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STUDENT INSTRUCTIONS

1. Insert the stickers with your Personal Education Number (PEN) in the allotted spaces above. **Under no circumstance is your name or identification, other than your Personal Education Number, to appear on this booklet.**
2. Ensure that in addition to this examination booklet, you have a **Data Booklet** and an **Examination Response Form**. Follow the directions on the front of the Response Form.
3. **Disqualification** from the examination will result if you bring books, paper, notes or unauthorized electronic devices into the examination room.
4. When instructed to open this booklet, **check the numbering of the pages** to ensure that they are numbered in sequence from page one to the last page, which is identified by

END OF EXAMINATION.

5. At the end of the examination, place your Response Form inside the front cover of this booklet and return the booklet and your Response Form to the supervisor.

GEOLOGY 12

JUNE 2000

COURSE CODE = GEOL

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Question 1:
1. .
(8)

Question 8:
8. .
(1)

Question 2:
2. .
(3)

Question 9:
9. .
(3)

Question 3:
3. .
(2)

Question 10:
10. .
(4)

Question 4:
4. .
(3)

Question 11:
11. .
(4)

Question 5:
5. .
(3)

Question 12:
12. .
(4)

Question 6:
6. .
(3)

Question 13:
13. .
(3)

Question 7:
7. .
(2)

Question 14:
14. .
(2)

GEOLOGY 12

JUNE 2000

COURSE CODE = GEOL

GENERAL INSTRUCTIONS

1. Electronic devices, including dictionaries and pagers, are **not** permitted in the examination room.
2. All multiple-choice answers must be entered on the Response Form using an **HB pencil**. Multiple-choice answers entered in this examination booklet will **not** be marked.
3. For each of the written-response questions, write your answer in **ink** in the space provided in this booklet.
4. Ensure that you use language and content appropriate to the purpose and audience of this examination. Failure to comply may result in your paper being awarded a zero.
5. This examination is designed to be completed in **two hours**. *Students may, however, take up to 30 minutes of additional time to finish.*

GEOLOGY 12 PROVINCIAL EXAMINATION

	Value	Suggested Time
1. This examination consists of two parts:		
PART A: 55 multiple-choice questions	55	65
PART B: 14 written-response questions	45	55
	Total: 100 marks	120 minutes
2. The Data Booklet contains information, graphs, and colour photographs you will need to answer certain questions on this examination.		

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PART A: MULTIPLE CHOICE

Value: 55 marks

Suggested Time: 65 minutes

INSTRUCTIONS: For each question, select the **best** answer and record your choice on the Response Form provided. Using an HB pencil, completely fill in the circle that has the letter corresponding to your answer.

1. In addition to silicon, which of the following elements is found in all the silicate rocks and minerals?
 - A. iron
 - B. carbon
 - C. oxygen
 - D. magnesium

**REFERENCE
DATA BOOKLET**

Refer to pages vi and xi of the Data Booklet.

Use Photographs 1, 2 and 3, the Table of Hardness, and the Properties of Common and Important Minerals table to answer questions 2 to 4.

2. The mineral that makes up the light-coloured crystals shown in photograph 1 can easily scratch glass. The mineral is
 - A. gold.
 - B. pyrite.
 - C. pyrrhotite.
 - D. chalcopyrite.
3. The mineral in photograph 2 commonly occurs in schists and gneisses. The mineral can scratch quartz, and can also be scratched by quartz. The mineral is
 - A. garnet.
 - B. olivine.
 - C. hematite.
 - D. muscovite mica.
4. The mineral in photograph 3 is one of the most common rock-forming minerals. A steel knife will **not** scratch it. How many cleavage directions does this mineral have?
 - A. none
 - B. 1
 - C. 3
 - D. 6

Refer to page v of the Data Booklet.
Use the Percentage of Minerals in Igneous Rocks table and the following table to answer questions 5 and 6.

Percentage of minerals in four samples of igneous rocks

Mineral composition	Rock W	Rock X	Rock Y	Rock Z
Quartz	40	16	0	2
Pink potassium feldspar	53	20	0	2
Plagioclase feldspar	6	42	5	64
Dark ferromagnesian	7	22	95	32
All other minerals	4	0	0	0

5. Which of the igneous rocks above would be considered ultramafic?
- A. W
 - B. X
 - C. Y
 - D. Z
6. Rock **W** is shown in photograph 4 on page vii of the Data Booklet. This rock is
- A. basalt.
 - B. gabbro.
 - C. granite.
 - D. rhyolite.

Refer to page iv of the Data Booklet.
Use Bowen's Reaction Series chart to answer question 7.

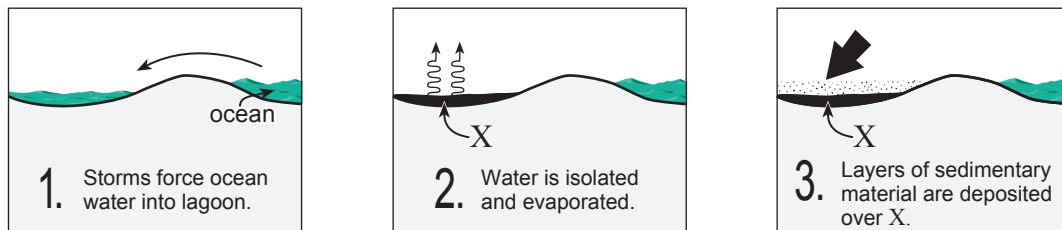
7. Which of the following minerals would crystallize first from a mafic magma?
- A. quartz
 - B. pyroxene
 - C. biotite mica
 - D. sodium-rich feldspar

Refer to page vii of the Data Booklet.
Use Photograph 5 of Mt. St. Helen's to answer question 8.

8. What is the name of the volcanic feature forming from viscous lava in Mt. St. Helen's crater?
- A. lava dome
 - B. mafic dike
 - C. pillow lava
 - D. volcanic breccia
-

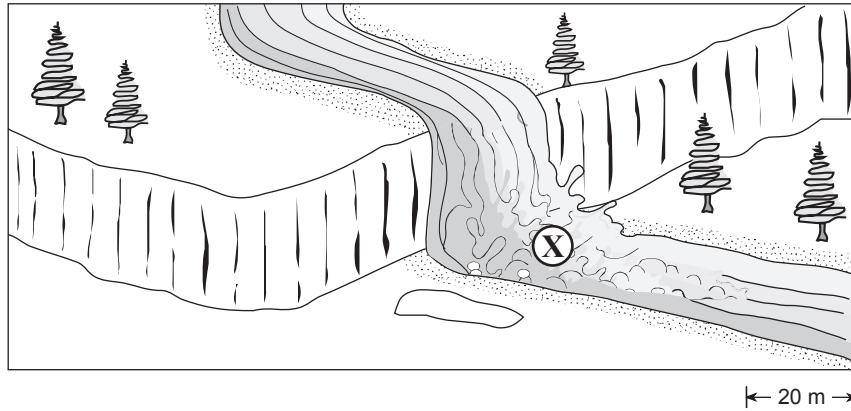
9. Which of the following is a sedimentary rock formed by the lithification of silt and clay?
- A. shale
 - B. breccia
 - C. sandstone
 - D. conglomerate

Use the following sequence of events to answer question 10.

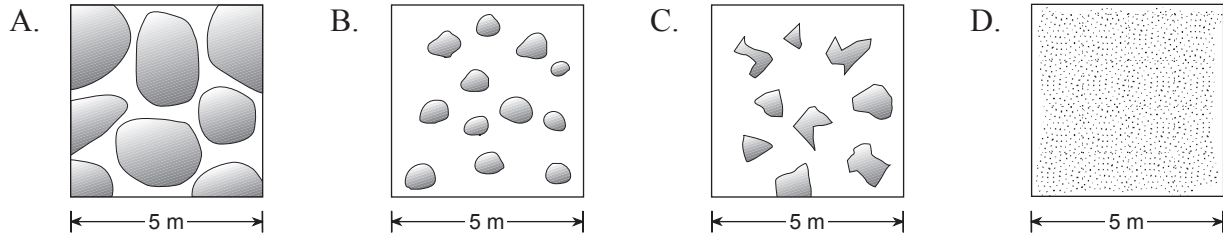


10. A sedimentary rock has formed at **X** as a result of the sequence of events shown above. This rock would **most likely** be
- A. chert.
 - B. shale.
 - C. siltstone.
 - D. rock salt.

Use the following diagram of a river and a waterfall to answer question 11.



11. A sample of sediments taken beneath location **X** in the diagram above would **most likely** look like



12. Which of the following pairs shows the correct relationship between a metamorphic rock and its parent rock?

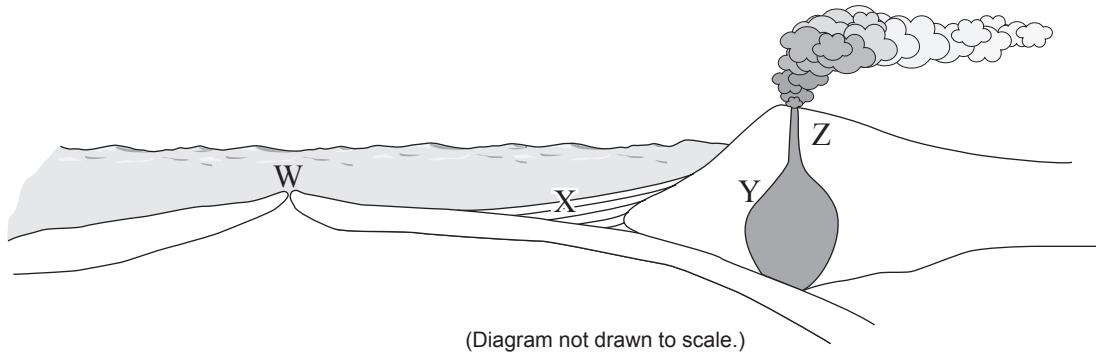
	Parent Rock	Metamorphic Rock
A.	shale	quartzite
B.	limestone	marble
C.	gypsum	phyllite
D.	sandstone	slate

13. Which of the following would be an **unlikely** result of regional metamorphism?

- A. greater rock porosity
- B. formation of foliation
- C. increased rock density
- D. formation of a new mineral

14. Which of the following is **directly** associated with hydrothermal activity?
- A. crude oil
 - B. placer gold
 - C. vein galena
 - D. rock gypsum
15. Which of the following BC resources is the main source of a metal used in making water pipes and electrical wiring?
- A. galena
 - B. gypsum
 - C. sphalerite
 - D. chalcopyrite

Use the following cross section to answer question 16.

















16. In which of the four locations on the cross section would you **least** expect to find a hydrothermal ore deposit?
- A. W
 - B. X
 - C. Y
 - D. Z
-

17. The process of crude oil formation generally would **most likely** begin in
- A. deep caves.
 - B. arctic tundra.
 - C. marine deltas.
 - D. magma bodies.

18. Which of the following igneous features is younger than both the layers above **and** below it?
- A. sill
 - B. dyke
 - C. ash fall
 - D. lava flow

Use the following table to answer questions 19 to 21.
The table shows four layers of Silurian sedimentary rock found in a cliff section.

	FOSSIL U	FOSSIL V	FOSSIL W	FOSSIL X	FOSSIL Y	FOSSIL Z
Layer 4						
Layer 3						
Layer 2						
Layer 1						

19. The best index (guide) fossil for layer 3 is
- A. V
 - B. W
 - C. X
 - D. Z
20. A geologist working at another cliff section has discovered a layer of similar sedimentary rock that contains fossils **Y** and **Z**. The newly-discovered layer **best** correlates with layer
- A. 4
 - B. 3
 - C. 2
 - D. 1

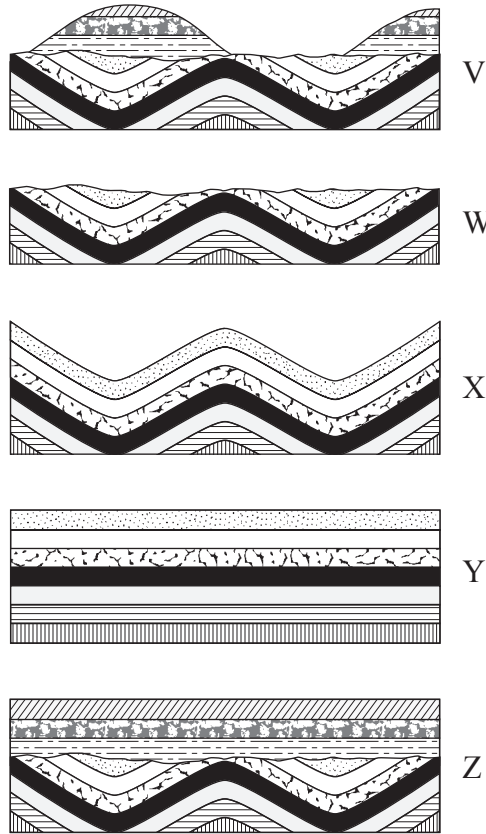
21. In which of the following sedimentary environments were layers 1 to 4 **most likely** deposited?
- A. desert
 - B. river bed
 - C. shallow marine
 - D. freshwater lake
-

22. Which of the following lists major events in Earth's history in the correct order?

A.	B.	C.	D.
Youngest	Youngest	Youngest	Youngest
amphibians dominated	invertebrates dominated	mammals dominated	amphibians dominated
first land plants	mammals dominated	amphibians dominated	invertebrates dominated
mammals dominated	amphibians dominated	first land plants	mammals dominated
invertebrates dominated	first land plants	invertebrates dominated	first land plants
Oldest	Oldest	Oldest	Oldest

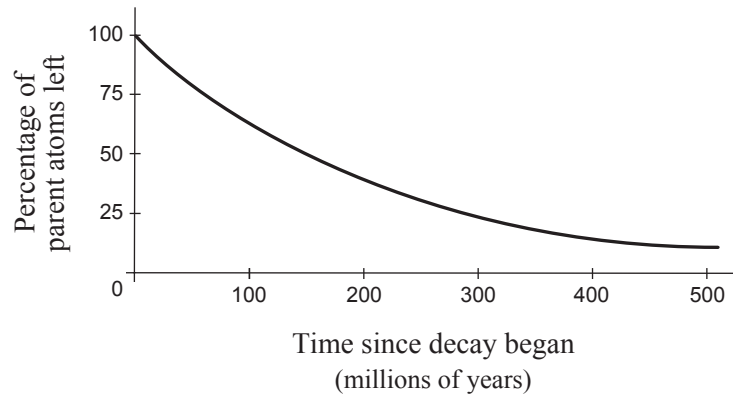
23. A rock is dated using radiometric methods. If one-half of the daughter atoms have leaked out and been lost, the calculated age of the rock will be
- A. too old.
 - B. accurate.
 - C. too young.
 - D. reset to zero.

Use the following series of geological cross sections to answer question 24.



24. The geological cross sections above show all stages in the development of a section of the earth's crust. The correct sequence (from oldest to youngest) in the development of the crust is
- A. X, Y, V, W, Z
 - B. Y, W, X, V, Z
 - C. Y, X, W, Z, V
 - D. X, W, Y, Z, V

Use the following radioactive decay graph to answer questions 25 and 26.



25. The half-life of the element, for which the decay curve is graphed above, is
- A. 50 million years.
 - B. 100 million years.
 - C. 150 million years.
 - D. 200 million years.
26. A rock sample is estimated to be approximately 3 000 million (3 billion) years old. The element, for which the decay curve is graphed above, would **not** be suitable for dating this rock sample because
- A. the half-life of the radioactive element would be too long.
 - B. the radioactive element would not have decayed sufficiently.
 - C. not enough of the daughter product would have accumulated.
 - D. not enough of the parent element would be left to measure accurately.
-
27. Charles Darwin proposed that organisms evolved through a process of natural selection. Natural selection means that a species may change over time by
- A. the best adapted organisms surviving.
 - B. organisms being able to select their mates.
 - C. groups of organisms selecting their environment.
 - D. individual organisms changing to suit their environment.

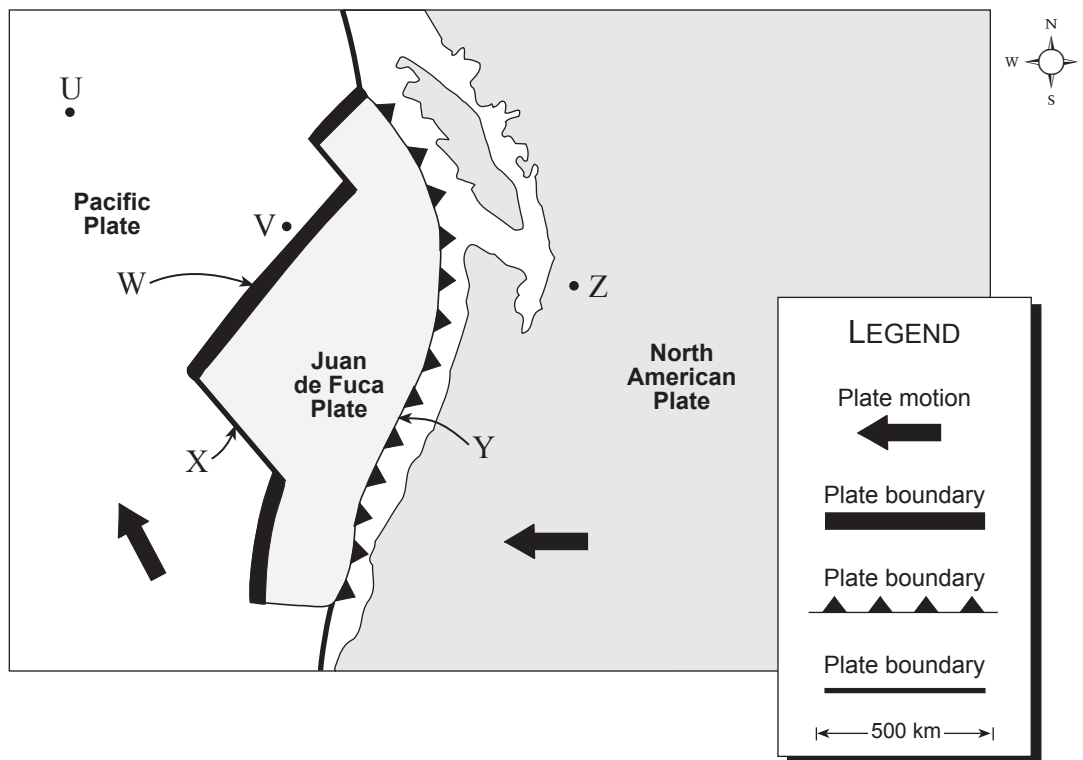
28. A feature in a layer of conglomerate that is older than the layer itself is a(n)

- A. pebble.
- B. fault plane.
- C. mineral vein.
- D. igneous intrusion.

29. The layer of the earth that is responsible for the motion of the plates is the

- A. crust.
- B. mantle.
- C. inner core.
- D. outer core.

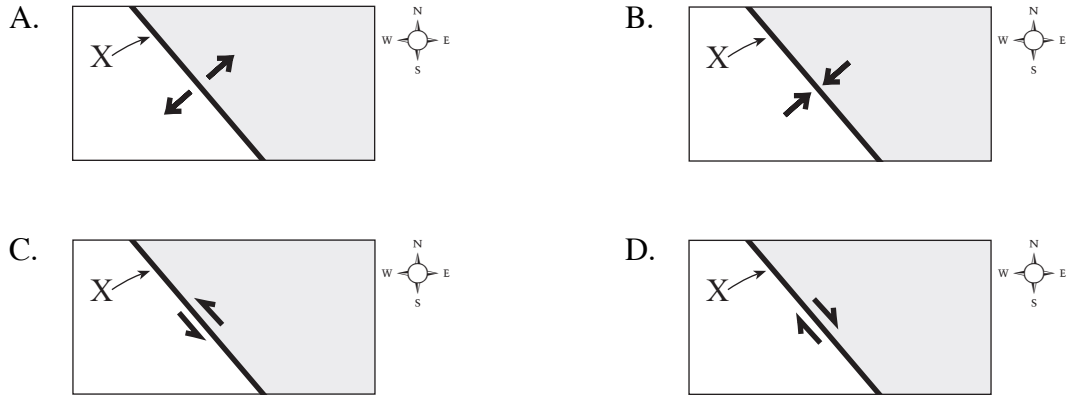
Use the map below to answer questions 30 to 35. The map shows an area of western North America and the sea floor off that coast. Several plate boundaries are shown.



30. The feature labelled **W** is a(n)

- A. island arc.
- B. ocean trench.
- C. oceanic ridge.
- D. transform fault.

31. The relative plate motion at feature **X** is best shown as



32. An earthquake along feature **X** would **most likely** have a(n)

- A. shallow focus (depth less than 100 km).
- B. deep focus (depth greater than 400 km).
- C. intermediate focus depth (from 100 – 400 km).
- D. wide range of possible focus depths (from 0 – 700 km).

33. Composite (strata) volcanoes would **most likely** be found at

- A. U
- B. W
- C. Y
- D. Z

34. A rock sample taken at feature **V** is found to have an age of 2 000 000 years. Feature **V** is located 80 km away from the centre of feature **W**. (Note: 1 km = 100 000 cm.) The rate of plate motion in this area is

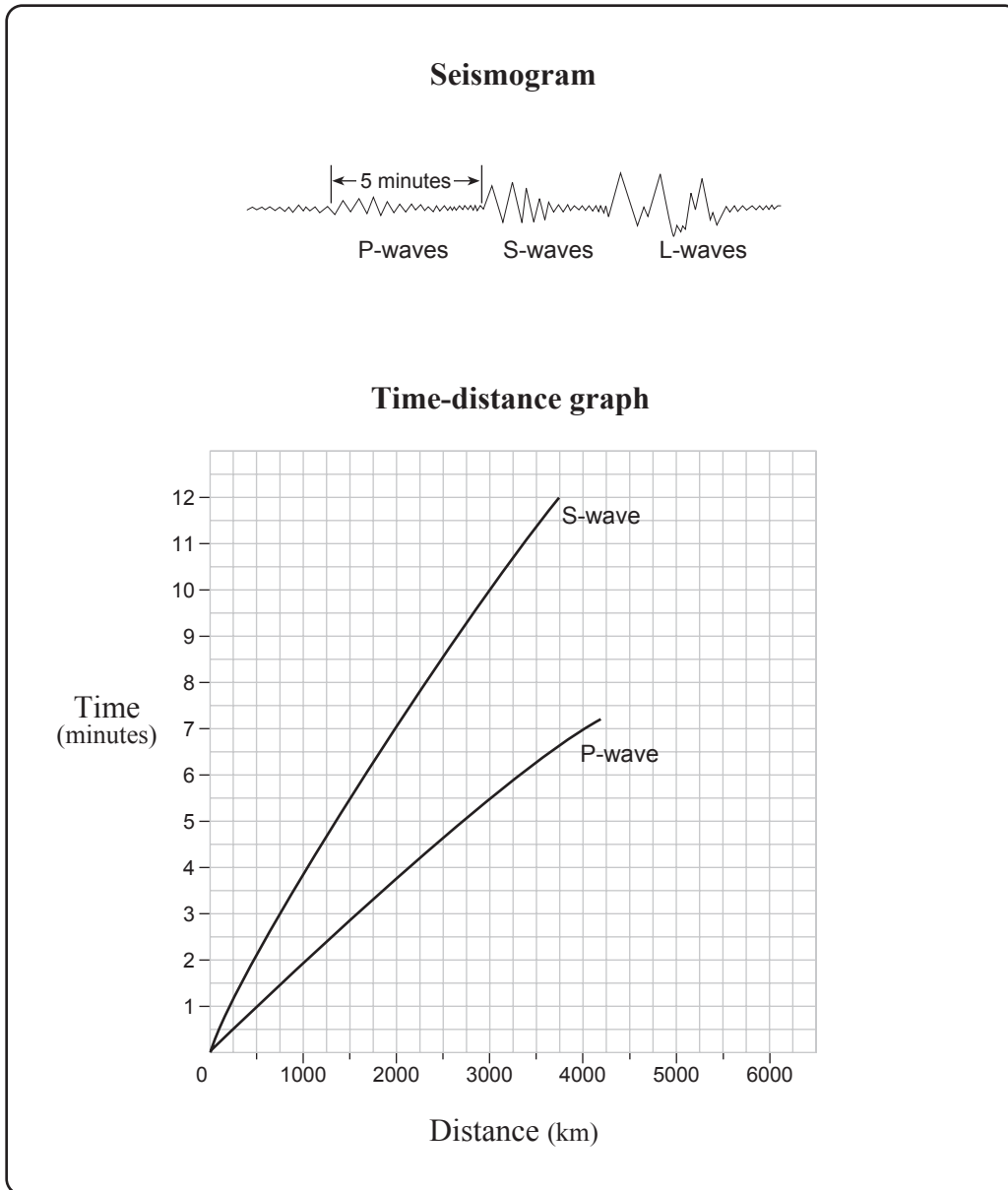
- A. .25 cm/y.
- B. 2.0 cm/y.
- C. 4.0 cm/y.
- D. 8.0 cm/y.

35. The most common igneous rock type found at a divergent plate boundary is

- A. basalt.
- B. granite.
- C. rhyolite.
- D. andesite.

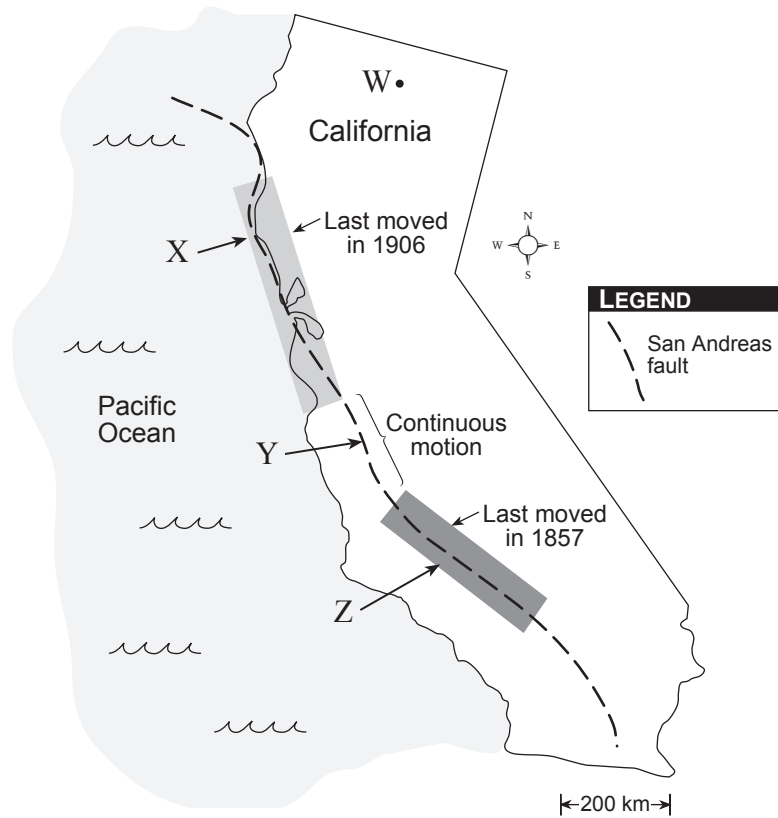
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Use the following seismogram and time-distance graph for P- and S-waves to answer question 36.



36. The distance from the seismometer to the epicentre of the earthquake is
- A. 1 300 km.
 - B. 2 000 km.
 - C. 2 750 km.
 - D. 3 400 km.

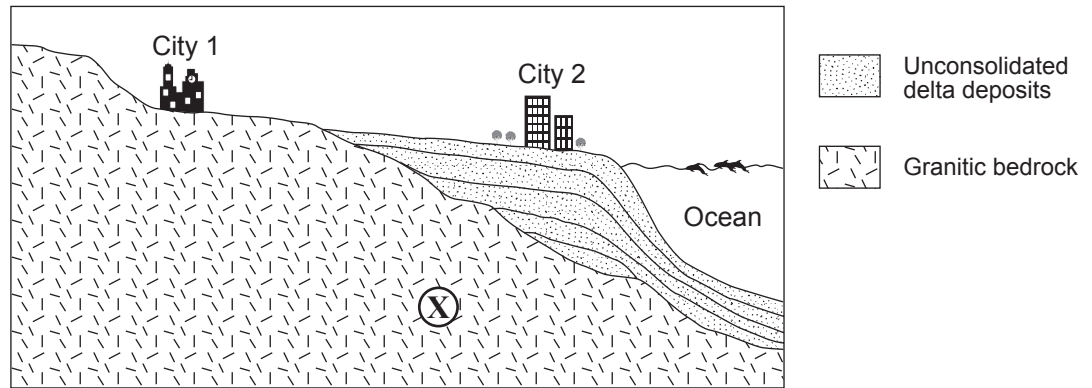
Use the following sketch map of California to answer question 37.



37. The region which has stored the most elastic energy, due to deformation of the crust, is

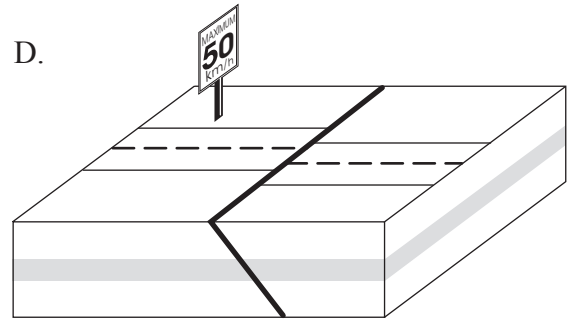
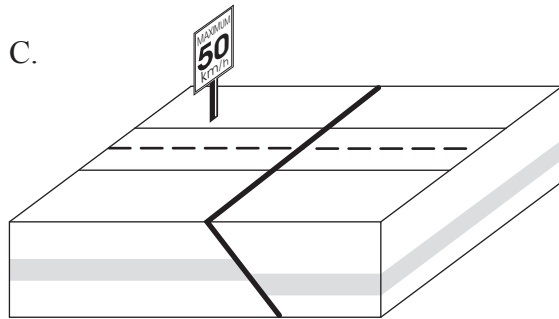
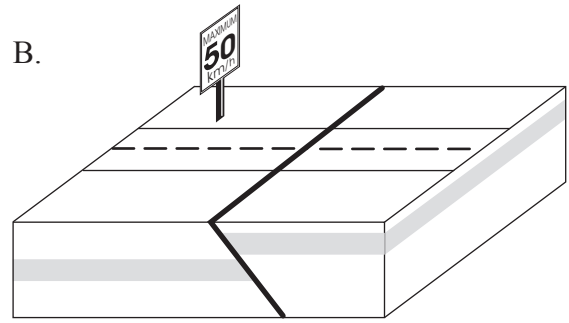
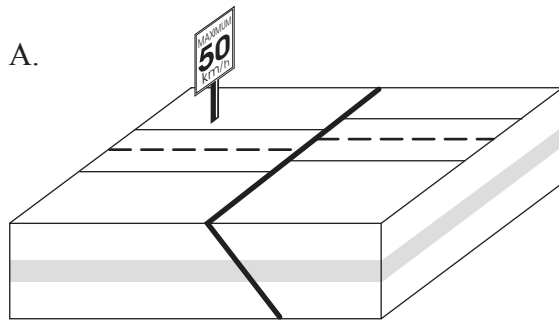
- A. W
- B. X
- C. Y
- D. Z

Use the following cross-section sketch to answer question 38.

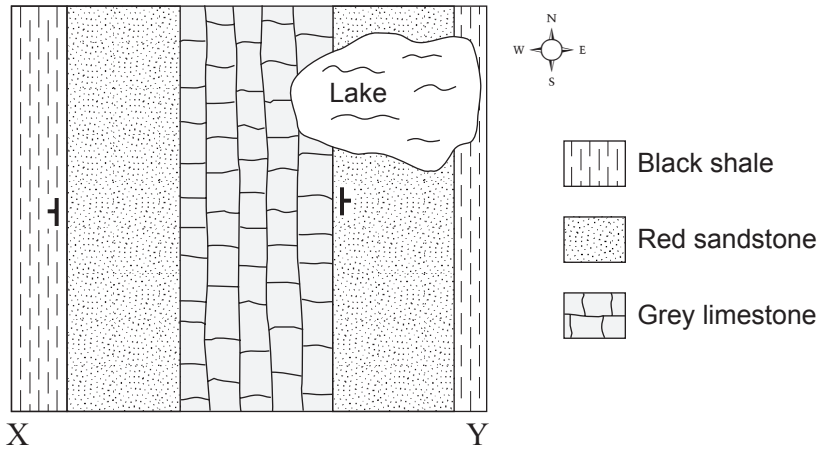


38. An earthquake has occurred at **X**. Compared to city 2, city 1 would experience
- A. lower intensity and higher magnitude.
 - B. greater intensity and lower magnitude.
 - C. lower intensity and the same magnitude.
 - D. the same intensity and the same magnitude.
-
39. Which of the following is a result of isostatic adjustment?
- A. glacial flow down a valley
 - B. crust sinking beneath a delta
 - C. displacement along a transform fault
 - D. mountain building at a convergent plate boundary
40. Which of the following is the **best** evidence that the earth has a layered internal structure?
- A. xenoliths
 - B. drill core samples
 - C. composition of lavas
 - D. sudden changes in the velocity of P- and S-waves

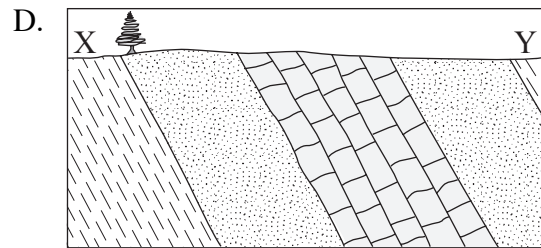
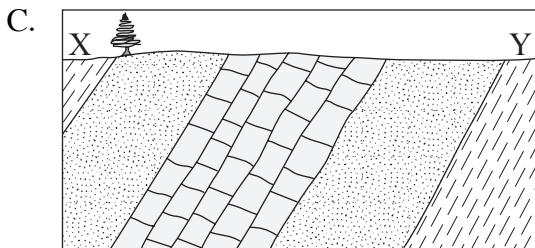
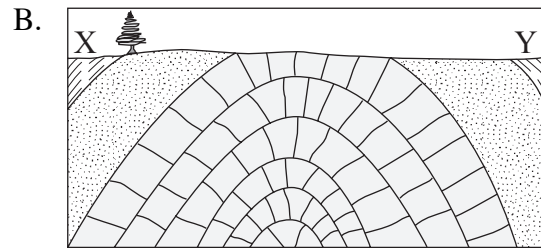
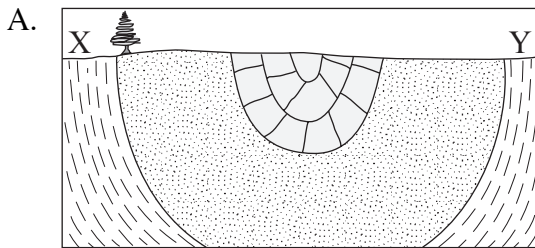
41. Which of the following block diagrams shows a left lateral strike-slip fault?



Use the following map to answer question 42.

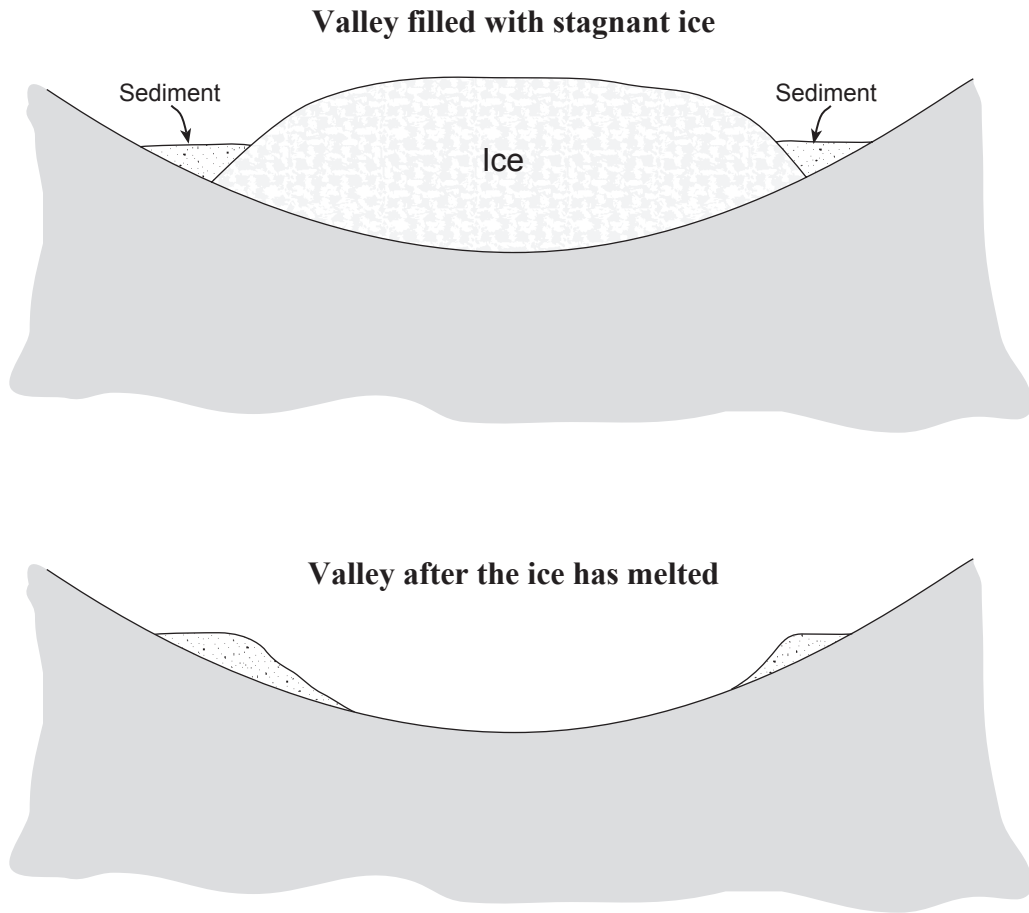


42. Which of the following sketches corresponds to the cross section along X and Y in the map above?



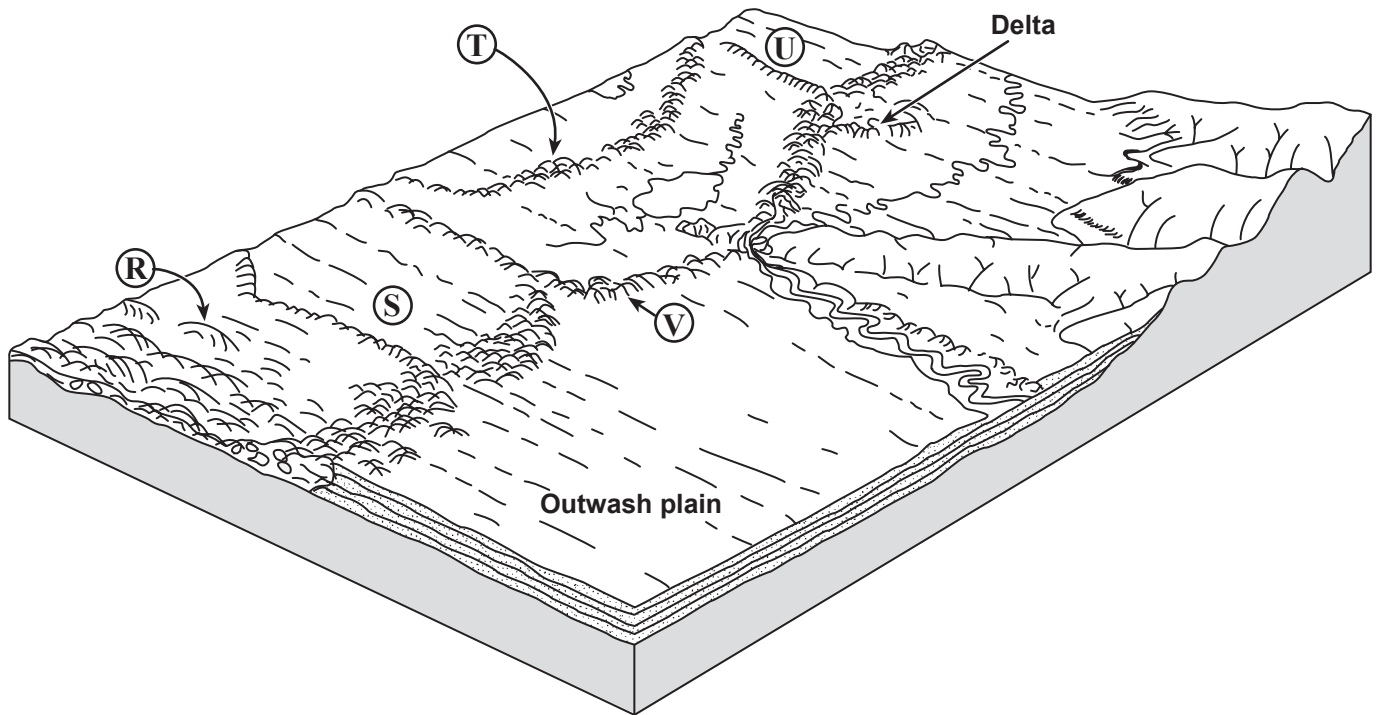
43. Photograph 6 shows a vertical cliff section. The major structure shown in the photograph is a(n)
- A. syncline.
 - B. anticline.
 - C. thrust fault.
 - D. overturned fold.
44. The forces required to form this structure are **most likely**
- A. shear.
 - B. tensional.
 - C. gravitational.
 - D. compressional.

Use the following cross sections to answer question 45.



45. The sediments at the sides of the valley were deposited in glacial streams and lakes. These deposits are
- A. eskers.
 - B. kettles.
 - C. kame terraces.
 - D. lateral moraines.

Use the following diagram of an area that has recently been partially covered by a continental glacier to answer questions 46 to 48.



46. The features at **R** are small, elongated hills composed of till and shaped by the advancing ice sheet. These features are
- drumlins.
 - kame terraces.
 - outwash ridges.
 - lateral moraines.
47. The farthest advance of the glacier is indicated by
- S
 - T
 - U
 - V
48. The deposit of ground moraine at **S** is also shown in photograph 7 on page viii of the Data Booklet. Which of the following **best** describes the texture of the sediment in the ground moraine?
- well-sorted, with smooth, well-rounded boulders
 - very poorly-sorted, with smooth, well-rounded boulders
 - well-sorted, with striated, sub-rounded and angular boulders
 - very poorly-sorted with striated, sub-rounded and angular boulders

OVER

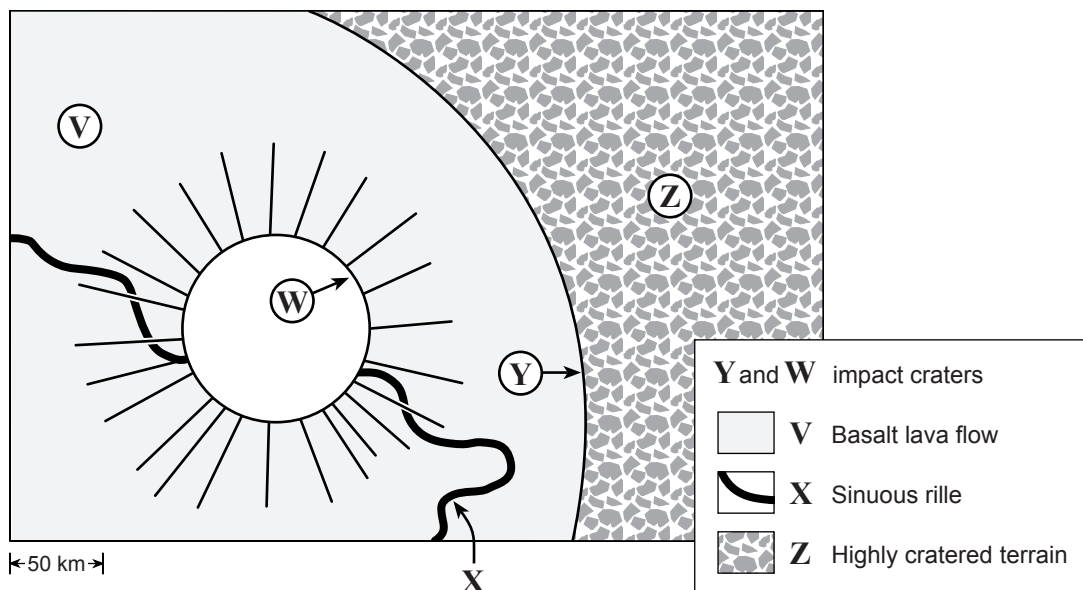
49. Which of the following human activities is **least likely** to cause the failure of a steep slope?
- A. installing perforated drainage pipes
 - B. excavating a road cut across the slope
 - C. cutting a homesite into the base of the slope
 - D. allowing septic drain waters into the slope sediments
50. A common result of poor logging techniques on steep slopes in British Columbia is a fast-moving, chaotic flow of water, soil, rock and trees that may travel for many kilometres. Flows of this type are known as
- A. rock falls.
 - B. soil creep.
 - C. nuée ardentes.
 - D. debris avalanches.
51. A river is likely to pick up more sedimentary material where it
- A. enters a lake.
 - B. flows into a wider channel.
 - C. flows around the outside of a meander.
 - D. flows from a high gradient to a low gradient.

**REFERENCE
DATA BOOKLET**

**Refer to page ix of the Data Booklet.
Use Photograph 8 to answer question 52.**

52. The major river flowing into the lake shown in the photograph is forming multiple channels as a result of
- A. an increase in velocity.
 - B. an increase in gradient.
 - C. a decrease in water volume.
 - D. a decrease in sediment-carrying capacity.

Use the following sketch of a section of the moon's surface, which shows a variety of geological features, to answer question 53.



53. The **most likely** order of ages of the moon's geological features, from oldest to youngest, is

- A. V, Z, Y, X, W
- B. V, Y, W, Z, X
- C. Z, Y, V, X, W
- D. Z, V, Y, W, X

54. The surface of Mars shows evidence of running water. Which of the following is **least likely** to be found on Mars?

- A. coal
- B. shale
- C. sandstone
- D. conglomerate

55. The feature that all of the planets have in common is

- A. their average density.
- B. their surface temperature.
- C. the number of moons orbiting each.
- D. the direction of revolution around the sun.

**This is the end of the multiple-choice section.
Answer the remaining questions directly in this examination booklet.**

OVER

PART B: WRITTEN RESPONSE

Value: 45 marks

Suggested Time: 55 minutes

INSTRUCTIONS: Answer each question in the space provided. You may not need to use all of the space given.

1. A geologist collected four rock samples in the land area shown in diagram 1. Unfortunately, the labels fell off each sample. All that was left to identify each sample were field-note descriptions and a magnified view showing the microscopic make-up of each rock.

Diagram 1

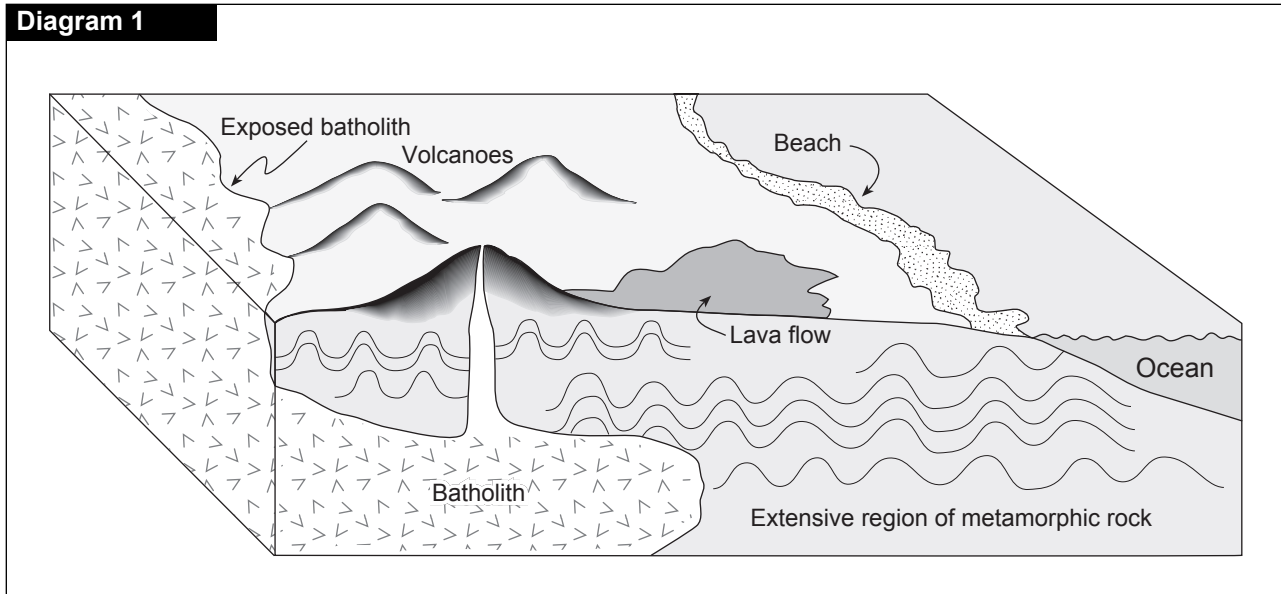
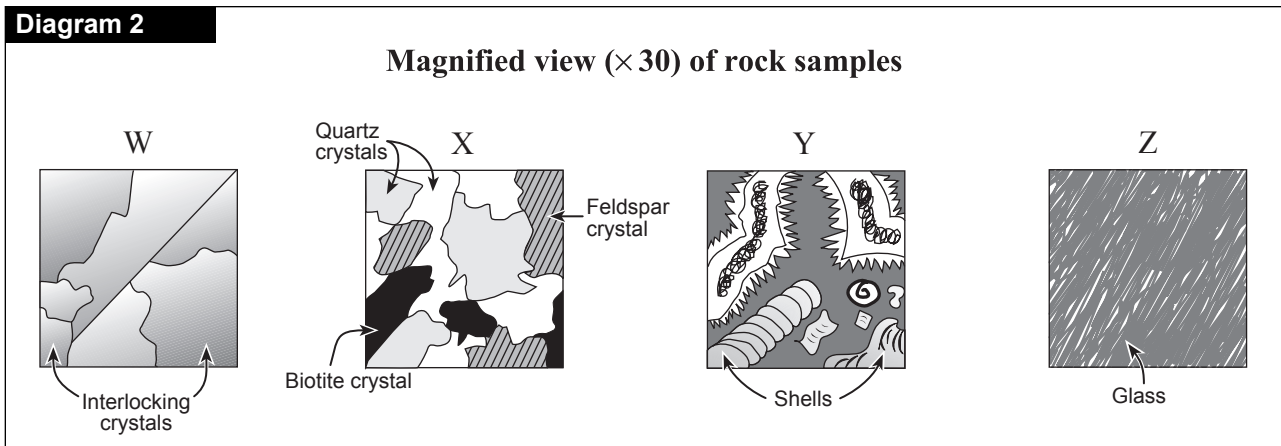


Diagram 2

Magnified view ($\times 30$) of rock samples



- a) Complete the following table using information from diagram 2 and the description of each rock sample below. **(4 marks)**

SAMPLE	EXAMPLE	W	X	Y	Z
Description	<ul style="list-style-type: none"> • <i>large pebbles in a fine-grained matrix</i> • <i>rounded pebbles</i> 	<ul style="list-style-type: none"> • tightly interlocking crystals • hardness of 7 • crystalline • granular texture 	<ul style="list-style-type: none"> • large, interlocking crystals • light-coloured • clear, beige, pink and black crystals 	<ul style="list-style-type: none"> • made from shells and shell fragments cemented together • reacts with dilute acid 	<ul style="list-style-type: none"> • glassy texture • dark • slightly opaque • conchoidal fracture
Type of rock	<i>sedimentary</i>				
Specific rock name	<i>conglomerate</i>				

- b) For each rock sample, place its corresponding **letter** on diagram 1 in a location where it would **most likely** form. **(2 marks)**
- c) The texture of a rock tells a great deal about how that rock was formed. Pick **two** of the rocks from a) and, with reference to **texture**, describe how each rock was formed. **(2 marks)**

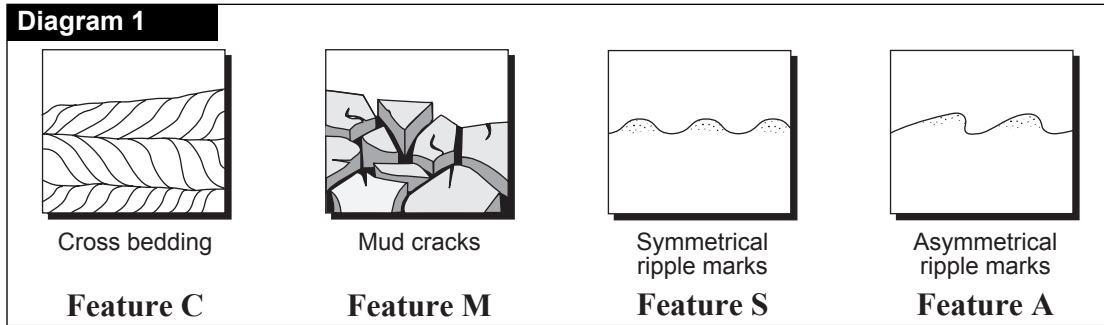
Rock sample: _____

How rock sample was formed: _____

Rock sample: _____

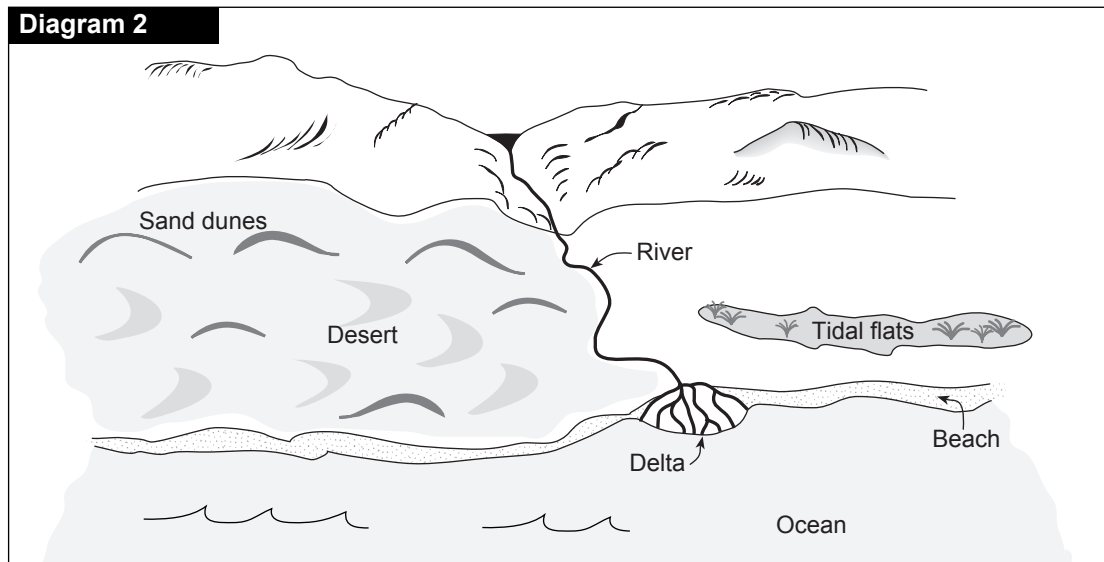
How rock sample was formed: _____

Select two of the features in Diagram 1 below to answer question 2.



I have chosen feature _____ and feature _____ .

2. a) Indicate a location **where** each of the two features that you have chosen could form, by placing the letter of the feature on diagram 2. **(1 mark)**



- b) Describe **how** the features you have chosen were formed. **(2 marks)**

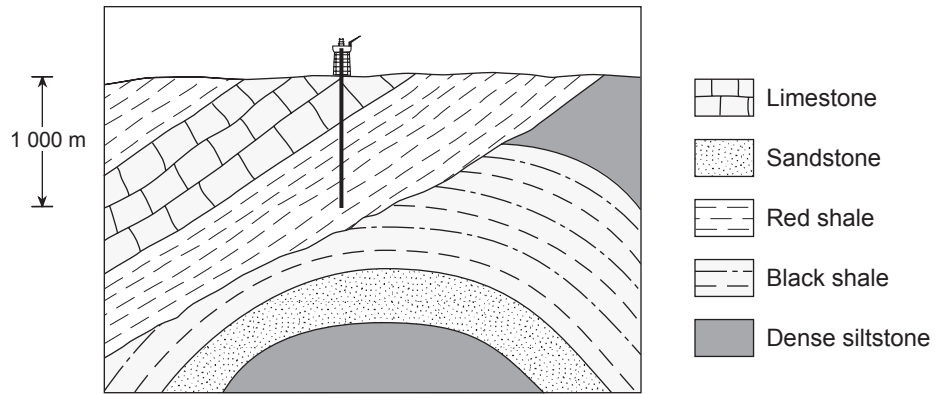
i) Feature: _____

Description of how feature formed: _____

ii) Feature: _____

Description of how feature formed: _____

Use the following cross section to answer question 3.
The well has been drilled to a depth of 1 000 m.



3. a) Referring to the cross section above, explain why this well would **not** produce oil. (1 mark)

b) Name a more appropriate layer to drill to, and explain the reason for your choice. (1 mark)

4. Paleontologists have estimated that of all the different species that ever lived on Earth, less than 1 in 5 000 left any fossil remains to show that they ever existed. Describe **three** reasons why a modern-day woodland slug is unlikely to become part of the fossil record. (3 marks)

i)

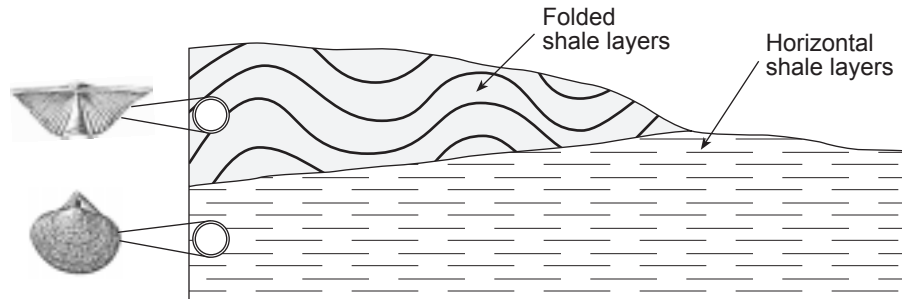
ii)

iii)

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Refer to pages ii and iii of the Data Booklet.

Use the Geological Time Scale and the Fossil Samples chart, along with the following geological cross section showing folded and horizontal shale layers, to answer question 5.



5. a) Both fossils shown in the cross section above belong to the same fossil group. Name the group to which they belong.

(1 mark)

Use the following list to answer question 5b).

Types of geological boundaries

- i) Unconformity
- ii) Fault
- iii) Undisturbed sedimentary contact

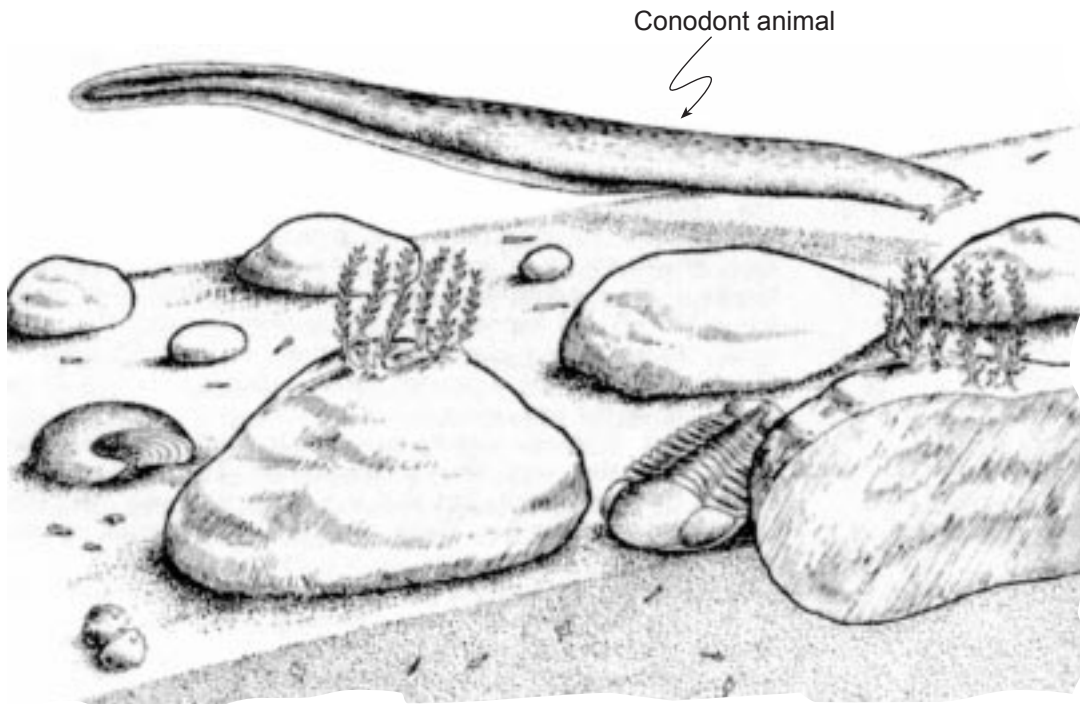
- b) Three types of geological boundaries are given in the list above. Which of these boundaries **most likely** exists between the folded and horizontal shale layers? **(1 mark)**

- c) Give **one** reason that justifies your answer to part b).

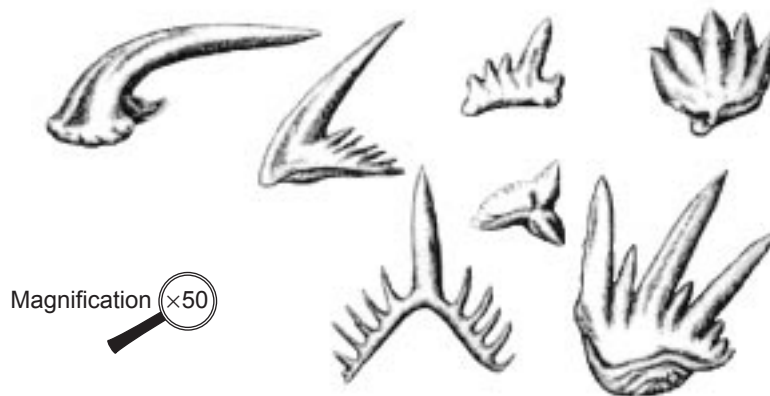
(1 mark)

Use the following description and diagrams of a conodont animal and conodont elements to answer question 6.

Conodont elements are very common, microscopic, tooth-like fossils made of the same material as vertebrate teeth. They occur in a large range of marine sedimentary rocks, ranging in age from the late Precambrian to the Triassic, and are found all over the world. Conodonts evolved rapidly into distinct forms through time. The three specimens of the conodont animal that have been found are about five centimetres long and contain the conodont elements in the head area. The elements are likely to be part of a food processing device.



Conodont elements



6. a) The form and lifestyle of the conodont animal shown in the diagram was created by comparing its fossil remains with modern creatures. When paleontologists engage in this sort of activity, which geological principle are they applying? **(1 mark)**

- b) Give **two** reasons why conodont elements are such useful index (guide) fossils. **(2 marks)**

i) _____

ii) _____

7. The continents of South America and Africa contain many features which suggest that they were once joined together and have since drifted apart. Describe **two** of these features. **(2 marks)**

i) _____

ii) _____

8. Describe a major geological feature which suggests that the Indian subcontinent has drifted into Asia. **(1 mark)**

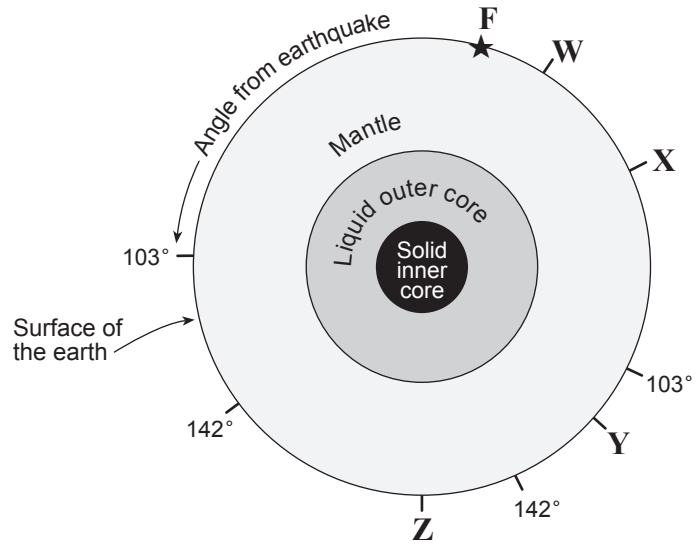
9. Describe **three** pieces of evidence which demonstrate that sea-floor spreading is occurring. **(3 marks)**

i) _____

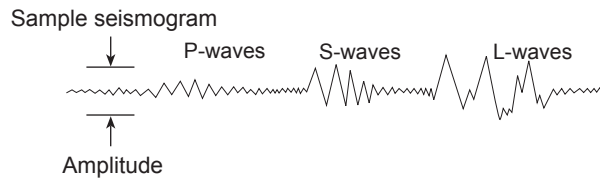
ii) _____

iii) _____

Use the following sketch of the cross section of the earth to answer question 10.



Strong earthquake at F
Seismometer stations at W, X, Y, Z



10. A strong earthquake occurred at location **F**.

a) The time difference between the arrival of P- and S-waves is known as the P- and S-wave interval. Describe how the P- and S-wave interval varies between stations **W** and **X**.

(1 mark)

b) Describe the difference in amplitude between direct path P-waves at station **W** and at station **X**.

(1 mark)

c) Explain why no direct path S-waves would be recorded at station **Z**.

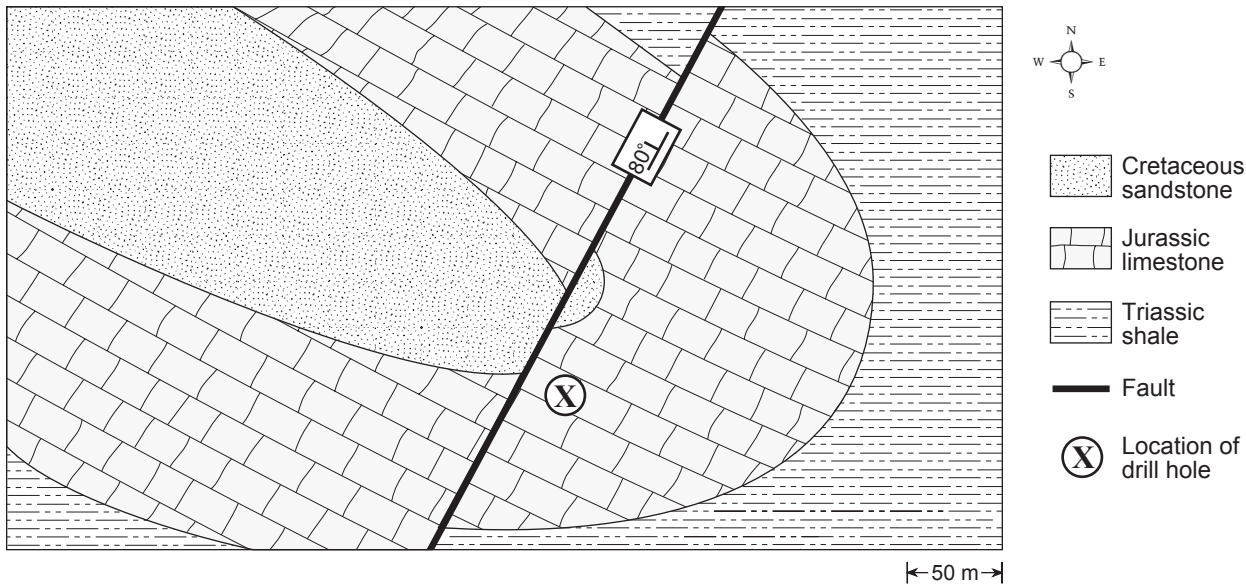
(1 mark)

d) Explain why no direct path P-waves would be recorded at station **Y**.

(1 mark)

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Refer to page ii of the Data Booklet.
Use the Geological Time Scale and the following map to answer question 11.
The map shows outcrops of rocks in a generally flat area.
A slight depression occurs along the fault trace.



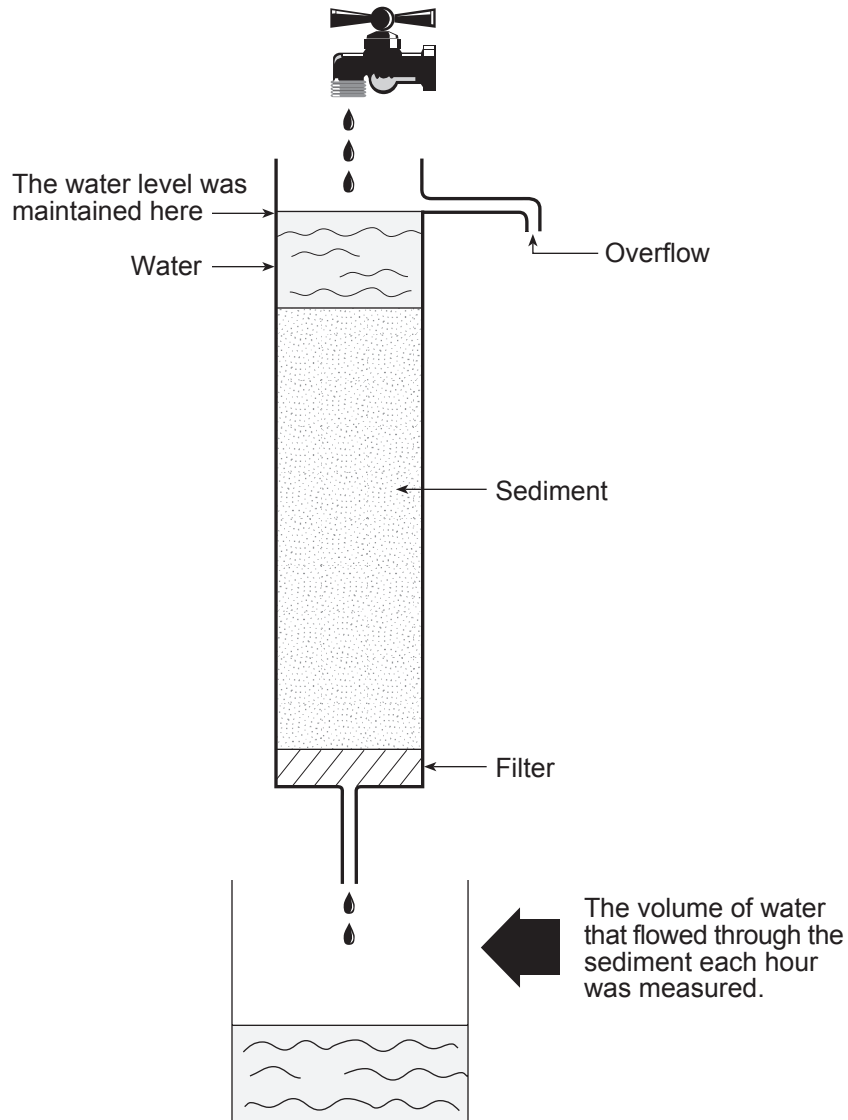
11. a) A geologist has determined that the fold structure shown above is a syncline. Describe the evidence that helped her come to this conclusion. **(1 mark)**

- b) Describe the type of plate tectonic situation where a fold of this type would **most likely** be formed. **(1 mark)**

- c) Explain why the fault would not be crossed by a vertical drill hole at **X**. **(1 mark)**

- d) Explain why there would be a depression in the ground along the fault trace. **(1 mark)**

Use the following diagram and table to answer question 12.



Sediment	Flow rate of water (litres per hour)	Porosity (%)
Well-sorted gravel	3 000	30
Well-sorted sand	250	40
Well-sorted silt	0.5	45
Well-sorted clay	0.0001	55
Silty sand	5	20
Glacial till	0.2	10

12. A student used the equipment shown on the previous page to determine the rate of water flow through a variety of sediments. The student also measured the porosity of each material by determining how much water was required to completely saturate the dry sediment.

a) **According to the data** for the well-sorted sediments, what is the relationship between particle size and porosity of the sediments? **(1 mark)**

b) Which of the six sediments listed in the table would make the **best** seal to stop toxic waste from leaching from a toxic waste pond? Give a reason for your answer. **(2 marks)**

Sediment: _____

Reason: _____

c) Give a reason why the permeability and porosity of the silty sand is so different from the permeability and porosity of the well-sorted sand. **(1 mark)**

Refer to page ix of the Data Booklet.

Use Photograph 9 which shows vertical alternating layers of light-coloured limestone and dark-coloured shale to answer question 13.

13. a) Referring to the photograph, describe evidence which shows that the limestone and the shale are weathering at different rates. **(1 mark)**

- b) Describe **one** type of chemical weathering that could be affecting the layers. **(1 mark)**

- c) Describe **one** type of biological weathering that is likely affecting the layers. **(1 mark)**

**Refer to page x of the Data Booklet.
Use the Basic Data on the Solar System chart to answer question 14.**

14. a) Density can be used to divide the planets into two groups: the inner and outer planets. What difference in **composition** would account for the difference in density of the two groups? **(1 mark)**

- b) Describe how the Nebular Theory of the origin of the solar system explains the difference in density between the inner and outer planets. **(1 mark)**

END OF EXAMINATION

DATA BOOKLET

Geology 12

JUNE 2000

Acknowledgements for Photographs

PHOTOGRAPHS 1, 3, 7 AND 9
N. Gato



PHOTOGRAPHS 2 AND 4
J.L.M. Visuals



PHOTOGRAPH 5
United States Geological Survey



PHOTOGRAPH 6
Geological Survey of Canada



PHOTOGRAPH 8
Mining Association of British Columbia Education Division

GEOLOGICAL TIME SCALE



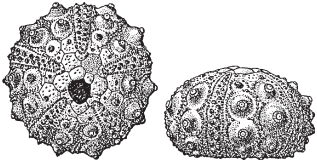



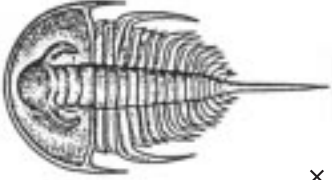


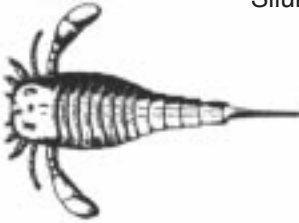

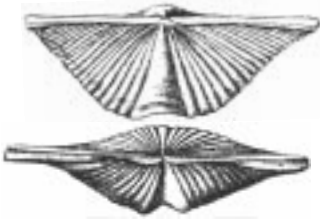
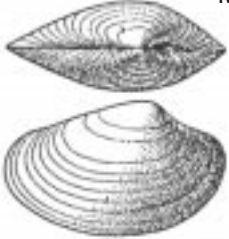
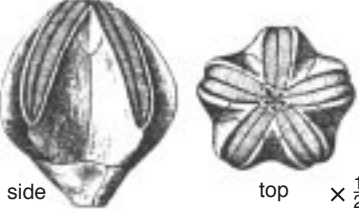



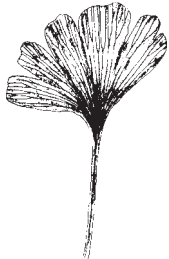
ERA	PERIOD	EPOCH	TIME
Cenozoic	Quaternary	Holocene	0.01
		Pleistocene	2
	Tertiary	Pliocene	5
		Miocene	24
		Oligocene	37
		Eocene	58
		Paleocene	66
Mesozoic	Cretaceous		144
	Jurassic		208
	Triassic		245
Paleozoic	Permian		286
	Carboniferous	Pennsylvanian	320
		Mississippian	360
	Devonian		408
	Silurian		438
	Ordovician		505
	Cambrian		570
	Precambrian		

Based on Hamblin, *The Earth's Dynamic Systems*, 1982. Dates from Montgomery, *Physical Geology*, 1987.

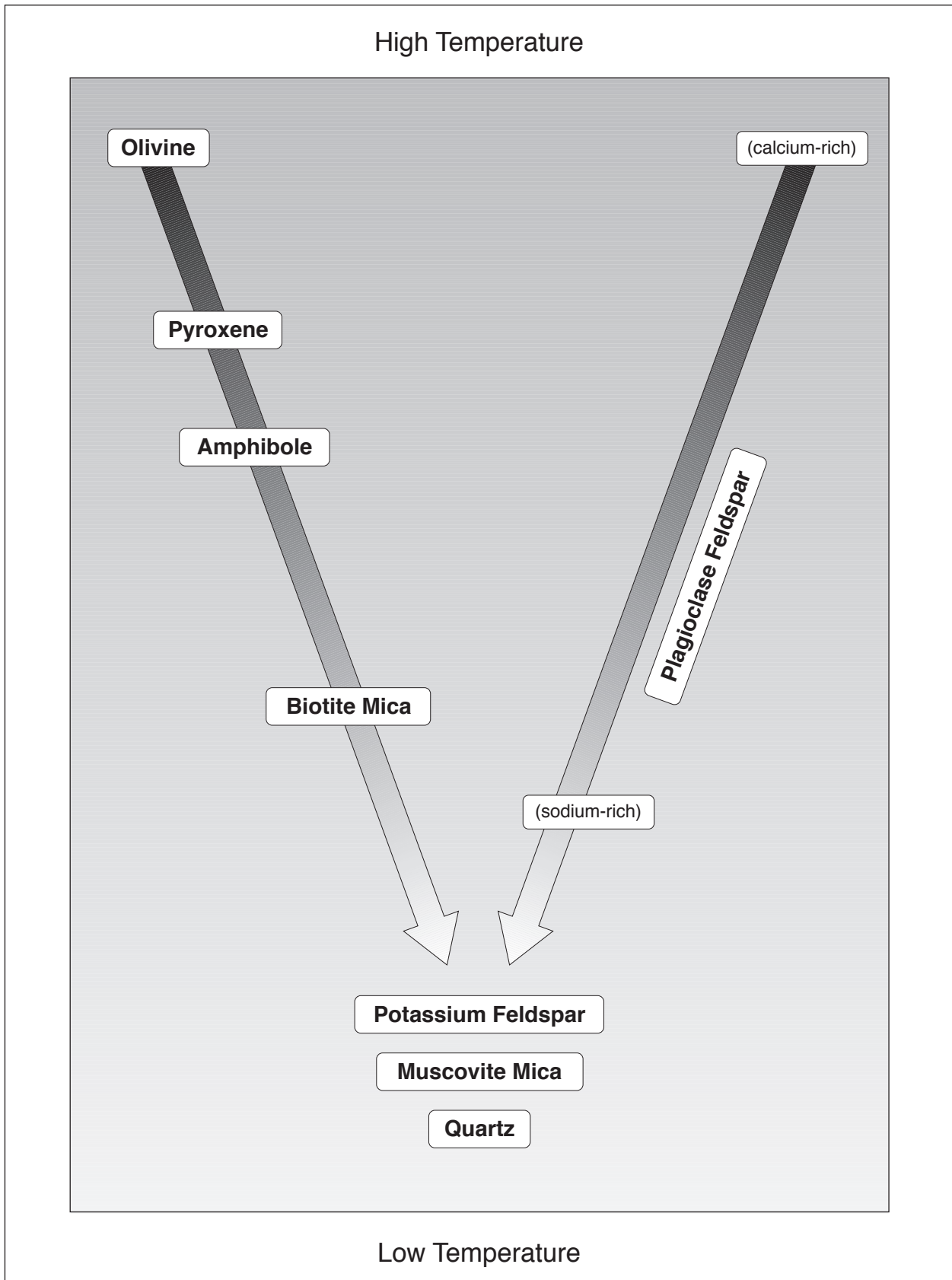
It is recognized that there is some variation in the dates given in the literature.

*Approximate age of the oldest rocks.

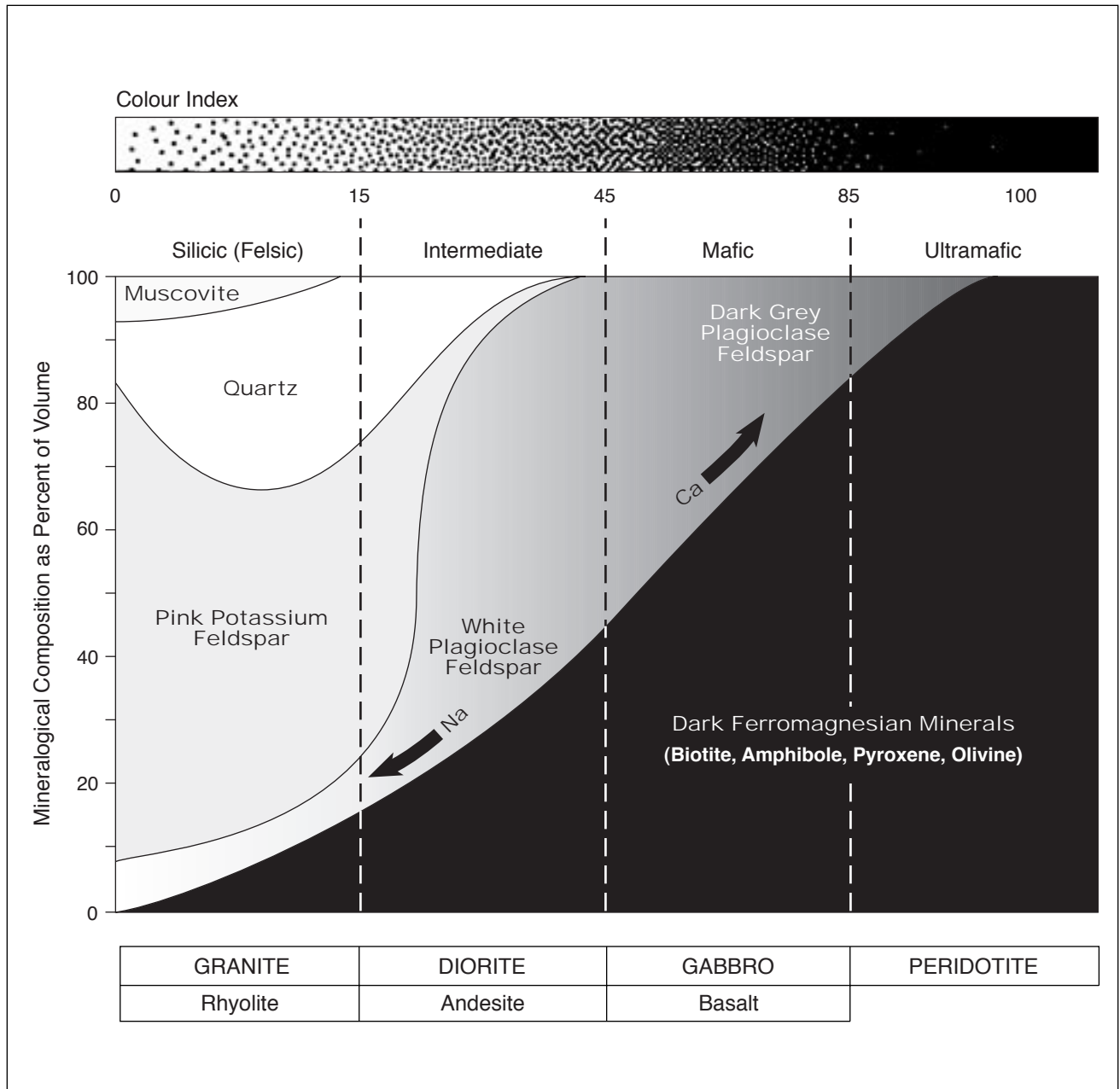
FOSSIL SAMPLES

<p>1</p>  <p>Tertiary (Eocene)</p> <p style="text-align: right;">× $\frac{1}{2}$ Magnification</p>	<p>2</p>  <p>Tertiary (Oligocene)</p> <p style="text-align: right;">× 1 Magnification</p>	<p>3</p>  <p>Jurassic</p> <p style="text-align: right;">× $\frac{1}{4}$ Magnification</p>
<p>4</p>  <p>Triassic</p> <p style="text-align: right;">× $\frac{1}{2}$</p>	<p>5</p>  <p>Mississippian</p> <p style="text-align: right;">× $\frac{1}{2}$</p>	<p>6</p>  <p>Mississippian to Permian</p> <p style="text-align: right;">× $\frac{1}{2}$</p>
<p>7</p>  <p>Cambrian</p> <p style="text-align: right;">× $\frac{1}{2}$</p>	<p>8</p>  <p>apertural ventral</p> <p style="text-align: right;">× 45</p>	<p>9</p>  <p>Mississippian</p> <p style="text-align: right;">× $\frac{1}{4}$</p>
<p>10</p>  <p>Silurian</p> <p style="text-align: right;">× $\frac{1}{4}$</p>	<p>11</p>  <p>Ordovician</p> <p style="text-align: right;">× $\frac{1}{2}$</p>	<p>12</p>  <p>Devonian</p> <p style="text-align: right;">× $\frac{1}{2}$</p>
<p>13</p>  <p>Miocene</p> <p style="text-align: right;">× $\frac{1}{2}$</p>	<p>14</p>  <p>side top</p> <p style="text-align: right;">× $\frac{1}{2}$</p>	<p>15</p>  <p>Ordovician to Devonian</p> <p style="text-align: right;">× 25</p>
<p>16</p>  <p>Pennsylvanian</p> <p style="text-align: right;">× $\frac{1}{2}$</p>	<p>17</p>  <p>Devonian</p> <p style="text-align: right;">× 1</p>	<p>18</p>  <p>Jurassic to Quaternary</p> <p style="text-align: right;">× $\frac{1}{2}$</p>

BOWEN'S REACTION SERIES



PERCENTAGE OF MINERALS IN IGNEOUS ROCKS



PHOTOGRAPHS



PHOTOGRAPH 1



PHOTOGRAPH 2



PHOTOGRAPH 3

TABLE OF HARDNESS

Object	MOHS Scale of Hardness
Glass or steel knife	5.5
Wire nail	4.5
Copper penny	3.5
Fingernail	2.5



PHOTOGRAPH 4



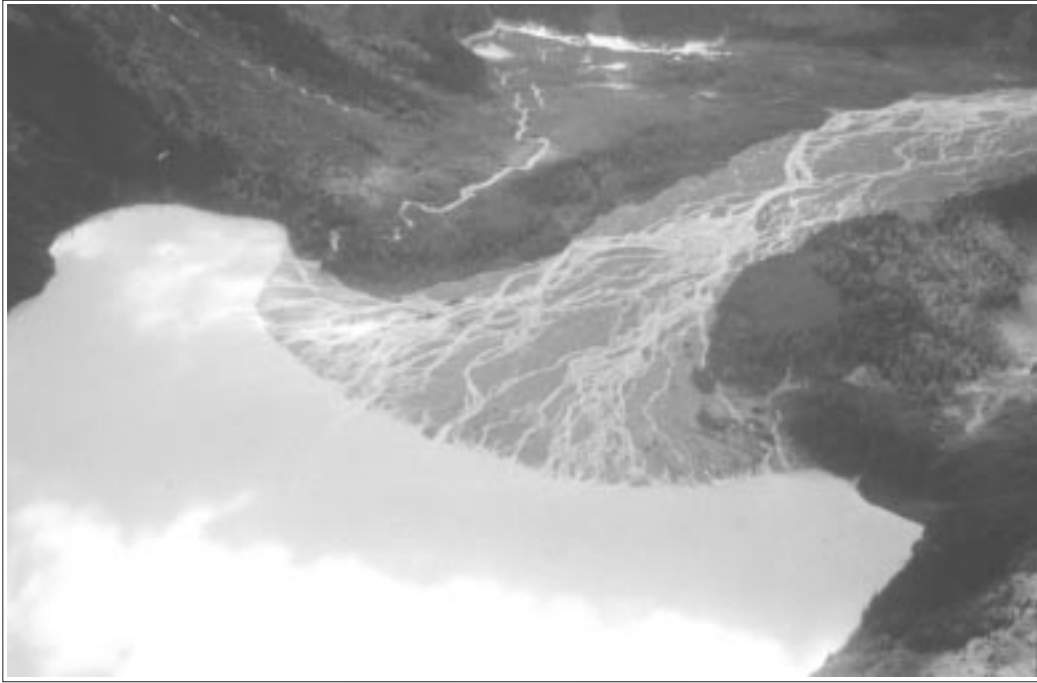
PHOTOGRAPH 5



PHOTOGRAPH 6



PHOTOGRAPH 7



PHOTOGRAPH 8



PHOTOGRAPH 9

BASIC DATA ON THE SOLAR SYSTEM

Planet	Mean Distance From Sun ¹	Equatorial Radius (km)	Mass Relative to Earth ²	Density (g/cm ³)	Number of Moons	Mean Surface Temperature (°C)
Mercury	57.9	2 440	0.0558	5.42	0	350 / -170*
Venus	108.2	6 050	0.8150	5.25	0	475
Earth	149.6	6 378	1.000	5.52	1	22
Earth's Moon	—	1 738	0.012	3.34	n/a	110 / -180*
Mars	227.9	3 397	0.107	3.94	2	-23
Jupiter	778.3	71 400	317.90	1.31	16	-150
Saturn	1 425	60 330	95.15	0.69	22	-180
Uranus	2 870	25 400	14.54	(1.19)	17	-210
Neptune	4 490	24 300	17.23	1.66	8	-220
Pluto	5 900	(1 500)	0.0022	(0.9)	1	-230

¹ In millions of kilometres.

² (mass of planet) / (mass of earth)

* Two surface temperatures are given for Mercury and the Moon because the very slow rotations of these planets result in extreme temperature differences between day and night.

Numbers in parentheses are approximate.

PROPERTIES OF COMMON AND IMPORTANT MINERALS

Mineral	Colour	Streak	Lustre	Form	Cleavage	Hardness	Specific gravity
Amphibole (hornblende)	dark green to black	white to grey	vitreous	long crystals, grains	2 excellent at 56°	6	3.0 – 3.4
Apatite	usually green	white	vitreous	crystals or massive	1 poor	5	3.1
Asbestos	green or black	none to white	waxy	massive or fibrous	none to fibrous	2.5 – 5.0	3.1
Azurite	blue	pale blue	earthy or vitreous	earthy mass or tiny crystals	seldom visible	3.5 – 4.0	3.8
Bornite	iridescent blue, purple	grey-black	metallic	massive	none	3	5.0
Calcite	white, pink or yellow	white to grey	vitreous	rhombohedral crystals, granular	3 perfect, not at 90°	3	2.7
Chalcopyrite	golden-brassy yellow	black	metallic	tetrahedral crystals, massive	1 poor	3.5 – 4.0	4.2
Chlorite	green to dark green	pale green	vitreous-earthy	scaly masses	1 perfect	2.5	2.6 – 3.3
Feldspar (plagioclase)	white to grey	white	vitreous	tabular crystals, grains	2 excellent at 90°	6	2.6 – 2.8
Feldspar (potassium)	white or pink	white	vitreous-pearly	stubby crystals, grains	2 excellent at 90°	6	2.7
Fluorite	variable: green, purple	white	vitreous	cubic crystals, massive	4 excellent, octahedral	4	3.0 – 3.3
Galena	lead-grey	grey-black	metallic	cubes or massive	3 perfect at 90°	2.5	7.6
Gamet	variable: commonly red	white/pale red	vitreous	12 or 24 faced crystals	none	7	3.6 – 4.0
Gold	gold yellow	yellow	metallic	flakes, grains, massive	none	2.5 – 3.0	19
Graphite	black	dark grey	metallic	massive or scaly masses	1 perfect	1 – 2	2.1
Gypsum	colourless or white	white	vitreous to pearly	tabular crystals or massive	1 excellent, 2 good	2	2.3
Halite	colourless, white	white	vitreous	cubes, massive, granular	3 excellent at 90°	2.5	2.2
Hematite	steel grey, earthy red	red brown	metallic or earthy	scaly or earthy masses	none	5 – 6	5.2
Limonite	brown to yellow brown	brownish yellow	earthy	earthy masses, granular	rarely observable	5.5 – 6.0	3.0 – 4.0
Magnetite	black	black	metallic	commonly massive	seldom visible	5.5 – 6.5	5.0
Malachite	bright green	pale green	earthy	flakes or earthy masses	seldom visible	3.5 – 4.0	3.6 – 4.0
Mica (muscovite, biotite)	white, green, black	white to grey	vitreous	flakes, scaly masses	1 perfect	2.5	2.8 – 3.2
Molybdenite	lead grey, bluish tinge	bluish grey	metallic	scaly masses, flakes	1 perfect	1.0 – 1.5	4.7
Olivine	olive green, olive brown	white, grey	vitreous	granular masses, grains	none	6.5	3.3
Pyrite	brass yellow	greenish black	metallic	cubic crystals or massive	1 very poor	6.0 – 6.5	5.0
Pyroxene (augite)	dark green to black	white-grey	vitreous	stubby crystals	2 excellent at 90°	6	3.3
Pyrrhotite	bronze yellow	grey-black	metallic	usually massive or granular	none	3.5 – 4.5	4.6
Quartz family	variable: clear, white	white	vitreous	prismatic crystals, granular	none	7	2.6
Sphalerite	brown to yellow	yellow to brown	resinous/metallic	tetrahedral crystals, massive	6 perfect	3.5 – 4.0	4.0
Talc	white, pearly	white	waxy, greasy	fibrous, massive	1 perfect	1	2.7 – 2.8