Department of Education

GOVERNMENT OF WESTERN AUSTRALIA

Year 12 General Geography

The study of a natural hazard: Earthquakes

Depth Study 1

GTGEO
Geography
General 12

Depth Study One
The study of a natural hazard: Earthquakes

The study of a natural hazard: Earthquakes

Instructions

- This work booklet should be completed over three (3) weeks.
- Work with this booklet in conjunction with the key text below.
- Occasionally, there are links and references to materials online but this should not prevent you from completing the booklet.

Essential text

Griffin, A. (ed.) (2018) *WA ATAR Geography: Units 1 & 2*, Geographical Association of WA Inc., Perth, Western Australia.

- Note: this resource is referred to as the **'Read *GAWA WA ATAR Geography: Units 1 & 2*'** in this package

Useful SCSA ATAR Geography documents
Year 12 Geography General Syllabus
https://senior-secondary.scsa.wa.edu.au/__data/assets/pdf_file/0010/10135/Geography-Y12-Syllabus-General-GD-EST.pdf

Syllabus points - Depth study one

Students study a natural hazard. The context will be earthquakes, in order to investigate:

- the nature and causes of the hazard
- the nature of the risks to be managed such as:
  - loss of property/life
  - effects on infrastructure, jobs and the economy
  - the impact on physical and mental health
- the space and time distribution of the hazard and how an understanding of biophysical and human processes can be used to explain the patterns that are identified
- the magnitude, duration, frequency, probability and scale of spatial impact of the hazard
- the physical and human factors that explain why some places and people are more vulnerable to the hazard than others
- the means by which the activities of people can intensify the impacts of the hazard, such as:
  - using construction techniques unable to withstand seismic activity
- the environmental, economic and social impacts of the hazard in a developed country, such as Australia compared with at least one less developed country or region.

Depth Study One: Earthquakes

WEEK ONE

Nature and causes of earthquakes

Syllabus content:

- the nature and causes of the hazard

Read *GAWA WA ATAR Geography: Units 1 & 2*, Chapter 2, pages 40 to 44.

Earthquake are a series of shock waves that are generated by a disturbance of the Earth's crust. Earthquakes occur when buit-up of tension, compression or shear forces in the Earth's rocks break and move, suddenly releasing energy in waves. The ground shakes as a series of seismic shock waves spread out from where the earthquake originated inside the Earth's crust.

Physical structure of Earth

The physical structure of Earth is divided into four major layers: the crust, the mantle, the outer core and the inner core (see Image 1). Each layer has different physical properties and chemical composition.

The Earth's crust is the surface layer. There are two types of crust; continental and oceanic crust. Continental crust is older, thicker and less dense. Oceanic crust is denser, newer and thinner. The crust is fractured into tectonic plates.

The mantle is the thickest layer of Earth (approximately 2,900 kilometres). It is made up of molten silicates and other minerals. As it is molten it moves.

The outer core is a liquid layer made up of iron and nickel. It is under slightly less pressure than the inner core.

The inner core is in the centre and is the hottest part of the Earth (temperatures of up to 5,500°C). Due to the intense pressure experienced, the inner core is a solid, made up of iron and nickel.

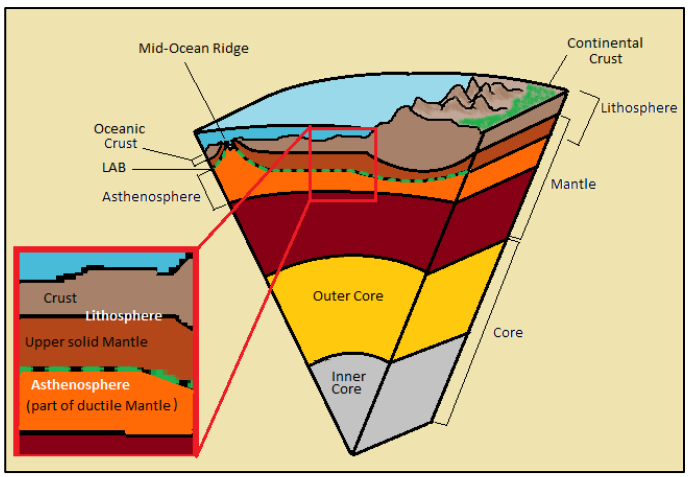


Image 1 Internal Structure of Earth.

Image by NealeyS at English Wikipedia, CC BY-SA 3.0, https://commons.wikimedia.org/w/index.php?curid=39760998

Earthquakes occur in the Earth's lithosphere. The lithosphere is made up of the crust and the upper mantle, making it the most rigid and coolest part of the Earth.

The **focus** of an earthquake is the point where it originated within the Earth. The point on the Earth's surface directly above the focus is called the earthquake **epicentre**.

Tectonic plates

The Earth's crust is broken into large pieces called tectonic plates. These plates fit together like a giant jigsaw puzzle (see Image 2).

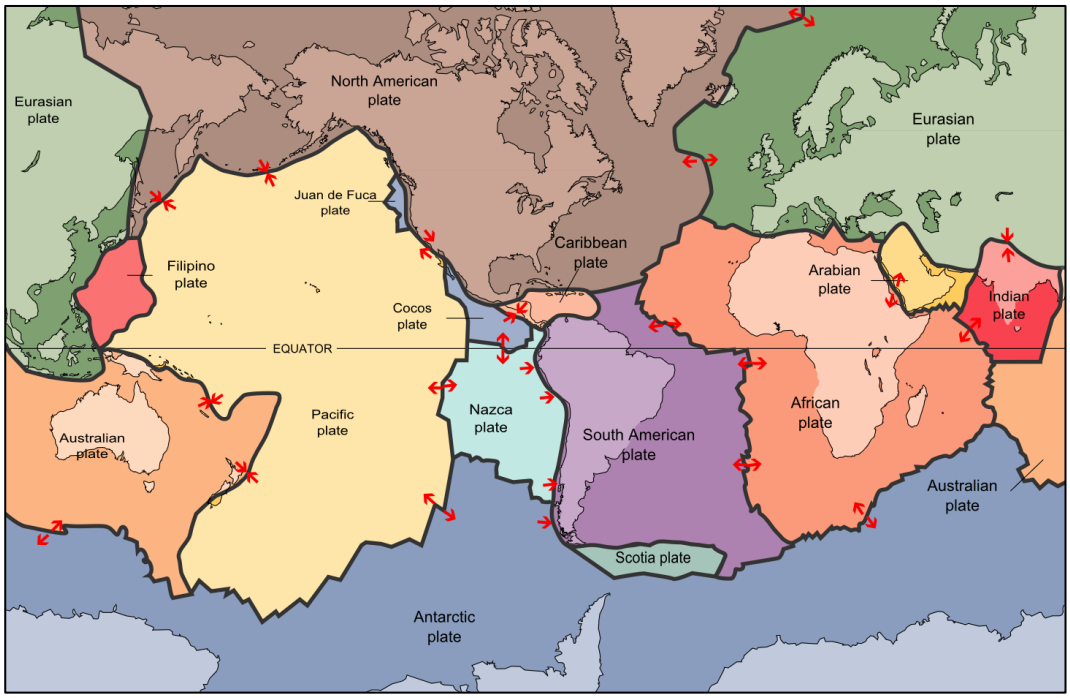


Image 2 Map of the major tectonic plates.

Convection currents in the mantle

In the mantle, heat rises and falls, creating convection currents due to the heat of the core. It is these convection currents that cause the movement of the tectonic plates. The mantle material remains solid. It is the heat and pressure that allow convection currents to move the mantle material slowly.

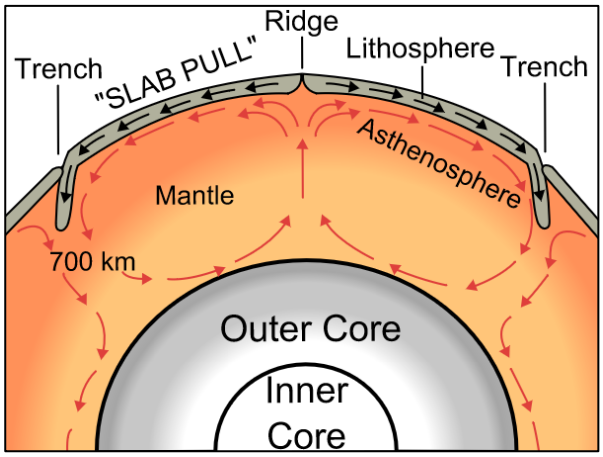


Image 3 Convection currents in the whole mantle.

The warmer, less dense rock material near the core slowly moves upwards. Relatively cooler rock closer to the lithosphere slowly sinks towards the mantle. This creates a cycle. As the warmer material rises, it also cools and sinks back toward the core as it is pushed away by warmer rising material.

Movement of tectonic plates

Oceanic and continental plates move at a rate of three to five centimetres per year. Plates either move towards or away from each other, or slide past each other by the forces of gravity and the convections currents in the mantle (see Image 3). The movement of tectonic plates is responsible for earthquakes.

Movement of the plates creates three types of tectonic boundaries. These are:

- Convergent
- Divergent
- Transform

Earthquakes are found along all types of plate boundaries.

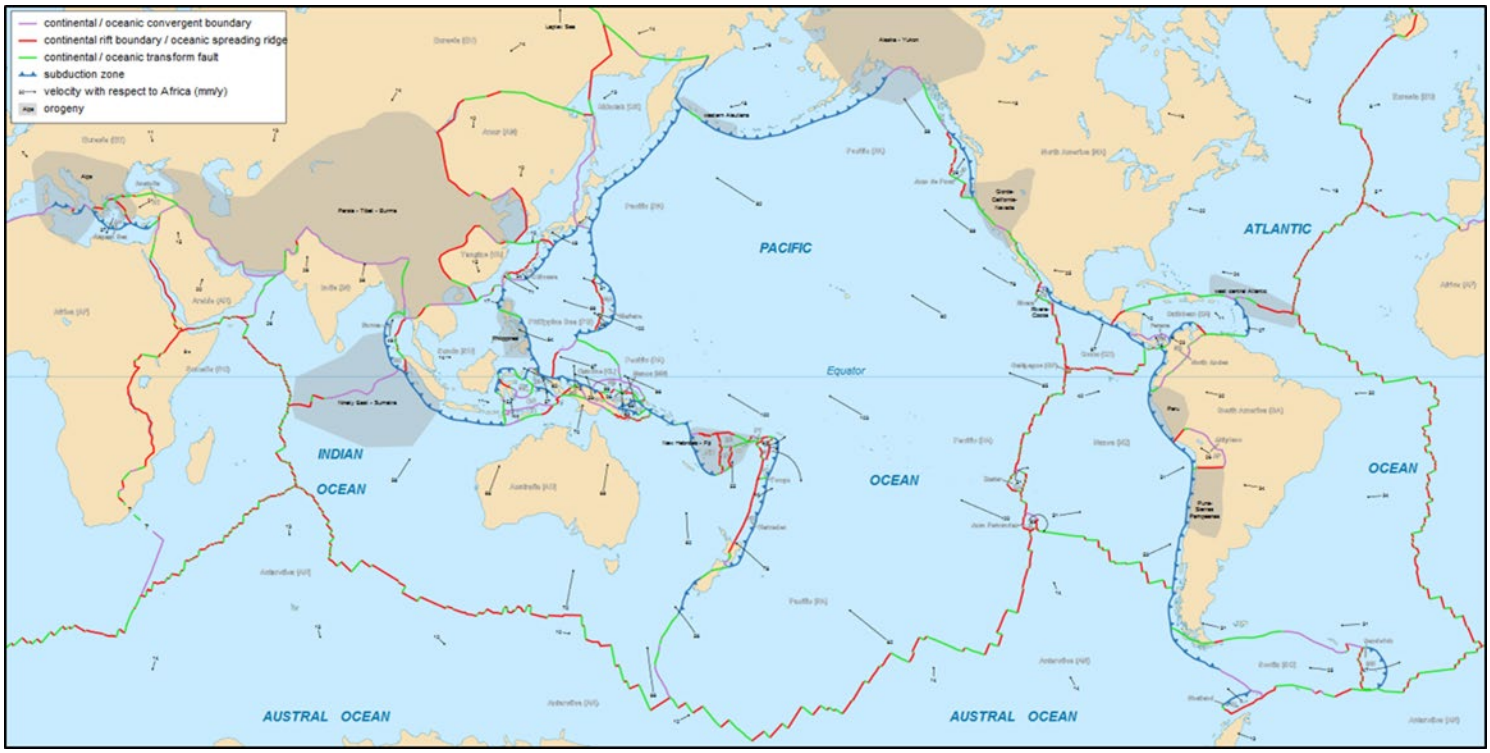


Image 4. Map of tectonic plates and directions of movement.

Image by Eric Gaba (Sting - fr:Sting) - Background map: NGDC World Coast Line dataData: Prof. Peter Bird's map, CC BY-SA 2.5, https://commons.wikimedia.org/w/index.php?curid=1307879

1. **Convergent plate boundaries** are where plates move towards each other. Convergence can occur between continental and continental plates; continental plate to oceanic plate and oceanic to oceanic plates. Forces of compression exist at the plate boundaries. The plate collisions that occur in these areas can produce earthquakes, volcanic activity and crustal folding.

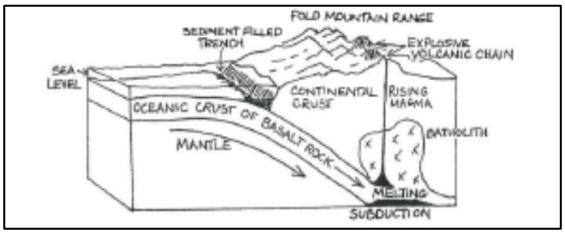


Image 5 Convergent plate boundaries

When **continental and oceanic plates collide**, the thinner and denser oceanic plate is forced down into the mantle in a process known as **subduction**. An example is Andes Mountain Range. The Nazca Plate is subducting beneath the South American plate.

When **continental plates collide**, mountain chains are produced. Shallow earthquake activity and shortening and thickening of the plates also occur within the collision zone. The intense compression causes the crust to fold and fault. The Himalaya Mountain Range is the best active example of two plates pushing against each other.

When **oceanic plates collide**, one plate will subduct beneath the other. Normally the older plate will subduct because it's denser. Activities experienced around the collision zone includes: earthquakes; development of an oceanic trench; a chain of volcanic islands; and the destruction of oceanic lithosphere. Japan, the islands of the Philippines and the Aleutian Islands are examples of islands formed through the collision of two oceanic plates. The Philippine trench is an example of a deep oceanic trench.

2. **Divergent plate boundaries** are where plates move apart from each other, releasing molten rock material (magma) from the mantle. New crustal material is created. Forces of tension exist at the plate boundaries. When divergence occurs on the floor of oceans, mid ocean ridges are produced. The Mid Atlantic Ridge is an example. Examples of divergent boundaries between continental plates include the Red Sea and the East Africa Rift Valley.

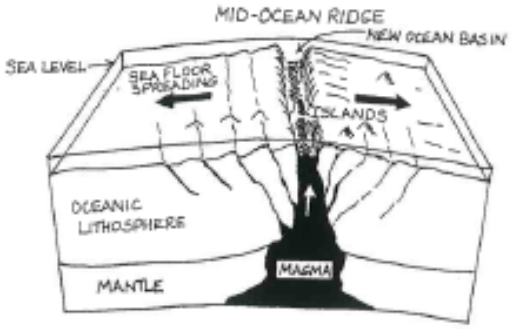


Image 6 Divergent plate boundaries

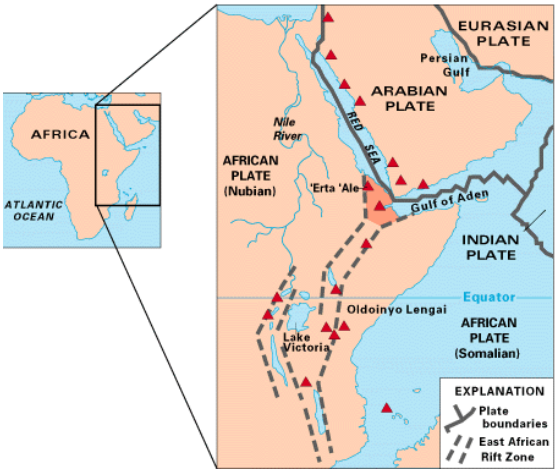


Image 7 A map of East Africa showing where three plates are pulling away from one another: Arabian Plate and two parts of the African Plate (Nubian and Somali) splitting along the East African Rift Zone.

Image by USGS - http://pubs.usgs.gov/gip/dynamic/East_Africa.html, Public Domain, https://commons.wikimedia.org/w/index.php?curid=37695246

3. **Transform plate boundaries** are where plates slide horizontally past each other, either in the same or opposite direction. The friction caused by the two plates trying to move builds up pressure. Eventually the pressure needs to be released, sending out a large amount of energy, causing an earthquake. California's San Andreas Fault (Image 9) is the best-known transform plate boundary. This is the cause of tremors and earthquakes in this region.

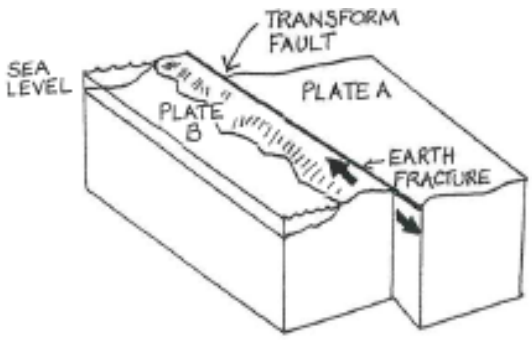


Image 8 Transform plate boundaries

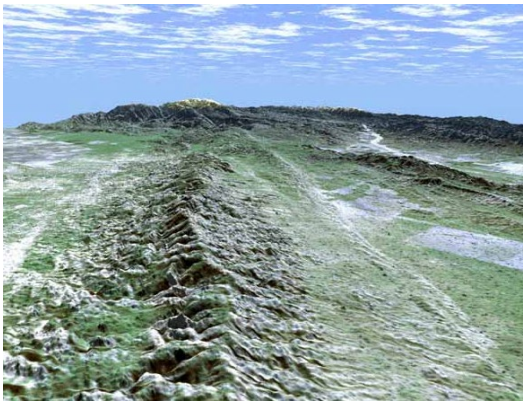


Image 9 View of the San Andreas Fault on the Carrizo Plain in central California.

Image By NASA - http://antwrp.gsfc.nasa.gov/apod/ap001207.html, Public Domain, https://commons.wikimedia.org/w/index.php?curid=1307852

Check your understanding

1. What type of natural hazard are earthquakes?

2. Brainstorm - What is an earthquake?
(hint: think of **how** an earthquake is caused, **where** earthquakes occur and **why** an earthquake occurs).

What is an earthquake?

3. Using your brainstorm, describe the **nature** of earthquakes in a paragraph.

4. Write a brief description of the **characteristic**s of each layer of the earth.

Layer		**Characteristics**
Core	solid	
	outer	
Mantle		
Lithosphere or crust	continental crust	
	oceanic crust	

5. Draw a labelled diagram to show how convection currents in the Earth's mantle.

6. In your own words, explain how convection currents transfer heat from the core to the mantle.

7. Convergent plate boundaries

Draw a labelled diagram of convergent plate boundaries.

Describe the forces at the plate boundaries (what movement is occurring).
Give an example of where this type of plate boundary is found on Earth.

8. Divergent plate boundaries

Draw a labelled diagram of divergent plate boundaries.
Describe the forces at the plate boundaries (what movement is occurring).
Give an example of where this type of plate boundary is found on Earth.

9. Transform plate boundaries

Draw a labelled diagram of transform plate boundaries.

Describe the forces at the plate boundaries (what movement is occurring).
Give an example of where this type of plate boundary is found on Earth

10. Write a well-developed sentence that describes the relationships between earthquakes and plate boundaries.

11. Identify the type of plate boundary where most earthquakes occur.

The spatial location and spatial distribution pattern of earthquakes

Syllabus content:

- the space (spatial) and time (temporal) distribution of the hazard and how an understanding of biophysical and human processes can be used to explain the patterns that are identified.

Read *GAWA WA ATAR Geography: Units 1 & 2*, Chapter 2, pages 46 to 47.

Spatial location

Earthquakes are found predominately along the plate boundaries. Earthquake activity is also located along fault lines within tectonic plates such as the Eurasian Plate and Indo Australian plate.

Spatial distribution

These earthquakes are irregularly distributed in a linear pattern mainly along the plate boundaries. The greatest density of earthquakes is apparent along the Pacific Ring of Fire. The Pacific plate shares its boundaries with other converging plates such as the Eurasian plate, Indo - Australian and North American plate. Sparse distribution of earthquake activity is located within tectonic plates.

Image 10 Map of earthquakes greater than magnitude 5, from 2000 to 2008.
View Image 10 by clicking this link:

https://www.nsf.gov/news/mmg/media/images/global_seismicity_h.jpg

Temporal distribution

Earthquakes are always happening somewhere. Most earthquakes go unnoticed as they are minor. On average, magnitude 2.0 and smaller earthquakes occur a number of times a day world-wide. Earthquakes with a magnitude greater than 7.0 occur more than once per month. Earthquakes with a magnitude of 8.0 and higher occur about once a year.

Geoscience Australia has an excellent webpage where you can see the occurrence of earthquakes over the last seven days. Information on each earthquake is provided. Take a look if you have the opportunity. The web page is: https://earthquakes.ga.gov.au/

Check your understanding

1. Using the map from Image 10, give an example of the **location** of an **area** prone to earthquakes.

2. Using your research skills, identify the percentage (%) of earthquakes occurring in the location mentioned in question 1. [Hint: https://www.nationalgeographic.org/encyclopedia/ring-fire/]

Magnitude, duration and frequency of earthquakes

Syllabus content:

- the magnitude, duration, frequency, probability and scale of spatial impact of the hazard

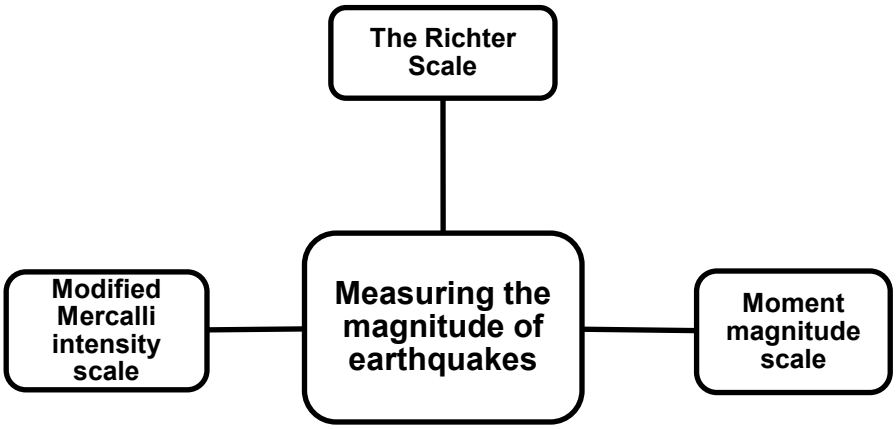
Read *GAWA WA ATAR Geography: Units 1 & 2*, Chapter 2, pages 48 to 50.

Earthquakes are measured according to their magnitude, duration, frequency, probability and scale.

Check your understanding

1. In one (1) sentence, explain what the term ***magnitude*** means when discussing an earthquake.

2. In dot point form, explain the different ways magnitude of earthquakes can be measured.



3. Match the word with the correct simple definition.

Duration	how often earthquakes occur
Frequency	how long the earthquake lasts
Probability	the extent of the area affected by earthquakes
Scale	how likely earthquakes are to occur in space and time

4. Fill in the following table. You will need to do some of your own research.

Earthquake	**Magnitude**	**Description**	**Duration**
1995 Japan Kobe	6.9	Major	20 seconds
2010 Haiti	7.0	Major	30 seconds
2005 Pakistan			
2008 Sichuan			
2015 Hindu Kush			
2014 Iquique (Chile)			
2019 Peru, Loreto	8.0	Great	60 seconds

5. **Answer the following questions with true/false**
   a. There are very few earthquakes around the world each year. (T or F)
   b. Earthquakes above 5 on the Richter Scale are classified as major. (T or F)
   c. Earthquakes are always followed by a tsunami. (T or F)
   d. Earthquakes are more frequent on converging plate boundaries than on diverging plate boundaries. (T or F)
   e. The depth of a focal point of an earthquake impacts on the magnitude of the earthquake. (T or F)

WEEK TWO

Earthquakes and types of risks to be managed

Syllabus content:

- the nature of the risks to be managed such as:
  - loss of property/life
  - effects on infrastructure, jobs and the economy
  - the impact on physical and mental health

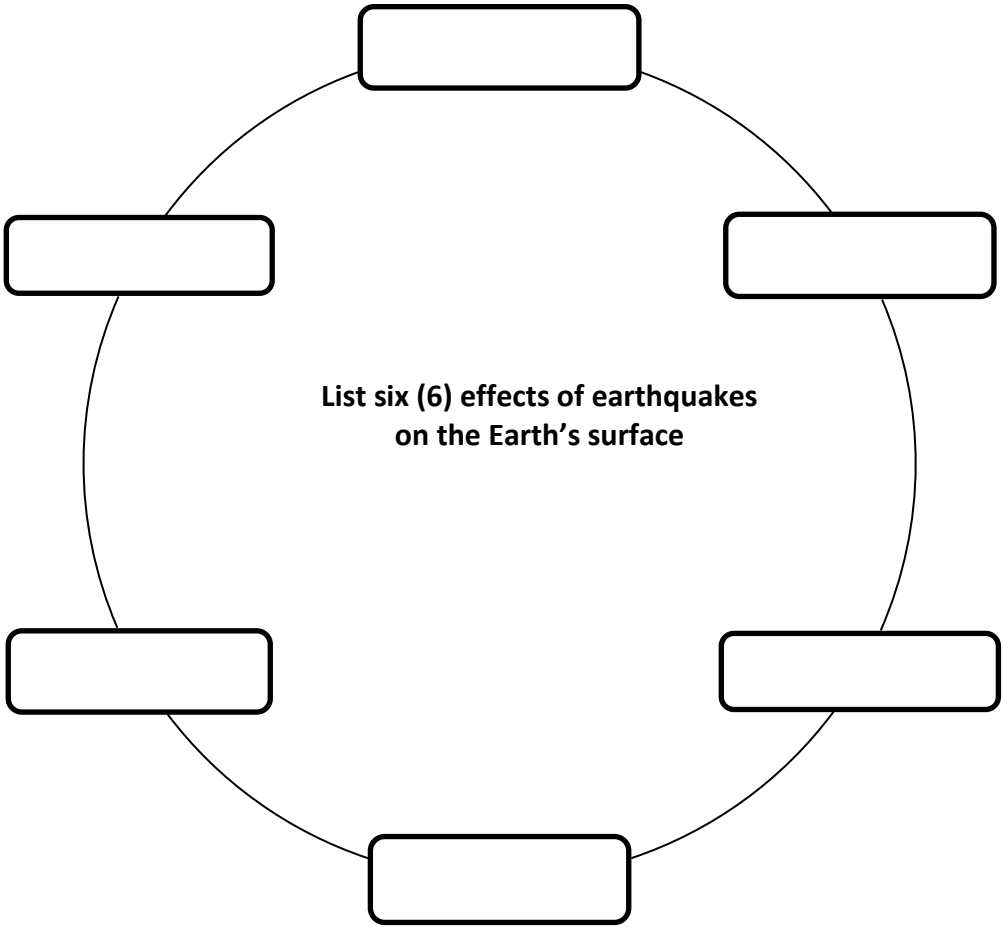
Read *GAWA WA ATAR Geography: Units 1 & 2*, Chapter 2, pages 44 to 46.

Impact of earthquakes

In built up areas, an earthquake can cause massive damage. Buildings and infrastructure can be destroyed. Infrastructure, such as gas, sewer and water mains can be damaged and electricity and telephone lines can be cut.

Check your understanding

1. List six (6) effects of the earthquakes on the Earth's surface in the graphic organiser below.



2. In the table below, list some primary and secondary effects of earthquakes.

Primary effects of earthquakes	Secondary effects of earthquakes

What is risk?
Earthquakes create a risk for both natural and cultural environments. These risks must be managed. The risk of being affected by a hazard event, such as an earthquake, is determined by the probability or likelihood that a community will be exposed to a particular natural or human hazard. The three factors that greatly increase the potential risk by all tectonic hazards are the three Ps: **proximity, poverty and population**. Risk can be categorised as low, moderate or high.

Areas that can be impacted upon by earthquakes include:
- loss of property and life
- effects on infrastructure, jobs and the economy
- the impact on physical and mental health

Earthquakes pose serious threats to the safety, health and economic viability of communities. The impact of the earthquake can be affected by the level of development of a country. A developed country such as Australia can afford to have early warning systems, public awareness campaigns to reduce risk, shelters and resources in place to cope both before and after the event. This is not the case in poorer less developed countries such as Nepal.

Since most of the damage caused directly by earthquakes is the failure and collapse of constructions, the best way to minimise the risks is to engineer structures that can withstand the ground shaking. This however is an extra cost, hence why they are not generally adopted in developing countries or in areas seen as low risk. Governments need to enforce earthquake-resistant structures through building code regulations.

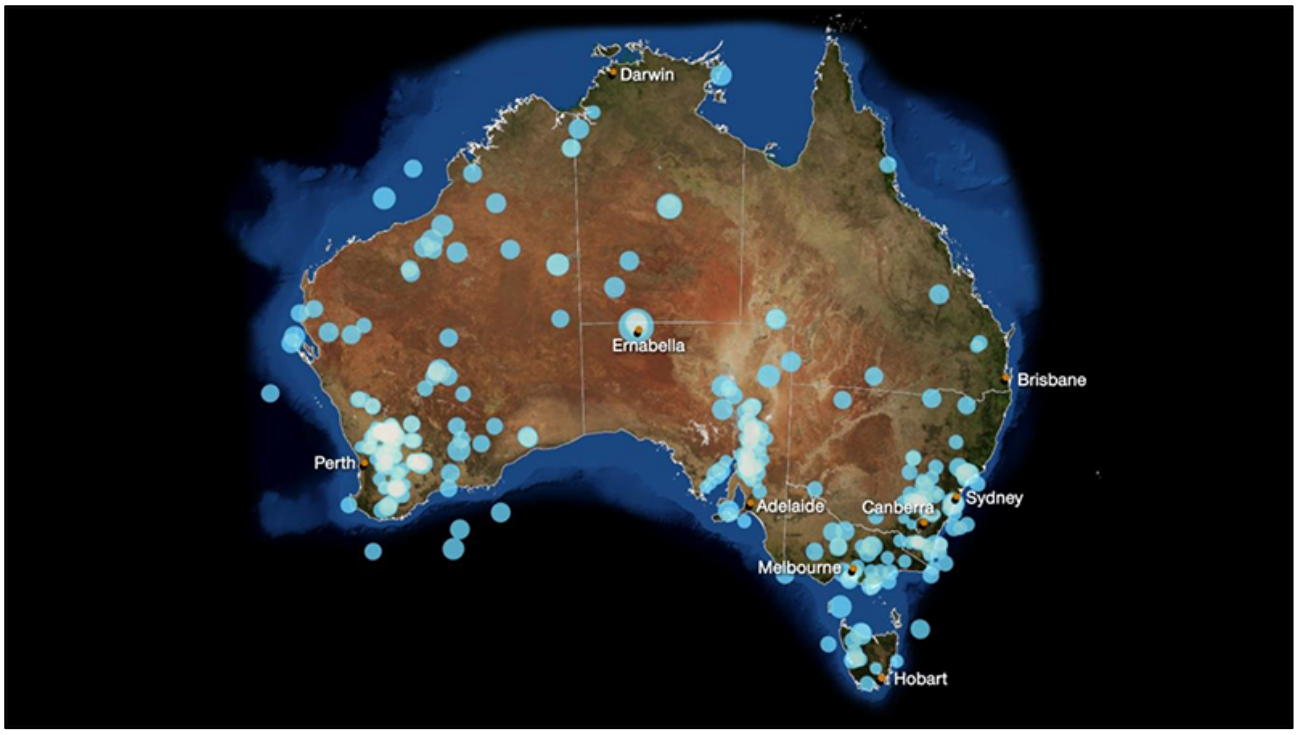


Image 11 Map of 2013 Australian Earthquakes recorded by Geoscience Australia.
Image by Geoscience Australia © Commonwealth of Australia (Geoscience Australia) 2020. CC BY 4.0
https://www.ga.gov.au/__data/assets/image/0018/20961/figure-1-large.jpg

The map in Image 11 plots the epicentre and magnitude of earthquakes recorded in Australia since 2013. Although Australia has far fewer earthquakes than northern neighbouring countries, we do still experience them. Some areas are more active, such as Western Australia and Bass Strait, while other areas such as western parts of Queensland and New South Wales are less active.

Most of the earthquakes experienced in Australia are under magnitude 4.0, which are considered small as they don't usually cause damage. Australia's earthquakes are caused by the Indo-Australian plate being pushed northeast about 7cm per year, colliding with the Eurasian, Philippine and Pacific plates. This movement causes the build-up of stress in the interior of the Australian plate, which is then released during earthquakes.
Source: Geoscience Australia © Commonwealth of Australia (Geoscience Australia) 2020. CC BY 4.0
http://www.ga.gov.au/news-events/news/latest-news/south-australian-town-tops-annual-list-of-australian-earthquakes-two-years-in-a-row.

Check your understanding

3. In dot-point form, write some notes on each of the following areas that are impacted by earthquakes.

Loss of property and life	Effects on infrastructure, jobs and the economy	The impact on physical and mental health

4. Refer to **Image 11** (Map of 2013 Australian Earthquakes recorded by Geoscience Australia), and explain the distribution of earthquakes in Australia.

5. What does the term **risk management** mean?

Physical and human factors cause varying vulnerability to earthquakes

Syllabus content:

- the physical and human factors that explain why some places and people are more vulnerable to the hazard than others
- the means by which the activities of people can intensify the impacts of the hazard, such as:
  - using construction techniques unable to withstand seismic activity

Read *GAWA WA ATAR Geography: Units 1 & 2*, Chapter 2, pages 50 to 52.

Check your understanding

1. Define **vulnerability**.

2. Explain one (1) **physical factor** that affects human vulnerability to earthquake disasters.

3. Explain each of the **human factors** that affect human vulnerability to earthquake disasters.

HUMAN FACTORS	DECSRIPTION	EXAMPLES
Location near fault zones		
Economic factors		
Education		
Government		
Technology		

GEO SKILL: SKETCH MAPPING

As a geography student, you will use a number of geographical skills. One particular practical and mapping skill you will learn and develop is **sketch mapping and photo sketching.**

A photo sketch is a simplified hand drawn illustration (drawing) of an area, which shows the positions of selected features from a **ground-level** or **oblique aerial photograph**.

A **sketch map** is also a simplified hand drawn illustration of an area, which shows the positions of selected **features,** but these maps are drawn from the **vertical aerial photograph** (i.e. looking directly down on the area) **or a topographic map**.

A photo sketch or a sketch map usually show the main **features** of an area and are not cluttered with unnecessary detail. In most cases, the photo sketch or sketch map will have annotations (labels), legend, a title and some reference to the boundaries or extent of the sketch.

When drawing your photo sketch or sketch map, remember to include essential map elements (think BOLTSS).

- **Border:** draw a frame in the same proportion of the map.
- **Orientation:** an indication of direction, usually shown with a north compass point orientation
- **Legend:** identifying the colour or shading of specific natural and/ or cultural features
- **Title:** the location of the sketch map
- **Scale:** if provided on a photograph that is being sketched
- **Source:** information of the photograph that is being sketched.

Check your understanding

Image 12 Downtown Port-au-Prince, Haiti.

Using the ground photo from the 2010 Haiti earthquake (Image 12), construct an annotated (labelled) sketch map. A frame below has been provided for you. Ensure your sketch map consists of all the possible map elements (think BOLTSS).

Title:

Source:

Legend:

WEEK THREE

Impacts of earthquakes on people, property and economic activity

Syllabus content:

- the environmental, economic and social impacts of the hazard in a developed country, such as Australia compared with at least one less developed country or region.

Read *GAWA WA ATAR Geography: Units 1 & 2*, Chapter 2, pages 53 to 46.

Earthquakes pose serious threats to the health, safety and economic viability of communities. The impact of the earthquake can be affected by the level of development of a country. A developed country such as Australia can afford to have early warning systems, public awareness campaigns to reduce risk, shelters and resources in place to cope both before and after the event. This is not the case in poorer less developed countries such as Haiti.

Check your understanding

Earthquake Case Studies: Kobe 1995 (Japan) and Haiti 2010

Use the information in the textbook and your own research to investigate the Kobe earthquake (1995).

1. With reference to the **Kobe earthquake**, discuss the impact on the city in terms of:

Loss: (life and property)
Life

Property

2. Identify risk factors that affected **Kobe's vulnerability**.

RISK FACTORS	**DESCRIPTION**
Location	
Population of Kobe	
Buildings and Transport Systems	
Mitigation (what strategies were in place to reduce the impacts of an earthquake?)	

Use the information in the textbook and your own research to investigate the Kobe earthquake (1995) and the Haiti earthquake (2010).

3. **Research the earthquakes** and fill in the following information. Provide information in dot-points. Give place names, statistics and specific examples.

	Kobe Earthquake 1995 (Japan – a developed country)	**Haiti Earthquake 2010 (less-developed region)**
Date and Time		
Location		
Magnitude		
Duration		
Impact on the **natural** environment • Landforms • Drainage e.g. rivers, lakes • Vegetation		
Impact on the **cultura**l or human environment • Loss of life, injuries • Loss of property • Effect on infrastructure e.g. roads, bridges, houses, factories, ports • Effects on the economy and jobs	• Loss of life, injuries • Loss of property	• Loss of life, injuries • Loss of property

	• Effect on infrastructure e.g. roads, bridges, houses, factories, ports • Effects on the economy and jobs	• Effect on infrastructure e.g. roads, bridges, houses, factories, ports • Effects on the economy and jobs

4. Which earthquake do you think had the greatest impact on the community? Use the information you have gathered in the table to provide reasons and specific evidence to support your choice.

5. Define **preparedness**.

6. Define **prevention**.

7. Define **mitigation.**

8. Provide dot-point information in the table below on the **preparedness**, **prevention** and **mitigation** of earthquakes. Where possible, use specific examples related to the Kobe earthquake 1995 and Haiti earthquake 2010.

Preparedness	Prevention	Mitigation

Well done, you have completed the depth study on Earthquakes.