MINISTRY USE ONLY

MINISTRY USE ONLY

Place Personal Education Number (PEN) here.

Place Personal Education Number (PEN) here.

MINISTRY USE ONLY

BRITISH COLUMBIA

Geology 12

JUNE 2001

Course Code = GEOL

Student Instructions

1. Place 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.

Question 1:

1. ☐ . ☐

(1)

Question 7:

7. ☐ . ☐

(3)

Question 2:

2. ☐ . ☐

(3)

Question 8:

8. ☐ . ☐

(7)

Question 3:

3. ☐ . ☐

(6)

Question 9:

9. ☐ . ☐

(3)

Question 4:

4. ☐ . ☐

(3)

Question 10:

10. ☐ . ☐

(2)

Question 5:

5. ☐ . ☐

(4)

Question 11:

11. ☐ . ☐

(4)

Question 6:

6. ☐ . ☐

(7)

Question 12:

12. ☐ . ☐

(2)

GEOLOGY 12

JUNE 2001

COURSE CODE = GEOL

GENERAL INSTRUCTIONS

1. Aside from an approved calculator, 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: 12 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.

THIS PAGE INTENTIONALLY BLANK

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.

REFERENCE DATA BOOKLET

For question 1, refer to the following in the Data Booklet.

page v: Photograph 1
page xi: Properties of Common and Important Minerals

1. In photograph 1, the key identifying property of the mineral being demonstrated is its

   A. lustre.
   B. colour.
   C. cleavage.
   D. hardness.

REFERENCE DATA BOOKLET

For question 2, refer to the following in the Data Booklet.

page v: Photograph 2
page x: Table of Hardness

2. The test result shown in photograph 2 indicates that the Mohs hardness of the mineral is

   A. less than 3.5
   B. exactly 3.5
   C. between 3.5 and 5.5
   D. greater than 5.5

REFERENCE DATA BOOKLET

For question 3, refer to the following in the Data Booklet.

page v: Photograph 3
page x: Table of Hardness
page xi: Properties of Common and Important Minerals

3. The mineral shown in photograph 3 is harder than a glass plate. The mineral is **most likely**

   A. gold.
   B. pyrite.
   C. magnetite.
   D. chalcopyrite.

OVER

REFERENCE DATA BOOKLET

For question 4, refer to the following in the Data Booklet.

page v: Photograph 4
page x: Table of Hardness
page xi: Properties of Common and Important Minerals

4. The three specimens shown in photograph 4 are varieties of the same mineral. The mineral is harder than glass. The mineral is **most likely**

   A. quartz.
   B. calcite.
   C. fluorite.
   D. feldspar.

REFERENCE DATA BOOKLET

For question 5, refer to the following in the Data Booklet.

page vi: Photograph 5
page xi: Properties of Common and Important Minerals

5. The mineral shown in photograph 5 can occur in many colours and also cleaves in more than three directions. The mineral is **most likely**

   A. galena.
   B. azurite.
   C. fluorite.
   D. sphalerite.

REFERENCE DATA BOOKLET

For question 6, refer to the following in the Data Booklet.

page vi: Photograph 6
page x: Percentage of Minerals in Igneous Rocks

6. The two rocks shown in photograph 6 could **both** be classified as

   A. mafic and intrusive.
   B. mafic and extrusive.
   C. silicic and intrusive.
   D. silicic and extrusive.

REFERENCE DATA BOOKLET

For question 7, refer to the following in the Data Booklet.

page x: Percentage of Minerals in Igneous Rocks

7. A student views a rock sample with a hand lens. Tiny, randomly-arranged, interlocking crystals are seen. The sample contains mostly calcium-rich (dark grey) plagioclase feldspar and dark ferromagnesian minerals. The rock is **most likely**

   A. basalt.
   B. gabbro.
   C. rhyolite.
   D. peridotite.

REFERENCE DATA BOOKLET

For question 8, refer to the following in the Data Booklet.

page ix: Bowen's Reaction Series
page x: Percentage of Minerals in Igneous Rocks

8. Which of the following minerals would be the **first** to start crystallizing in a silicate magma?

   A. quartz
   B. pyroxene
   C. amphibole
   D. potassium feldspar

OVER

REFERENCE DATA BOOKLET	*For question 9, refer to the following in the Data Booklet.* **page vi: Photograph 7**

9. The arrangement and shape of the igneous rock formation shown in photograph 7 suggests that the rock

   A. formed underwater.
   B. cooled slowly at depth.
   C. formed in a volcanic dome.
   D. cracked into columns during cooling.

REFERENCE DATA BOOKLET	*For questions 10 and 11, refer to the following in the Data Booklet.* **page vi: Photograph 8**

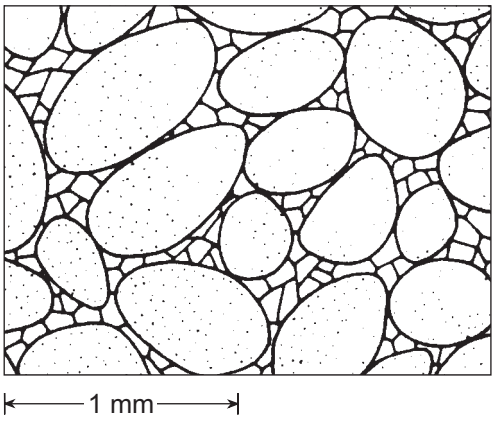
10. Photograph 8 shows a thick horizontal layer of dark igneous rock (X) surrounded by limestone (Y). The white zones (Z) above and below the dark layer (X) are where the country rock has been changed. The dark rock feature is a

    A. sill.
    B. dike.
    C. batholith.
    D. buried lava flow.

11. The light-coloured rock (Z) above and below the feature in photograph 8 is **most likely**

    A. gneiss.
    B. marble.
    C. granite.
    D. quartzite.

Use the following diagram of a rock sample viewed under a microscope to answer question 12.



12. The sample has small (< 2.0 mm) rounded grains of quartz. Cement can be seen between the grains. The rock is **most likely**

    A. garnet schist.
    B. red sandstone.
    C. black quartzite.
    D. fossil limestone.

REFERENCE DATA BOOKLET

For question 13, refer to the following in the Data Booklet.

page vii: Photograph 9

13. The sedimentary feature shown in photograph 9 would **most likely** be found in a(n)

    A. alluvial fan.
    B. limestone cave.
    C. lateral moraine.
    D. shallow sea floor.

---

14. Metamorphic rocks are often classified according to their "grade". Which of the following is the **highest grade** metamorphic rock?

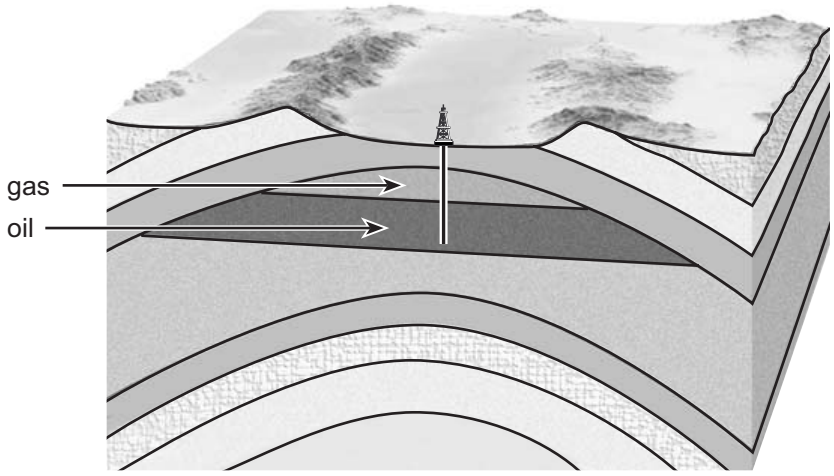
    A. slate
    B. shale
    C. gneiss
    D. phyllite

OVER

15. Which of the following minerals is a source of a metal used to produce home electrical wiring?

A. gold
B. galena
C. sphalerite
D. chalcopyrite

Use the following diagram of a fold trap to answer question 16.



16. Which of the following pairs of properties **best** describes the characteristics of the rock layer in which the oil and gas are found?

A. porous and permeable
B. porous and impermeable
C. non-porous and permeable
D. non-porous and impermeable

---

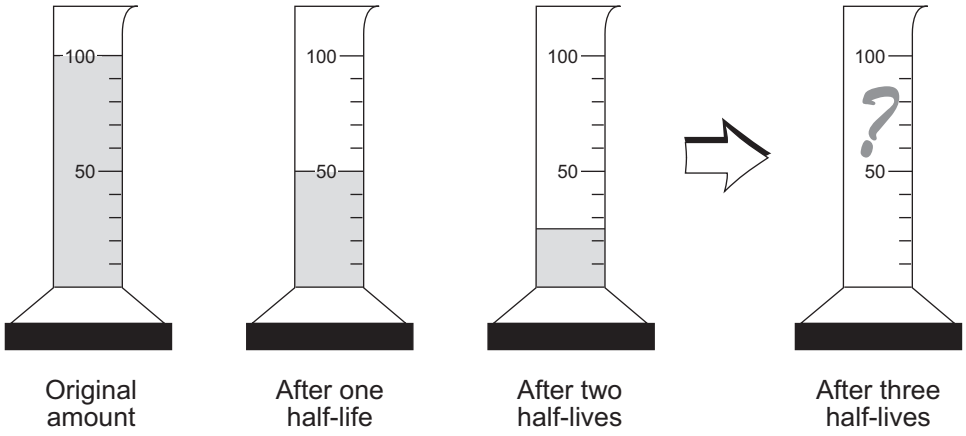
17. The process of matching rock layers from different locations based on the presence of the same guide (index) fossils is an example of

A. correlation.
B. superposition.
C. included fragments.
D. original horizontality.

18. James Hutton stated that all geological features on Earth could be explained by present-day processes operating over long periods of time. This principle is called

A. correlation.
B. superposition.
C. faunal succession.
D. uniformitarianism.

Use the following diagram to answer question 19.



19. The water in the graduated cylinders **represents** the amount of parent isotope in a mineral sample. The decrease in the water level illustrates the radioactive decay of parent material within the sample. The percentage of original parent material remaining after three half-lives is closest to

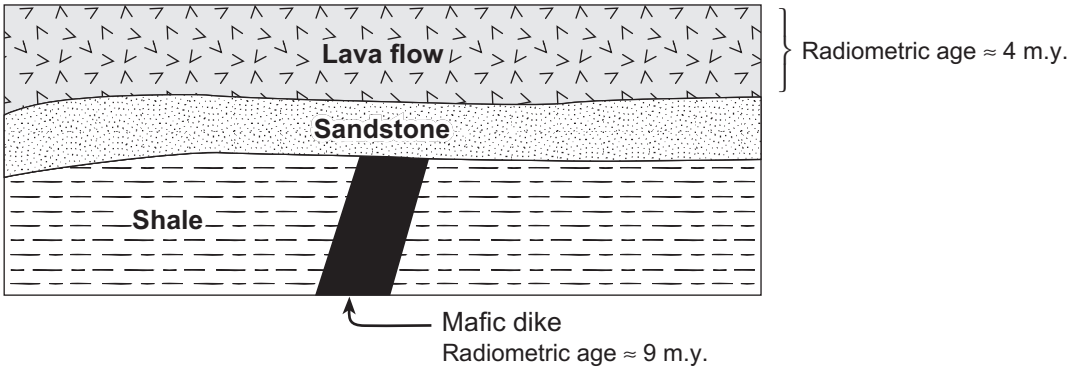
A. 6%
B. 13%
C. 25%
D. 33%

OVER

REFERENCE DATA BOOKLET

For questions 20 and 21, refer to the diagram below, and the following in the Data Booklet.

page ii: Common Isotope Pairs Chart



20. Which of the following isotope pairs would **best** be used to find the radiometric age of the lava flow?

    A. Uranium 238 – Lead 206
    B. Carbon 14 – Nitrogen 14
    C. Potassium 40 – Argon 40
    D. Rubidium 87 – Strontium 87

21. Which of the following **best** describes the probable age of the sandstone layer?

    A. 1 to 2 million years
    B. 3 to 4 million years
    C. 5 to 8 million years
    D. 9 to 12 million years

REFERENCE DATA BOOKLET

For question 22, refer to the following in the Data Booklet.

page iv: Development of Life Through Time

22. Which of the following is the correct sequence of events in Earth's history?

A.	B.	C.	D.
Youngest	**Youngest**	**Youngest**	**Youngest**
mammals dominated	fishes dominated	mammals dominated	amphibians dominated
invertebrates dominated	invertebrates dominated	amphibians dominated	mammals dominated
fishes dominated	mammals dominated	fishes dominated	invertebrates dominated
amphibians dominated	amphibians dominated	invertebrates dominated	fishes dominated
Oldest	**Oldest**	**Oldest**	**Oldest**

REFERENCE DATA BOOKLET

For question 23, refer to the following in the Data Booklet.

page i: Geologic Columns
page ii: Geological Time Scale
page iii: Fossil Samples

23. Where in Column 2 of the Geologic Columns does an unconformity definitely exist?

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

OVER

REFERENCE DATA BOOKLET

For questions 24 to 28, refer to the following in the Data Booklet.

page i: Geologic Columns
page ii: Geological Time Scale
page iii: Fossil Samples

24. What is the likely age range for layer V in Column 3?

    A. 360 to 408 million years
    B. 408 to 438 million years
    C. 438 to 570 million years
    D. less than 360 million years

25. Which layer in Column 1 contains a fossil of an organism that would **most likely** produce a trace fossil?

    A. I
    B. III
    C. IV
    D. VII

26. Which layer in Column 2 contains the fossil of an organism that was non-mobile?

    A. II
    B. III
    C. IV
    D. V

27. Which layer in Column 1 contains a mollusc?

    A. I
    B. III
    C. IV
    D. VII

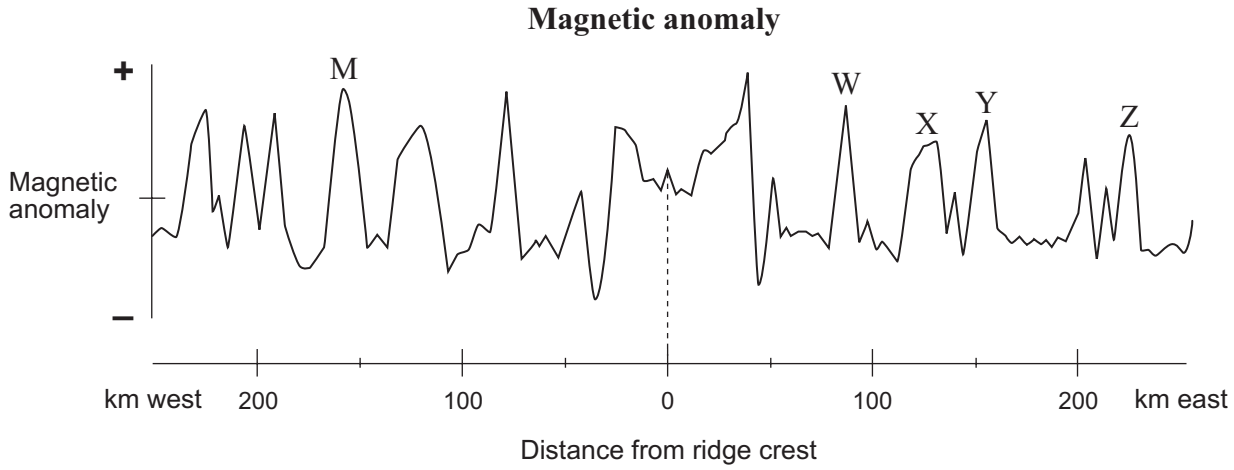
28. Based on the fossil found in layer IV in Columns 1 and 2, what was the **probable** environment at the time the layer was forming?

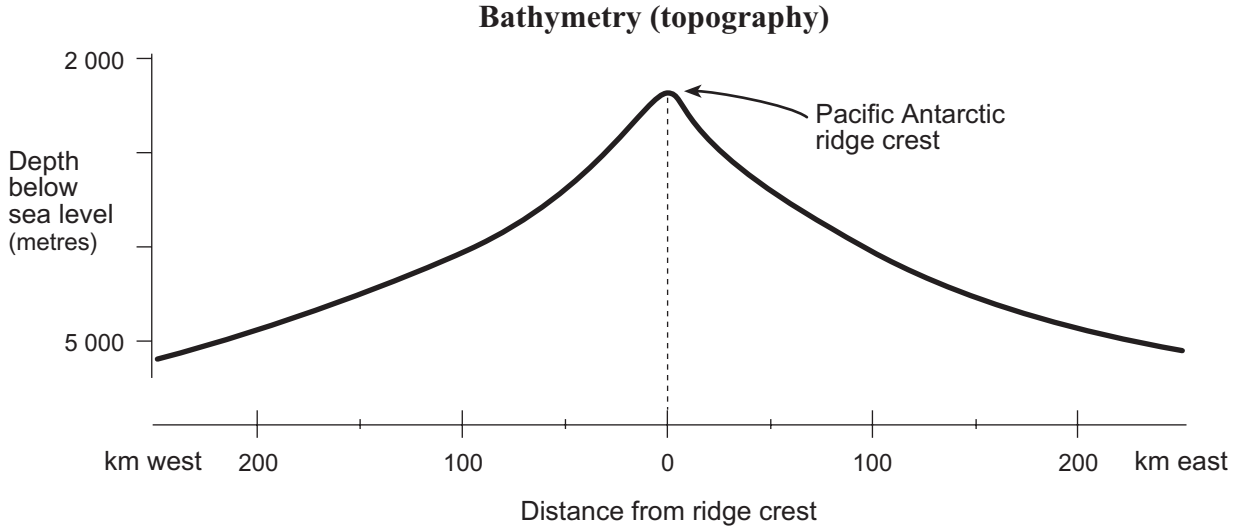
    A. hot, dry desert
    B. deep ocean trench
    C. cold, dry mountain
    D. shallow, tropical sea

29. Which of the following is evidence used by Alfred Wegener that the continents have moved?

A. chains of undersea volcanoes
B. movement along the San Andreas Fault
C. matching fossils on separated continents
D. deep-focus earthquakes at subduction zones

Use the following diagrams of data collected across the Pacific-Antarctic Ridge in the South Pacific Ocean to answer question 30.



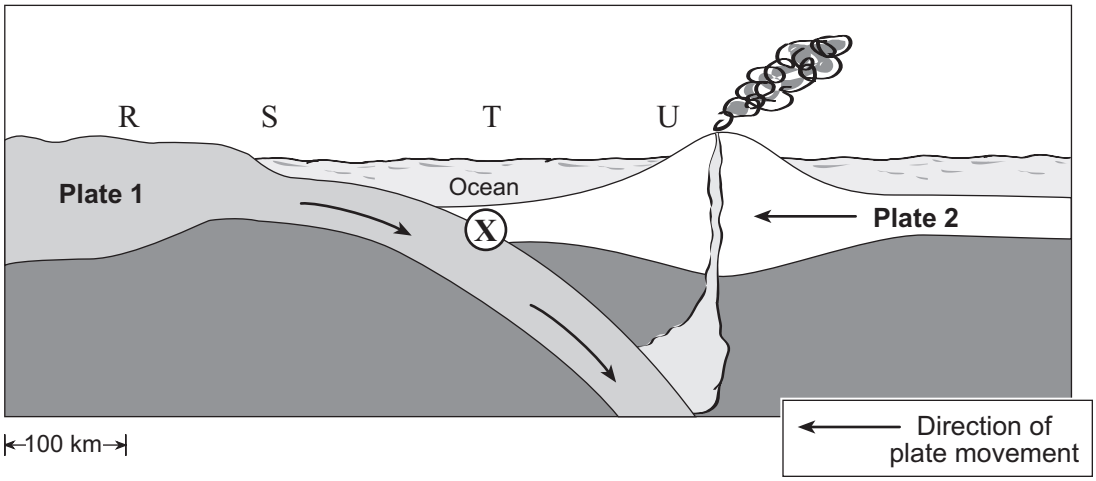


30. Which of the following magnetic anomalies is the same age as **M**?

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

OVER

Use the following diagram to answer questions 31 and 32.



31. The **best** name for the type of plate boundary shown at **X** is

    A. rifting.
    B. divergent.
    C. transform.
    D. convergent.

32. Which location would be directly above a deep-focus earthquake?

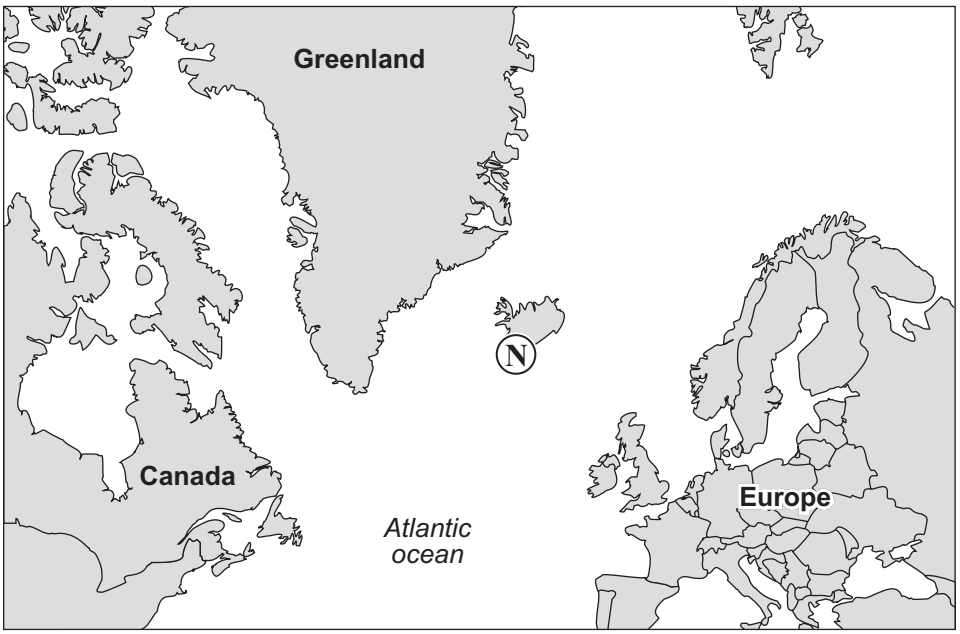
    A. R
    B. S
    C. T
    D. U

---

33. Which of the following is a possible driving mechanism for the movement of the earth's tectonic plates?

    A. fault creep
    B. mantle convection
    C. magnetic reversals
    D. isostatic adjustment

Use the following map to answer question 34.



(Map not drawn to scale)

34. Which of the following is **most likely** to occur at location **N**?

A. fold mountains
B. dome volcanism
C. plate subduction
D. shallow focus earthquakes

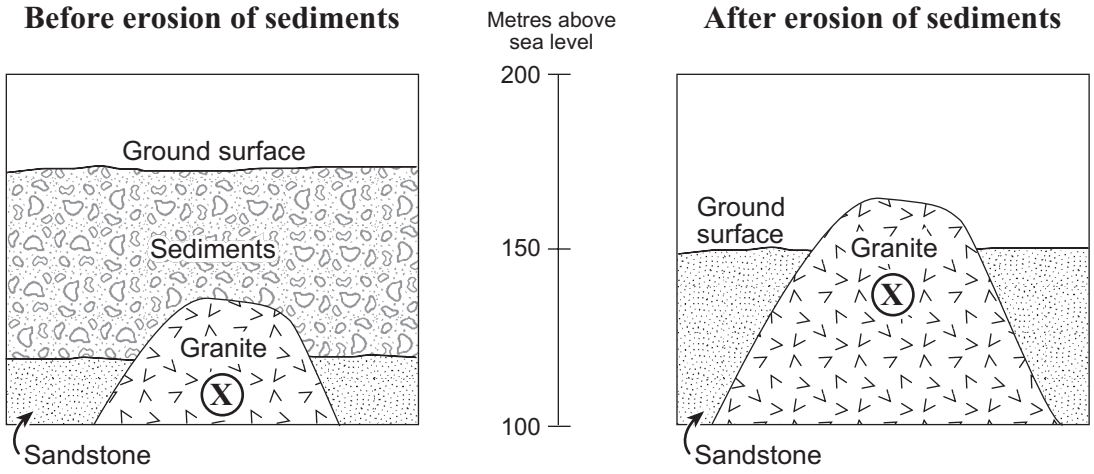
---

35. After an earthquake, rocks that were deformed snap back to their pre-stressed shape. This process is called

A. seismic creep.
B. elastic rebound.
C. transform faulting.
D. plastic deformation.

OVER

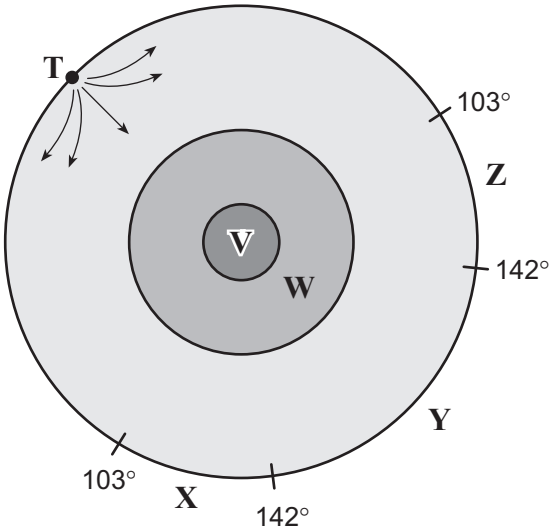
Use the following cross section to answer question 36.



36. After the sediments have been eroded, location **X** in the granite will be at a higher elevation above sea level. This is due to the process of

    A. isostasy.
    B. subduction.
    C. contact metamorphism.
    D. regional metamorphism.

Use the following cross section of the earth to answer questions 37 to 39.



37. A large earthquake occurs at location **T**. The P-wave shadow zone will include

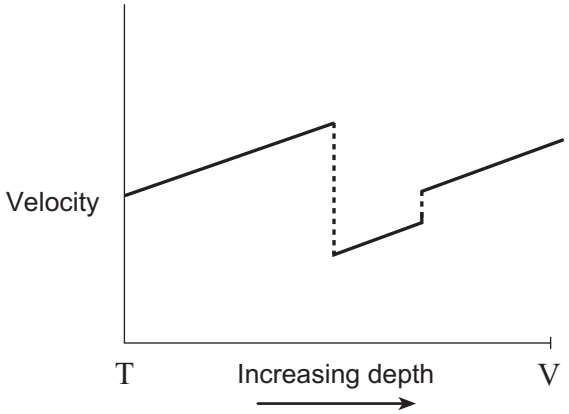
    A. Y only.
    B. X and Z.
    C. V and W.
    D. X, Y and Z.

38. The layer on the cross section of the earth labelled **W** is

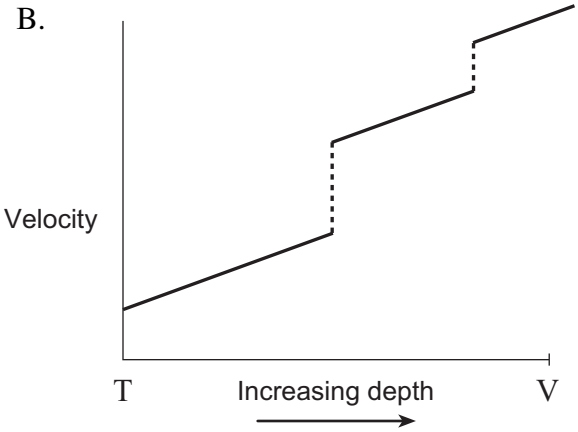
A. metal-rich and solid.
B. metal-rich and liquid.
C. silicate-rich and solid.
D. silicate-rich and liquid.

39. A graph of wave velocity for a P-wave travelling from **T** to **V** would look **most** like

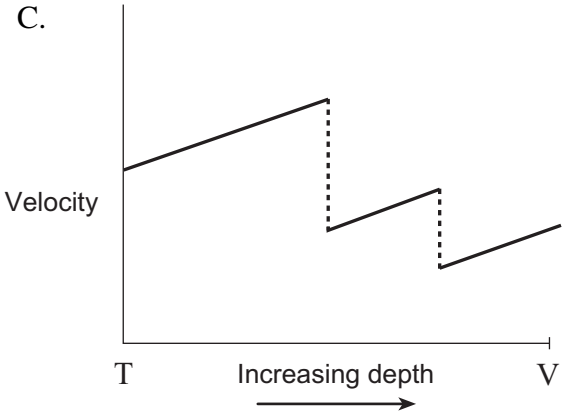
A.



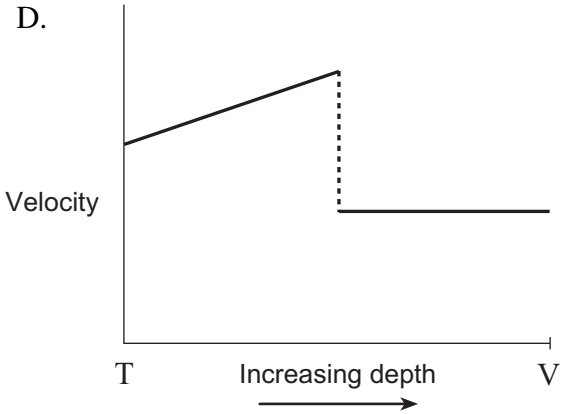
B.



C.

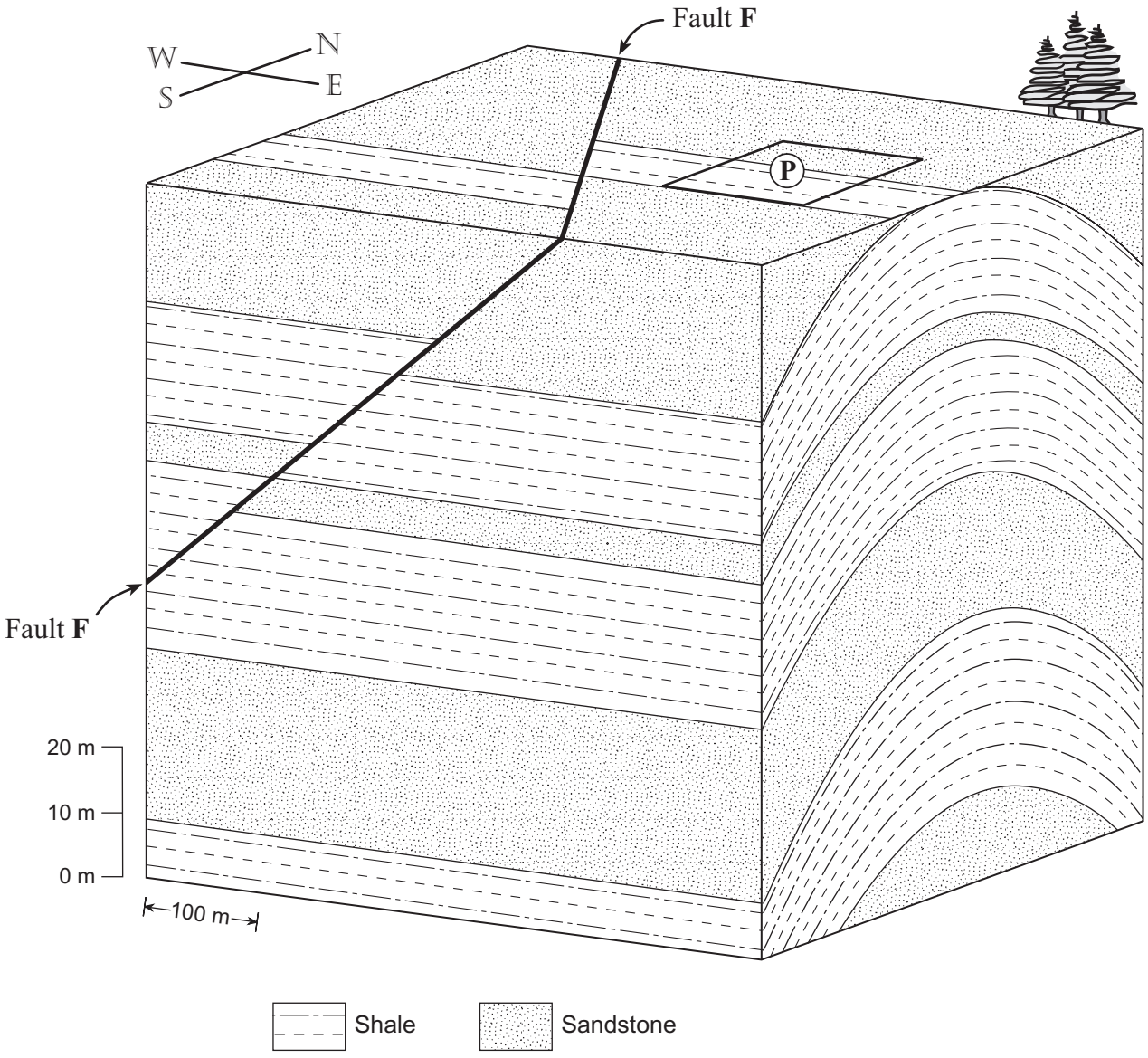


D.



OVER

Use the following geologic block diagram to answer questions 40 to 42.



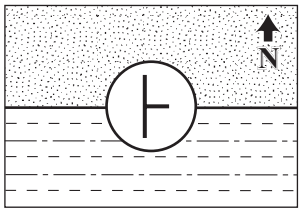
40. There has been no vertical movement on fault **F**. Fault **F** would be **best** classified as a

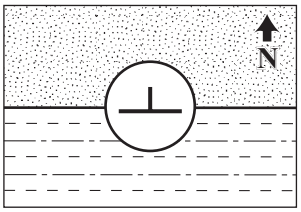
    A. normal dip-slip fault.
    B. reverse dip-slip fault.
    C. left lateral strike-slip.
    D. right lateral strike-slip.

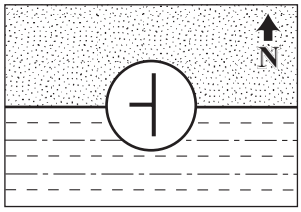
41. The fold shown on the block diagram would be **best** described as a

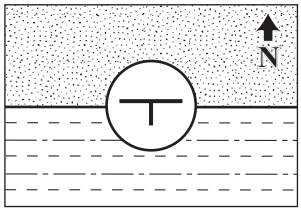
A. plunging syncline.
B. plunging anticline.
C. non-plunging syncline.
D. non-plunging anticline.

42. Location **P** lies on the contact between the shale and the sandstone. The correct strike and dip symbol at location **P** would be

A. 

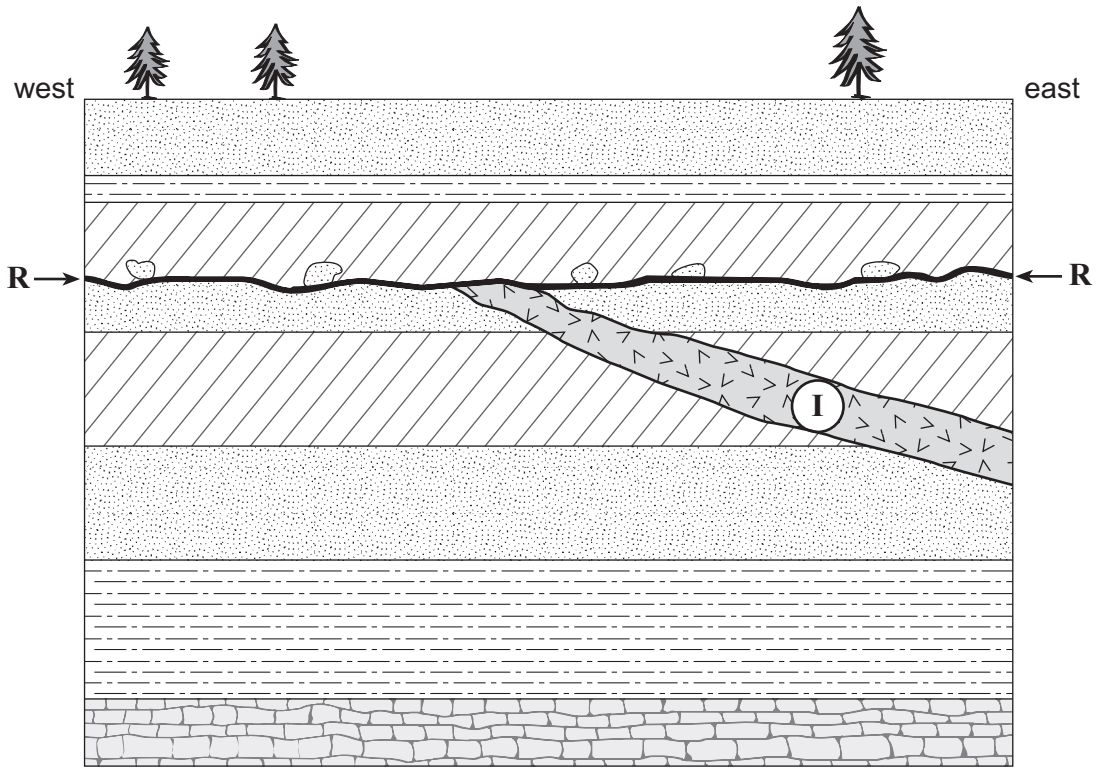
B. 

C. 

D. 

OVER

Use the following cross section to answer questions 43 and 44.



43. The structure indicated at **R** is **best** described as a(n)

A. normal fault.
B. Benioff zone.
C. unconformity.
D. transform fault.

44. Intrusion **I** is dipping at approximately

A. 20° east.
B. 70° east.
C. 20° west.
D. 70° west.

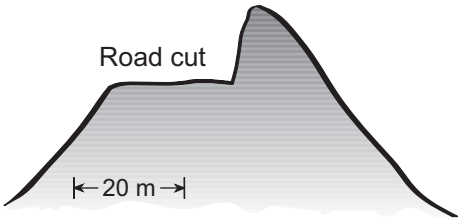
45. All of the following are examples of chemical weathering **except**

A. ice expanding in rock cracks.
B. organic material dissolving rock.
C. iron and oxygen forming iron oxide.
D. potassium feldspar changing into clay.

46. The Grand Canyon of Arizona, USA, is approximately 1.5 km (1.5 million mm) deep. Recent measurements suggest the canyon depth is increasing at a rate of 0.25 mm/yr. At this rate, how long did it take to create the canyon?

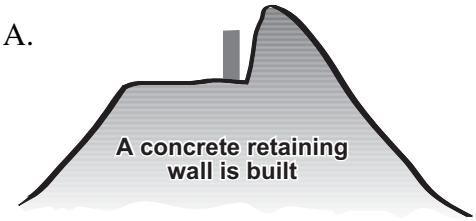
A. 6 hundred years
B. 6 thousand years
C. 6 million years
D. 6 billion years

Use the following diagram to answer question 47.

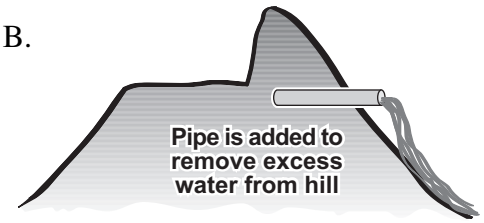


47. The diagram above shows a cross section of a road cut into a hill. Which of the following modifications would most likely **add** to problems already caused by the road cut?

A.

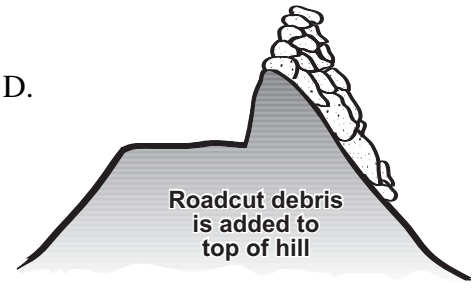


B.



C.

D.



OVER

REFERENCE DATA BOOKLET

For questions 48 and 49, refer to the following in the Data Booklet.

page vii: Photograph 10

48. Where in photograph 10 would the **greatest** stream velocity be found?

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

49. A cross section taken from **J** to **K** in the stream would **most likely** look like

A. 

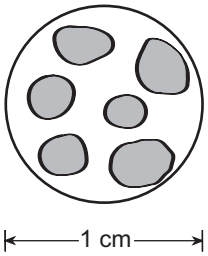
B. 

C. 

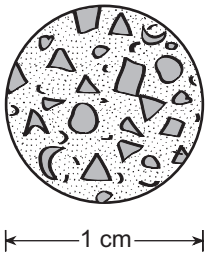
D. 

50. The diagrams below represent a variety of sediments. Which **best** represents a desert sand?

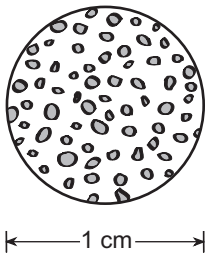
A.



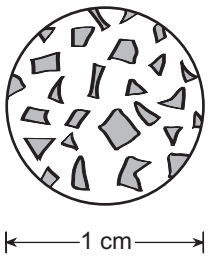
B.



C.



D.



51. All of the following result from glacial deposition **except**

A. kames.
B. erratics.
C. moraines.
D. striations.

52. Drumlins can be used to give an indication of a glacier's

A. rate of advance.
B. direction of flow.
C. time of formation.
D. duration of advance.

OVER

Use the following image of Mars to answer question 53.

NASA/National Space Science Data Center

53. Which of the following geologic processes is indicated by the branching patterns shown in the image of the Martian surface?

A. cratering
B. volcanism
C. wind erosion
D. stream erosion

REFERENCE DATA BOOKLET

For question 54, refer to the following in the Data Booklet.

page xii: Basic Data on the Solar System

54. Which of the following is **not** consistent with the Nebular Model for the origin of the solar system?

    A. Each planet rotates about its axis.
    B. The outer planets have a higher density.
    C. The planets revolve in the same direction.
    D. All planets revolve approximately in the same plane.

---

55. All of the following can be found on the earth and the moon **except**

    A. metallic cores.
    B. impact craters.
    C. basaltic plains.
    D. active volcanoes.

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. Oxygen and silicon are the two most abundant elements in the earth's crust. Support this fact using your knowledge of the abundance of common minerals and their composition. **(1 mark)**

_____

_____

_____

_____

REFERENCE DATA BOOKLET

For question 2, refer to the following in the Data Booklet.

page viii: Photograph 11

2. a) Photograph 11 shows a cut section of a **metamorphic** rock specimen. Suggest an appropriate name for this rock and its parent. **(1 mark)**

Metamorphic rock: _____

Parent rock: _____

b) Describe evidence from the photograph that suggests this rock was metamorphosed. **(1 mark)**

_____

_____

_____

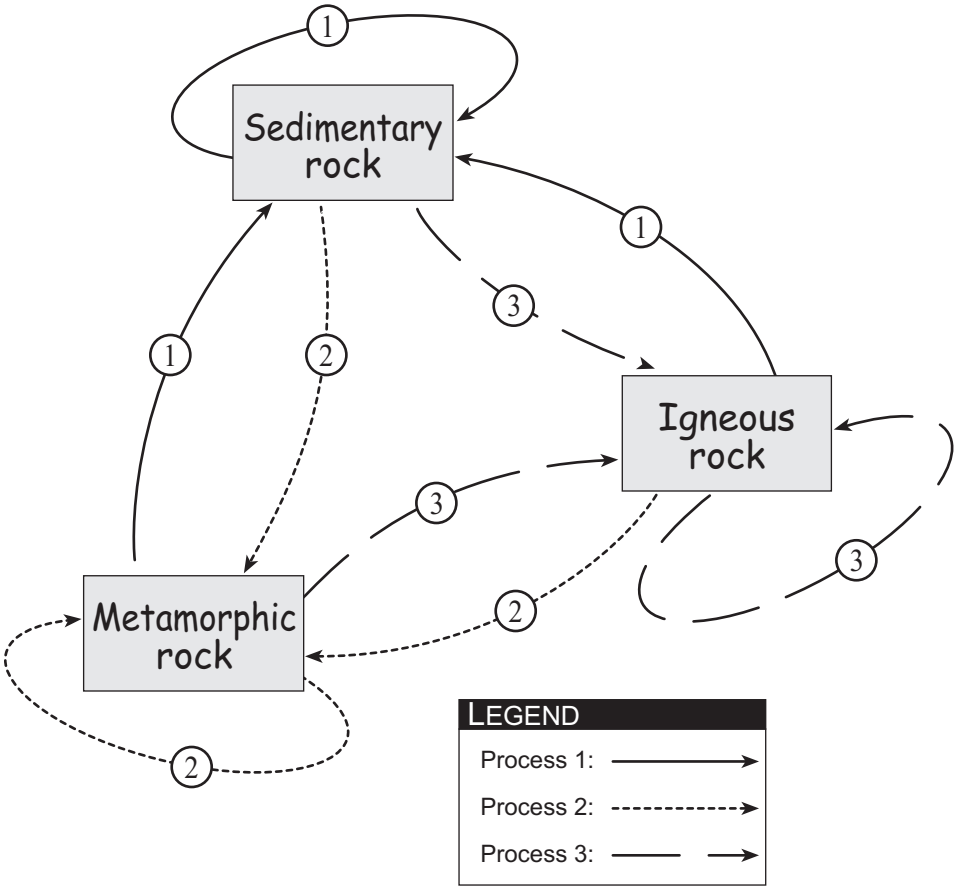
c) Describe a typical environment in which the parent rock would form. **(1 mark)**

_____

_____

_____

Use the following diagram to answer question 3.



3. The rock cycle diagram above shows the relationships among the three major rock types. The diagram is missing information which describes the processes that change one rock type into another. In the space below, provide a **complete description** for each of the three processes. **(6 marks)**

Process 1:

_____

_____

Process 2:

_____

_____

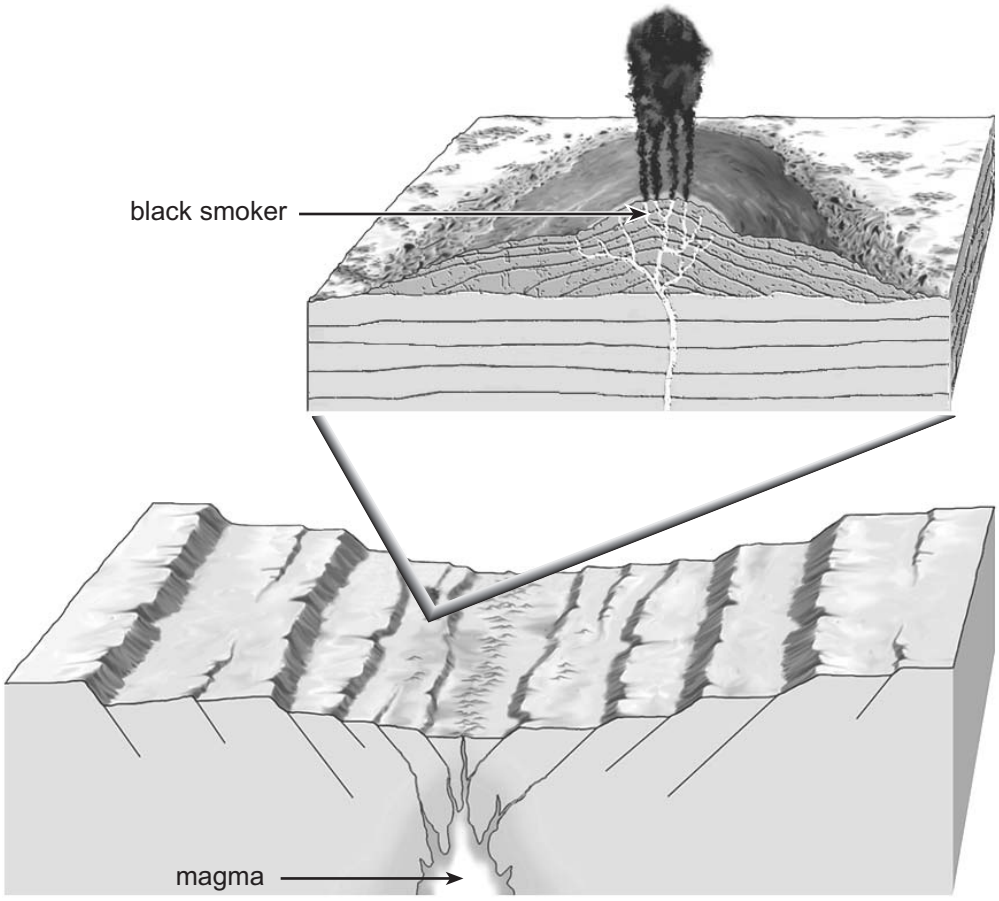
Process 3:

_____

_____

OVER

Use the following diagram of an oceanic rift and a hydrothermal vent to answer question 4.



4. The diagram shows the formation of a hydrothermal vent (black smoker) on the sea floor near an ocean rift. Hydrothermal vents are thought to be an important way of forming certain mineral ores.

   a) Name **two** metallic minerals that might be formed by a black smoker in this environment. **(1 mark)**

      i) _____

      ii) _____

   b) Describe how minerals are moved and eventually deposited in this environment. **(2 marks)**

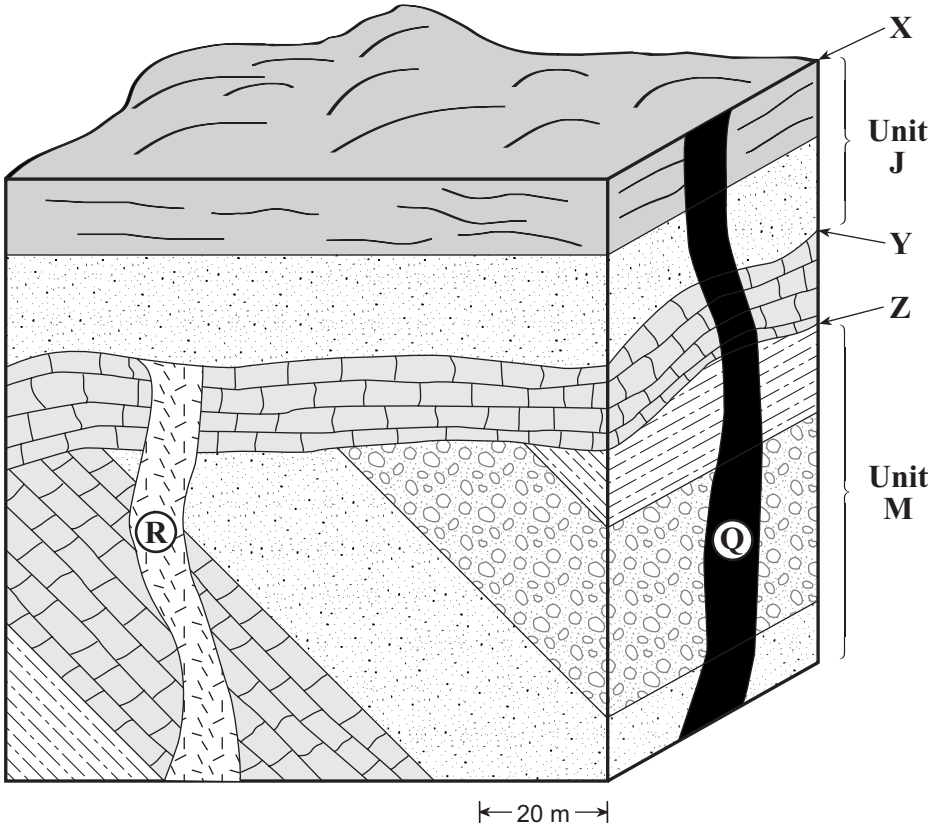
      _____

      _____

      _____

      _____

Use the following geological block diagram to answer question 5.



5. The geological block diagram shows a series of geologic events involving intrusions, tilting, deposition and erosion. In the table below, the events are not listed in chronological order. Place a number beside each event to indicate the correct order, from oldest (1) to youngest (8).

(4 marks)

Event (not in order)	**Order**
Deposition of Unit M	
Deposition of Unit J	
Erosion of Surface Y	
Erosion of Surface X	
Erosion of Surface Z	
Intrusion Q	
Intrusion R	
Tilting of Unit M	

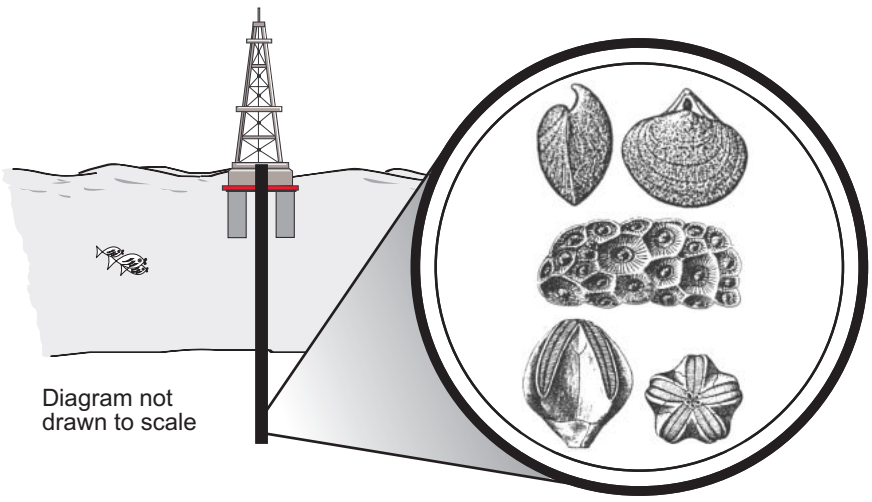
OVER

REFERENCE DATA BOOKLET

For question 6, refer to the following in the Data Booklet.

page ii: Geological Time Scale
page iii: Fossil Samples
page iv: Development of Life Through Time

6. An offshore oil rig drills through a layer of rock that contains a number of fossils, as shown in the diagram below.



a) Name and describe **one** method of preservation for one of these fossils. **(2 marks)**

Name: _____

Description: _____

_____

b) Give **two** reasons why it would be unlikely to find fossil 16 in this rock layer. **(2 marks)**

i) _____

_____

ii) _____

_____

c) What was the dominant vertebrate group at the time the rock layer was being deposited?

_____ **(1 mark)**

d) The Development of Life Through Time chart indicates that there was a dramatic change in the abundance of almost every group present at the end of the Paleozoic. Why did this change occur? **(1 mark)**

_____

_____

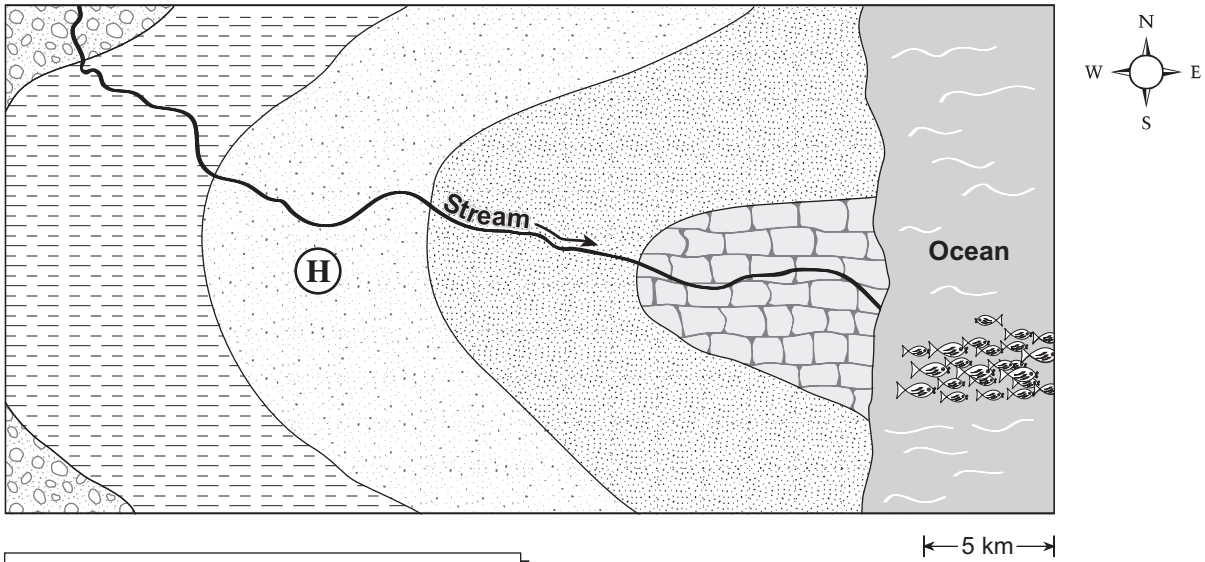
e) Although relatively abundant during the Paleozoic, jellyfish are generally poorly represented in the fossil record. Suggest a reason why. **(1 mark)**

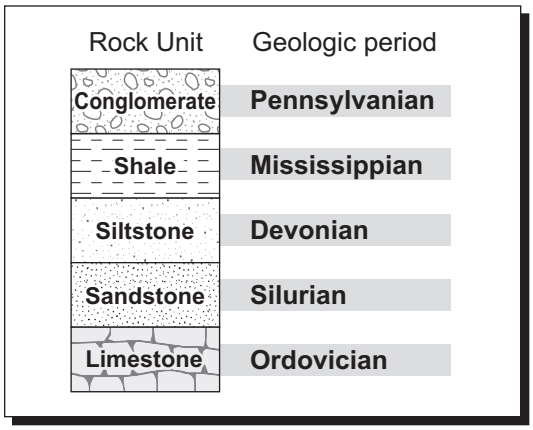
_____

_____

OVER

Use the following sketch map of a geologic structure to answer question 7.





7. The geologic structure in the sketch map is a plunging anticline. The general topography of the area is reasonably level.

   a) Give **one** piece of geological evidence shown on the map that indicates the structure is an anticline. **(1 mark)**

   _____

   _____

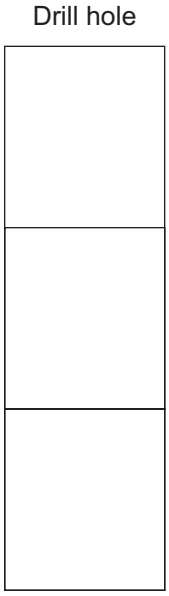
   b) Give **one** piece of geological evidence shown on the map that indicates the structure is plunging. **(1 mark)**

   _____

   _____

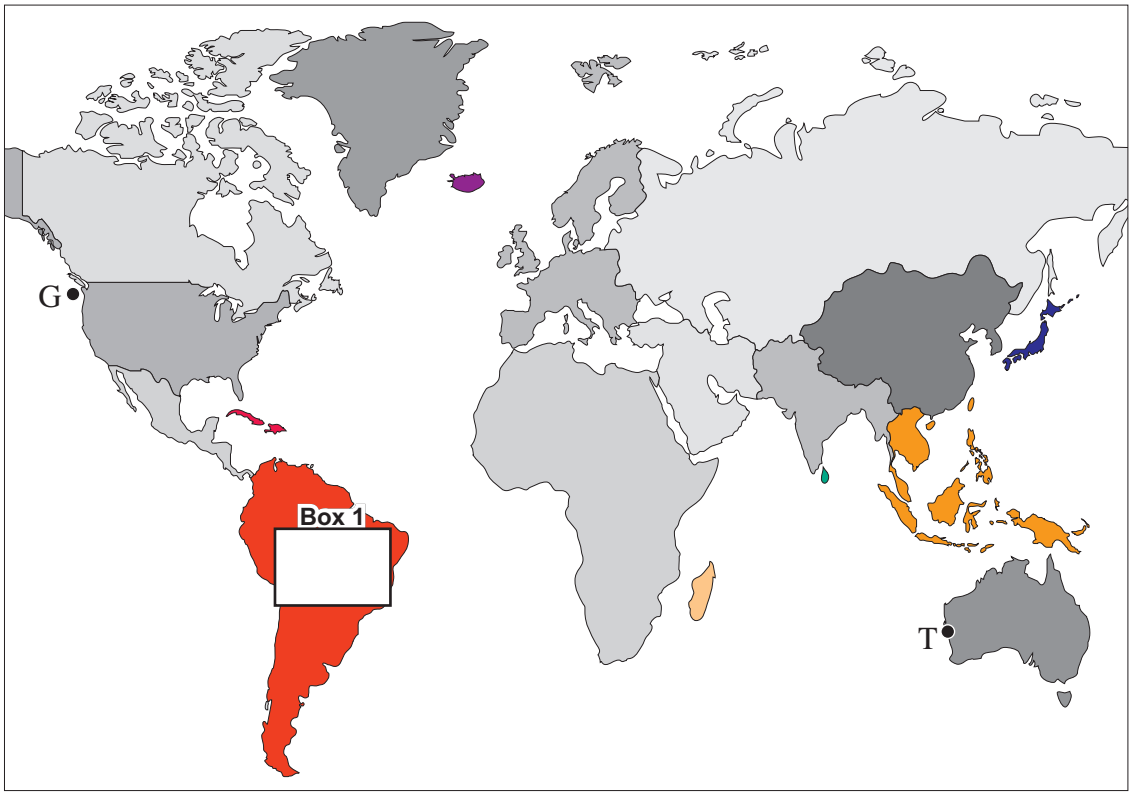
c) A vertical hole is drilled at location **H**. Complete the geologic column below by sketching the first three rock strata that would be encountered in the drill hole. Label the rock units.

(1 mark)



OVER

Use the following map to answer question 8.



8. a) A major earthquake with Richter magnitude 8.7 has occurred at location **G**. S- and L- (surface) waves were not detected at location **T**. **(2 marks)**

Why were S-waves not detected at location **T**? _____

_____

Why were L-waves not detected at location **T**? _____

_____

b) Place an arrow in **Box 1** to indicate the direction South America is moving relative to Africa. **(1 mark)**

c) Explain your choice of direction in question b). **(1 mark)**

_____

_____

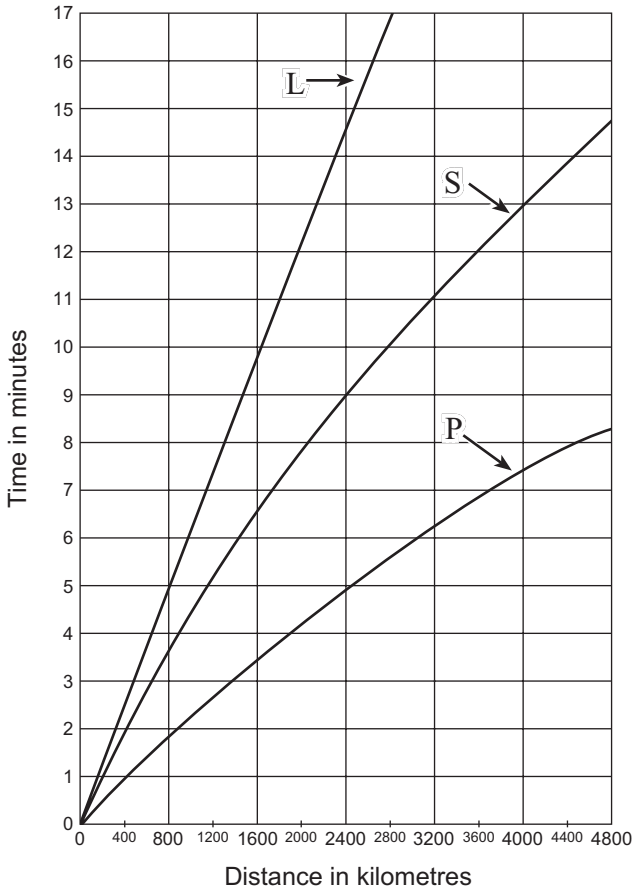
d) What type of plate boundary exists at location **G**? **(1 mark)**

_____

e) A seismograph station determines the travel time interval between the first arrival of P- and S-waves at 4 minutes. Using the travel time graph below, determine the distance to the epicentre from this station. **(1 mark)**

Distance: _____

Travel Time Graph



f) A seismograph station in Prince George (700 km from the earthquake) assigned the earthquake a Richter magnitude of 8.7. The same earthquake was assessed a low rating (II) on the Mercalli Intensity scale at Prince George. Give **one** reason why there would be such a difference between the Mercalli and Richter ratings. **(1 mark)**

_____

_____

OVER

9. Three geologically active faults are located in a tectonically active region of south-western British Columbia. Each fault has its own history of seismic activity.

Fault A has had slow continuous motion over the past 30 years. Continuous micro-seismic activity has been recorded along the fault.

Fault B has had several small earthquakes during the past 30 years.

Fault C has had no earthquakes recorded during the last 30 years. However, historical evidence suggests that a large earthquake happened on this fault 150 years ago.

a) What is the name given to the type of fault motion shown by fault **A**? **(1 mark)**

_____

b) Which fault is **most likely** to produce a large, damaging earthquake at some time in the future? Check (✓) one.

Fault A: ❒ Fault B: ❒ Fault C: ❒

With reference to all three faults, use geological principles to explain your answer. **(2 marks)**

_____

_____

_____

_____

REFERENCE DATA BOOKLET

For question 10, refer to the following in the Data Booklet.

page viii: Photograph 12

10. a) What is the name for the glacial feature labelled **X** in photograph 12? **(1 mark)**

_____

b) Briefly describe how the feature was formed. **(1 mark)**

_____

_____

11. In the spaces provided below, describe how human activities affect both the quality and quantity of groundwater. An example is provided. Point form answers are acceptable. **(4 marks)**

Human activity	Effect on groundwater quantity	Effect on groundwater quality
Example: *Septic tank fields*	***Example:*** *Large amounts of waste water are introduced into the ground.*	***Example:*** *Groundwater is contaminated by bacteria.*
1. Urbanization		
2. Agriculture		

12. The moon has a more highly-cratered surface than the earth. Give **two** reasons for this difference. **(2 marks)**

i) _____

_____

ii) _____

_____

END OF EXAMINATION

DATA BOOKLET

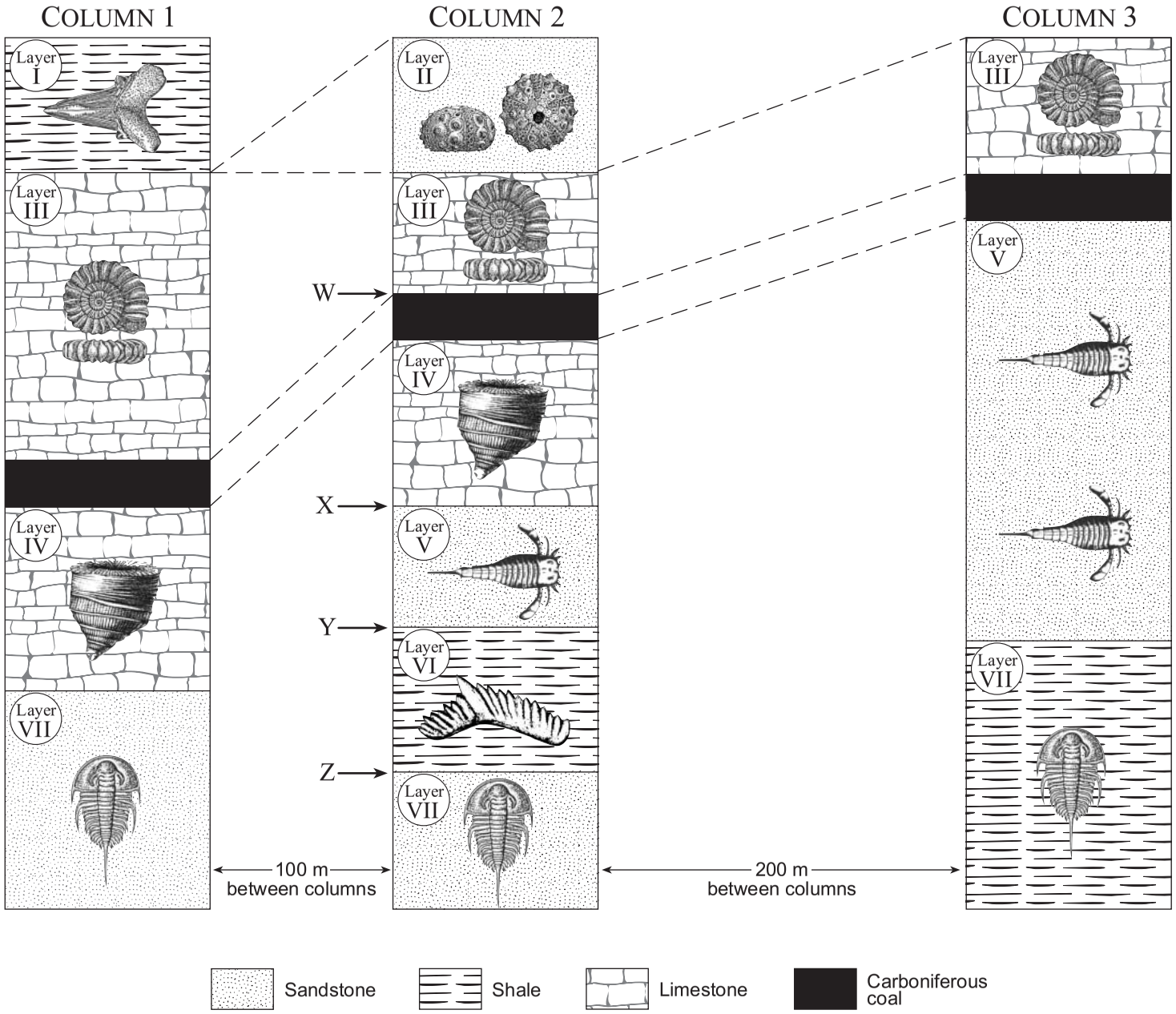
Geology 12

June 2001

Acknowledgements for Photographs

Photographs 1–12
J.L.M. Visuals

GEOLOGIC COLUMNS



GEOLOGICAL TIME SCALE

ERA	PERIOD		EPOCH	TIME (m.y.)
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				4000*

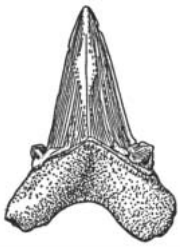
Based on Hamblin, *The Earth's Dynamic Systems*, 1982. Dates from Montgomery, *Physical Geology,* 1987.
It is recognized that there is some variation in the dates given in the literature.
*Approximate age of the oldest rocks.

COMMON ISOTOPE PAIRS CHART

Isotope		**Half-life of Parent (years)**	**Effective Dating Range (years)**
Parent	*Daughter*		
Uranium 238	Lead 206	4.5 billion	10 million to 4.6 billion
Rubidium 87	Strontium 87	48.8 billion	10 million to 4.6 billion
Potassium 40	Argon 40	1.3 billion	10 000 to 4.6 billion
Carbon 14	Nitrogen 14	5 730	< 100 000

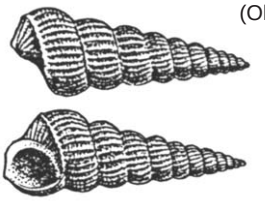
FOSSIL SAMPLES

1 Tertiary (Eocene)



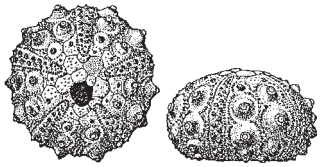
× ½ Magnification

2 Tertiary (Oligocene)



× 1 Magnification

3 Jurassic

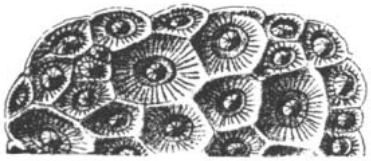


× ¼ Magnification

4 Triassic

× ½

5 Mississippian

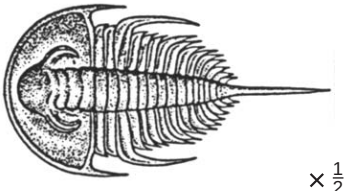


× ½

6 Mississippian to Permian

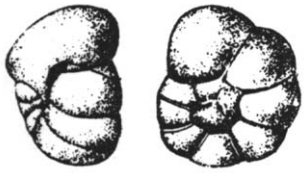
× ½

7 Cambrian



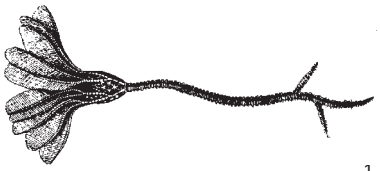
× ½

8 Cretaceous to Holocene



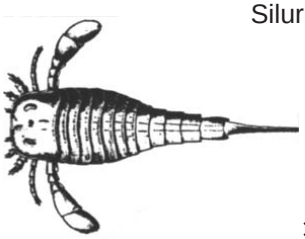
apertural ventral × 45

9 Mississippian



× ¼

10 Silurian

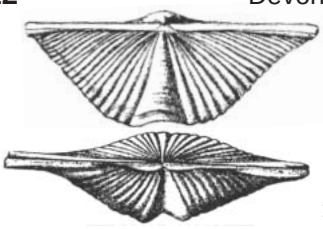


× ¼

11 Ordovician

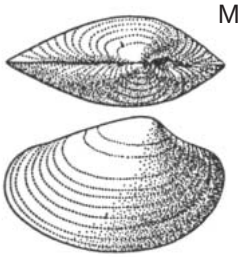
× ½

12 Devonian



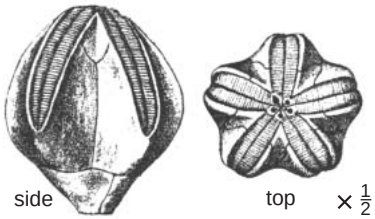
× ½

13 Miocene



× ½

14 Mississippian



side top × ½

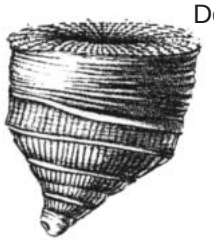
15 Ordovician to Devonian

× 25

16 Pennsylvanian

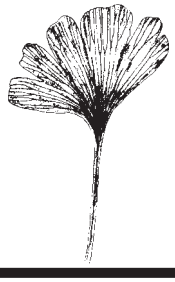
× ½

17 Devonian



× 1

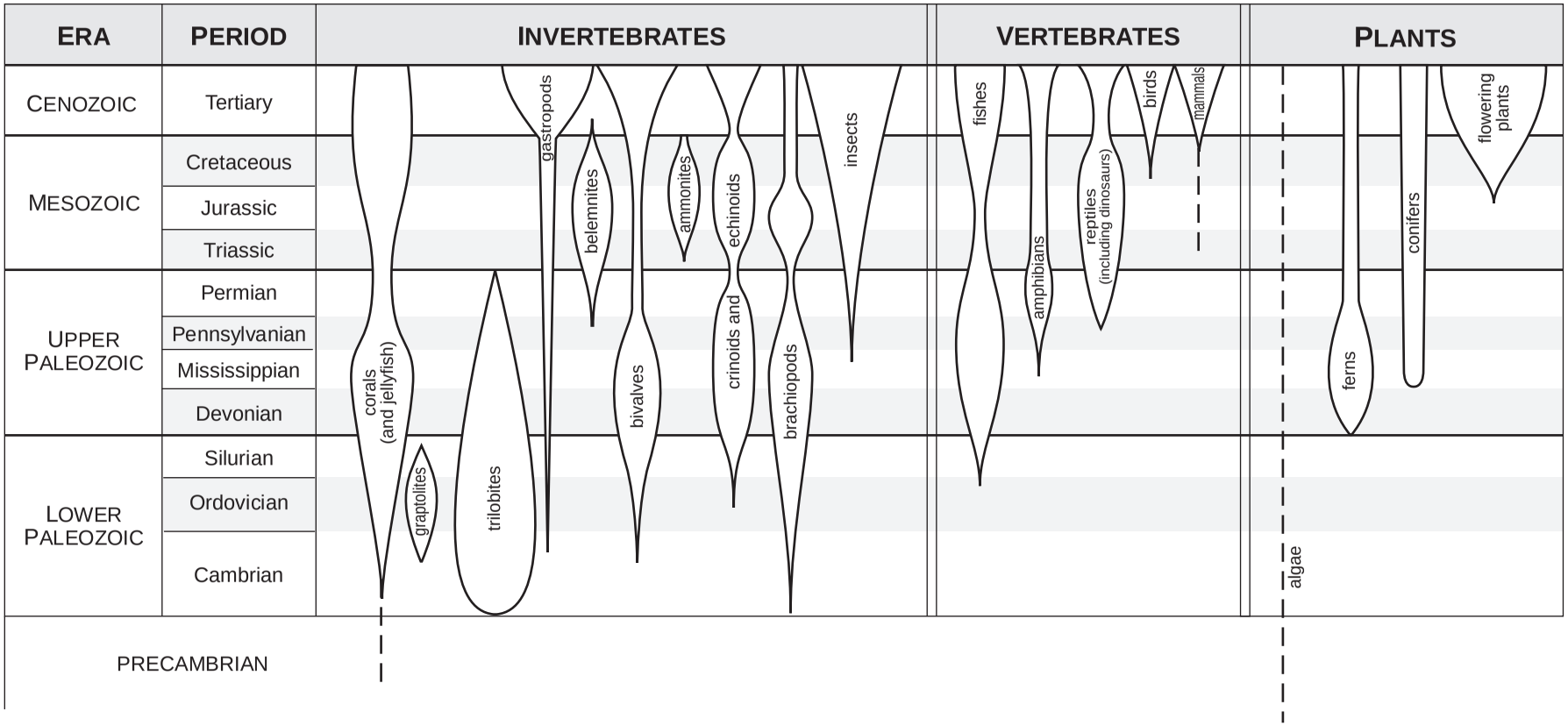
18 Jurassic to Quaternary



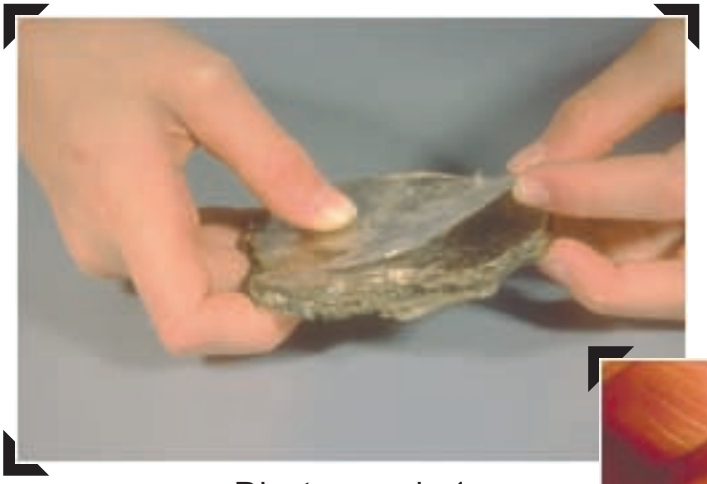
× ½

DEVELOPMENT OF LIFE THROUGH TIME

The life-span of each group is shown. The relative abundance of each group is shown by the thickness of the column.



PHOTOGRAPHS



Photograph 1

Photograph 2

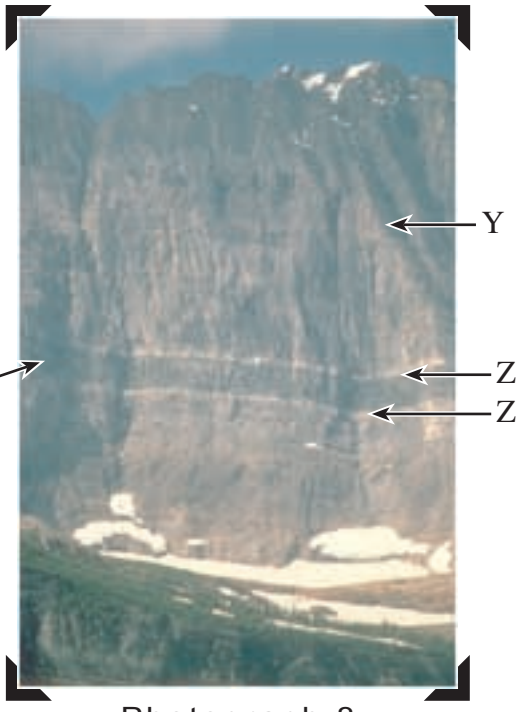
Photograph 3

Photograph 4

Photograph 5

Photograph 6

Photograph 7



Photograph 8

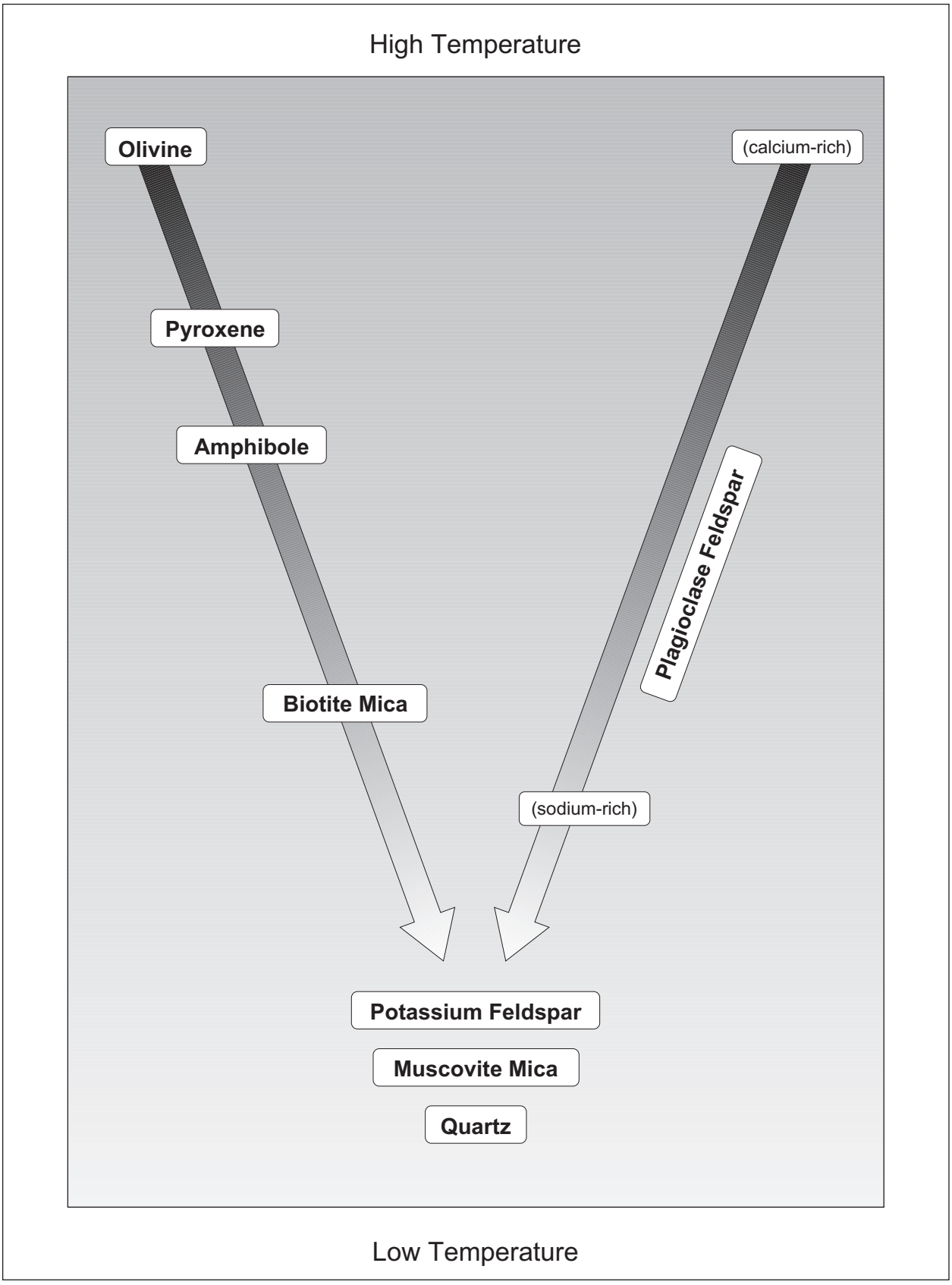
Photograph 9

Photograph 10

Photograph 11

Photograph 12

BOWEN'S REACTION SERIES



PERCENTAGE OF MINERALS IN IGNEOUS ROCKS

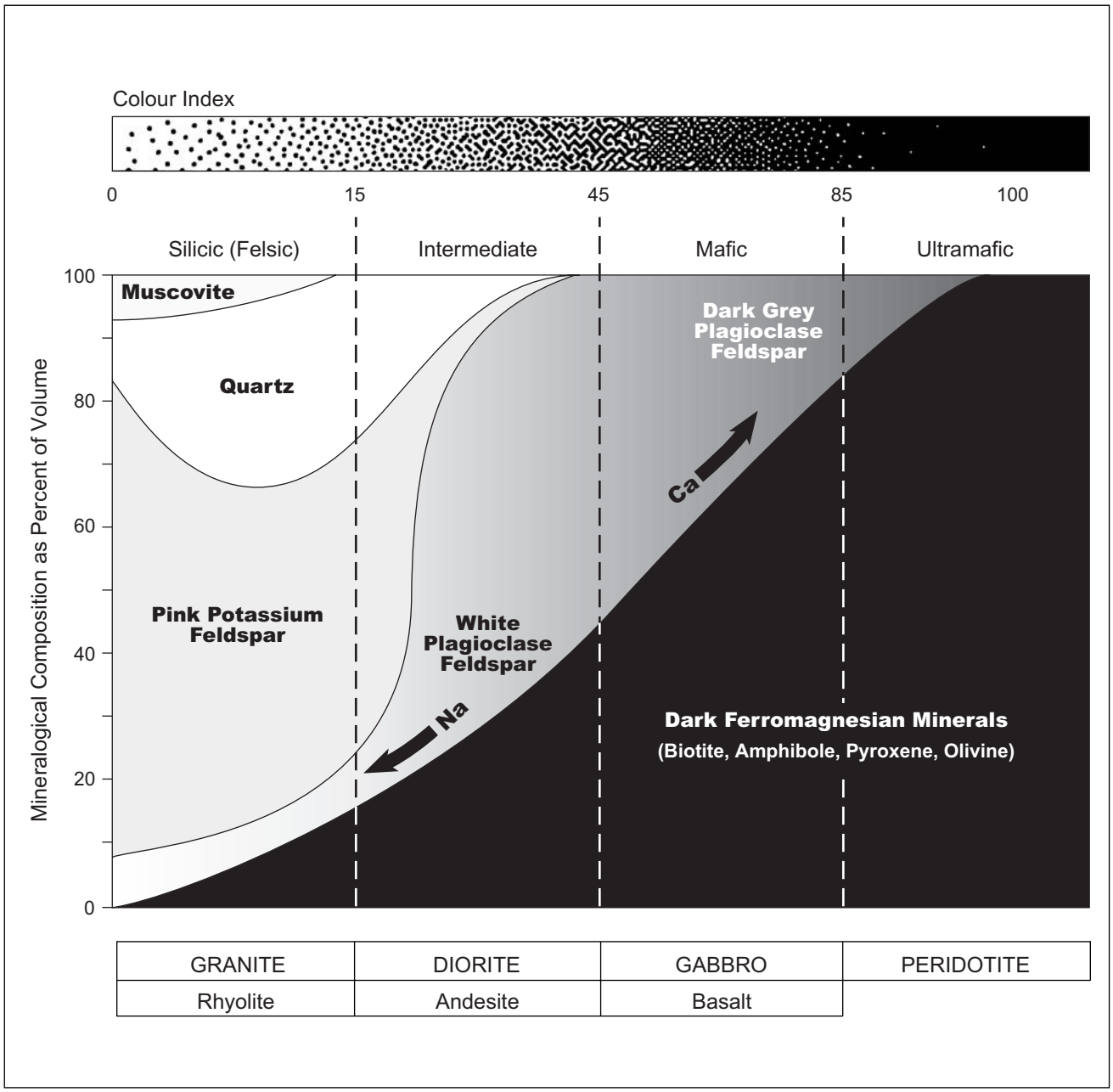


TABLE OF HARDNESS

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

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
Garnet	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

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.