Geology 12

June 2004 Provincial Examination

ANSWER KEY / SCORING GUIDE

Topics:
1. Earth Materials
2. Time and Fossil Record
3. Internal Structures and Processes
4. Surficial Processes
5. Comparative Planetology

Part A: Multiple Choice

Q	K	C	S	CO	PLO	Q	K	C	S	CO	PLO
1.	B	U	1	1	A7; M1	29.	C	U	1	3	K3, 7
2.	B	U	1	1	B1, 3	30.	D	U	1	3	L5; O3
3.	C	U	1	1	B2	31.	D	U	1	3	L2, 3, 5
4.	C	U	1	1	B3; C4; D3; E2	32.	A	U	1	3	L5
5.	D	H	1	1	C3	33.	C	U	1	3	K3, 7; O3
6.	D	U	1	1	C1, 2, 3, 8	34.	D	U	1	3	L1
7.	B	U	1	1	C5	35.	C	H	1	3	K7; L5
8.	A	H	1	1	C3, 4	36.	B	U	1	3	K5, 7
9.	C	H	1	1	C6, 8; E5	37.	A	U	1	3	K3, 4, 7
10.	D	U	1	1	D3	38.	B	U	1	3	L5, 2
11.	D	U	1	1	D4	39.	A	K	1	3	M1
12.	A	U	1	1	D1, 4	40.	D	H	1	3	N1, 2, 3
13.	D	U	1	1	E2	41.	C	U	1	3	N1, 3
14.	C	U	1	1	E1, 3	42.	B	U	1	3	O7
15.	D	U	1	1	E5; F1	43.	B	H	1	3	O6, 7, 9
16.	A	U	1	1	F1, 6	44.	A	K	1	3	O2; C6
17.	C	K	1	1	E4, 5; F7	45.	C	H	1	4	P3
18.	B	U	1	2	G3	46.	C	K	1	4	P4
19.	B	U	1	2	G4	47.	B	U	1	4	P1
20.	C	U	1	2	H1	48.	A	U	1	4	Q1
21.	D	U	1	2	H2	49.	A	U	1	4	Q3
22.	B	U	1	2	I1	50.	C	U	1	4	S2
23.	C	U	1	2	I2	51.	C	U	1	4	S1, 2
24.	A	U	1	2	J1	52.	A	H	1	4	P2
25.	C	K	1	2	J2	53.	D	U	1	5	T3
26.	D	U	1	2	J7	54.	B	U	1	5	T2
27.	C	K	1	2	J5	55.	A	H	1	5	T3
28.	C	U	1	2	J3						

Multiple Choice = 55 marks

Part B: Written Response

Q	B	C	T	S	PLO
1.	1	U	1	2	A3, 4, 5
2.	2	U	1	6	C2, 3, 4, 6, 7
3.	3	U	1	2	D1
4.	4	U	1	2	B2, 3
5.	5	U	1	2	F3
6.	6	U	2	4	J3, 4, 5, 6
7.	7	U	2	4	G2, 5; H4
8.	8	U	3	6	K1, 2, 7; A7
9.	9	H	3	4	O6, 9, 10
10.	10	U	3	4	L4
11.	11	H	4	2	S1, 4
12.	12	U	4	5	R1
13.	13	U	5	2	T1, 2

Written Response = 45 marks

Multiple Choice = 55 (55 questions)
Written Response = 45 (13 questions)
EXAMINATION TOTAL = 100 marks

LEGEND:

Q = Question Number **K** = Keyed Response **C** = Cognitive Level
B = Score Box Number **S** = Score **T** = Topic
PLO = Prescribed Learning Outcome

PART B: WRITTEN RESPONSE

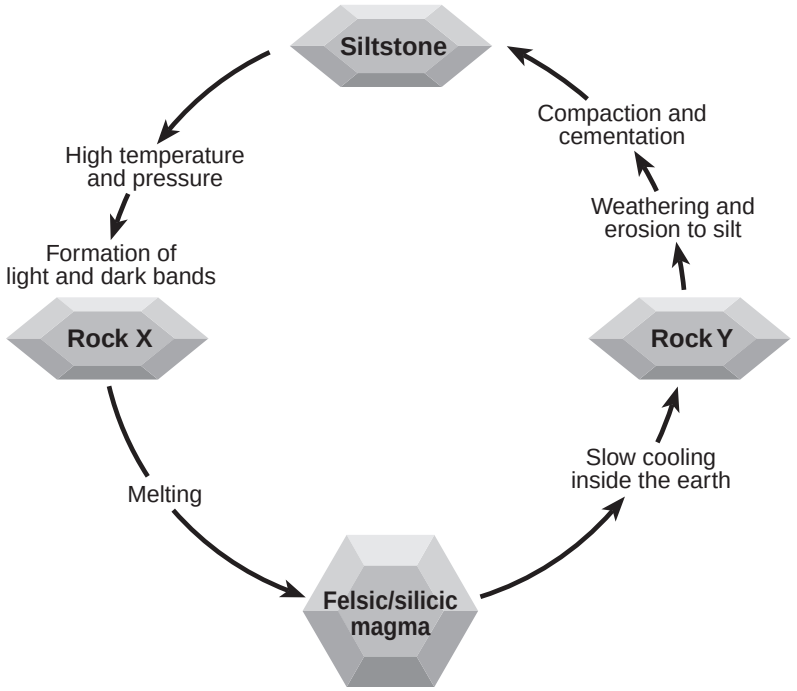
Value: 45 marks **Suggested Time: 55 minutes**

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

REFERENCE DATA BOOKLET

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

page 10: Percentage of Minerals in Igneous Rocks



1. a) What type of rocks are rocks **X** and **Y** shown in the diagram above? **(1 mark)**

Rock X: **gneiss/schist** ← **½ mark**
OR
metamorphic or recrystallized

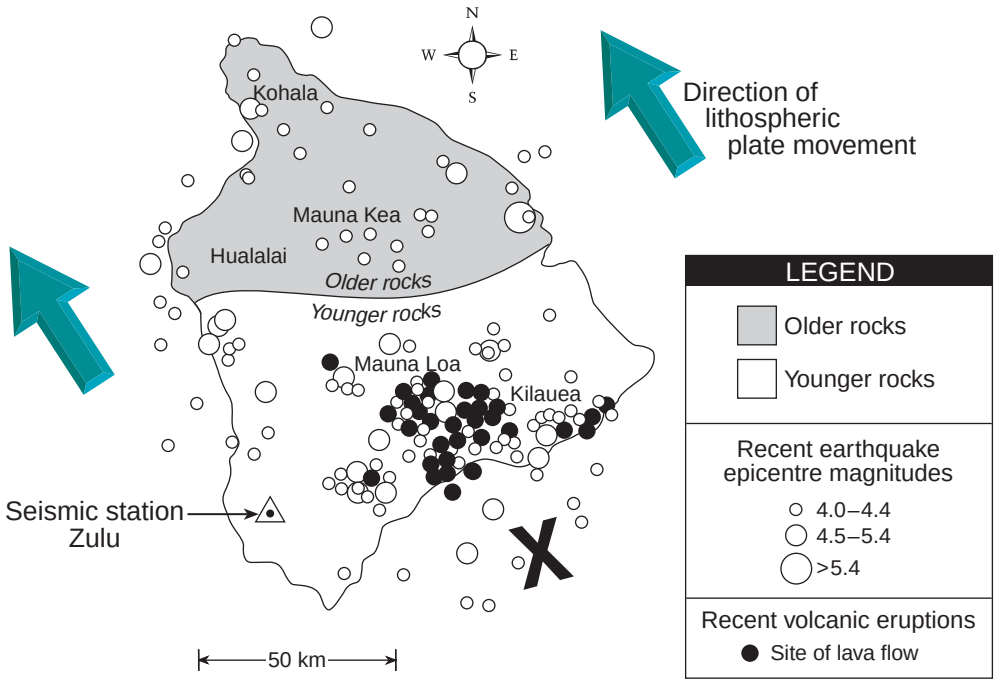
Rock Y: **granite/diorite/syenite** ← **½ mark**
OR
igneous, plutonic, intrusive

b) Describe a plate tectonic situation that would cause the high-grade metamorphism of the siltstone. **(1 mark)**

Any **one** for **1 mark:**

- **Large scale metamorphism, characteristic of mountain building.**
- **Deep burial, as in accretionary prism.**
- **Tectonic settings, i.e. converging boundaries, subduction zones.**

Use the following map to answer question 2.



2. The map above shows the island of Hawaii, and the locations of several recent volcanic eruptions which are building shield volcanoes. The island is over a hot spot.

   a) What is the **likely** composition of the lava from these eruptions? **(1 mark)**

mafic, or basaltic, or 60% dark ferromagnesians, 40% plagioclase ← **1 mark**

b) Explain why a pyroclastic flow (nuée ardente) is **unlikely** in this area. **(1 mark)**

Any **one** for **1 mark:**

- **The mafic lava is thin (has low viscosity) and unlikely to trap the large amounts of gas associated with pyroclastic eruptions.**
- **gas was able to escape**
- **low viscosity/thin lava/low silica**

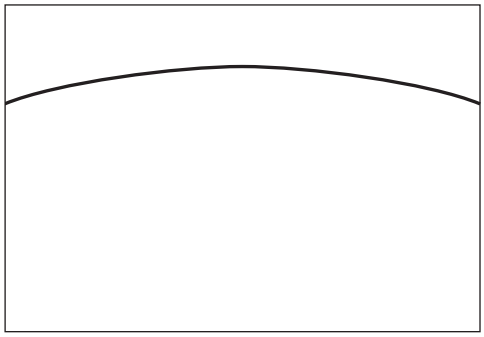
$\frac{1}{2}$ mark for "nuée ardentes occur with composite volcanoes"

c) Place an **X** on the map in an area where you would expect the volcanic activity to increase over the next several hundred years. **(1 mark)**

See diagram. X can be anywhere to the southeast of Kilauea. ← **1 mark**

d) Sketch **and** describe the likely cross-sectional shape of the shield volcanoes in this area of Hawaii. **(2 marks)**

Sketch



Description

Shield volcanoes: shallow-sloped, extremely wide volcanoes.

REFERENCE DATA BOOKLET

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

page 10: Percentage of Minerals in Igneous Rocks
page 12: Bowen's Reaction Series

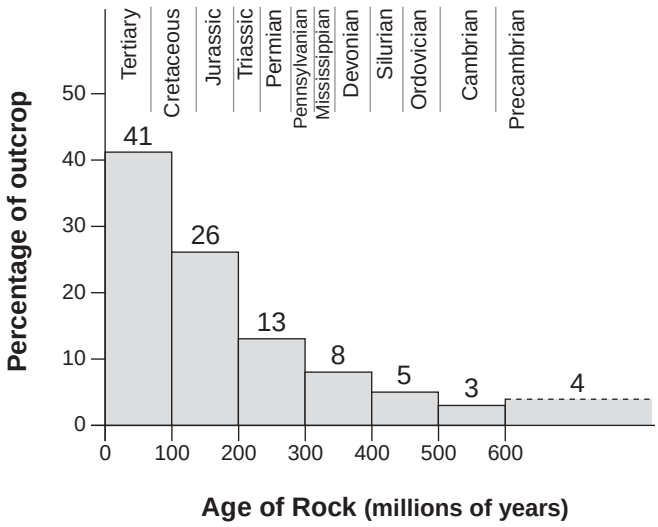
e) A sample of coarse-grained rock was collected from a Kilauea lava flow, and geologists think it is an ultramafic xenolith brought up from the mantle. The rock has the following mineral composition.

Mineral	Percent by volume
plagioclase feldspar	5%
pyroxene	70%
olivine	25%

How can geologists tell that the material in the xenolith must have formed at a temperature above 1000° C? **(1 mark)**

Bowen's Reaction Series shows the materials found in the xenolith crystallize above 1000° C, i.e.: pyroxene, olivine, plagioclase feldspar. } **← 1 mark**

Use the following graph to answer question 3.



3. The graph shows the relationship between the age of sedimentary rocks compared to the amount of outcrop, or area, they cover on the Earth's surface. Give two reasons why **only** 20% of the sedimentary rocks visible today are older than 300 million years. **(2 marks)**

Any **two** for **1 mark each:**

- **All the extremely old sedimentary rocks have been eroded.**
- **The sedimentary rocks have changed through metamorphism.**
- **The sedimentary rocks have been remelted at subduction zones.**
- **Older layers are buried/are covered by sediments.**
- **Rocks are recycled – only acceptable with buried idea as other answer.**

REFERENCE DATA BOOKLET

For question 4, refer to the following in the Data Booklet.
page 11: Properties of Common and Important Minerals

4. Describe **two** properties that would help distinguish between chalcopyrite and pyrite. **(2 marks)**

Any **two** for **1 mark each:**

Property	Description for chalcopyrite	Description for pyrite
Property 1:	**hardness between 3.5–4**	**hardness between 6–6.5**
Property 2:	**has a golden-brassy yellow colour**	**has a brassy yellow colour**
Property 3:	**tetrahedral crystals**	**cubic crystals**
Property 4:	**has a specific gravity of 4.2**	**has a specific gravity of 5.0**
Property 5:	**black streak**	**greenish black streak**

5. Name a resource found in British Columbia that has resulted from glacier or river processes. Give a specific use for that resource. **(2 marks)**

Any **one** resource for **1 mark;** any **one** use for **1 mark:**

Resource	Use
sand	**• cement** **• road construction** **• pre-loading for foundations**
gravel	**• concrete** **• construction**
placer deposits **(Au, Pt, Cr, diamonds, etc)**	**• jewellery** **• electronics** **• art**
glacial till	**• earth fill** **• dam construction**
silt and clay	**• pottery** **• bricks** **• impermeable base for landfill sites or ponds**
water	**• agriculture** **• power** **• sanitation** **• drinking**

REFERENCE DATA BOOKLET

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

page 6: Photograph 6
page 8: Geological Time Scale
page 9: Fossil Samples
page 13: Development of Life Through Time

6. A local farmer presents you with a fossil that looks like the specimen shown in Photograph 6.

a) Give the fossil name or phylum for this fossil. **(1 mark)**

trilobite/arthropod ← 1 mark

b) State a probable geological period for this fossil. **(1 mark)**

Cambrian through Permian ← 1 mark
OR
Paleozoic ← $\frac{1}{2}$ mark

c) Describe the environment in which this organism **likely** lived. **(1 mark)**

Either **one** for **1 mark:**

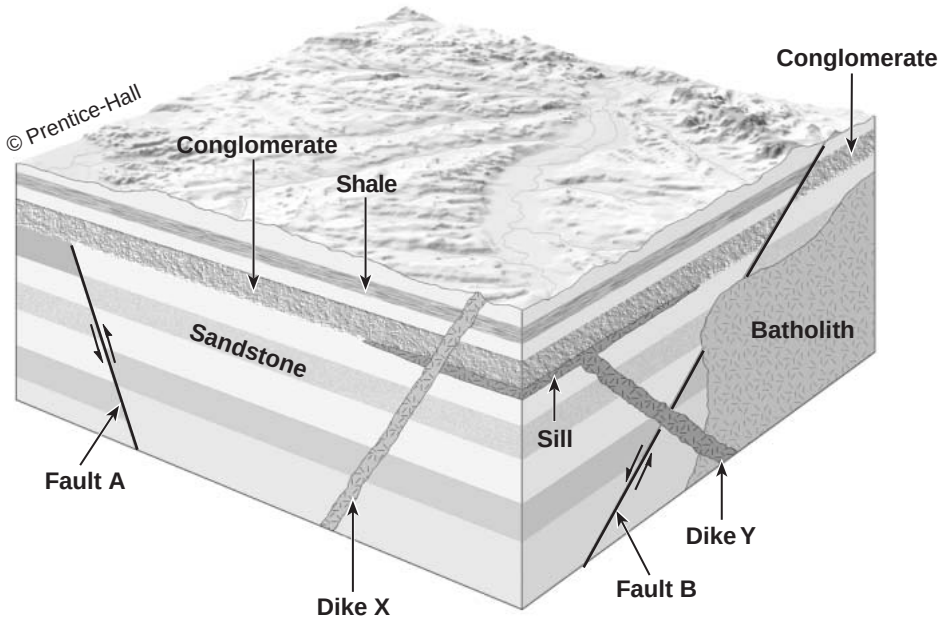
- **ocean floor**
- **shallow marine**

d) Describe a characteristic of the organism or its environment that would improve its chances of being fossilized. **(1 mark)**

Any **one** for **1 mark:**

- **hard parts**
- **multiple molts**
- **lived in a low-energy environment**
- **rapid sedimentation**
- **low oxygen environment**

Use the following block diagram showing several geological structures to answer question 7.



7. a) What principle allows you to determine the relative ages of the shale and the conglomerate? **(1 mark)**

superposition ← **1 mark**

b) Which is older, the conglomerate or the batholith? Explain your reasoning. **(2 marks)**

The conglomerate is older.
The fault cuts the conglomerate; the batholith cuts the fault, therefore the batholith is younger.

} ← **2 marks**

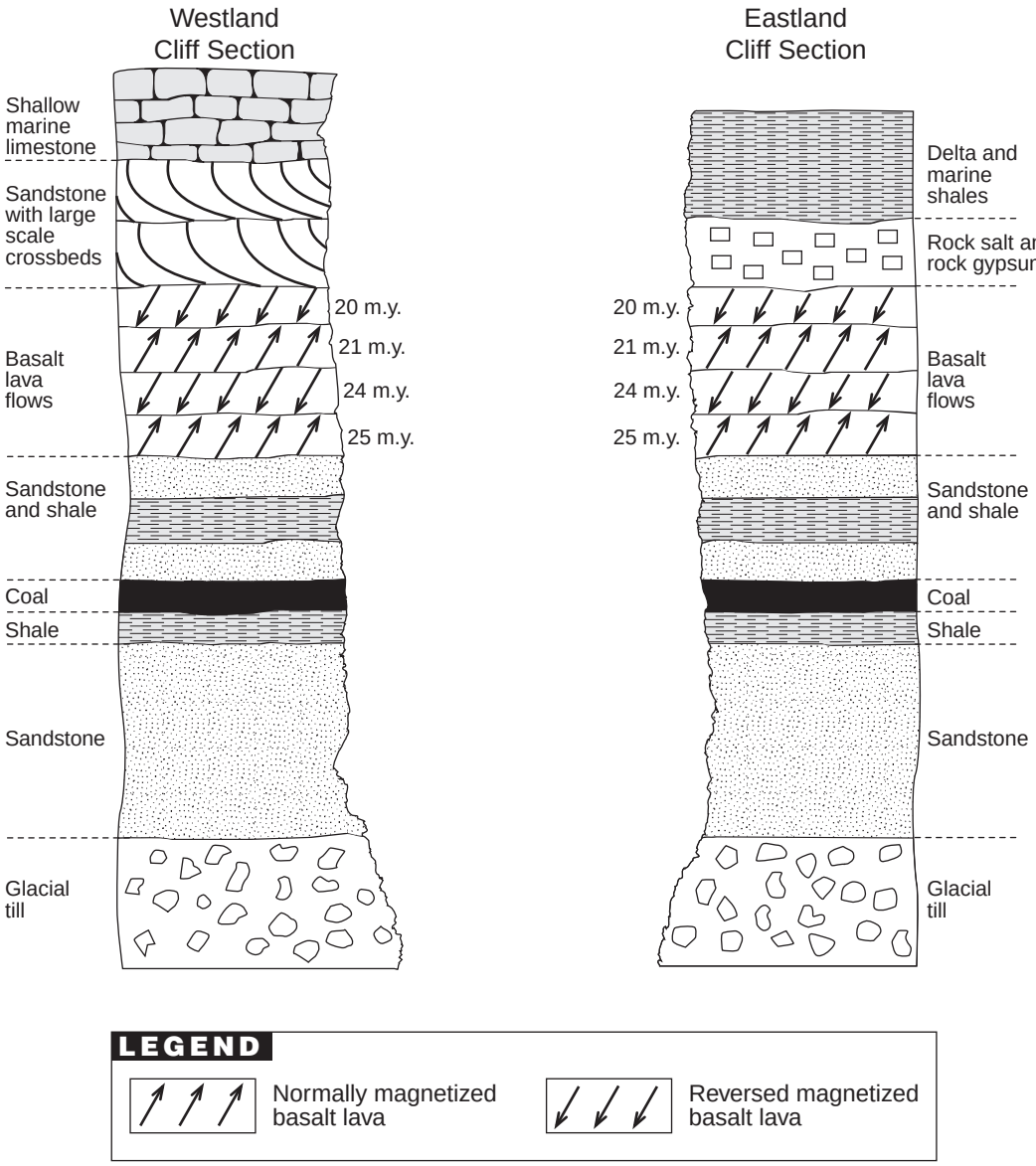
c) The following radiometric ages have been determined.

Dike X: 20 million years
Dike Y: 60 million years
Batholith: 100 million years

Give a possible age for fault **B**. **(1 mark)**

The age is greater than 100 million years. ← **1 mark**

Use the following diagram of two cliff sections, Westland and Eastland, to answer question 8.



8. The two cliff sections, Westland and Eastland, were discovered on different continents separated by an ocean. From evidence in the cliff sections, a geologist concludes that the two continents were joined together at one time and have since drifted apart.

   a) Describe **two** different types of evidence that can be seen in the Westland and Eastland cliff sections which indicate that the continents were joined at one time. **(2 marks)**

Any **two** for **1 mark each:**

- **Various individual identical rock units match with each other across the ocean, i.e. the glacial till.**
- **The pattern of rock layers matches.**
- **The ages of the layers of volcanic lava match.**
- **The pattern of magnetic reversals matches.**
- **Rock units correlate well.**

b) Describe a different piece of evidence **not** present in the cliff sections that a geologist could look for which would indicate that the continents were joined at one time. **(1 mark)**

Any **one** for **1 mark:**

- **Identical fossils on either continent.**
- **Truncated structures which match (i.e. mountain belts, mineral belts, rock structures, faults, folding).**
- **Jigsaw fit of continental shelves or coastlines.**

c) The geologist believes that the continents started drifting apart approximately 20 million years ago. Describe, in detail, the evidence visible in the cliff sections that would support the timing of the continental separation. **(1 mark)**

The cliff sections are almost identical until the top of the lava flows where the rock layers are quite different. The top lava layer is 20 m.y. old and thus the continents would have separated about 20 m.y. ago. ← **1 mark**

d) The ocean is now 400 km wide. If the continents started drifting apart 20 million years ago, at what rate (in centimetres per year) have the continents been separating?
N.B. 1 kilometre = 100 000 cm. **(2 marks)**

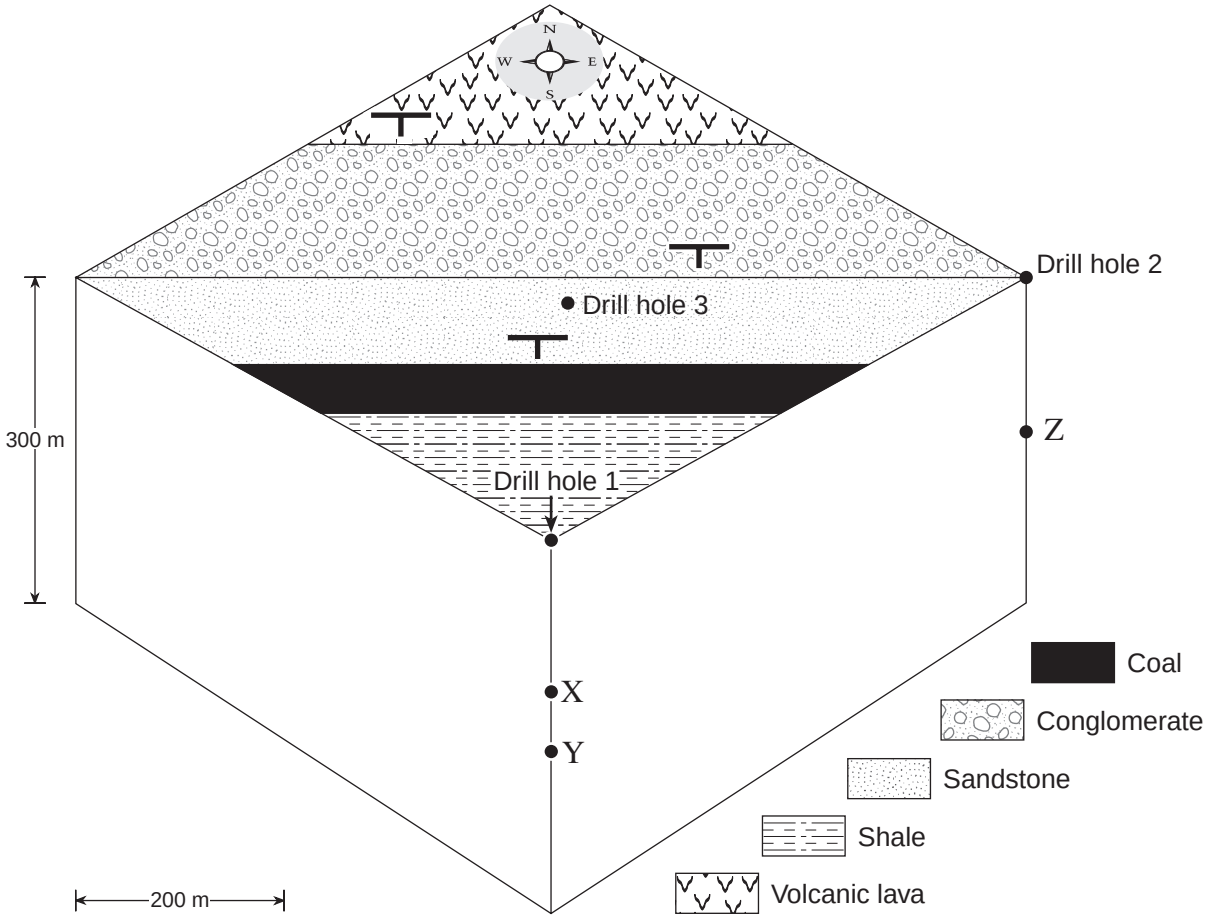
Show all your calculations.

Rate of separation of the continents = distance/time
Rate = 400 km × 100 000 cm/km ÷ 20 000 000 years
Rate = 2 cm per year
← **2 marks**

Note: Students may do a calculation for the rate of movement of one continent from the central ridge. This would be acceptable.

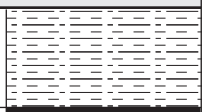
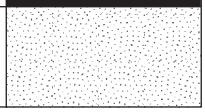
Rate of movement of one continent = distance/time
Rate = 200 km × 100 000 cm/km ÷ 20 000 000 years
Rate = 1 cm per year
← **2 marks**

Use the following block diagram to answer question 9.

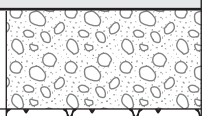


9. The area shown in the top of the block diagram has been mapped by a geologist. In order to find out more information about the geological structures and the coal seam, two holes, drill hole 1 and drill hole 2, were also drilled to a depth of 300 metres. Information obtained from the drill holes is shown below and important contacts have been marked on the block diagram.

Drill Hole 1

Description	Depth in metres	Rock Type	
surface to contact location X	0 150	shale	
contact location X to contact location Y	150 200	coal	
contact location Y to bottom of drill hole	200 300	sandstone	

Drill Hole 2

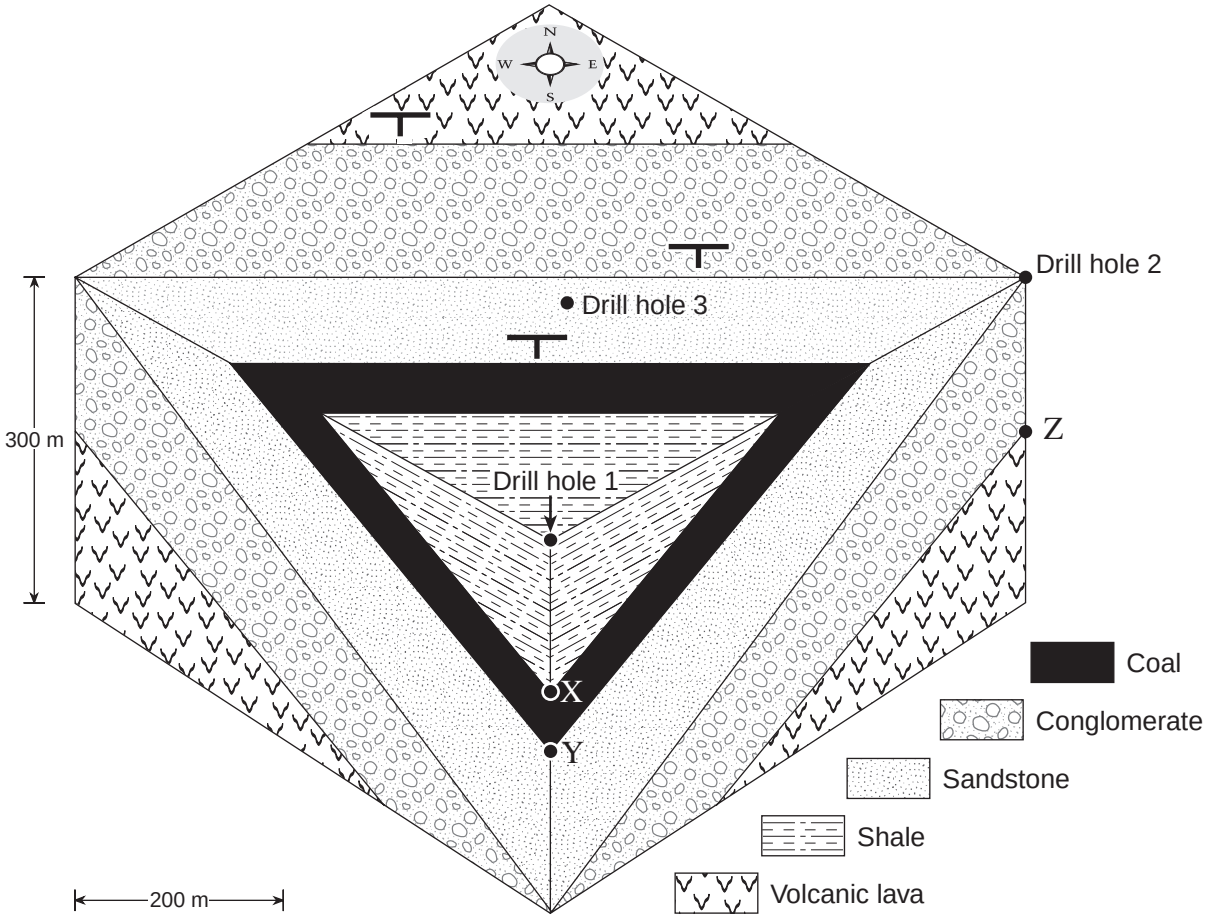
Description	Depth in metres	Rock Type	
surface to contact location Z	0 175	conglomerate	
contact location Z to bottom of drill hole	175 300	volcanic lava	

a) What is the strike direction and dip direction of the rock layers? **(1 mark)**

Strike direction: **west or east** ← **$\frac{1}{2}$ mark**

Dip direction: **south** ← **$\frac{1}{2}$ mark**

b) Using information from the block diagram and the drill holes, complete the two faces (cross sections) of the block diagram, showing the contacts between rock layers. Identify the layers using the patterns in the map legend. Marks will be awarded for completeness and accuracy. **(2 marks)**



Accurate completion of vertical faces – correct number of beds, correct angle of dip and constant thickness of layers. } ← **2 marks**

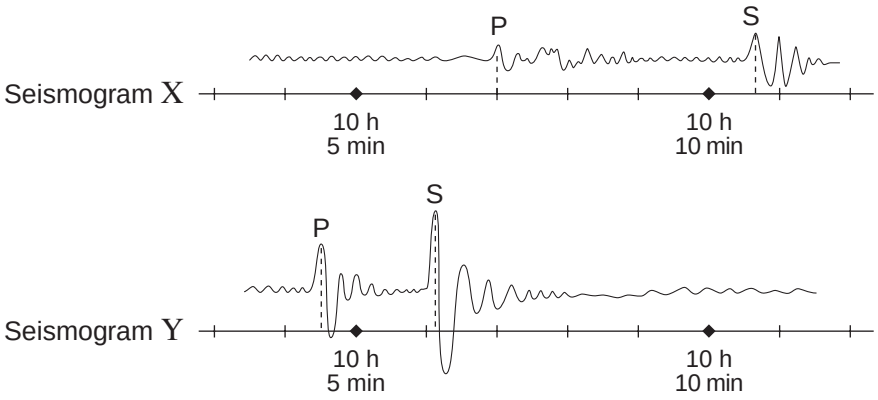
Other acceptable cross-sections would be showing curve of non-plunging anticline or syncline.

c) List, from top to bottom, the three rock layers that would **likely** be encountered if a hole 400 metres deep was drilled at drill hole 3. **(1 mark)**

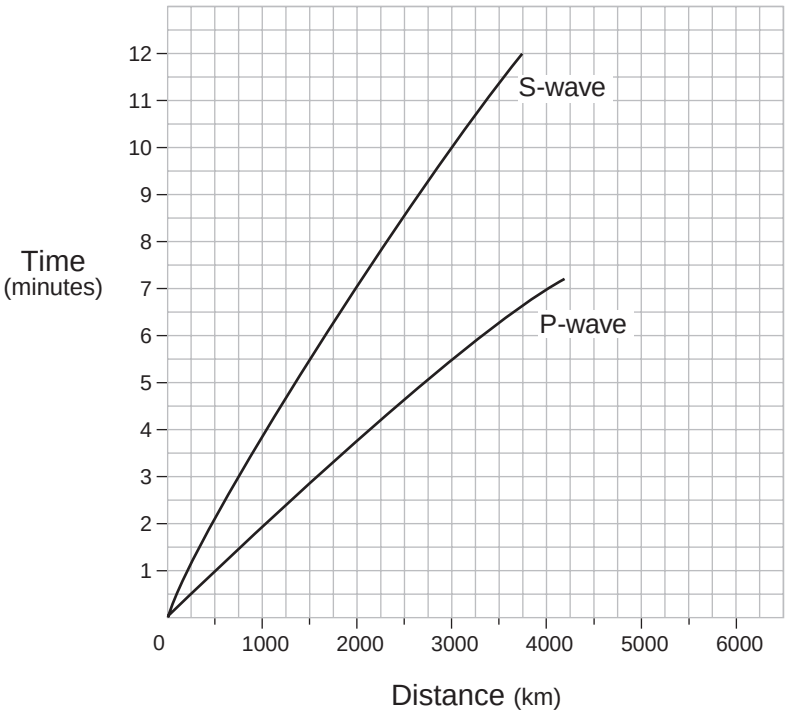
Students must get all three rock layers correct for 1 mark:

Rock layer 1: **sandstone**
Rock layer 2: **conglomerate**
Rock layer 3: **volcanic lava**

Use the following two seismograms and the time-distance graph to answer question 10.



Time-distance graph for P- and S-waves



10. The two seismograms, X and Y, were recorded at different locations for the same earthquake.

a) Describe **two** pieces of evidence, seen on the seismograms, which prove that seismogram **Y** was recorded closer to the epicentre of the earthquake. **(2 marks)**

Any **two** for **1 mark each:**

- **P-waves arrive at Y before X.**
- **The difference in P and S-wave arrival times is smallest for Y.**
- **The amplitude of seismogram Y is the largest.**

b) What is the difference in arrival times between the S- and the P-waves for seismogram **X**? **(1 mark)**

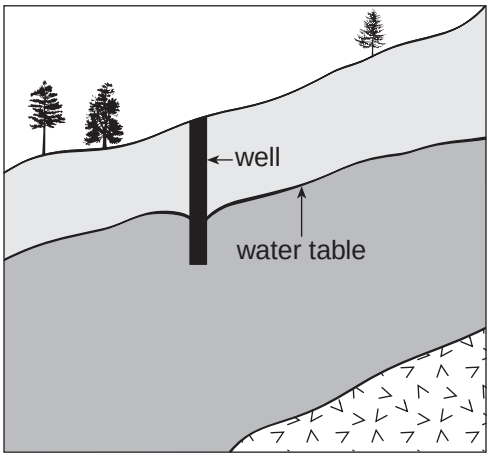
Approximately 3.5 to 3.7 minutes. ← **1 mark**

c) What is the distance from seismogram **X** to the epicentre of the earthquake? **(1 mark)**

Approximately 2000 to 2500 kilometres. ← **1 mark**

Note: **answer c) must correspond to answer given in b) (whether b) was correct or not)**

Use the following cross-sectional diagram to answer question 11.

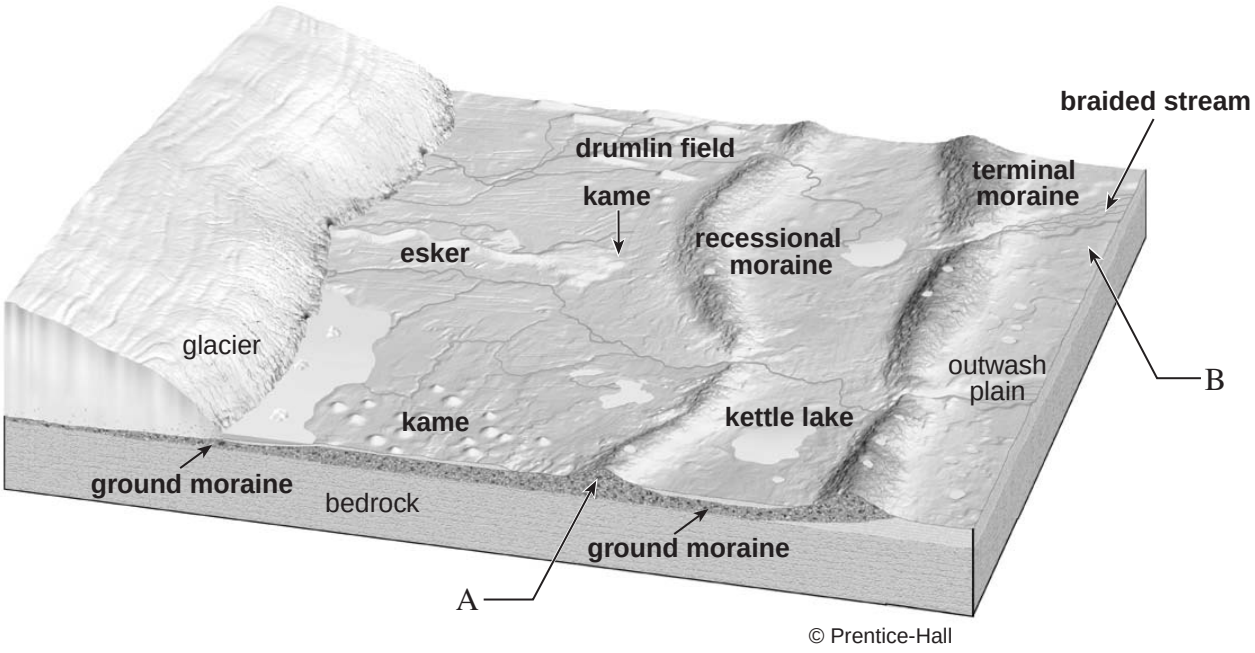


11. The diagram shows a well drilled on a steep slope to obtain a supply of water. Give any **two** geological reasons why this well might not give a reliable long-term supply of drinking water. **(2 marks)**

Any **two** for **1 mark each:**

- **Excessive withdrawal creates a cone of depression which brings the water table below the base of the well.**
- **Drought causes the regional water table to be lowered below the base of the well.**
- **Inadequate recharge/excessive withdrawal causes regional water table to be lowered below the base of the well.**
- **The rocks are not permeable enough to allow a high rate of pumping.**
- **The well is not deep enough.**
- **There may be pollution uphill from the well.**
- **Urbanization may limit recharge.**
- **Downhill failure.**
- **Mass wasting.**

Use the following block diagram of a glaciated landscape to answer question 12.



12. a) Clearly label **four depositional** features on the landscape diagram. **(2 marks)**

See diagram above.
Any **four** features for $\frac{1}{2}$ **mark each. (Total 2 marks)**

b) For **two** of the features you have labelled, describe how the feature formed. **(2 marks)**

Any **two** for **1 mark each:**

ground moraine: **sheet-like layer (blanket) of till left on the landscape by a receding (wasting) glacier.**

terminal moraine: **ridge of till that forms at the farthest advance of a glacier.**

recessional moraine: **ridge of till that forms at terminus of a glacier, behind (up-glacier) and generally parallel to the terminal moraine; formed during a temporary halt (stand) in recession of a wasting glacier.**

drumlin: **streamlined hill, asymmetrical in lengthwise profile, commonly composed of till; ideally with a steep slope facing the direction from which the ice came, and a gentle slope that points down-glacier.**

erratic: **boulder or smaller fragment of rock resting far from its source on bedrock of a different type.**

outwash: **sediment transported by meltwater from a glacier and deposited in front of (down-slope from) the terminus of the melting glacier.**

kame: **steep-sided mount of stratified drift that formed in contact with glacial ice.**

esker: **long, narrow, sinuous ridge of stratified drift deposited by meltwater streams flowing under glacial ice or in tunnels within the glacial ice.**

kettle lake: **block of ice created a depression which filled with water when the ice melted.**

braided stream: **build-up of sediment causing multiple channels.**

Note: No marks given for naming the feature.

c) Describe **one** observable geological difference between the sediment found at site A and that found at site B. **(1 mark)**

Site A: unsorted, more angular
Site B: sorted, more rounded

} ← **1 mark**

13. Describe **two** features of the solar system which suggest that all planets and their satellites were formed from a disk-shaped nebula spinning around the sun. **(2 marks)**

Any **two** features for **1 mark each:**

- **Orbits of the planets are in the same plane.**
- **Planets orbit the sun in the same direction.**
- **Planets composed of high temperature materials condensed closer to the proto sun where it was hotter.**
- **Comets and asteroids are in the same plane as the planets and orbit the sun in the same direction as the planets.**
- **Most of the planets spin on their axes in the same direction. This implies that the planets formed at the same time within a spinning disk.**
- **The sun is rotating on its axis (slowly) in the same direction as the planets are orbiting.**

END OF KEY