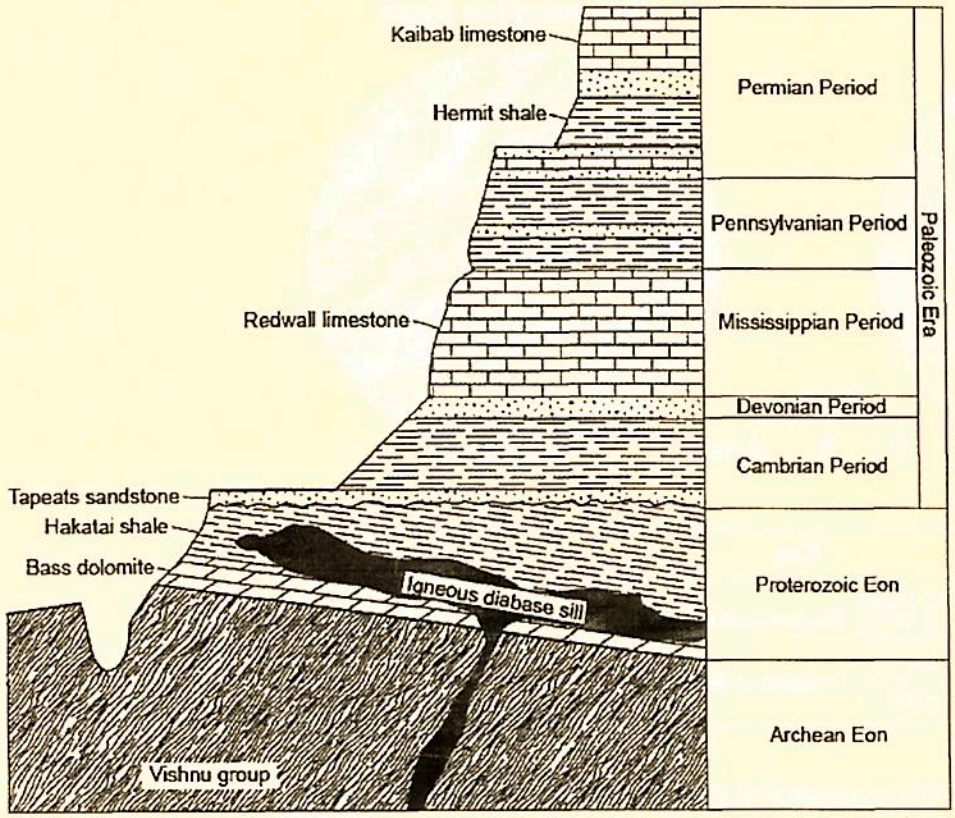
Name Sample key Date

Base your answers to questions **1** and **2** on the generalized cross section of the Grand Canyon represented below and on your knowledge of Earth science. Some rock layers have been labeled. The rock layers have *not* been overturned.



1. Describe how the calcite that composes the Redwall limestone can be distinguished from the quartz that composes that Tapeats sandstone.

Acid Test → • Calcite bubbles w/acid
• Calcite shows cleavage
• Quartz is harder
• chemical composition (Quartz SiO_2)

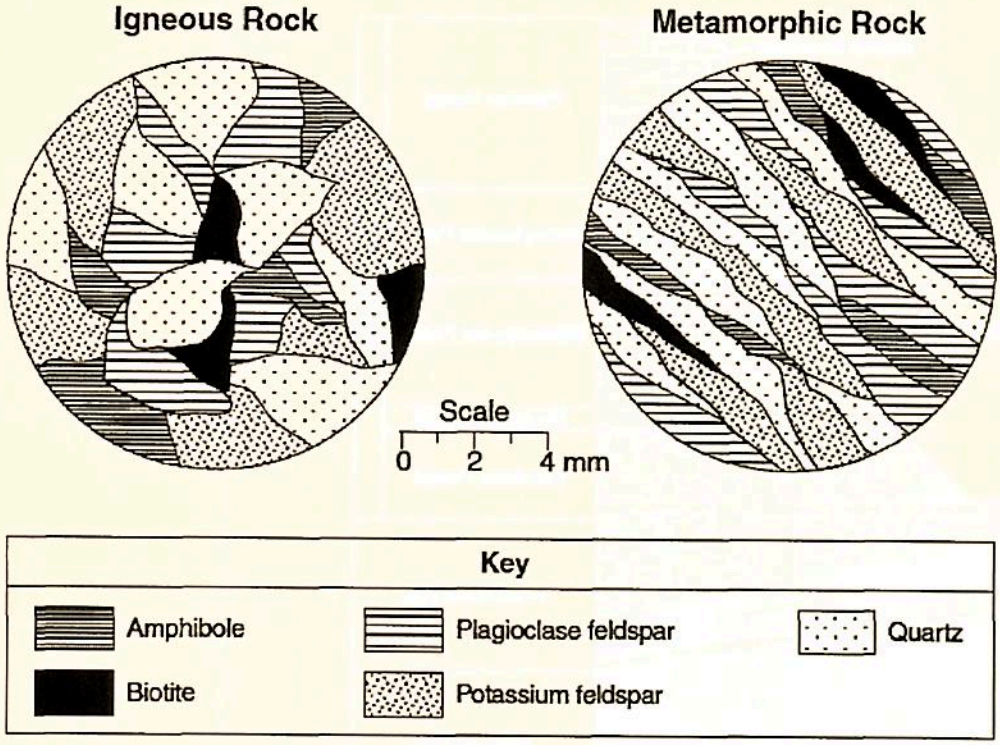
2. State the approximate age of the Redwall limestone, in million years.

318-359 my

3. A family wants to use rock materials as flooring in the entrance of their new house. They have narrowed their choice to granite or marble. Which of these rocks is more resistant to the physical wear of foot traffic and explain why this rock is more resistant.

GRANITE → harder (More resistant)
↓
Quartz

4. Base your answer to the following question on the magnified views shown below of the minerals found in an igneous rock and in a metamorphic rock. The millimeter scale indicates the size of the crystals shown in the magnified views.



Describe the texture shown by this metamorphic rock that indicates it could be schist.

Foliated / Mineral Alignment

Base your answers to questions **8** and **9** on the data table below, which shows some characteristics of four rock samples, numbered 1 through 4. Some information has been left blank.

Data Table

Rock Sample Number	Composition	Grain Size	Texture	Rock Name
1	mostly clay minerals		clastic	shale
2	all mica	microscopic, fine	foliated with mineral alignment	
3	mica, quartz, feldspar, amphibole, garnet, pyroxene	medium to coarse	foliated with banding	gneiss
4	potassium feldspar, quartz, biotite, plagioclase feldspar, amphibole	5 mm		granite

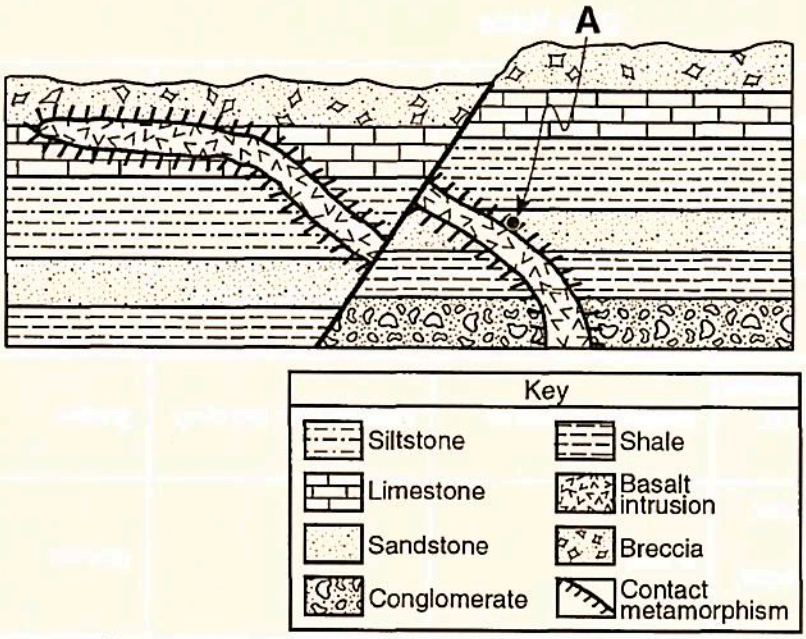
8. Write a term or phrase that correctly describes the texture of sample 4.

Coarse / Non-vesicular

9. Write the rock name of sample 2.

Slate

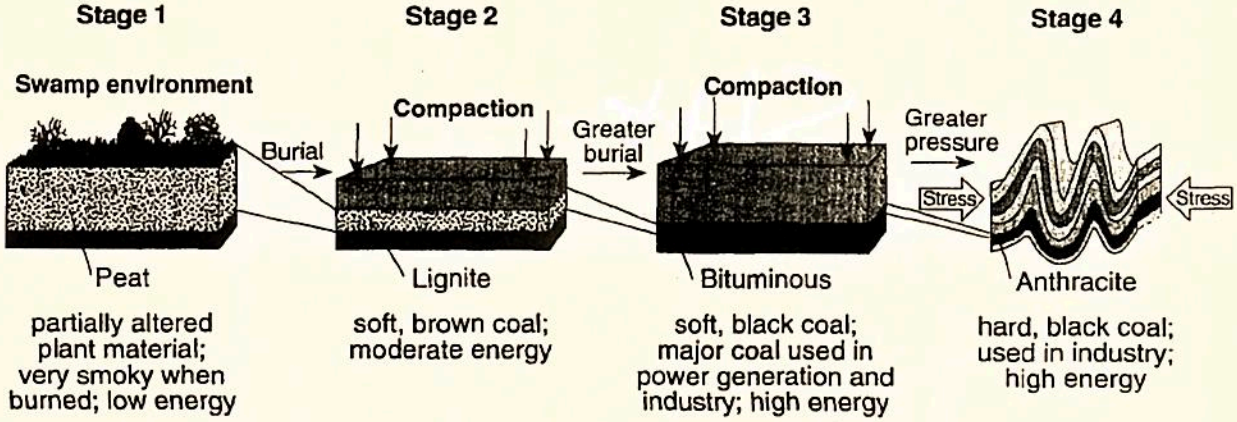
10. Base your answer to the following question on the geologic cross section below. The rock layers have not been overturned. Point *A* is located in the zone of contact metamorphism.



List basalt, limestone, and breccia in the order in which they were formed.

LS → BReccia → Basalt

Base your answers to questions **11** and **12** on on the sequence of diagrams below, which shows four stages in coal formation.



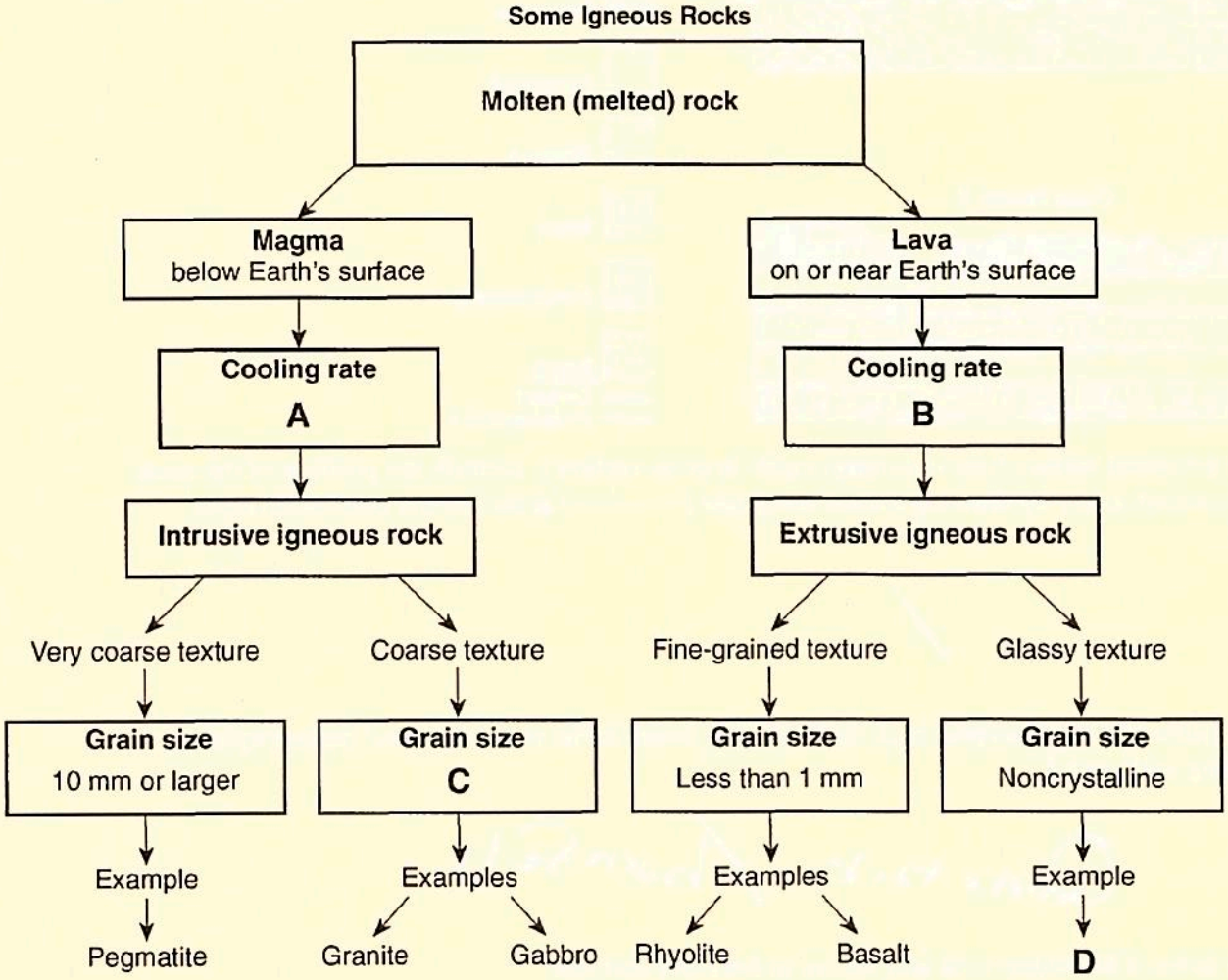
11. Explain why coal deposits are *not* found in bedrock older than Silurian-age bedrock.

Earliest Land Plants arrived in the Silurian

12. State the form of coal which normally has the highest density and explain why.

Anthracite Coal – forms from pressure (Regional Meta)

Base your answers to questions **13** and **14** on the flowchart below and on your knowledge of Earth science. The flowchart shows the formation of some igneous rocks. The bold letters ***A***, ***B***, ***C***, and ***D*** indicate parts of the flowchart that have not been labeled.



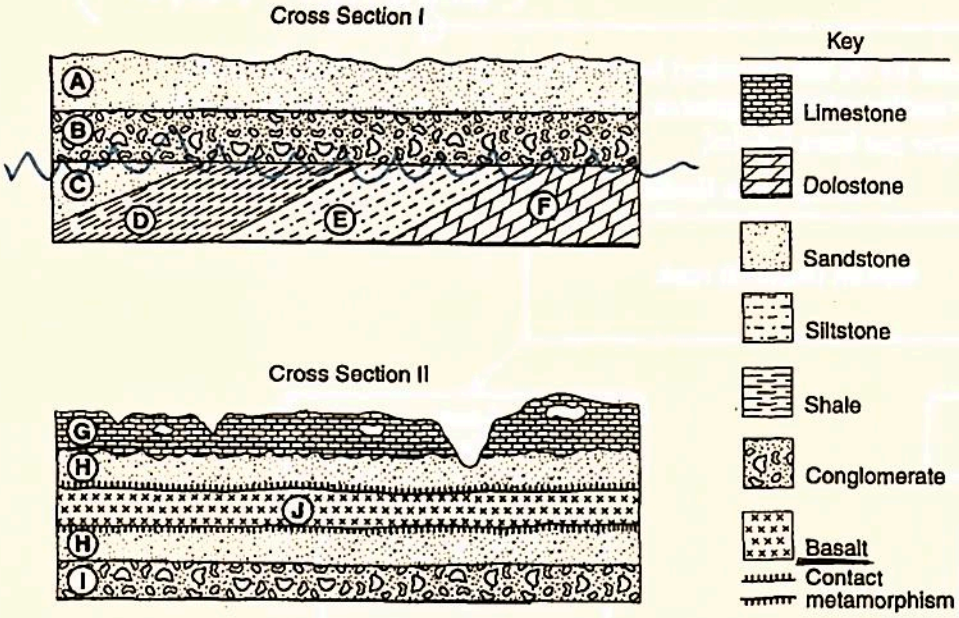
13. State *one* igneous rock that could be placed in the flowchart at ***D***.

Obsidian / Pumice / Scoria / Basaltic glass

14. Contrast the rate of cooling at ***A*** that forms intrusive igneous rock with a rate of cooling at ***B*** that forms extrusive igneous rock.

A = Slower cooling than B

Base your answers to questions **15** through **17** on cross sections I and II shown below. Letters *A* through *J* represent rock units. Rock units *B* and *I* are the same age. Overturning has not occurred in either cross section.



15. A buried erosional surface (unconformity) exists in cross section I. Identify the position of the most apparent unconformity by drawing a thick wavy line (~~~~~) at the correct position in cross section I .

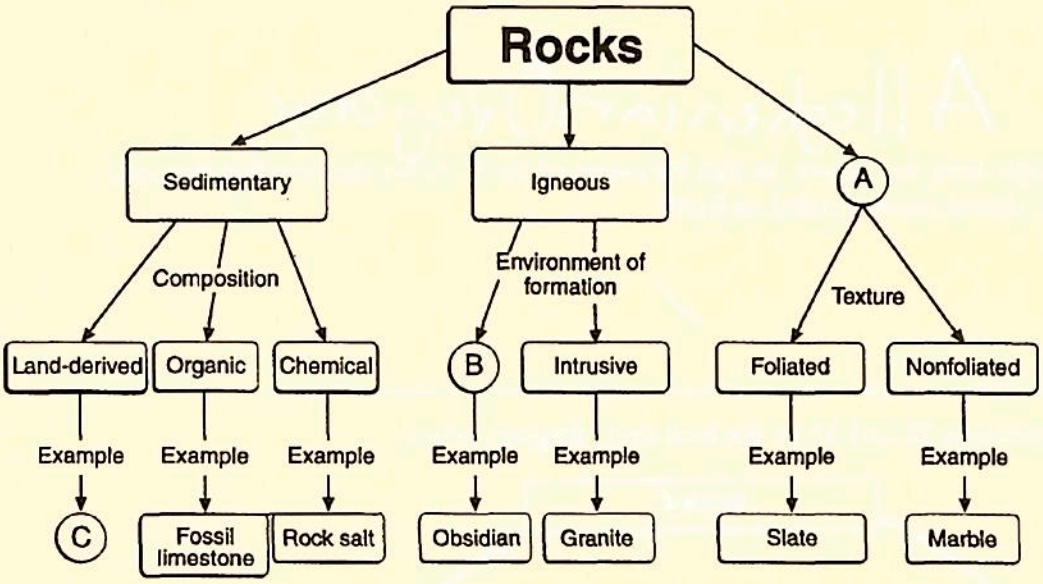
16. State the name of a metamorphic rock that would be found in the zone of contact metamorphism surrounding rock unit *J*.

Quartzite / hornfels

17. State the letter of the oldest rock unit shown in the cross sections.

F

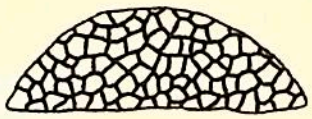
18. The chart below shows the different rock families and their subdivisions. The circled letters, *A*, *B*, and *C*, indicate parts of the chart that have not been completed.



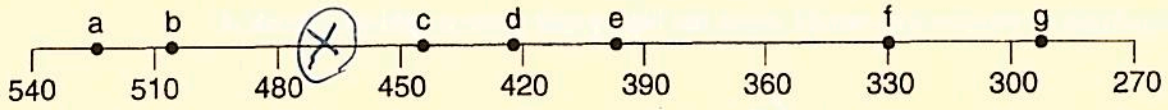
Complete the chart by writing the missing terms in the spaces labeled *A*, *B*, and *C* below

A Metamorphic
B Extrusive
C Cong / Breccia, Sandstone / Siltstone / Shale

Base your answers to questions **19** through **21** on the geologic time line shown in your answer booklet. Letters *a* through g on the time line indicate specific reference points in geologic time.



Geologic Time Line (millions of years ago)



19. Identify *one* letter that indicates a time for which there is no rock record in New York State.

G / f

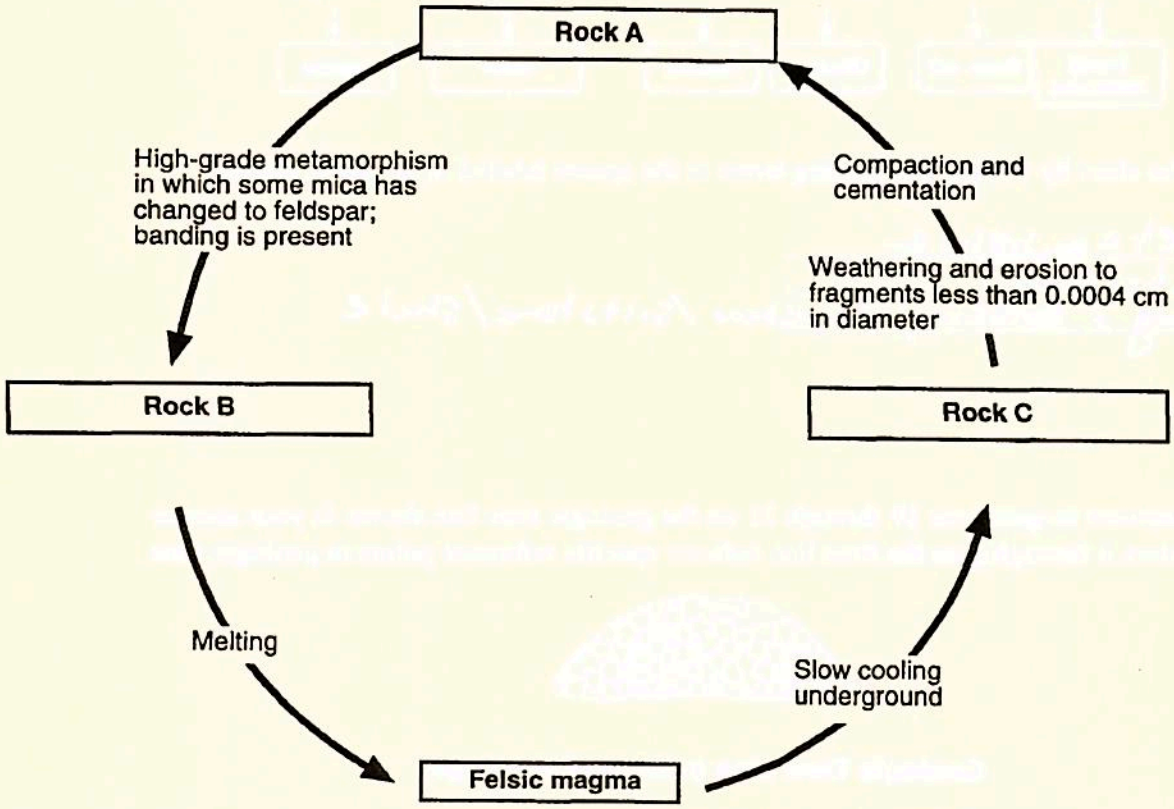
20. Identify the mountain building event (orogeny) that was occurring in eastern North America at the time represented by letter *g*.

Alleghenian Orogeny

21. Place an X on the geologic time line above, so that the center of the X shows the time that the coral index fossil *Lichenaria* shown above existed on Earth.

✓

Base your answers to questions **22** and **23** on the rock cycle diagram below.



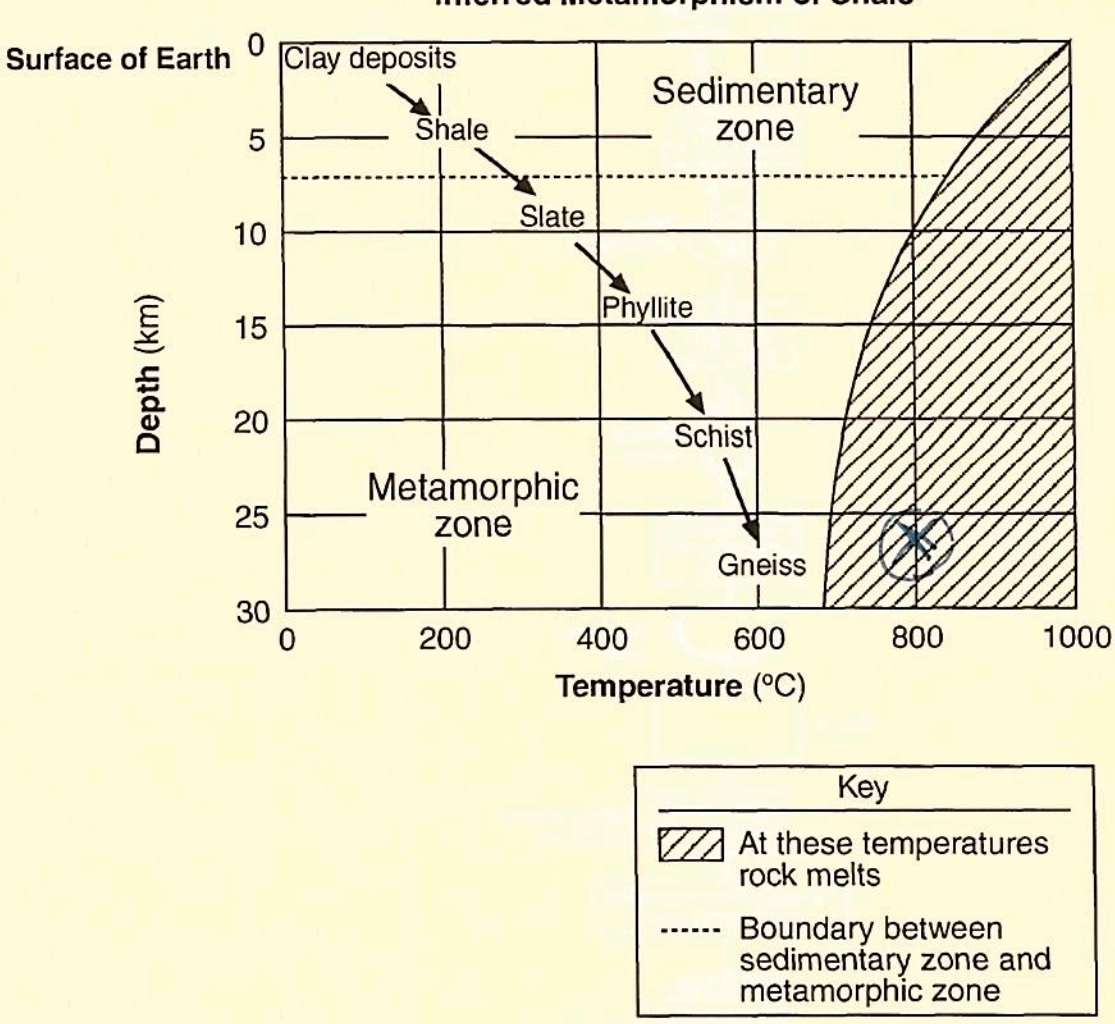
22. State *one* condition or process that would cause the high-grade metamorphism of rock *A*.

heat / pressure

23. State the specific names of rocks *A*, *B*, and *C* in the diagram. Do *not* write the terms "sedimentary," "igneous," and "metamorphic."

Shale → Gneiss → Granite (Pegmatite)

Base your answers to questions **24** and **25** on the graph below, which shows a generalized sequence of rock types that form from original clay deposits at certain depths and temperature conditions within Earth's interior.



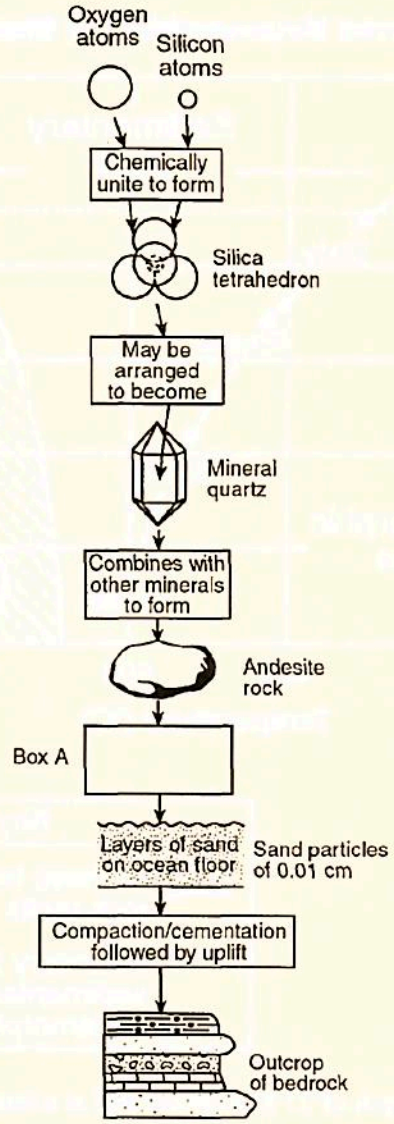
24. Explain why gneiss would *not* form at a depth of 27 kilometers and at a temperature of 800°C.

It gets too hot so it would Melt!

25. When clay materials are buried to a depth of 14 kilometers, which type of metamorphic rock is normally formed?

Phyllite

Base your answers to questions **26** through **28** on the flowchart below, which shows a sequence of geologic processes at or near Earth's surface. Box *A* has been deliberately left blank. The diagrams are not drawn to scale.



26. Identify by name one type of rock layer, other than sandstone, shown in the outcrop.

Siltstone/~~Clay~~ conglomerate/ limestone

27. State one geologic process represented by box *A*.

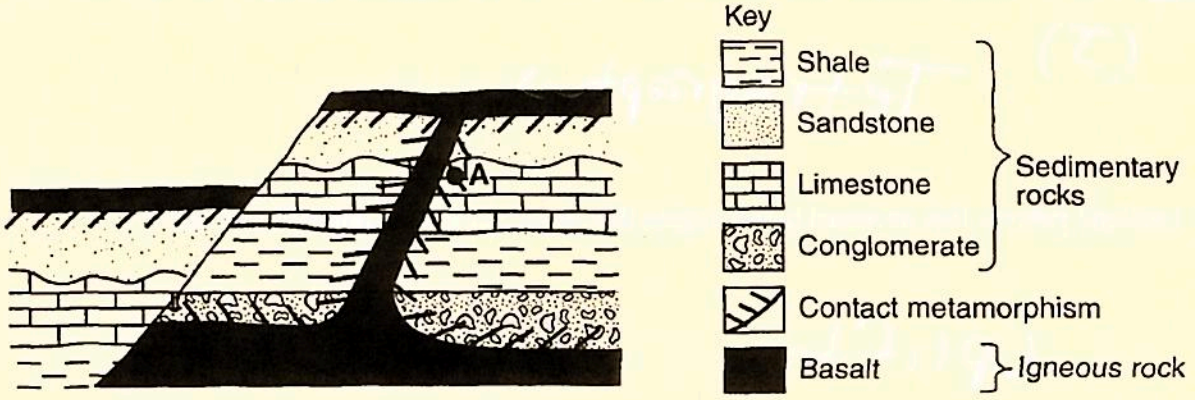
weathering, erosion, deposition

28. Identify the *three* minerals that are normally found with quartz in samples of andesite rock.

Plagioclase feldspar
Biotite
Amphibole

Base your answers to questions **29** and **30** on the diagram and information below.

The diagram shows a cross section of a portion of Earth's crust that has undergone geological processes. Overturning of rock layers has not occurred. Point *A* represents one location of metamorphic rock.



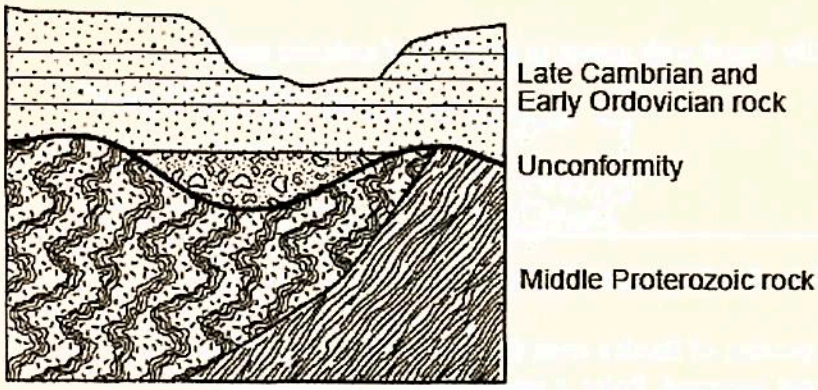
29. State *one* piece of evidence that indicates basalt is the youngest rock unit in the cross section.

- Contact lines from basalt touch all other rock layers
- it cuts through all rock layers

30. State *one* piece of evidence that shows that crustal uplift has occurred in this region.

Fault

Base your answers to questions **31** and **32** on the cross section below and on your knowledge of Earth science. The unconformity is located at the boundary between Middle Proterozoic rock and Late Cambrian and Early Ordovician rock.



31. Identify by name the oldest New York State index fossil that could be found in the Early Ordovician bedrock.

(J) Tetragraptus

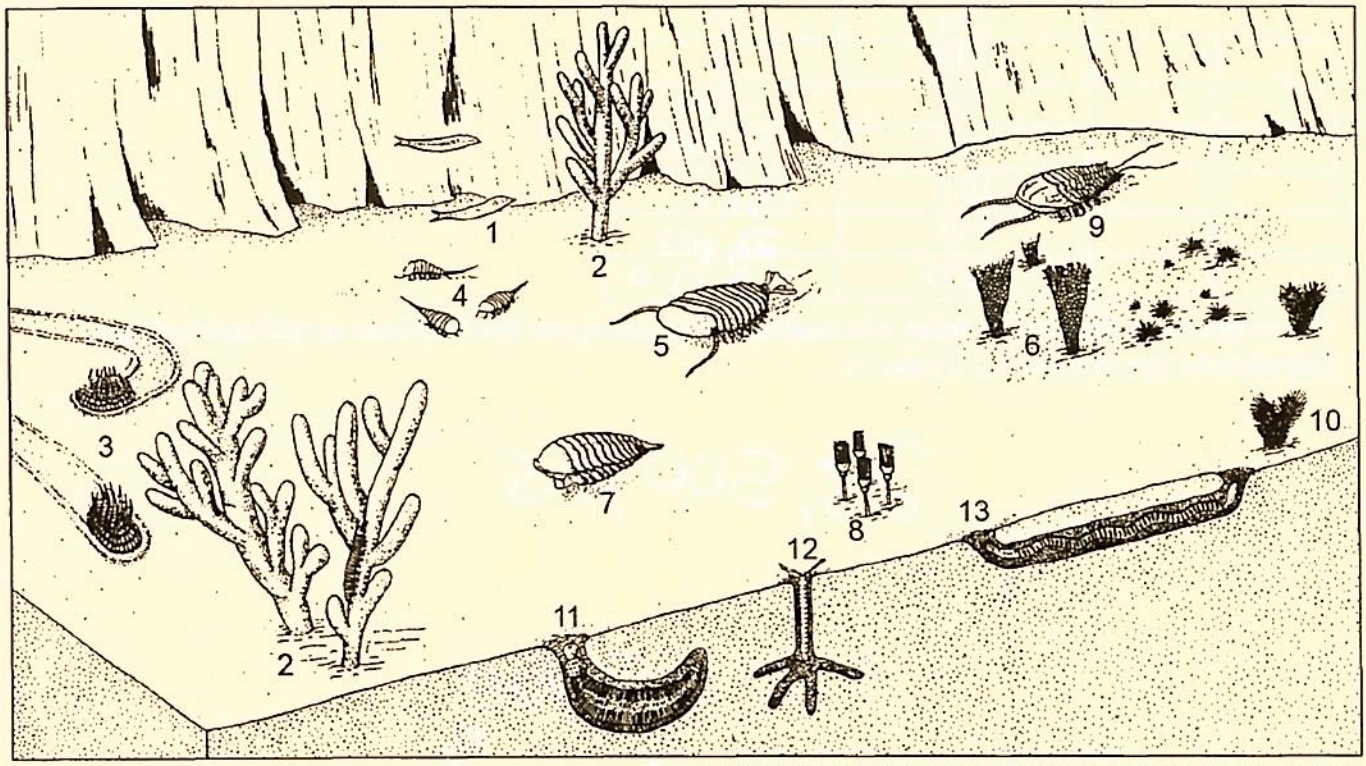
32. Identify *one* geologic process that occurred in this region that produced the unconformity in this outcrop.

- Uplift
- emergence
- erosion
- deposition
- submergence

Base your answers to questions **33** through **35** on the passage and diagram below and on your knowledge of Earth science. The diagram represents some of the Burgess shale community of organisms that existed together during part of the Cambrian Period. Thirteen different types of organisms are numbered in the diagram.

Burgess Shale Fossils

The Burgess shale fossil discovery revealed unique Cambrian life-forms, most of which were not present in the previously known fossil record. Normally, soft body parts of dead organisms are destroyed by scavengers and bacteria on the ocean floor. However, in the deep-water depositional environment of the Burgess shale, oxygen was lacking and organisms were buried rapidly, preserving the unique community seen in the diagram. The soft-bodied organisms had previously been unknown. The Burgess shale fossils were originally found in a layer of bedrock in southwestern Canada.



Adapted from: Briggs, et al., *The Fossils of the Burgess Shale*, Smithsonian Institution Press, 1994

33. Identify the number of *one* organism in the diagram that is most likely a trilobite.

4, 5, 7, and 9

34. Explain why so many soft body parts of organisms were preserved in the Burgess shale.

rapid burial, deep H_2O, low O_2

35. During which epoch of the Cambrian Period were the Burgess shale organisms and sediments deposited?

Middle

36. Base your answer to the following question on the data table and information below and on your knowledge of Earth science. The data table shows the radioactive decay of carbon-14 and the age of fossil remains, in years (y). Part of the table has been left blank.

Data Table

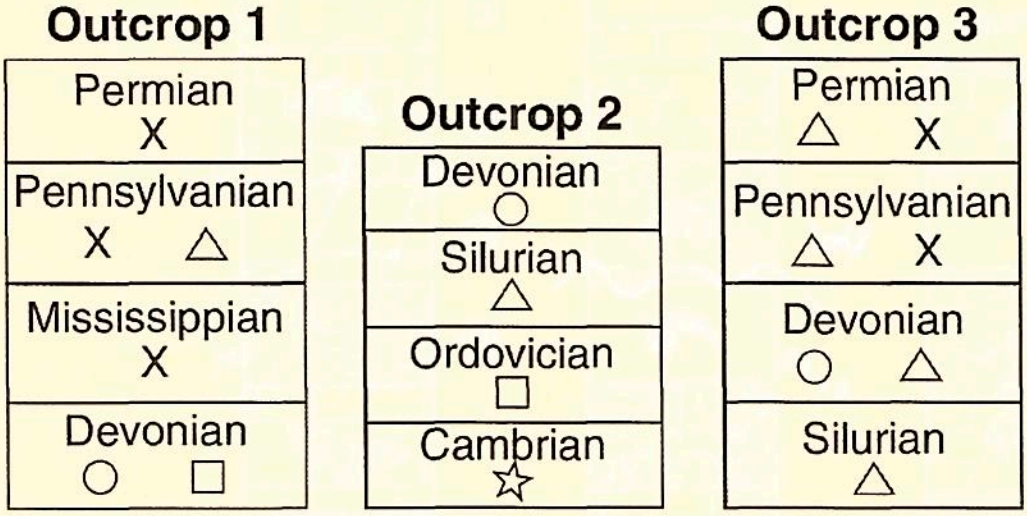
Number of Half – Lives	Remaining Carbon – 14 (%)	Age of fossil Remains (y)
0	100	0
1	50	5,700
2	25	11,400
3	12.5	17,100
4	6.25	22,800
5	3.125	28,500

The carbon-14 in the fossil remains of a mastodont has undergone five half-lives of radioactive decay. Calculate the age of these fossil remains.

28,500 yrs

5,700
x 5

Base your answers to questions **37** through **39** on the cross sections below and on your knowledge of Earth science. The cross sections represent three bedrock outcrops, 1, 2, and 3, found several kilometers apart. The geologic time period when each sedimentary rock layer formed is shown. The symbols (star, circle, cross, square, and triangle) represent fossils of different types of organisms present in the rock layers.



37. Explain why the index fossil *Coelophysis* is *not* preserved in any of the rock outcrops.

- It wasn't alive yet!
- Rocks are too old

38. Write the outcrop number of the cross section that could he found in New York State. Describe the evidence that supports your answer.

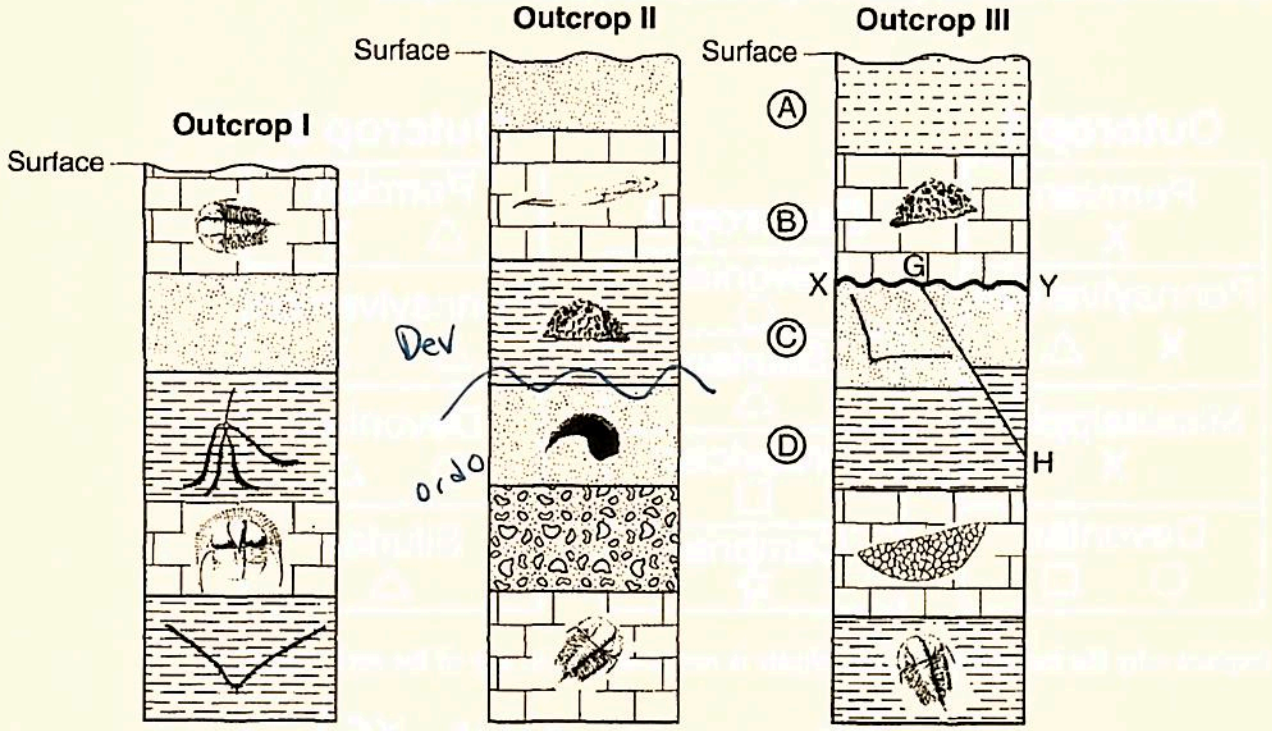
2 - all time periods are present in NYS rock record

39. Draw the fossil symbol that represents the best index fossil. Describe *one* piece of evidence shown in the outcrops that indicates that this fossil has characteristics of a good index fossil.

○ - found in all 3 outcrops but only appears 1 time within each outcrop

*Wide horizontal distribution
short vertical distribution

Base your answers to questions **40** through **42** on the cross sections below, which show widely separated outcrops labeled I, II, and III. Index fossils are found in some of the rock layers in the three outcrops. In outcrop III, layers *A*, *B*, *C*, and *D* are labeled. Line *XY* represents an unconformity. Line *GH* represents a fault.



40. List in order, from oldest to youngest, the relative age of the four rock layers, *A*, *B*, *C*, and *D*, fault *GH*, and unconformity *XY* shown in outcrop III.

D, C, G-H, X-Y, B, A

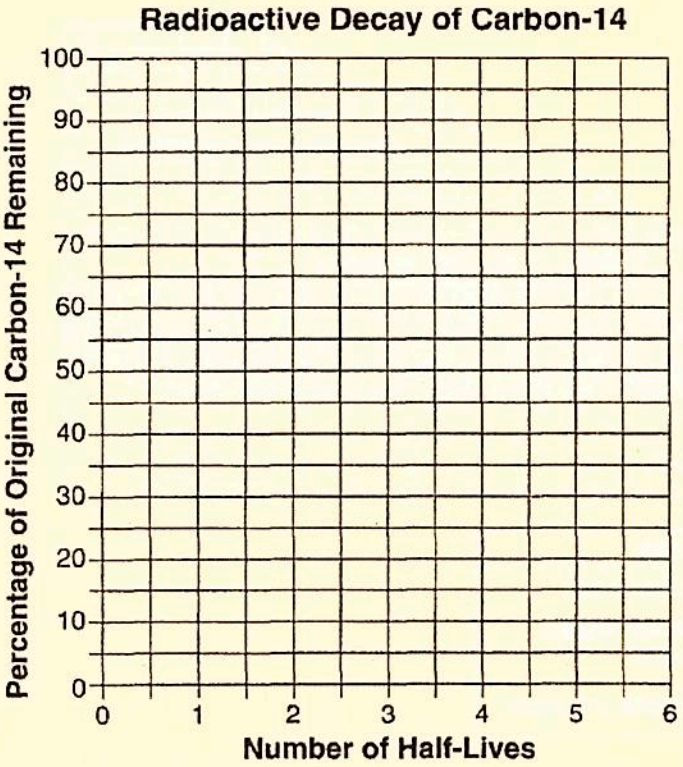
41. On outcrop II below, place the symbol ~~ for an unconformity between the two rock layers where the Silurian-age bedrock has been removed by erosion.

✓

42. Describe *one* characteristic necessary for a fossil to be classified as an index fossil.

- lived for a short period of time (short vertical distribution)
- widespread (large horizontal distribution)

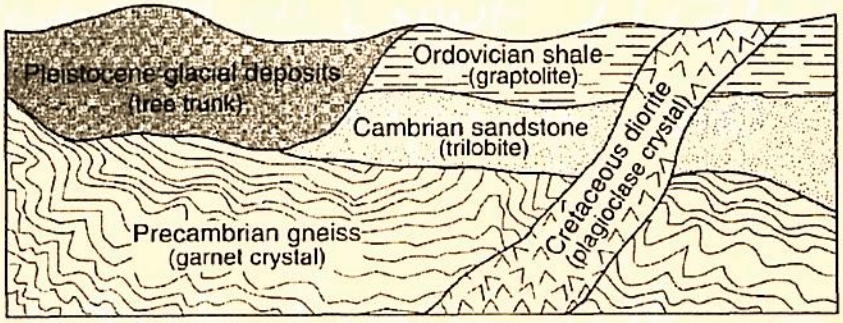
43. Base your answer to the following question on the date table below, which shows the radioactive decay of carbon-14. The number of years required to complete four half-lives has been left blank.



Radioactive Decay of Carbon-14

Number of Half-Lives	Percentage of Original Carbon-14 Remaining	Time (years)
0	100	0
1	50	5700
2	25	11,400
3	12.5	17,100
4	6.3	
5	3.1	28,500
6	1.6	34,200

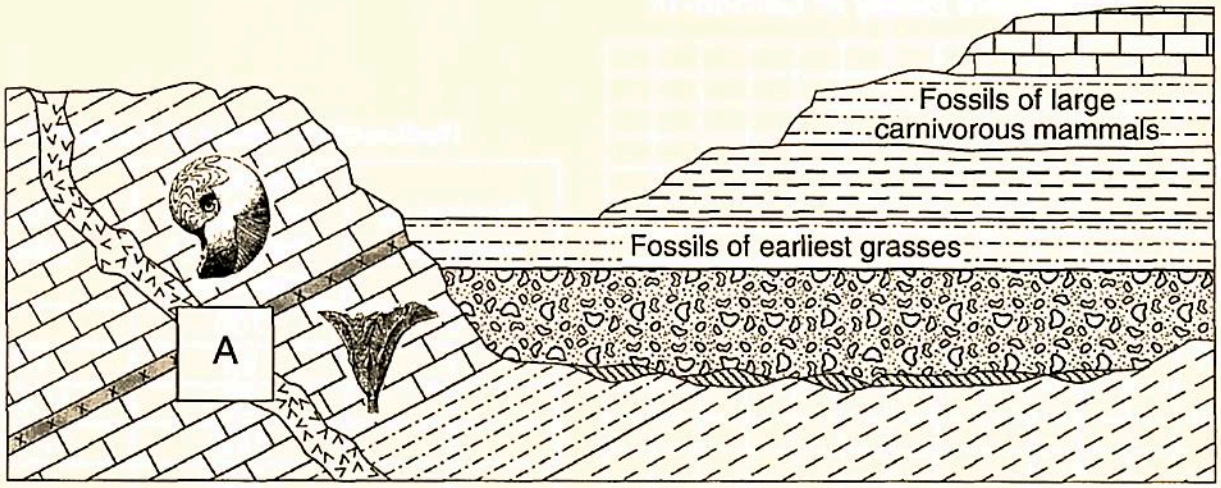
The cross section below shows part of Earth's crust. The objects in parentheses indicate materials found within each rock unit or deposit.

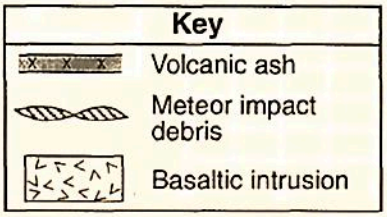


Which object in parentheses could be accurately dated using carbon-14? Explain your answer.

tree trunk from the Pleistocene → Recent + ORGANIC

Base your answers to questions **44** and **45** on the geologic cross section below, which represents a portion of Earth's crust. Some rock units contain index fossils. Box *A* indicates a missing portion of the cross section.



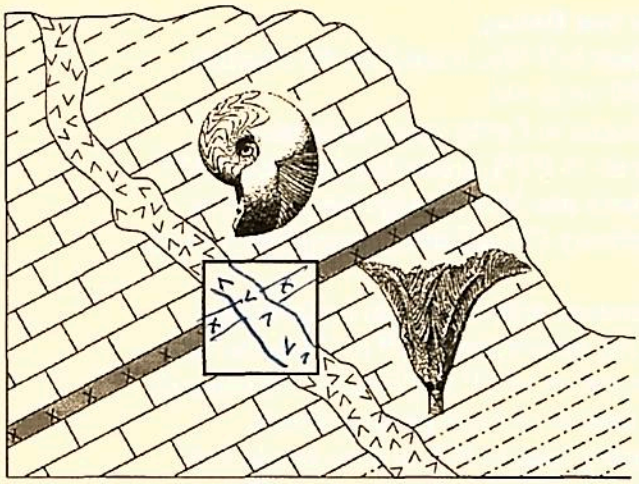


44. Describe *one* piece of evidence which indicates that the horizontal rock layers are younger than the tilted rock layers.

- Fossils types in horizontal are younger

- they aren't tilted but are on top

45. In the box that represents box *A* on the cross section below,draw *both* the volcanic ash layer and the basaltic intrusion to clearly show their relative age.



46. Base your answer to the following question on the table of index fossils shown below and on your knowledge of Earth science.

Table of Index Fossils


Eospirifer


Manticoceras


Phacops

Fossil Classification

Index Fossil	*Eospirifer*	*Manticoceras*	*Phacops*
General Fossil Group	Brachiopod	Ammonoid	trilobite

Complete the classification table above by filling in the general fossil group name for *each* index fossil.

47. Base your answer to the following question on the passage below and on your knowledge of Earth science.

Radiocarbon Dating

Radioactive carbon-14 (C^{14}), because of its short half-life, is used for the absolute dating of organic remains that are less than 70,000 years old.

Carbon-14 is an isotope of carbon that is produced in Earths upper atmosphere. High-energy cosmic rays from the Sun hit nitrogen-14 (N^{14}), producing radioactive C^{14}. This C^{14} is unstable and will eventually change back into N14 through the process of radioactive decay. The proportions of C^{14} and ordinary C^{12} in Earth's atmosphere remain approximately constant.

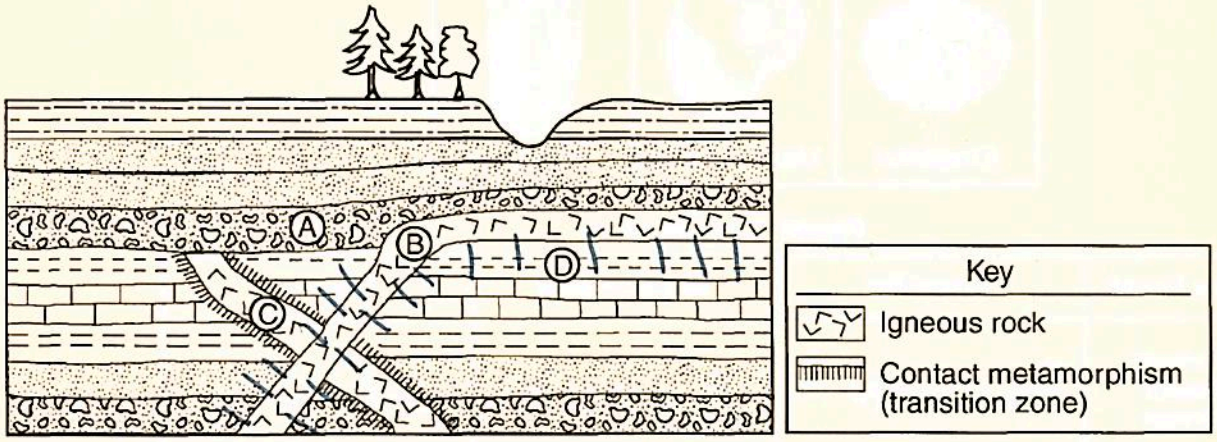
Radioactive C^{14}, just like ordinary C^{12}, can combine with oxygen to make carbon dioxide. Plants use CO_2 during photosynthesis. The proportion of C^{14} to C^{12} in the cells and tissues of living plants is the same as the proportion of C^{14} to C^{12} in the atmosphere. After plants die, no new C^{14} is taken in because there is no more photosynthesis. Meanwhile, the C^{14} in the dead plant keeps changing back to N^{14}, so there is less and less C^{14}. The longer the plant has been dead, the less C^{14} is found in the plant. The age of organic remains can be found by comparing how much C^{14} is still in the organic remains to how much C^{14} is in a living organism.

State *one* difference between dating with the radioactive isotope C14 and dating with the radioactive isotope uranium-238 (U238).

dates oldest known stuff (longer half-life

used to date recent (organic) → object

Base your answers to questions **48** and **49** on the cross section provided in your answer booklet. The cross section represents a portion of Earth's crust. Letters *A*, *B*, *C*, and *D* are rock units.



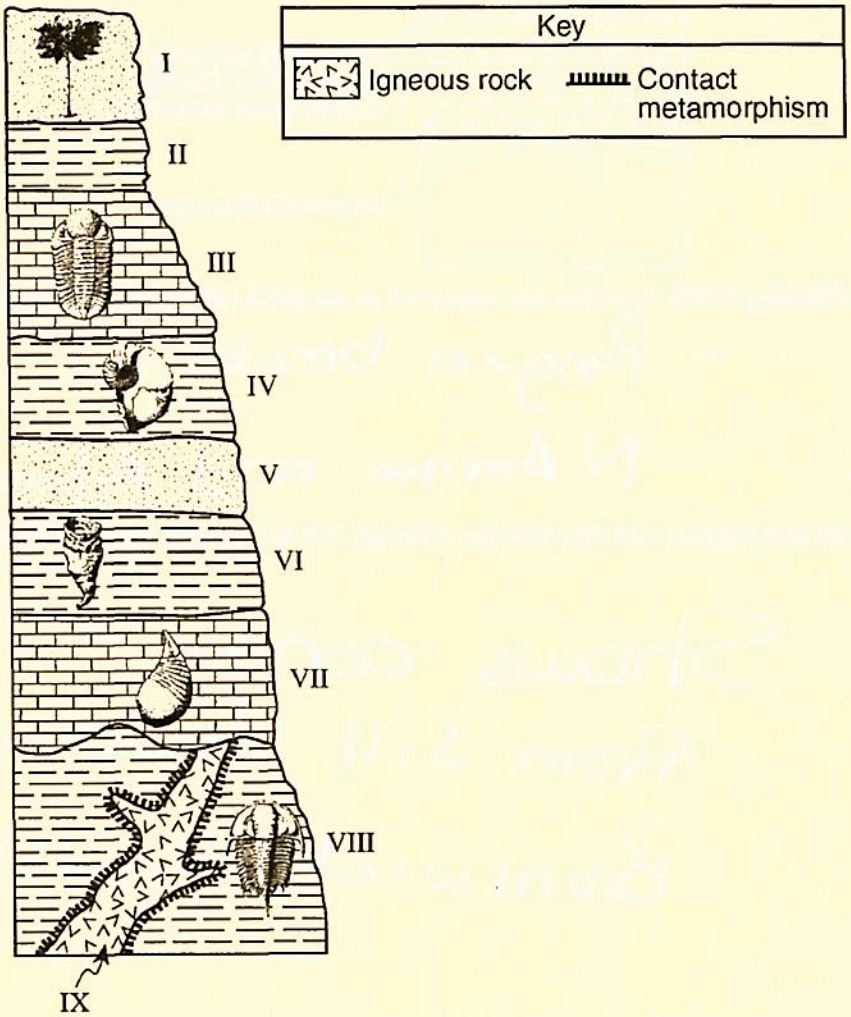
48. Describe one observable characteristic of rock *A* that indicates that rock *A* is sedimentary.

- clastic texture
- has fragments cemented together

49. Igneous rock *B* was formed after rock layer *D* was deposited but before rock layer *A* was deposited. Using the contact metamorphism symbol shown in the key, draw that symbol in the proper locations on the cross section provided above to indicate those rocks that underwent contact metamorphism when igneous rock *B* was molten.

✓

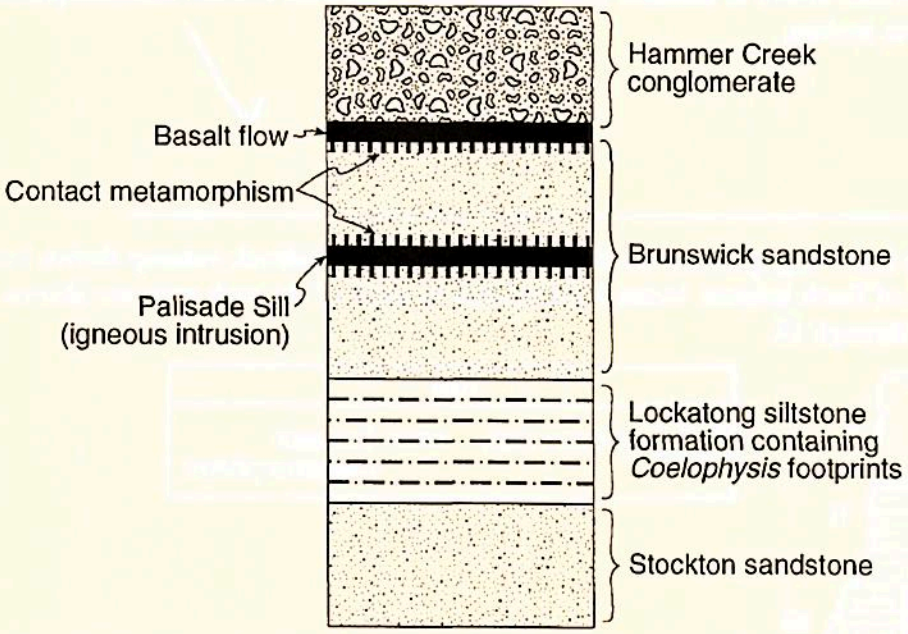
50. Base your answer to the following question on the cross section of the bedrock outcrop shown below and on your knowledge of Earth science. Index fossils found in some of the rock units are shown. The rock units are labeled I through IX.



Based on the fossils shown in the limestone and shale layers, state the type of environment in which these sedimentary rocks were deposited.

- Shallow Ocean
- Marine

Base your answers to questions **51** and **52** on The cross section below, which shows several rock formations found in New York State. The rock layers have not been overturned.



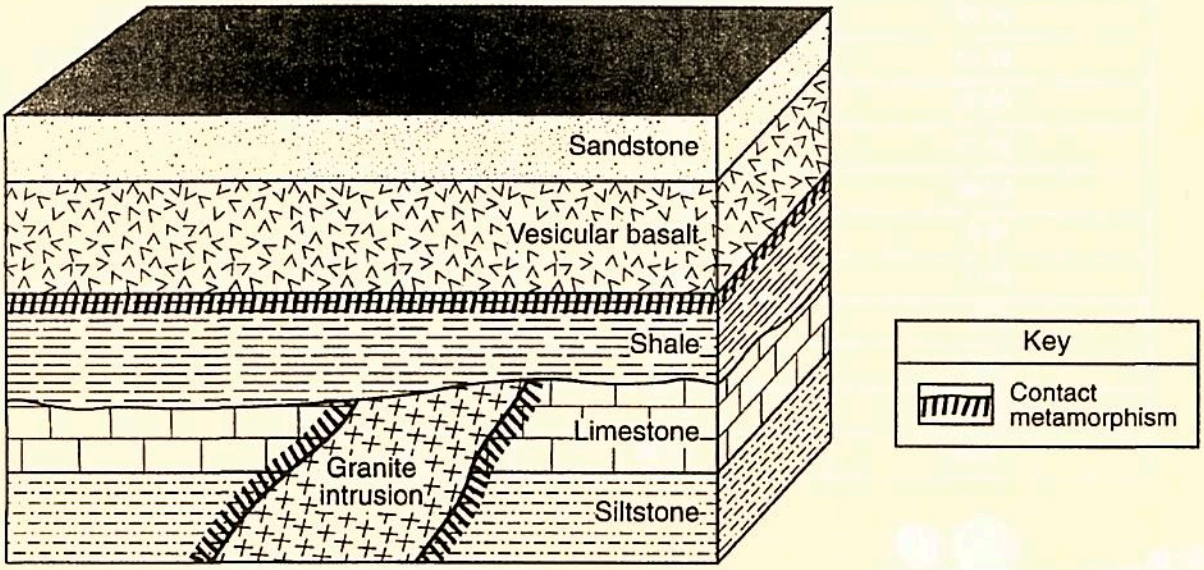
51. State one tectonic event affecting North America that occurred at the same time as the Palisade Sill intrusion.

- Pangea breaks up
- N. America and Africa separate

52. State one piece of evidence that supports the fact that the Palisade Sill is younger than the Brunswick sandstone.

Shows contact lines from Sill touching Brunswick sandstone

Base your answers to questions **53** and **54** on The geologic cross section below. Radioactive dating indicates that the granite intrusion is 279 million years old and the vesicular basalt is 260 million years old. The rock layers have not been overturned.



53. During which geologic time period did the shale layer form?

Permian

54. List the six rock units in the order from the oldest to the youngest.

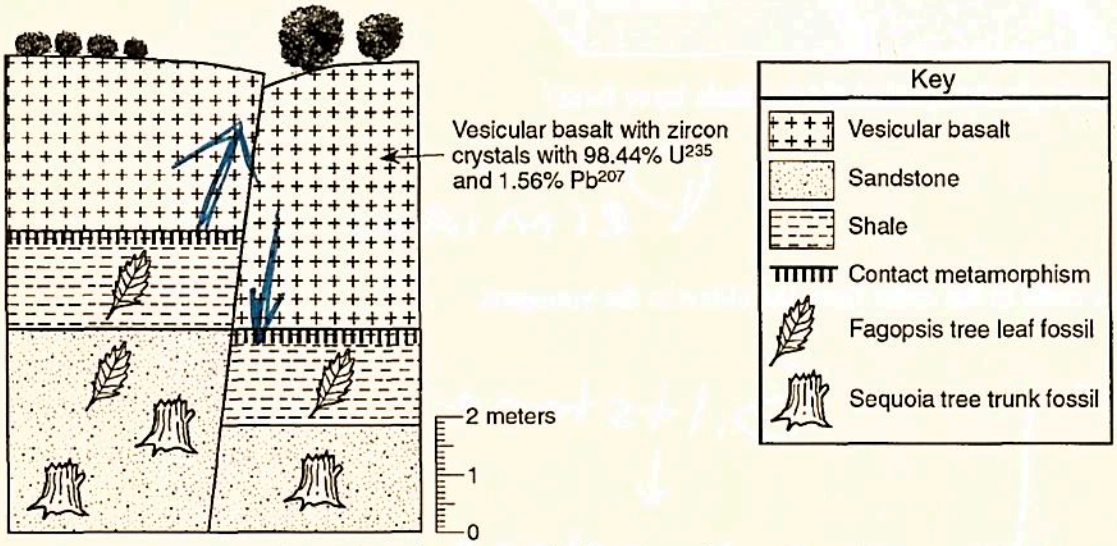
Oldest

Siltstone
↓
limestone
↓
granite intrusion
↓
Shale
↓
Basalt
↓
Sandstone

Youngest

Base your answers to questions **55** and **56** on the geologic cross section and graph provided below, which represents an outcrop of various types of bedrock and bedrock features in Colorado.

Percent of U-235 Remaining	Percent Decayed to Pb-207	Half-Lives Elapsed
99.22	0.78	$\frac{1}{64}$
98.44	1.56	$\frac{1}{32}$
96.88	3.12	$\frac{1}{16}$
93.75	6.25	$\frac{1}{8}$
87.50	12.5	$\frac{1}{4}$
75.0	25.0	$\frac{1}{2}$
50.0	50.0	1
37.5	62.5	$1\frac{1}{2}$
25.0	75.0	2
12.5	87.5	3
6.25	93.75	4



55. Place the geologic events listed in order by numbering them from oldest (1) to youngest (4).

4 The fault was formed.
2 The shale was deposited.
3 The vesicular basalt was formed.
1 The sandstone was deposited.

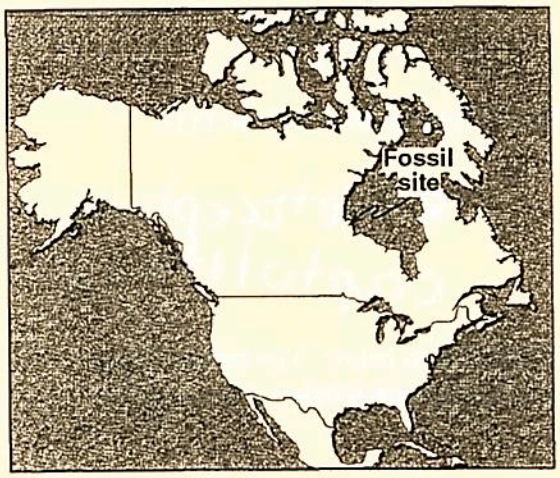
56. On the cross section provided above, indicate with arrows the direction of movement on *both* sides of the fault.

Base your answers to questions **57** through **59** on the reading passage below. The reading passage provides some background information about a recent fossil discovery. The map of Canada shows the fossil site. The scale drawing shows the new trilobite fossil compared to other trilobite fossils.

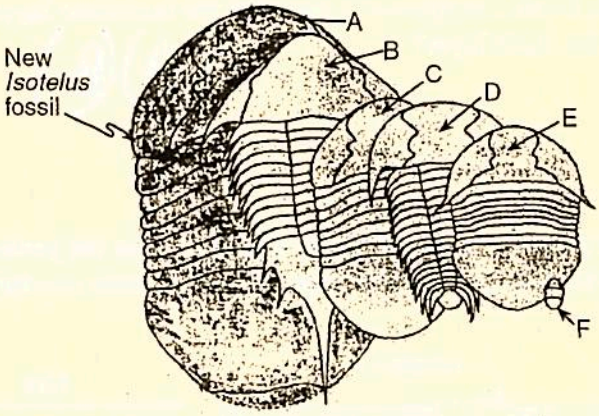
The World's Biggest Trilobite

A team of Canadian paleontologists examining rock units along the shore of Hudson Bay in northern Manitoba has discovered the world's largest recorded complete fossil of a trilobite, a many-legged, sea-dwelling animal inferred to have lived during the late Ordovician Period. The giant creature, measuring 70 centimeters in length, is a new speciesof the genus *Isotelus*. This remarkable discovery adds to our knowledge of the diversity of life following one of the greatest increases in the number and types of life-forms in history.The new Isotelusspecies existed just before the end of the Ordovician Period.

Map of North America



Scale drawings of the new trilobite *Isotelus (A)*, other big species reported from elsewhere *(B,C,D,E)*, and a typical large trilobite *(F)*.



57. What New York State nautiloid index fossil would most likely be found in the bedrock just below the new *Isotelus* fossil?

tetragraptus (J)

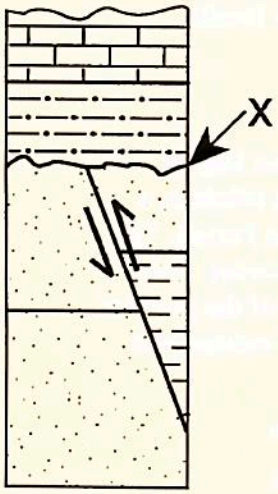
58. At the time the new *Isotelus* fossil lived and died, during the Ordovician Period, what was the approximate latitude of the fossil site according to plate tectonic theory?

≈ 0°

59. In what type of rock was the new *Isotelus* fossil most probably found?

Sedimentary

60. The diagram below shows a cross section of New York State bedrock that has not been overturned. Line *X* represents an unconformity.

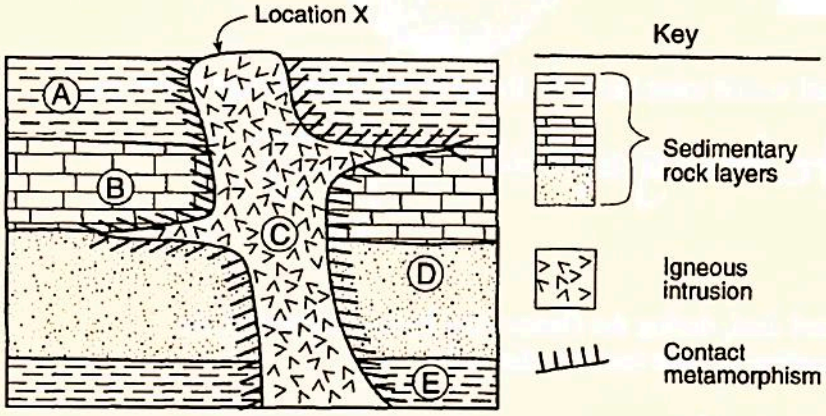


The index fossil *Eurypterus* is found in the limestone layer. What trilobite index fossil could be found in the shale layer?

(A)(B)

Elliptocephala cryptolithus

Base your answers to questions **61** through **63** on the geologic cross section below. The cross section shows an outcrop in which the layers have not been overturned. Rock units are labeled *A* through *E*.



61. State one observation about the crystals at location *X* that would provide evidence that igneous rock unit *C* was formed by very slow cooling of magma.

- large crystals

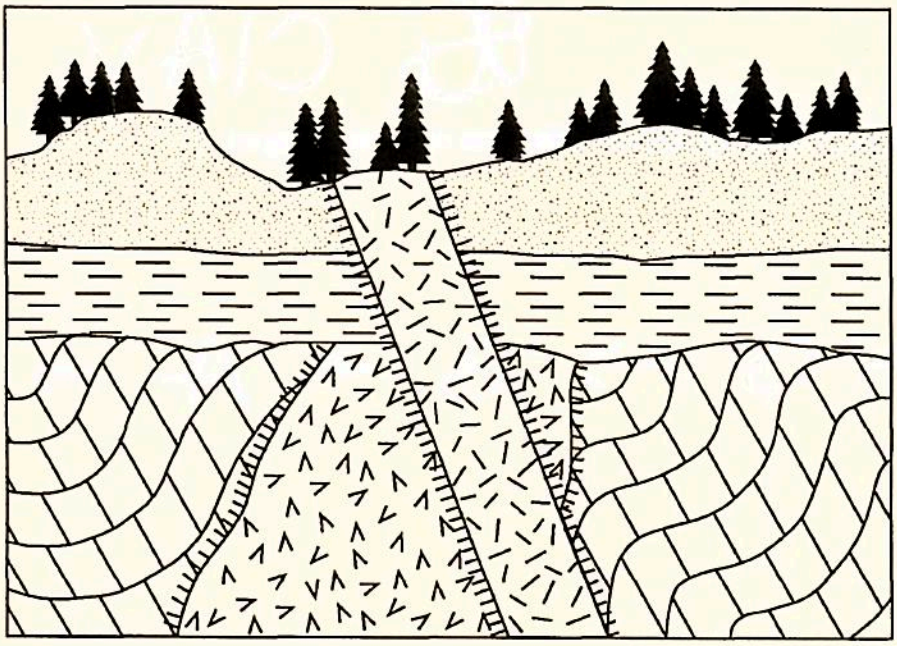
62. State the name of the sediment that was compacted to form rock unit *A*.

CLAY

63. Using letters *A* through *E*, list the rock units in order from oldest to youngest.

E → D → B → A → C

64. Base your answer to the following question on the information and diagram below. The diagram represents a cliff of exposed bedrock that was investigated by an Earth science class.



Key to Rock Symbols

Sandstone | Folded limestone | Granite

Basalt | Shale | Contact metamorphism

After the students examined the cliff, they made three correct inferences about the geologic history of the bedrock.
Inference 1: The shale layer is older than the basaltic intrusion.
Inference 2: The shale layer is older than the sandstone layer.
Inference 3: An unconformity exists directly under the shale layer.

Explain how *each* inference is supported by evidence shown in the diagram.

(1) - Shale has contact lines from Basalt touching it (contact metamorphism). Shale is "invaded" by basalt because Basalt cuts through it

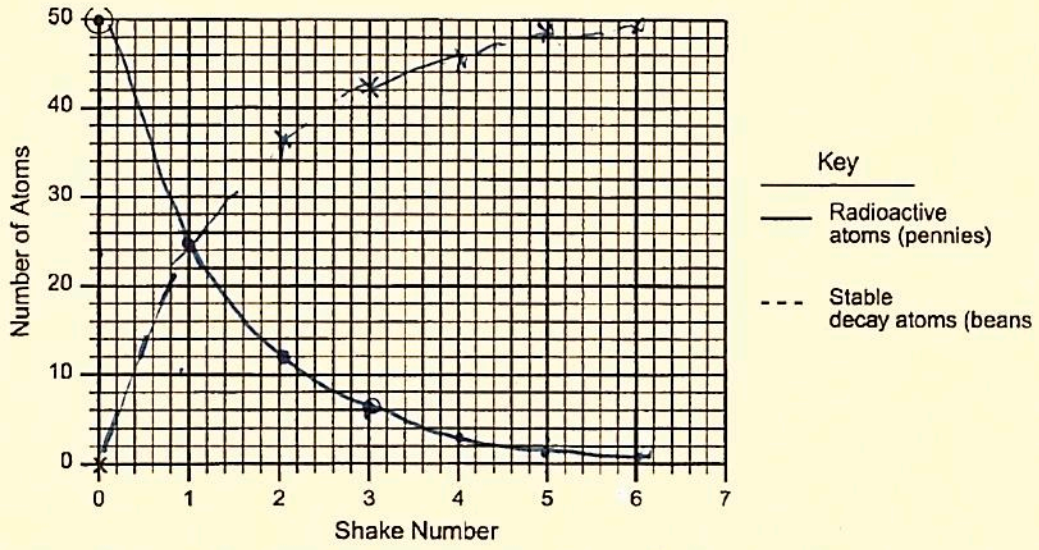
(2) Shale is beneath sandstone

(3) limestone + basalt were eroded

Base your answers to questions **65** and **66** on the table below, which shows the results of a student's demonstration modeling radioactive decay. To begin, the student put 50 pennies heads up in a container. Each penny represented one radioactive atom. The student placed a top on the box and shook the box. Each penny that had flipped over to the tails up side was replaced with a bean that represented the stable decay product. The student continued the process until all of the pennies had been replaced by beans.

Shake Number	Number of Radioactive Atoms (pennies)	Number of Stable Decay Atoms (beans)
0	50	0
1	25	25
2	14	36
3	7	43
4	5	45
5	2	48
6	1	49
7	0	50

Yrs
0
100
200
300
400
500
600
700



65. Assume that each shake number represents an additional 100 years. State the half-life of the radioactive material in this model.

100 years

66. On the grid provided on your answer paper, graph the data shown on the table by following the steps below.

a Mark with a dot each number of radioactive atoms (pennies) after each shake. Surround each dot with a small circle. The zero shake has been plotted for you.

b Connect all the dots with a solid line.

c Mark with an ***X*** the number of stable decay atoms (beans) after each shake. The zero shake has been plotted for you.

d Connect all the ***X***'s with a dashed line.