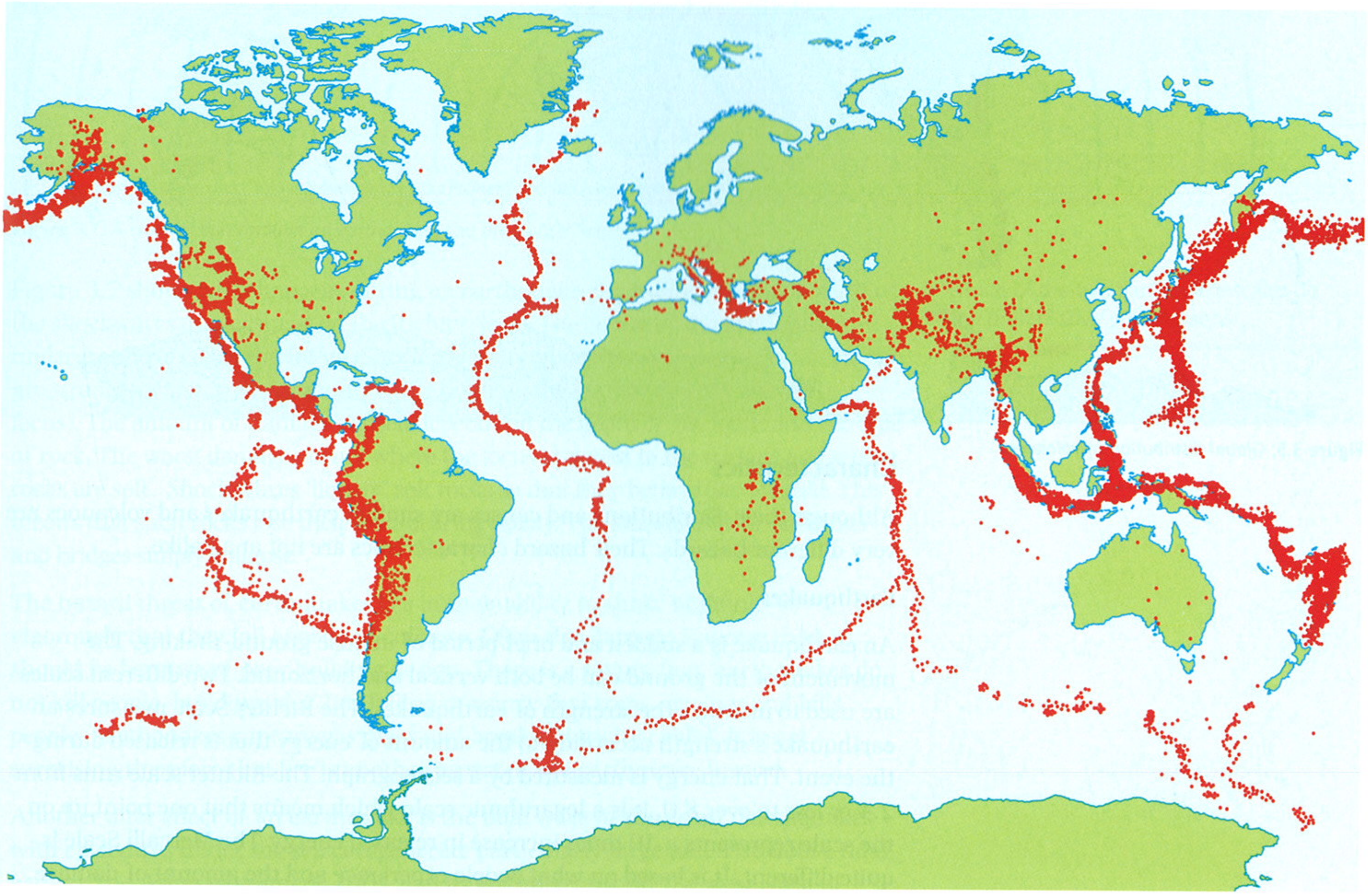

Figure 3.4: *Global distribution of earthquakes*

The distributions of earthquakes and volcanoes are similar in that they occur along tectonic plate boundaries. A comparison of Figure 3.4 and Figure 3.5 shows how similar the distributions are. There is an impressive density of earthquakes along the destructive plate margins that fringe the Pacific Ocean (Figure 3.4). The occurrence of earthquakes under the Atlantic, Indian and Pacific Oceans should be noted. When it comes to the distribution of volcanoes, again the concentration around the shores of the Pacific Ocean is noticeable (Figure 3.5). Another concentration occurs along the African Rift Valley formed by a constructive plate margin.

Underwater volcanic eruptions can cause tidal waves (tsunamis). See page 69.

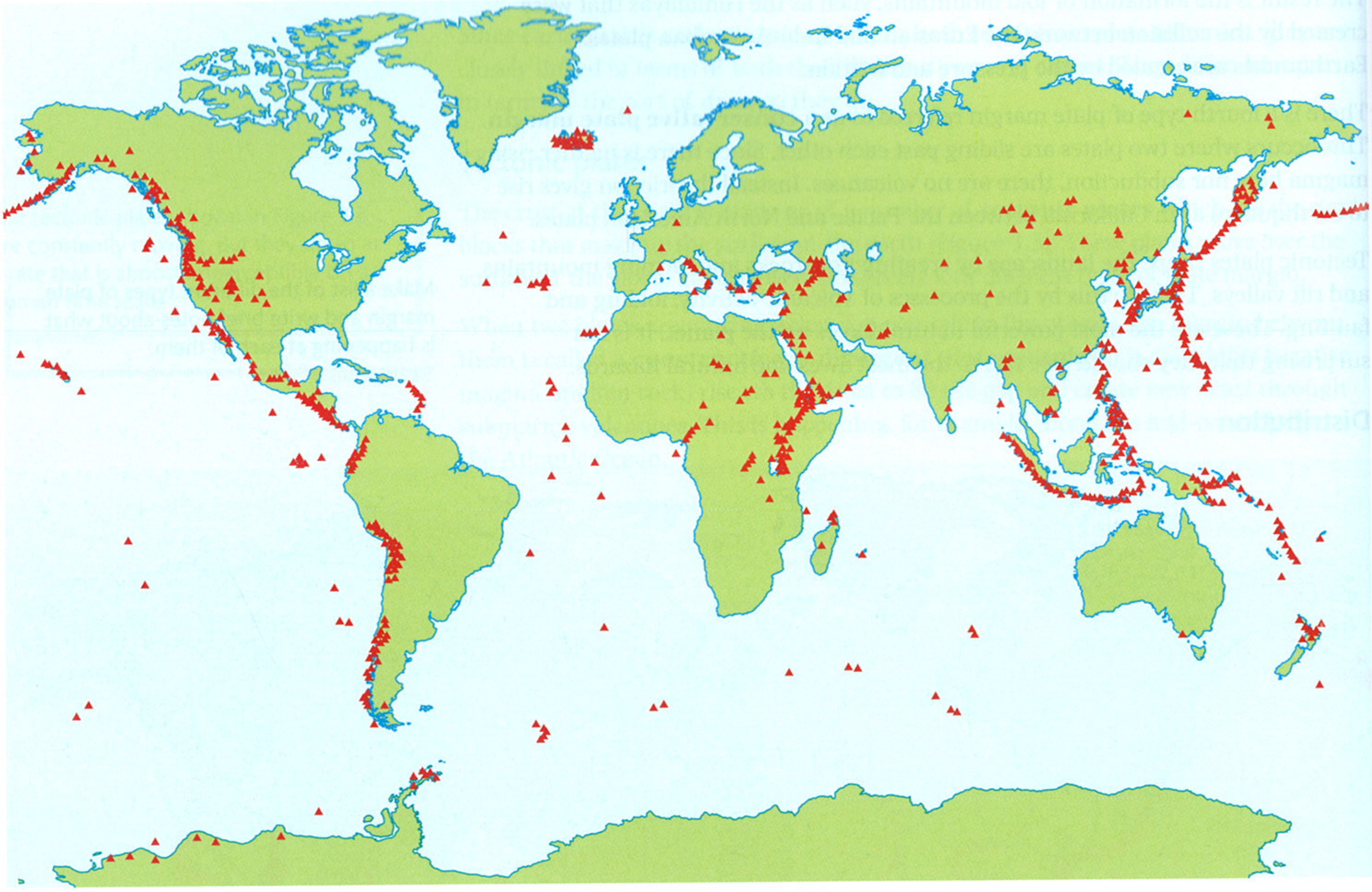

Figure 3.5: *Global distribution of volcanoes*

Characteristics

Although their distributions and causes are similar, earthquakes and volcanoes are very different hazards. Their hazard characteristics are not at all alike.

Earthquakes

An earthquake is a sudden and brief period of intense ground-shaking. The movement of the ground can be both vertical and horizontal. Two different scales are used to measure the strength of earthquakes. The Richter Scale measures an earthquake's strength according to the amount of energy that is released during the event. That energy is measured by a seismograph. The Richter scale runs from 2.4 or less to over 8.0. It is a logarithmic scale which means that one point up on the scale represents a 30 times increase in released energy. The Mercalli Scale is quite different. It is based on what people experience and the amount of damage done (Figure 3.6).

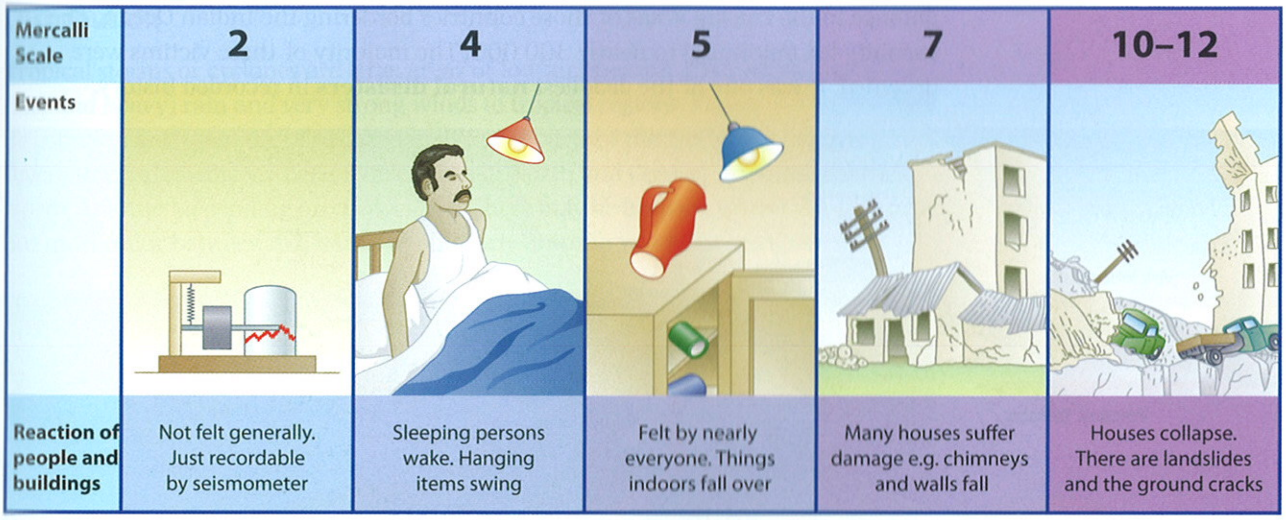

Figure 3.6: *Some examples from the Mercalli Scale*

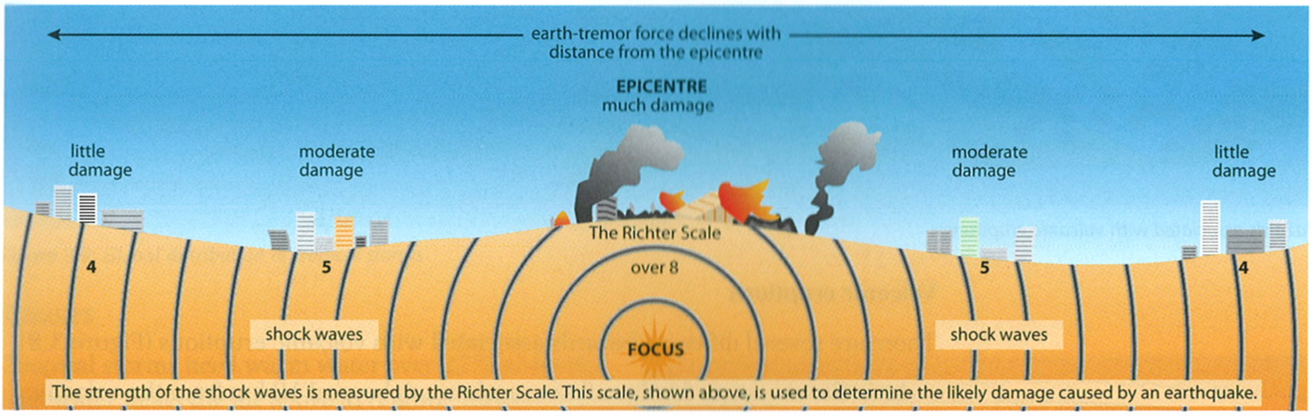

Figure 3.7: *A cross section through an earthquake, and the Richter Scale*

Figure 3.7 shows what happens during an earthquake, depending on the strength of the shockwaves as measured on the Richter Scale. The centre of the earthquake underground is called the **focus**. Shock waves travel outwards from the focus. These are strongest close to the **epicentre** (the point on the surface directly above the focus). The amount of damage caused depends on the depth of the focus and the type of rock. The worst damage occurs where the focus is closest to the surface and where rocks are soft. Shock waves 'liquefy' soft rocks so that they behave like a liquid. This means that such rocks lose their load-bearing ability. The foundations of buildings and bridges simply collapse.

Which of the two earthquake scales do you prefer? Give your reasons.

The hazard threat of earthquakes lies in their ability to shake buildings so vigorously that they fall apart and collapse. Often this damage is worse than it should be because of poor building design. There is a saying that 'earthquakes do not kill people, buildings do!' It is falling masonry that traps, crushes and kills people. Earthquakes rupture gas pipes and break electricity cables. It is not surprising therefore that fire is another aspect of the earthquake hazard.

Another after effect of an earthquake is the tidal wave or **tsunami**. Earthquakes with epicentres under the sea can generate particularly large and destructive tidal waves. The Asian tsunami of 2004 had its epicentre just off the west coast of Sumatra and generated a huge tidal wave up to 30 m high. It caused immense damage in the coastal areas of those countries bordering the Indian Ocean. The casualty list amounted to nearly 300 000. The majority of these victims were drowned. It was one of the deadliest **natural disasters** in recorded history.

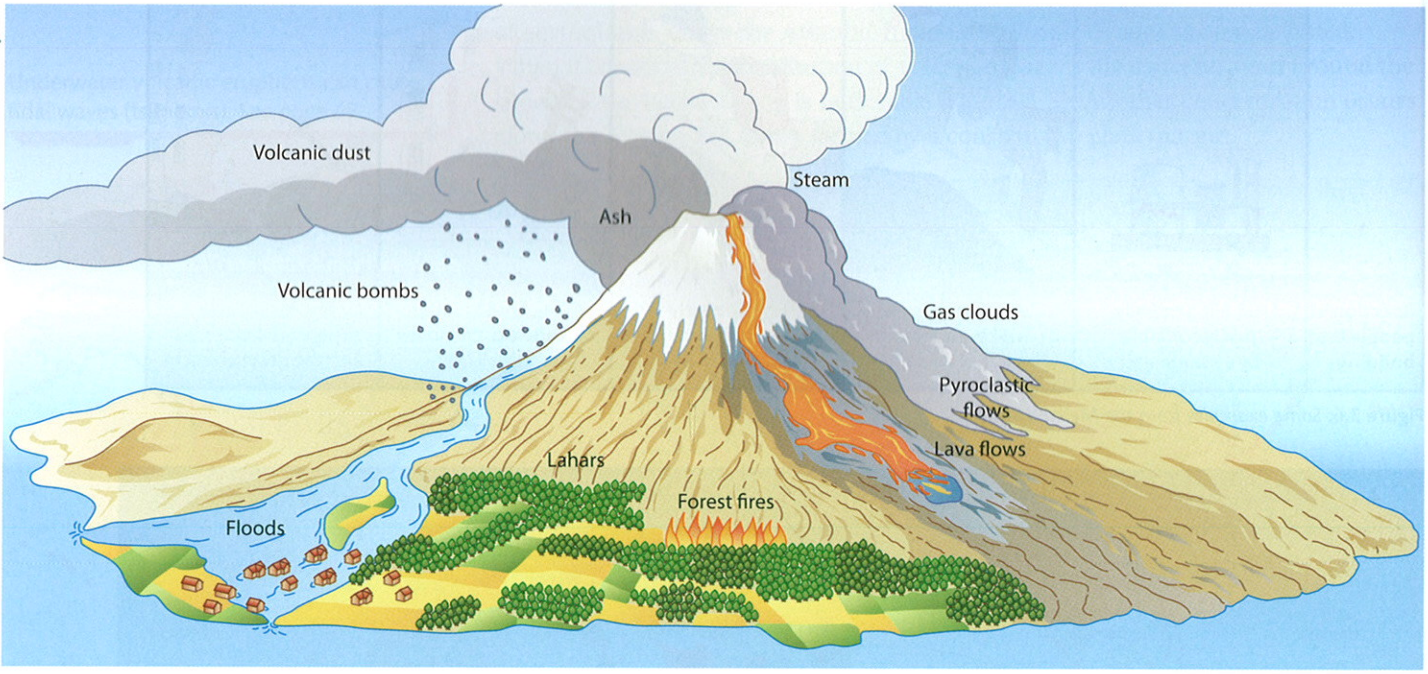

Figure 3.8: *Hazards associated with volcanic eruptions*

Volcanic eruptions

There are several different hazards associated with volcanic eruptions (Figure 3.8):

- **lava flows** – since few lava flows reach much beyond 10 km from the volcanic crater, they do not cause as much death and destruction as you might think. Lava flows may destroy farmland, buildings and lines of transport, but lives are rarely lost
- **ash** – ash may be thrown into the air during a violent eruption. Often this is carried in the wind and therefore can affect quite a large area. This happened over much of Europe in 2010 when a volcano in Iceland erupted. The ash cloud brought air travel to a halt. The further away from the volcano, the thinner will be the deposits of ash. Ash can cause much damage by simply blanketing everything, from crops to roads. Roofs of buildings will collapse if the weight of the deposited ash is great. Air thick with ash can asphyxiate humans and animals
- **gas emissions** – sulphur is not the only gas to be emitted during an eruption. Other gases emitted, notably carbon dioxide and cyanide, can kill. Being dense, they keep close to the ground

Under the heading of gas emissions, remember to include pyroclastic flows (see page 84).

Volcanic eruptions can also generate tsunamis. The huge eruption of Krakatoa in 1883 created waves up to 35 m high. These waves drowned over 36 000 people.

3.3 Tropical storms

In this part of the chapter, we focus on a third and very different natural hazard – the tropical storm. As in Part **3.2**, the same three aspects will be investigated, namely distribution, causes and hazard characteristics.