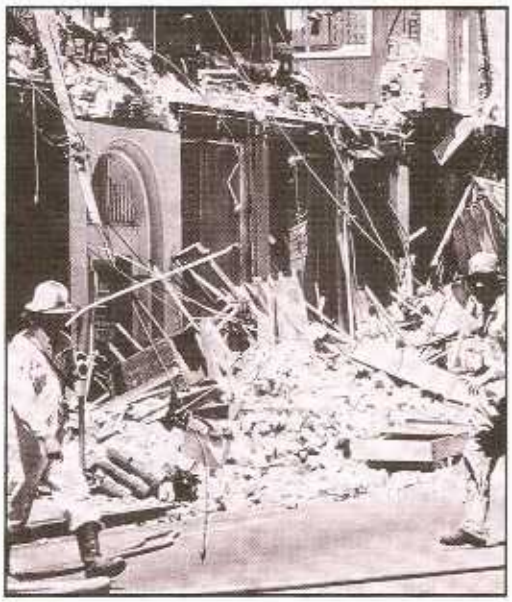
Section 7



The Earthquake Hazard

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Earthquakes: Glossary of Key Terms

Crust: The outer shell of the earth including the continents and the ocean floor.

Convection currents: In the study of earthquakes, the currents which result from the transfer of heat caused by movement of magma below the crust. These currents in turn cause the plates of the crust to move.

Epicentre: The point on the earth's surface which is directly above the focus of an earthquake.

Fault: A crack or fracture along which layers of rock move either vertically or horizontally.

Focus: The point of origin of an earthquake.

Intraplate earthquakes: Those earthquakes which occur away from the plate margins.

Magma: Molten rock below the earth's surface.

Magnitude (of an earthquake): A measure of the relative size of an earthquake based on amplitudes of seismic waves recorded using a seismograph. Magnitude is related to the amount of energy released by an earthquake.

Mantle: The layer of the earth beneath the crust.

Normal fault: Where the rock on the side hanging over the fracture appears to have moved downward relative to the other side.

Plates: Segments of the earth's crust which 'float' on the heavier, semi-molten rock of the mantle below. The edges or boundaries of the plates of the earth's crust are called plate margins.

Seismic waves: Waves which radiate in all directions from the focus of an earthquake.

Seismograph: Instrument used for recording and measuring seismic waves.

Strike-slip fault: A fault along which movement is parallel to the direction in which the fault runs.

Subduction: The process by which one plate descends under another plate.

Thrust fault: Where rock layers on the side hanging over the fracture have moved upwards relative to the other side.

Transcurrent fault: A large-scale strike-slip fault where the fault surface is steep.

Transform fault: A special type of strike-slip fault, along which displacement suddenly stops or changes form.

Tsunami: Huge ocean wave normally caused by an earthquake under the sea.

Plates, Faults and Earthquakes

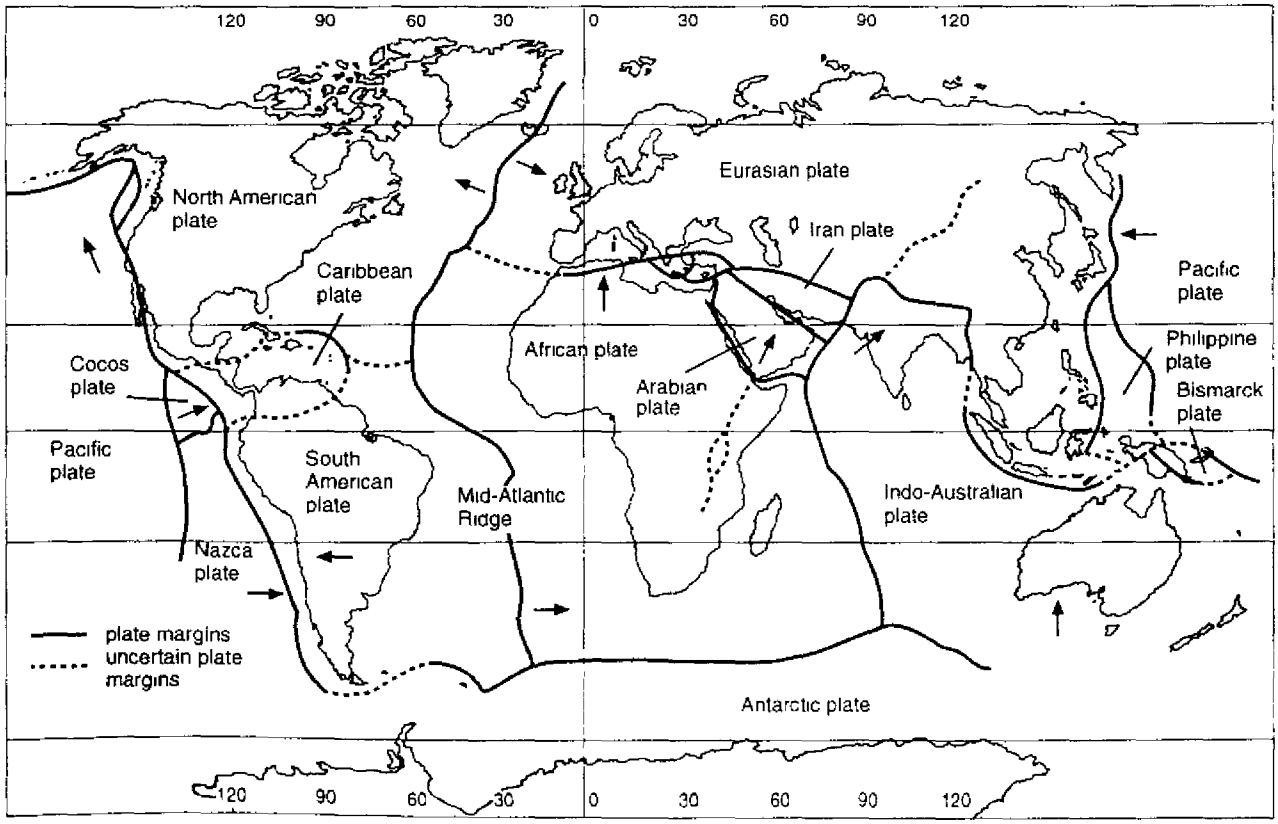
Activities

1 Using the information in 'Hazard Data' and in Figure 1, answer the following:
   a Explain why the plates of the earth's crust move.
   b One of the largest earthquakes this century occurred in Chile, South America, in 1960. Which plates would have been involved in this earthquake? Describe the directions in which they are moving.
   c Explain why earthquakes occur where pressure builds up over long periods of time? Why is this pressure more likely to build up where plates are colliding?
   d Explain why damage from major earthquakes often occurs hundreds of kilometres from the epicentre.
   e The epicentre for the disastrous Mexico City earthquake of 1985 was 400 kilometres south-west of the city in the Pacific Ocean. Which plates were involved in the earthquake? Describe the directions in which plate movement occurred.

HAZARD DATA

- Earthquakes result from rocks breaking under stress.
- These stresses build up beneath the earth's surface as a result of the constant movement of the jigsaw-like pieces that make up the thin outer shell of the earth.
- These pieces are the **plates** of the earth's **crust** (see Figure 1). There are more than a dozen separate plates of up to 100 km thick making up the crust.
- The plates rest on the **mantle** - the layer of the earth beneath the crust. In its outer layers the mantle is composed partly of molten rock or **magma**. The continual movement of this molten rock sets up **convection currents** which cause the plates above to drift slowly in different directions.
- The zones of contact between two plates can be a mid-ocean ridge (divergent), subduction zone (convergent), strike-slip fault (sliding) or collision zone (mountain building). See Figure 2.
- Movement at these edges (or **margins**) of plates in this fault zone usually occurs slowly over millions of years. Occasionally, however, enormous stresses build up which are released suddenly by fracturing of rocks as the earth's crust 'snaps' into a new position.
- This snapping causes the sudden and at times disastrous vibrations - known as **shock waves** or **seismic waves** - we call earthquakes.
- The point at which the fracturing occurs, which may be kilometres below the earth's surface, is called the **focus.** The point on the surface above the focus is the earthquake's **epicentre.** Seismic waves are sent out in all directions from the epicentre.

Figure 1: The plates of the earth's crust.



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Plates, Faults and Earthquakes (contd)

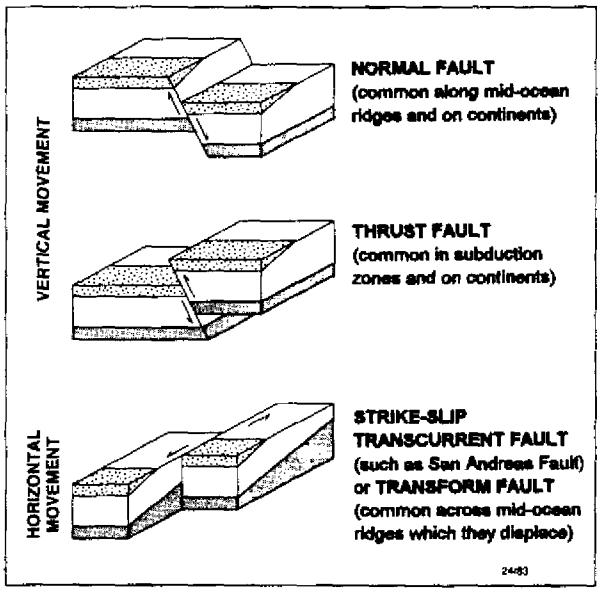

Figure 2: The three main types of faulting

Mid-ocean ridges mark the boundary between two plates which are pulling away from each other. Here the earth forms new crust and volcanoes are common. At the plate boundaries **normal faulting** occurs producing shallow earthquakes, less than 20km below the surface.

Where two plates are converging or colliding with each other one will be thrust over the other (i.e. **thrust faulting).** Violent earthquakes may result which can occur to depths of 700km. If two continental plates are involved, mountain chains may be built (e.g. the Himalayas). In thrust faulting involving heavier oceanic plates, one plate is pushed or **subducted** below the other. This may result in the formation of deep ocean trenches (e.g. the Marianas Trench). If a continental and oceanic plate collide, the latter will be subducted, with mountains forming at the edge of the continental plate (e.g. the Andes).

Where two plates slide laterally past each other, this is called a **transform fault.** The San Andreas fault in California is a famous example of a transform fault. Earthquakes associated with transform faults are usually quite shallow, occurring at depths of less than 20 kilometres.

Activities (contd)

2 Study the information in Figure 2 and complete the following:
   a Explain the formation of the Mid-Atlantic Ridge shown in Figure 1. Comment on the likely impact of earthquakes occurring along the Mid-Atlantic Ridge.
   b Why do you think volcanoes are common along mid-ocean ridges? How would they be connected to the formation of new crust at these locations?
   c Conduct some further research into the formation of each of the following:
   - the Himalayas
   - the Marianas Trench
   - the Andes.

   In each case find out the plates involved, their characteristics, their direction of movement and the processes which occur at the plate margins.

3 Complete the puzzle on the right by finding (a) each of the words listed, and (b) the names of four of the plates of the earth's crust (write these in the spaces provided at the end of the word list).

E	P	I	C	E	N	T	R	E	S	S	M
A	R	N	S	T	L	U	A	F	E	R	A
R	E	A	A	M	G	A	M	I	T	O	N
T	S	Z	S	E	I	S	S	P	A	C	T
H	S	C	T	O	O	M	B	L	L	K	L
Q	M	A	R	G	I	N	S	A	P	S	E
U	U	F	E	C	E	C	R	U	S	T	F
A	R	T	S	U	R	H	T	S	C	U	T
K	E	N	S	I	T	C	E	V	N	O	C
E	M	R	O	F	S	N	A	R	T	A	F
S	N	A	I	S	A	R	U	E	S	O	L
A	F	R	I	C	A	N	S	O	C	O	C

EPICENTRE
ROCKS
EARTHQUAKES
CRUST
SEISMIC
MANTLE
PLATES
FAULTS
TRANSFORM
THRUST
MARGINS
STRESS
FOCUS
MAGMA

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Earthquakes - Their Different Impacts

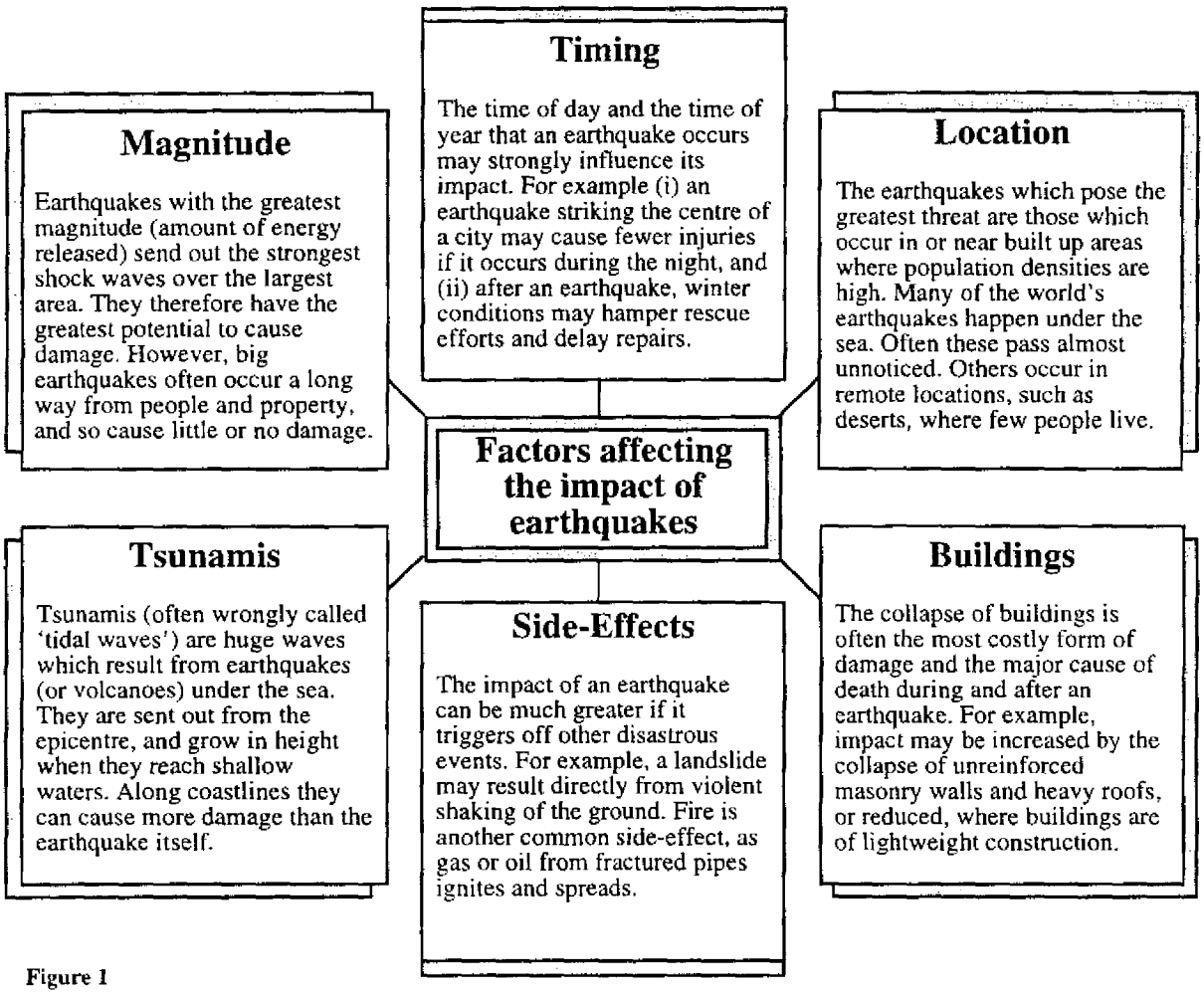

Figure 1

Activities

1 Using the information in Figure 1 answer the following.

a Comment on how timing may have contributed to the impact of each of the following earthquakes:
The Iranian earthquake of 1990 occurred in the middle of the night, demolishing 54 towns and villages. Most of the 50,000 people killed were farmers who spent their days in their fields.

In 1983 an earthquake occurred in the middle of the night in the city of Liege, Belgium. Showers of stones broke away from buildings and fell to the streets, but no-one was killed and there were few reports of injury.
Apart from timing, what other factors may have contributed to the impact of each earthquake?

b Is it always true to say that earthquakes with the greatest magnitude cause the most damage? Explain your answer.

c The Armenian earthquake of 1988, in which 25,000 people were killed, occurred in the middle of winter. Suggest one advantage and one disadvantage of the timing of this disaster.

d In Turkey and Iran, traditional houses have mud-brick walls and heavy roofs, while in many African countries local buildings are made of very lightweight materials. Explain the advantages and disadvantages of each type of dwelling in (i) protecting the buildings occupants during an earthquake and (ii) withstanding the effects of an earthquake.

e Explain how (i) fire and (ii) landslides are common side effects of earthquakes.

contd.....

Earthquakes - Their Different Impacts (contd)

Intraplate Earthquakes

About 95 per cent of earthquakes occur along the edges of the plates of the earth's crust. However, some earthquakes occur in the interior of plates. These are called **intraplate earthquakes**. They do not occur in well-defined patterns, like those at plate boundaries, and so they are not so easy to explain.

What is known about intraplate earthquakes is that they:

- are caused by stresses in the crust to depths of 50km;
- can be related to stresses at plate boundaries and temperature changes in the crust caused by processes deep in the earth;
- usually occur unexpectedly, as it is at present impossible to predict their location, size or timing;
- like other earthquakes, do not have to be of large magnitude to cause significant damage if they occur close to a population centre (eg Newcastle 1989).

In 1988, a series of relatively large intraplate earthquakes (of up to 6.8 on the Richter Scale) occurred near Tennant Creek in the Northern Territory. Located thousands of kilometres from the nearest plate margin, it was apparently caused by the release of stress that had built up in compressed rock only a few kilometres below the land surface. Figure 3a shows how the shifting ground opened large surface cracks, while Figure 3b shows a gas pipeline which was bent by the earthquake.

Intraplate earthquakes can also be caused by the filling of large dams. The water in reservoirs causes an increased load on the earth's crust, and, more importantly, causes the watertable to rise and lubricate nearby faults.

Figure 2

a.

b.

Figure 3: The impact of the Tennant Creek earthquake, 1988
a Ground rupture
b A warped gas pipeline

Activities (contd)

f Conduct some research into tsunamis. Find out:
- how they are formed;
- where they are most likely to occur;
- how they develop as they travel away from the earthquake epicentre;
- the speeds and heights they reach in open water and as they approach a shoreline;
- the impact they may have on people and property (including examples).

2 Read the information in Figure 2, and answer the following:
a What are 'intraplate earthquakes'?
b Why is it more difficult to predict the locations of intraplate earthquakes than those that occur at plate margins?
c Suggest why intraplate earthquakes would tend to be of lower magnitude than those at plate margins.
d Why do you think the intraplate earthquake which struck Newcastle in 1989, and measured 5.6 on the Richter Scale, had far greater impact than the bigger Tennant Creek earthquake of 1988?
e The damage bill as a result of the Tennant Creek earthquake was estimated at $2.3 million. From evidence in Figure 3, what types of damage would have contributed to this bill?
f Explain how the filling of large dams can cause intraplate earthquakes.

Earthquakes in Australia

Activities

1 Why do you think that, on average, Australian earthquake (i) occur less frequently and (ii) are less-damaging than earthquakes in many of our neighbouring Asian countries?

2 Why do many of Australia's largest earthquakes cause little concern?

3 Study Figure 1 and answer the following:
   a How do you account for Australia's relatively small damage bill from earthquakes, up until Newcastle in 1989?
   b Australia's largest earthquake (Richter scale 7.2) occurred at Meeberie, WA, in 1941. Why is it given a lower reading on the Mercalli scale than Newcastle, which was only a Richter scale 5.6 earthquake?
   c Conduct some further research into (i) the Richter Scale and (ii) the Modified Mercalli Scale. For each scale find out:
      - where and when it originated;
      - who devised it;
      - what it indicates;
      - its upper and lower limits;
      - who makes use of it.

HAZARD DATA

- Australia is prone to 'intraplate' earthquakes; those that occur away from plate margins.
- Historical records show that earthquakes occurred in most states during the first 50 years of European settlement.
- In the last 75 years there have been 17 earthquakes in Australia registering 6 or more on the Richter scale. Some of the largest / most damaging are shown in Figure 1.
- The western and central parts of Australia are the most active earthquake zones (Figure 2), but many of the bigger quakes have occurred in unpopulated regions and so have caused little damage.
- In built up areas, Australian earthquakes have caused significant damage. However, they are, on average, of smaller strength than the world's most damaging shocks.
- Until Newcastle in 1989, the earthquake damage bill in Australia had also been comparitively low.

adapted from 'Hazards, Disasters and Survival', Natural Disasters Organisation, 1992.

Year	Location	Richter Scale magnitude (1)	Mercalli Scale (2)	Insured Damage/Remarks
1892	Launceston TAS	6.9	VII	Unknown/offshore epicentre
1897	Beachport SA	6.5	VIII	Unknown
1902	Warooka SA	6.0	VII	Unknown
1903	Warnambool VIC	5.3	VII	$0.39m
1918	Bundaberg / Rockhampton QLD	6.3	VII	Unknown/offshore epicentre
1935	Gayndah QLD	5.7	VII	Unknown
1941	Meeberrie WA	7.2	VIII	Unknown
1946	Launceston TAS	6.0	VII	Unknown/offshore epicentre
1948	Robe SA	5.6	VI	Unknown
1949	Dalton-Gunning NSW	5.5	VIII	Unknown
1954	Adelaide SA	5.4	VIII	$78m
1959	Berridale NSW	5.3	VII	Unknown
1961	Robertson-Bowral NSW	5.6	VIII	$3.7m
1968	Meckering WA	6.9	IX	$10m/16 injured
1972	Wilpena SA	5.3	VII	Unknown
1973	Picton NSW	5.5	VII	$2.5m
1979	Cadoux WA	6.2	IX	$9.5m
1985	Lithgow NSW	4.3	VII	$0.1m
1988	Tennant Creek NT	6.8	VIII	$2.3m
1989	Newcastle NSW	5.6	VIII	$1,000m/13 dead, 150 injured

(1) Richter Scale: Note that energy of a magnitude 6.0 earthquake is about 30 times that of a magnitude 5.0, which is 30 times that of a magnitude 4.0 and so on.
(2) (Modified) Mercalli Scale: This scale measures earthquake *intensity* by rating the amount of damage caused. Roman numerals are used at each level, from I = a barely detectable tremor to XII = a major catastrophe.

Figure 1: Some large/ damaging Australian earthquakes over the last 100 years

adapted from 'Earthquake Awareness for Australians', Emergency Management Australia, 1994.

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Earthquakes in Australia (contd)

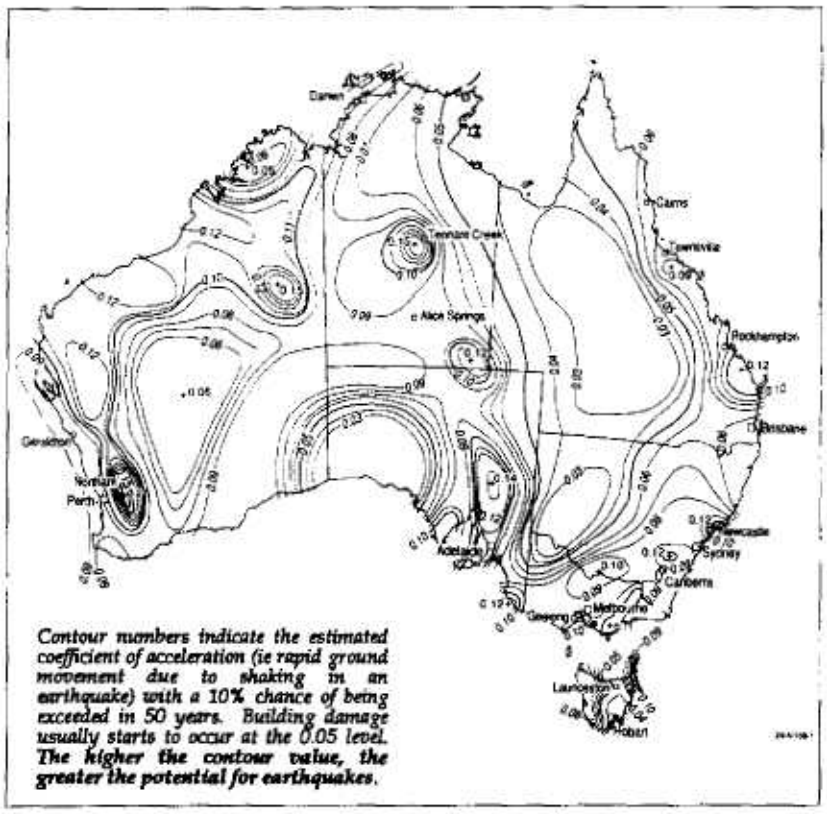


Figure 2: Earthquake hazard map of Australia

Activities (contd)

4 Using Figure 2 describe the distribution of areas with a high earthquake risk in Australia. Comment on the likelihood of serious earthquake *damage* in the areas you have described.

5 a Using an atlas, mark Meckering in Western Australia on the map, Figure 2.
  b Comment on the earthquake risk in the vicinity of Meckering.
  c Read the information in Figure 3. Why do you think no-one was killed in the large eathquake which struck Meckering in 1968?

6 Study the photograph Figure 4. What evidence from the photograph suggests that the earth moved both vertically and laterally (i.e. sideways) during the earthquake?

The Meckering Earthquake, 1968

The Meckering earthquake possibly affected a wider area of Australia than any other in recent history. Residents reported seeing the ground buckle, as well as experiencing steering difficulties when driving. Measuring 6.9 on the Richter Scale, the quake damaged 8000 buildings as well as destroying pipelines, roads and railway lines (Figure 4). The total damage was estimated at about $40m ($10m insured losses), however only 16 minor injuries were reported.

Figure 3

Figure 4: Damaged railway lines after the Meckering earthquake, 1968

Case Study: Newcastle, 1989

WHAT HAPPENED

At 10.27am on December 28, 1989, Newcastle, Australia's sixth largest city was devastated by a moderate earthquake measuring 5.6 on the Richter Scale. The earthquake dispelled the myth that Australia would never experience an earthquake of disastrous proportions. Lives were lost and buildings destroyed, as the ground motion was magnified by the thin layer of alluvium underlying the city. The epicentre of the earthquake was located 15km WSW of the city centre, near Boolaroo.

GEOLOGY AND EARTHQUAKE HISTORY

Newcastle experienced an 'intraplate' earthquake - one which occurs away from the plate margins of the earth's crust Where such earthquakes are likely to occur and how they are caused, are at present poorly understood The 1989 quake struck without warning in what was considered a low-risk area However, there had been six relatively large earthquakes (Richter scale 4.5-5.5) reported in the Hunter Valley region since 1829.

AFFECTED AREA

The effects of the Newcastle earthquake were felt up to 550km from the epicentre (e.g to the north at Coffs Harbour). The shaking lasted about six seconds in Newcastle, with the area suffering structural damage extending to Liverpool (Sydney) in the south (138km); Scone in the north-west (145km), and Gladstone in the north (320km). The damage was selective with the major contributing factor being the alluvial sediments on which many buildings were situated

INITIAL CONFUSION

Newcastle was in chaos immediately following the earthquake as office workers poured out of buildings into rubble-strewn streets. Police cordoned-off city streets and evacuated buildings in the central business district. Disaster response was hampered by a disrupted telephone service, damage to critical buildings and blocked road access.

BUILDING DAMAGE

Several hospitals were seriously damaged causing disruption to medical services and evacuation of patients. 147 schools were damaged in some way, with three deemed unsuitable for use. In all, 35,000 homes and 3,000 other buildings were moderately to seriously damaged, with older buildings suffering the most In all, insured losses were about $1 billion.

Earthquake damage to the Kent Hotel, Newcastle

The Newcastle Workers Club after the earthquake

DEATHS AND INJURIES

There were 13 deaths and 150 injuries. At the Kent Hotel three fatalities occurred, while another nine resulted from the collapse of the Newcastle Worker's Club (see photographs above). Three floors of the club's western wing collapsed during the earthquake, trapping many people. As a result of damage to hospitals, medical services were strained to cope with the disaster

EFFECTS ON LAND

There were several reports of people seeing earthquake waves travelling across the ground. However there was no evidence of ground deformation, surface rupture/faulting, mine subsidence or liquefaction. Unlike other earthquakes, fires were not one of the damaging side-effects in Newcastle. Only one fire was reported after the earthquake.

EFFECTS AT SEA

Unusual happenings at sea in the Newcastle area were reported. Several large ships east of the port of Newcastle, and boats on Lake Macquarie reported high-frequency vibrations of the vessels at the time of the earthquake. Surfboard riders at beaches reported two large waves appearing out of a fairly calm ocean, and sea-floor movements were reported by skin divers.

adapted from 'Earthquake Awareness for Australians', Emergency Management Australia, 1994

Figure 1: Features of the Newcastle earthquake 1989

Case Study: Newcastle, 1989 (contd)

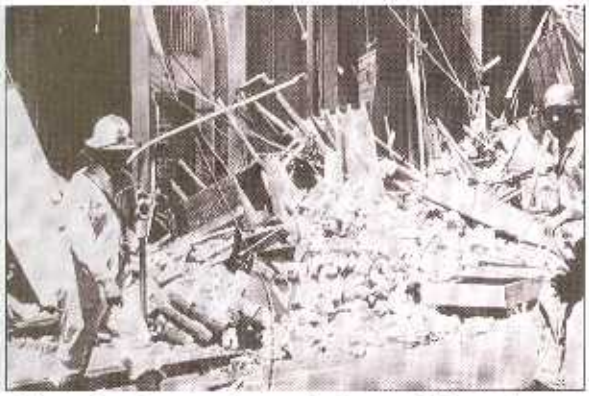


Figure 2: Rescue workers at the damaged Newcastle RSL Club

Figure 3: Rescue operations in the Newcastle Worker's Club

Activities

1 Using the information in Figure 1, answer the following:
   a What is meant by the 'epicentre' of the earthquake?
   b How did the location of the epicentre contribute to the Newcastle earthquake becoming the most damaging in Australia's history?
   c Find out what is meant by 'a thin layer of alluvium'. How did the presence of this layer beneath the city contribute to the severity of the Newcastle earthquake?
   d Conduct some research to find out:
      - what is meant by an 'intraplate earthquake',
      - how intraplate earthquakes differ from those that occur at plate margins;
      - why little is known about where they are likely to occur and how they are caused.
   e Do you think Newcastle should have been considered 'a low risk area' for earthquakes before 1989? Explain your answer. How would you describe the earthquake risk in Newcastle in light of the 1989 experience?
   f The Newcastle earthquake showed 'no evidence of ground deformation, surface rupture/faulting, mine subsidence or liquefaction'
      - What is meant by 'ground deformation' and 'surface rupture'? What does the absence of these two effects suggest about the Newcastle earthquake?
      - What is 'mine subsidence'? Why is it likely to occur during or after a major earthquake? What are some of the likely hazards related to mine subsidence?
      - What is 'liquefaction' and how is it related to earthquake activity? What are some of the hazards which could be caused by liquefaction?
   g What were the main causes of death and injury in the Newcastle earthquake?

2 The Newcastle earthquake occurred mid-morning on a business day in the school hoildays. Do you think the timing of the earthquake would have (i) contibuted to the death and injury toll, *or* (ii) helped reduce the death and injury toll? Explain your answer.

3 Imagine you were in the centre of Newcastle at 10.27am on December 28, 1989. Describe:
   - how you first recognised that an earthquake was occurring;
   - the activity you were participating in at the time of earthquake, and how this was affected;
   - the immediate effects of the earthquake on your surroundings;
   - your observations of noise, human behaviour and impact on lives and property,
   - your observation of the search and rescue operation following the earthquake, including your part in the operation;
   - the long term effects of the earthquake on the city of Newcastle and its people.

Tsunamis

Figure 1: Tsunami damage in the village of Kitahiyama after the Hokkaido-Nansei-Oki earthquake, 1993

HAZARD DATA

- Tsunami is a Japanese word meaning 'waves of the bay'.
- A tsunami is actually a series of travelling ocean waves of extremely long length and long wave period.
- Tsunamis are caused by earthquakes (or volcanic eruptions) below or near the ocean floor. Waves are sent out in all directions, much like the effect of dropping a stone into a pond.
- As a tsunami crosses a deep ocean, it may travel at speeds exceeding 1,000km/h, its length from crest to crest may be 150km or more, and yet height may only be a metre. It is not felt by ships in deep water and cannot be seen from the air.
- As a tsunami enters shallow water near a coastline, its wave speed drops and its height increases. It can reach heights of 30 to 50 metres and strike with devastating force, often thousands of kilometres from the earthquake or volcano which caused it.
- The majority of tsunamis occur in the Pacific Ocean, although their have been reports of tsunamis in all oceans of the world.
- The tsunami threat to Australia is very slight due to the protection from South West Pacific Islands and the Great Barrier Reef.

adapted from 'Hazards, Disasters and Survival', Natural Disasters Organisation, 1992.

Figure 2: Tsunami approaches the shore in Hachimori, Japan, after the Nihon-Kai-Chubu earthquake, 1993

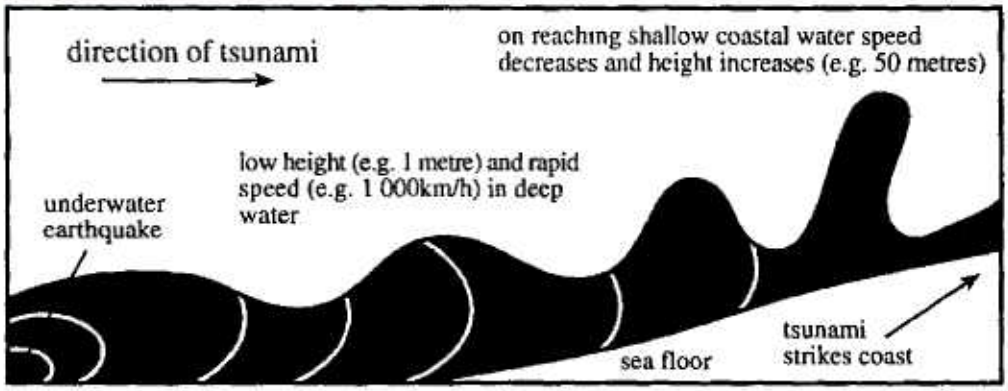


Figure 3: Tsunami formation

Activities

1 Using the information in 'Hazard Data' and in Figure 3, describe how the characteristics of tsunamis between when they are formed in deep ocean water and when they reach the shore.

2 a From the evidence in Figure 1, list 5 different impacts of tsunamis which would not otherwise be associated with earthquake activity.

b The village in Figure 1 had a breakwater protecting it from tsunami damage. Comment on its effectiveness.

c Figure 2 shows a tsunami approaching a protective wall on the shore. How is the wall designed to reduce the impact of the wave?

3 Conduct some research into the world's worst tsunami disaster - Krakatoa, 1883. Find out the cause of the tsunami, its characteristics, the area it affected and its impact on lives and property.

Earthquake-Resistant Buildings

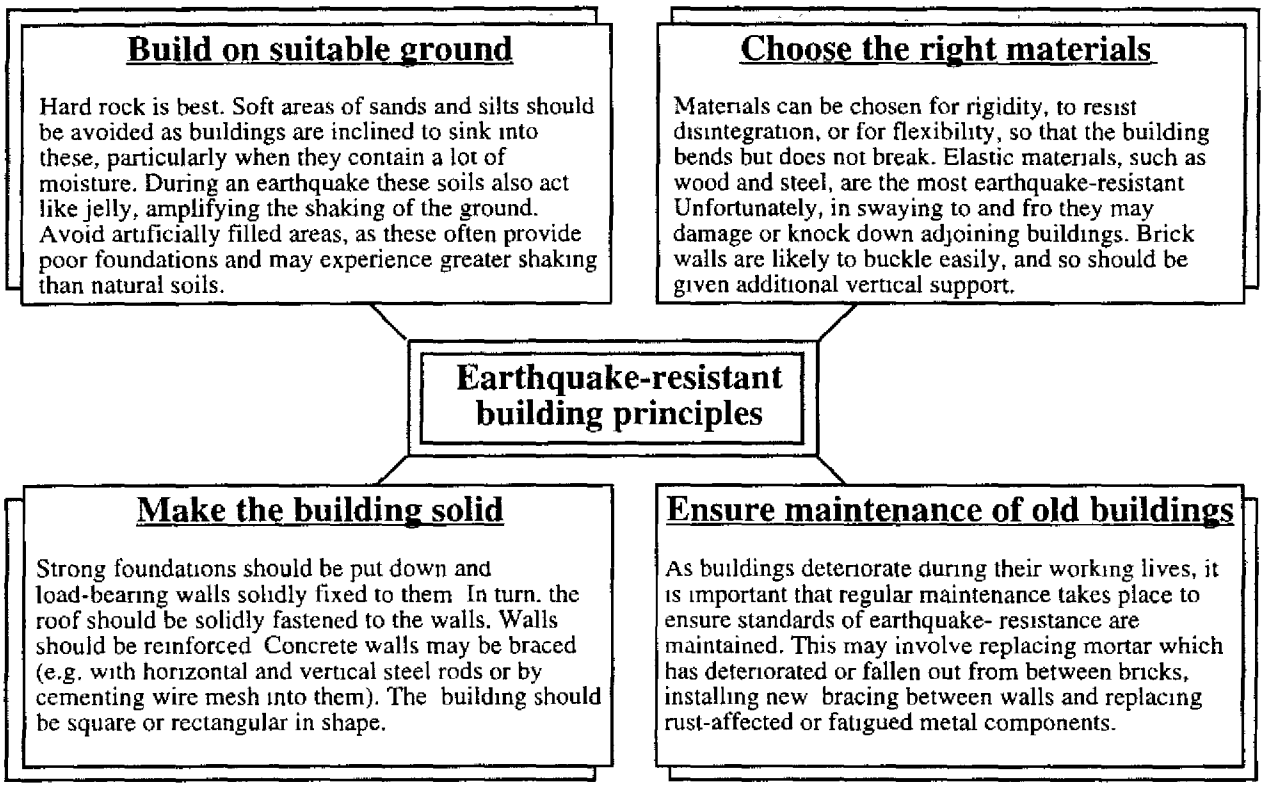


Figure 1

Activities

1 Study the information in Figure 1 and then answer the following:
   a Why should areas of sand and silt be avoided when choosing a site for a building in an earthquake- prone area?
   b In the San Francisco earthquake of 1989, the expensive Marina District, built on a landfill, suffered the most damage and also experienced more severe shaking than many areas closer to the epicentre How do you explain this?
   c Describe one advantage and one disadvantage of using flexible materials, such as wood and steel, when building in an earthquake-prone area.
   d What does it mean to say that brick walls 'should be given additional vertical support'?
   e The cementing of wire mesh into concrete walls to make them more earthquake-resistant has been likened to the laminating of a car windscreen. Explain the similarity.
   f Explain why square or rectangular buildings are most likely to resist earthquake damage?
   g In the Newcastle earthquake of 1989, building damage was confined almost entirely to old buildings. Suggest at least three reasons why this might have been the case.

2 In Newcastle, the the posts supporting awnings above many shops were replaced during the 1950s by tie-backs fixed high on the front wall Why do you think this was done? In the earthquake of 1989, many of the facades (fronts) of these shops suffered severe damage. Explain, using a diagram to help you, how this damage could be linked to the way the shop awnings were supported.

3 Conduct some research into the Mexico City earthquake of 1985. In particular, find out how the following factors contributed to the damage caused.
   • The quality of building construction in the the Zona Rosa (the city centre).

contd.....

Earthquake-Resistant Buildings (contd)

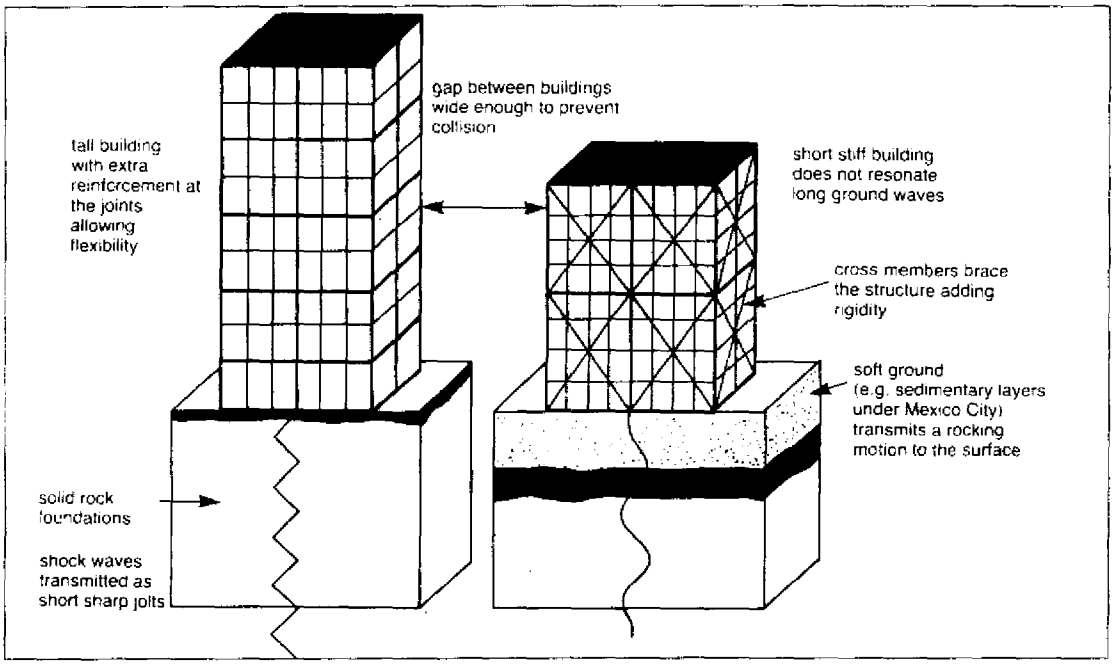


Figure 2: Earthquake-resistant high rise buildings
(Dolan, C. Hazard Geography, *Longman Cheshire, 1994)*

Activities (contd)

- The type and density of buildings inthe Zona Rosa.
- The level of upkeep and maintenance on buildings in the Zona Rosa.
- The type of soil underlying Mexico City.

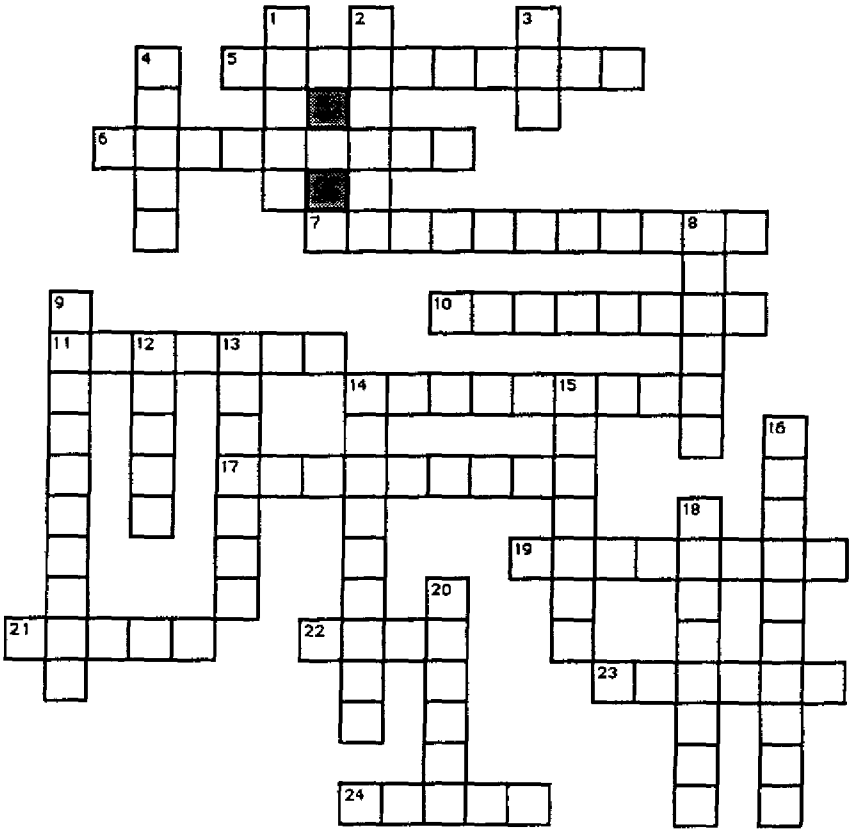
4 Study Figure 2, and answer the following:
  a Describe the different earthquake-resistant features in the two high rise buildings shown.
  b How are the differences between the buildings related to the type of ground on which each is built?
  c After the Armenian earthquake of 1989, *Geographical Magazine* provided the following explanation for the extensive damage to the town of Spitak:
  The destruction and loss of life in the Armenian town were increased by a very low quality of construction, with the use of sub-standard building materials, skimped and adulterated cement, with faulty and badly supervised building techniques ..... a prefabricated-panel type of construction has been used in all of the hundreds of thousands of apartment blocks built in every town across the USSR, including those within the regions subject to earthquakes. In the recent disaster, such prefabricated blocks collapsed like packs of cards.

  List four design or construction problems which contributed to buildings collapsing 'like packs of cards'. With the help of Figure 2 make a list of the earthquake-proof design and construction techniques which could be used in the rebuilding of Spitak.

5 As a result of the Newcastle earthquake of 1989, a local building company has shown interest in incorporating earthquake-resistant features into their homes. As a well respected and highly qualified housing consultant, you have been asked to design an earthquake-resistant house which can be used for display purposes in the Newcastle area.

  Using the design principles outlined in Figures 1 and 2, sketch your house design. Use labels to highlight the main design features.

Crossword: Earthquakes



answers in back of book

Across

5 Famous fault line which runs along the west coast of the USA (two words).
6 The point on the earth's surface which is directly above the focus of an earthquake.
7 Instrument used for measuring and recording earthquake shock waves.
10 One of the largest plates of the earth's crust.
11 Scale used to measure earthquake magnitude.
14 A measure of the size of an earthquake.
17 This Australian city suffered major earthquake damage in 1989.
19 The _ _ _ _ _ _ _ _ of buildings is a major cause of death during and after an earthquake.
21 The point of origin of an earthquake.
22 A common side-effect of earthquake activity, often caused by the rupturing of gas pipes.
23 Earthquake damage is usually greater in _ _ _ _ _ _ than in rural areas.
24 _ _ _ _ _ waves are sent out from the focus of an earthquake.

Down

1 Supplies of _ _ _ _ _ may be cut after an earthquake.
2 The layer of the earth beneath the crust.
3 Earthquakes which occur under the _ _ _ can cause tsunamis to form.
4 One of the most earthquake-prone countries in the world.
8 Segments of the earth's crust which 'float' on the heavier, semi-molten rock of the mantle below.
9 Accurate _ _ _ _ _ _ _ _ _ _ of an earthquake can greatly reduce its impact on people and property.
12 The outer shell of the earth.
13 Huge ocean wave nomally caused by an earthquake under the sea.
14 Western Australian town which experienced major earthquake damage in 1968.
15 Earth _ _ _ _ _ _ _ usually result from minor earthquake activity.
16 Ground _ _ _ _ _ _ _ _ _ _ is a common side-effect of earthquake activity.
18 Process where plates collide with each other, move apart or slide alongside one another.
20 _ _ _ _ _ _ City suffered major earthquake damage in 1985.