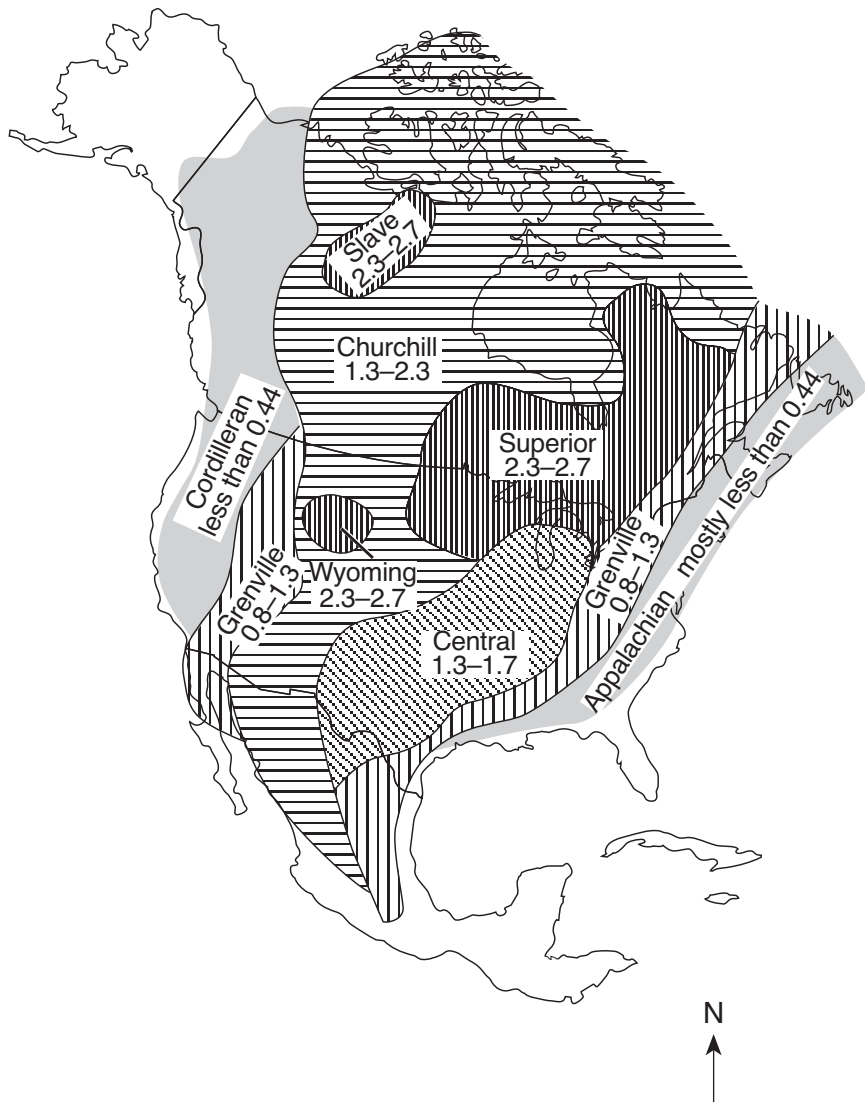


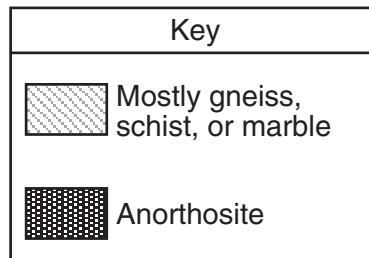
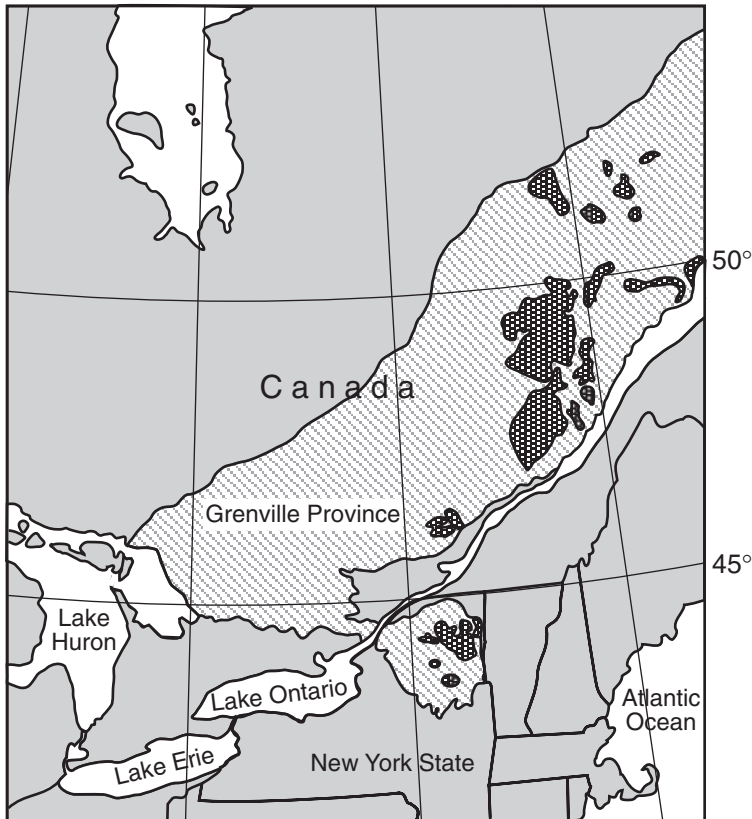
Oldest



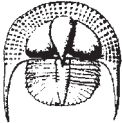
Youngest

Time



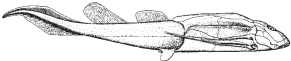








*Baragwanathia*,  
a lycopod — an  
early land plant

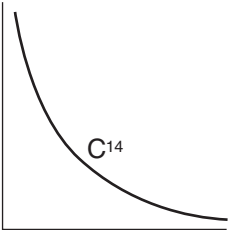


*Bothriolepis*



**Bothriolepis**

**Number of  $C^{14}$  Atoms**



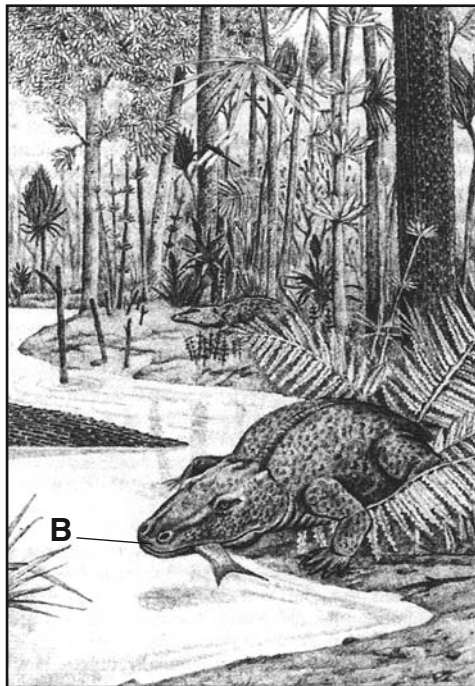
**Time (years)**

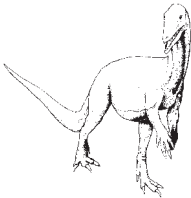
$C^{14}$

**Diagram 1:  
Carboniferous Seafloor**



**Diagram 2:  
Carboniferous Swamp-Forest**



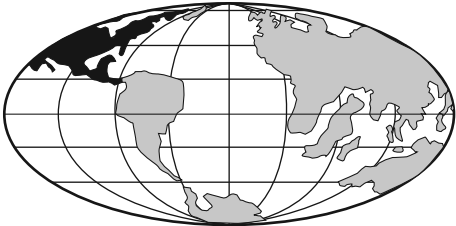


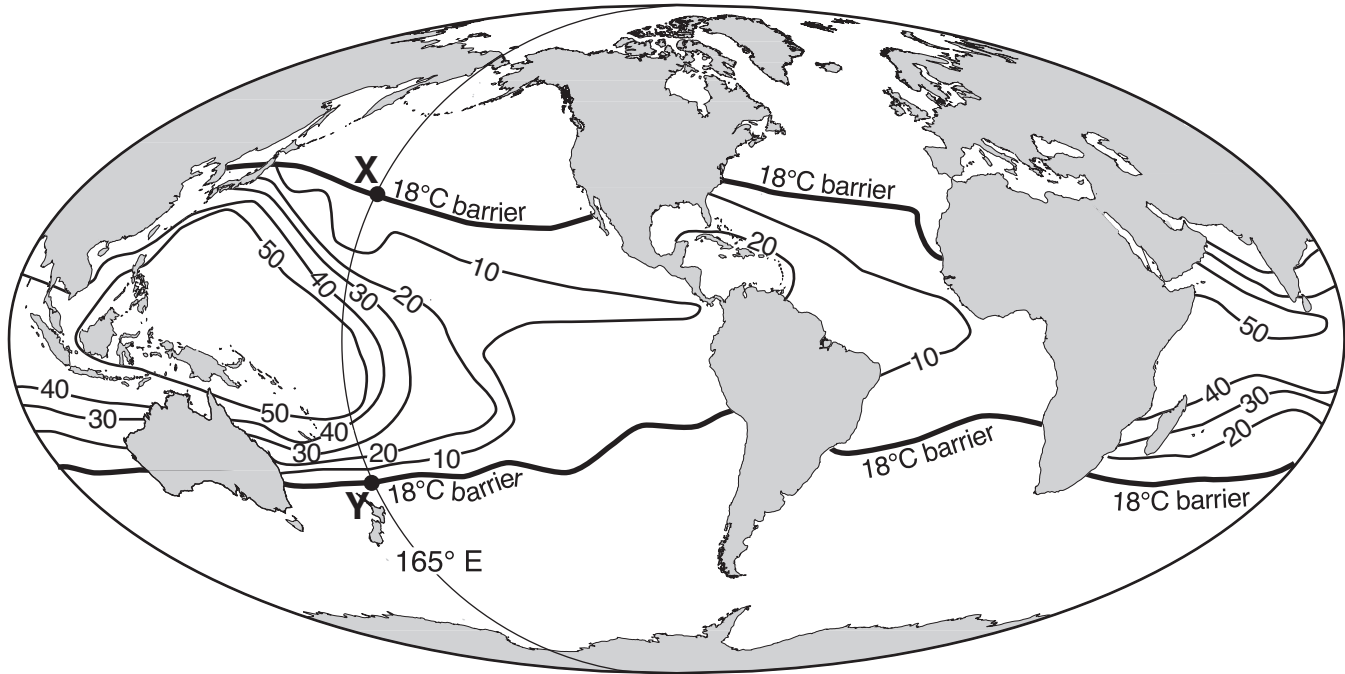
**Coelophysis**



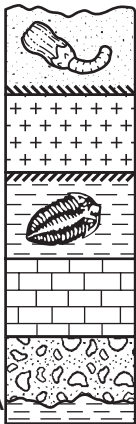
Condor



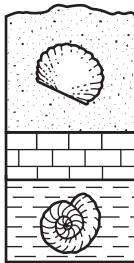




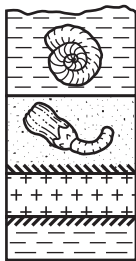
Location W



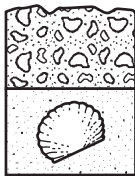
Location X



Location Y



Location Z



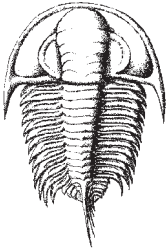
(Not drawn to scale)



*Cystiphyllum*,  
a solitary coral



*Cystiphyllum*



*Elliptocephala*



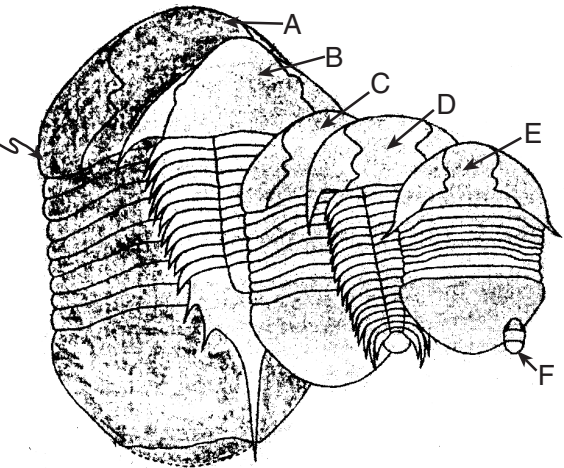
Elliptocephala

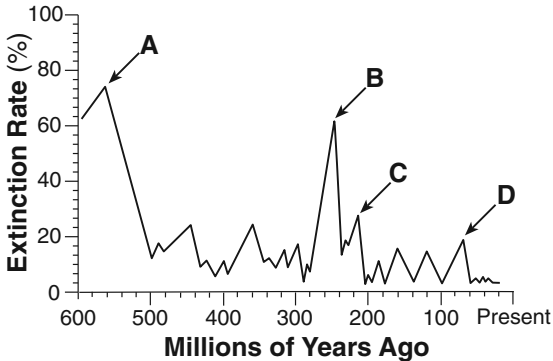


*Eospirifer*



New  
*Isotelus*  
fossil





North America

Atlantic  
Ocean

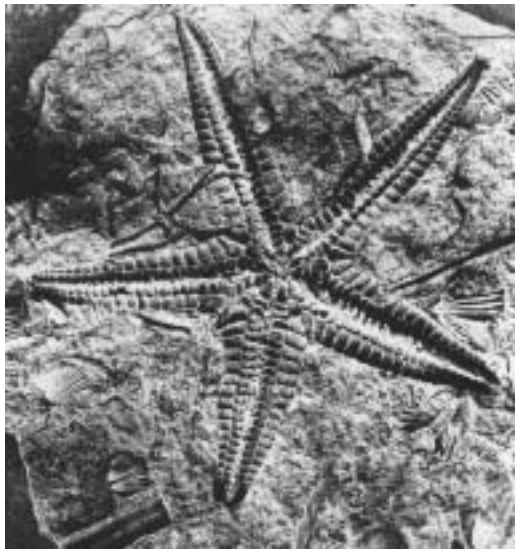
Chicxulub Crater

Pacific  
Ocean

South  
America



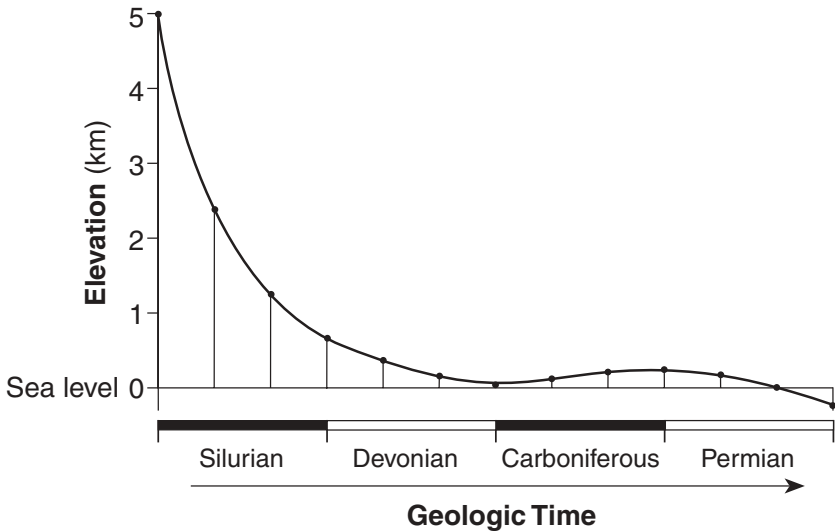


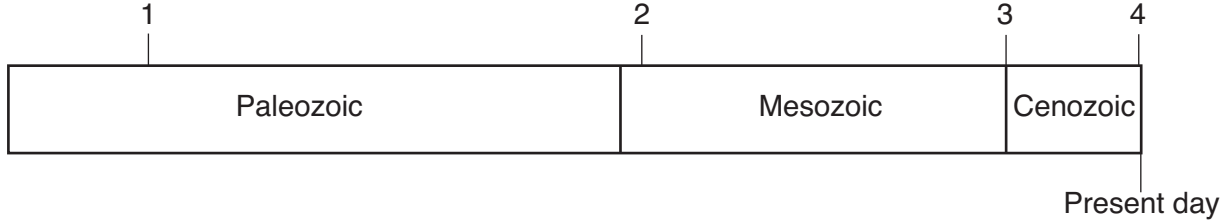


# Fossil Snail



Top view  
clockwise spiral







Mesozoic Era



*Acanthoscaphites*

Cretaceous

Jurassic



*Meekoceras*

Triassic

Paleozoic Era



*Neospirifer*

Permian

Pennsylvanian



*Spirifer*



Crinoid stem

Mississippian

Carboniferous



*Mucrospirifer*



*Phacops*

Devonian



*Eospirifer*

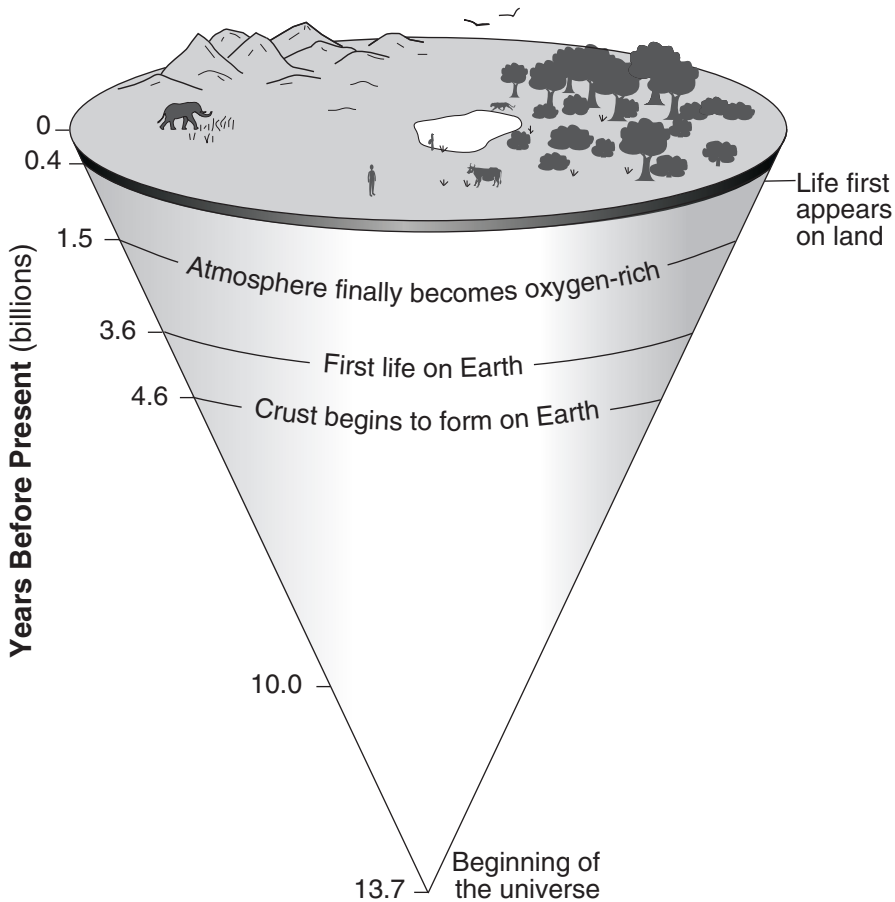
Silurian



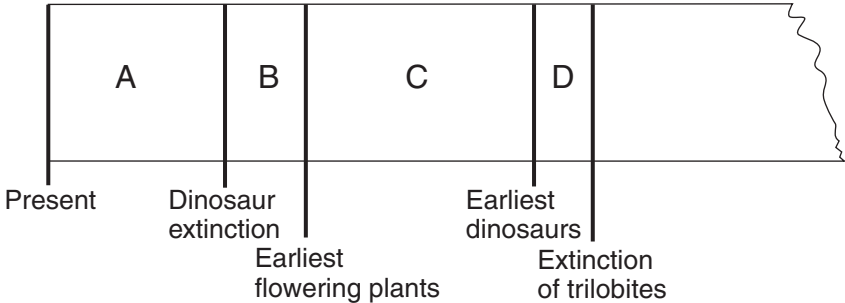
*Michelinoceras*

Ordovician

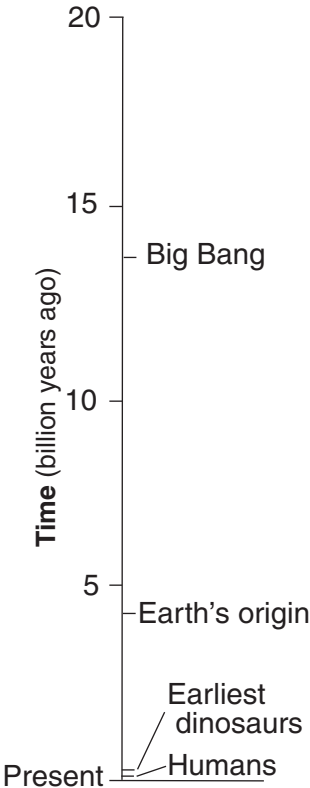
Cambrian

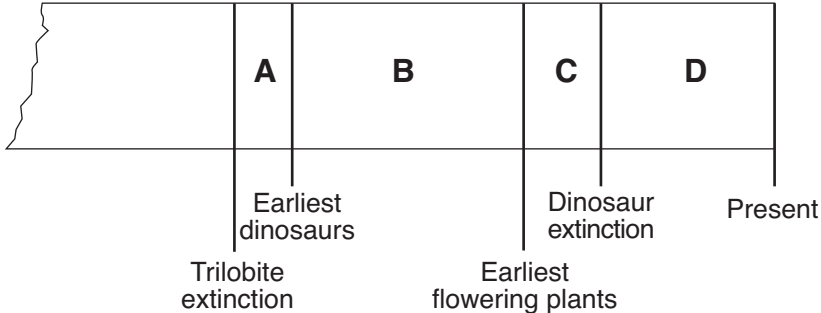


(Not drawn to scale)

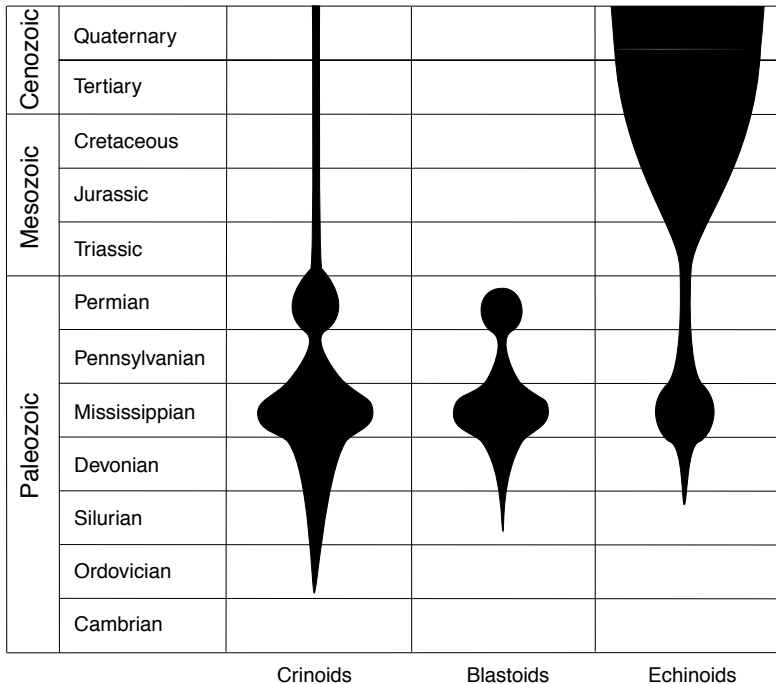


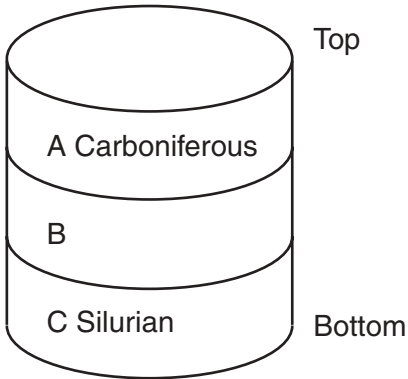






# Phylum Echinodermata





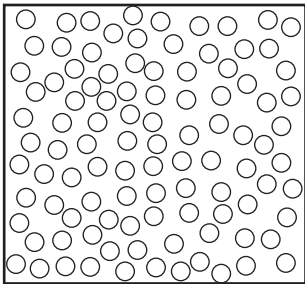




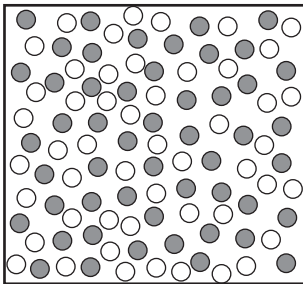
Floating graptolites

<b>Half-Life</b>	<b>Mass of Original Carbon-14 Remaining (g)</b>	<b>Number of Years</b>
0	1	0
1	$\frac{1}{2}$	5700
2	$\frac{1}{4}$	11,400
3	$\frac{1}{8}$	17,100

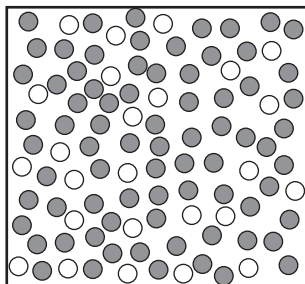
**Original sample of undecayed atoms**



**Atoms after one half-life**



**Atoms after two half-lives**



**Key**

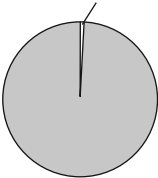
○ Undecayed radioactive atom

● Decayed atom (stable end product)

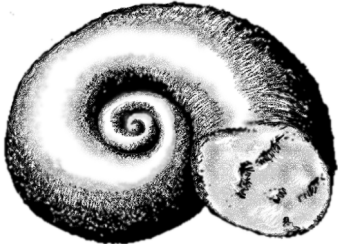
Sandstone {  
Shale {



# Human existence







*Maclurites*



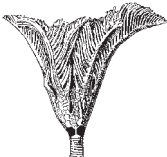


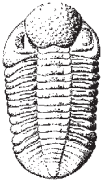


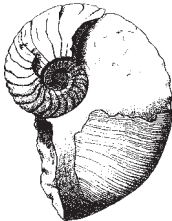












Centroceras

A A A

A B A

B B C C

A B D

D D D

A A A

C B C

A D

D D

A D B

C C A C

A B D



# Table of Index Fossils



Eospirifer



Manticoceras



Phacops

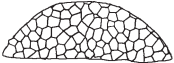
# Sample before decay



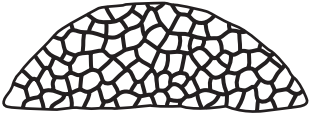








*Lichenaria*





*Maclurites*

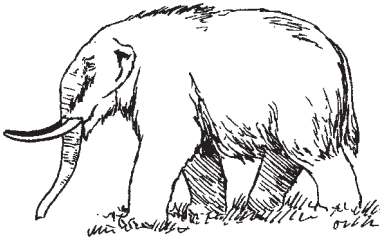




Maclurites

# Map of North America

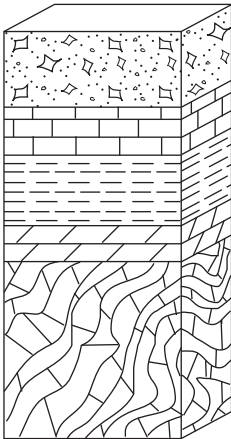




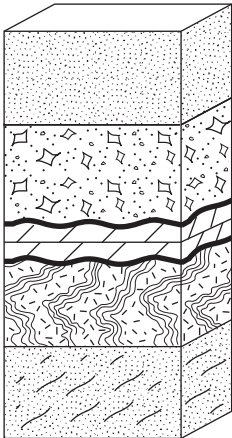
Mastodont



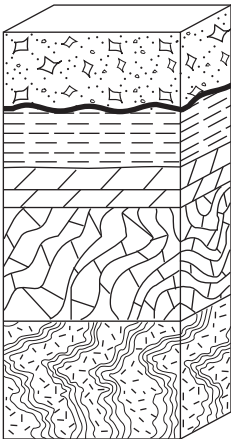
# Outcrop B



# Outcrop C



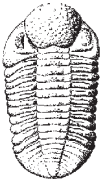
# Outcrop D



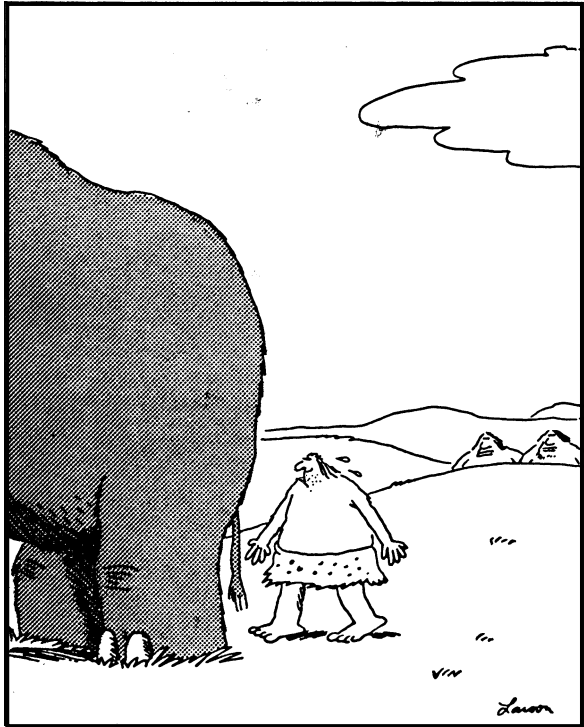


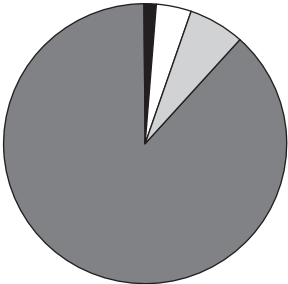
*Palaeophonus*,  
a scorpion — one of  
the first land animals



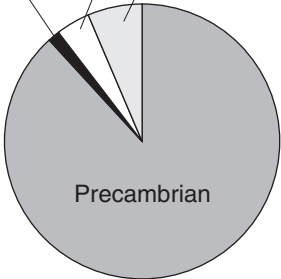


*Phacops*



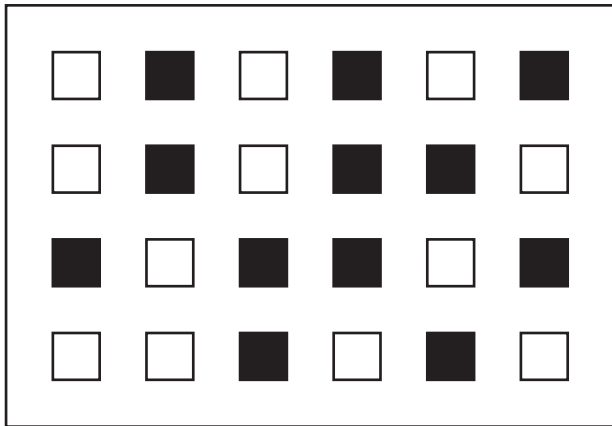




Mesozoic  
Cenozoic Paleozoic



<b>Percent of U-235 Remaining</b>	<b>Percent Decayed to Pb-207</b>	<b>Half-Lives Elapsed</b>
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

## Radioactive Sample After First Half-Life



Key	
	Undecayed radioactive material
	Decayed material

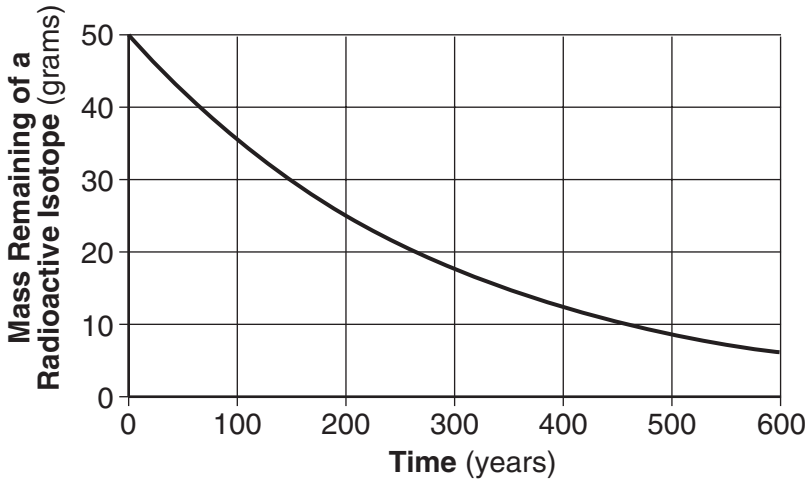
## Radioactive Decay of Carbon-14

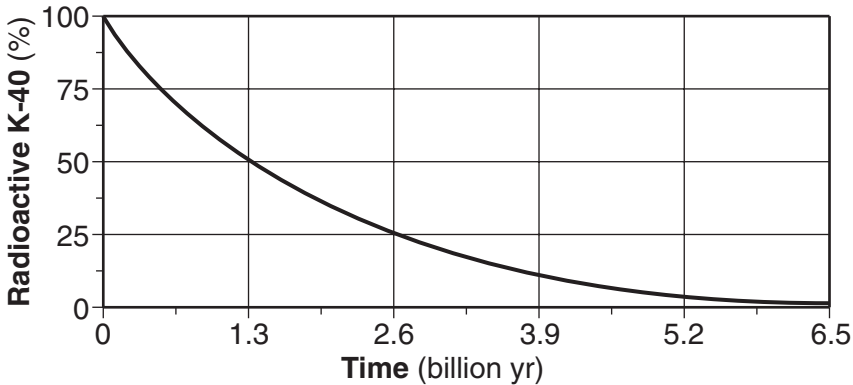
<b>Number of Half-Lives</b>	<b>Percentage of Original Carbon-14 Remaining</b>	<b>Time (years)</b>
0	100	0
1	50	5700
2	25	11,400
3	12.5	17,100
4	6.3	
5	3.1	28,500
6	1.6	34,200

<b>Ratio of Radioactive Potassium-40 to Nonradioactive Decay Products</b>	<b>Age of Rock (years)</b>
1:0	0
1:1	$1.3 \times 10^9$
1:3	$2.6 \times 10^9$
1:7	$3.9 \times 10^9$
1:15	$5.2 \times 10^9$
1:31	$6.5 \times 10^9$

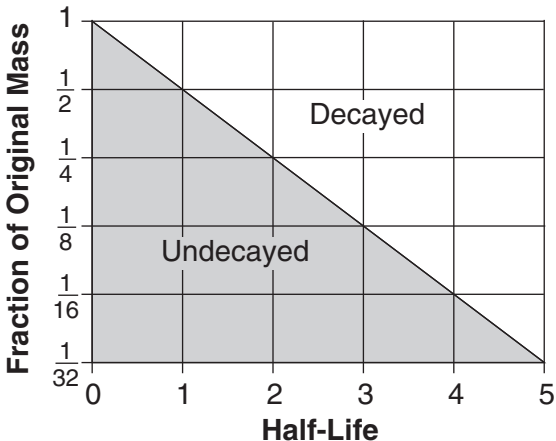


<b>Half-life</b>	<b>Mass of Original Carbon-14 Remaining (grams)</b>	<b>Number of Years</b>
0	1	0
1	$\frac{1}{2}$	5,700
2	$\frac{1}{4}$	11,400
3	$\frac{1}{8}$	17,100
4	$\frac{1}{16}$	
5		
6		
7		

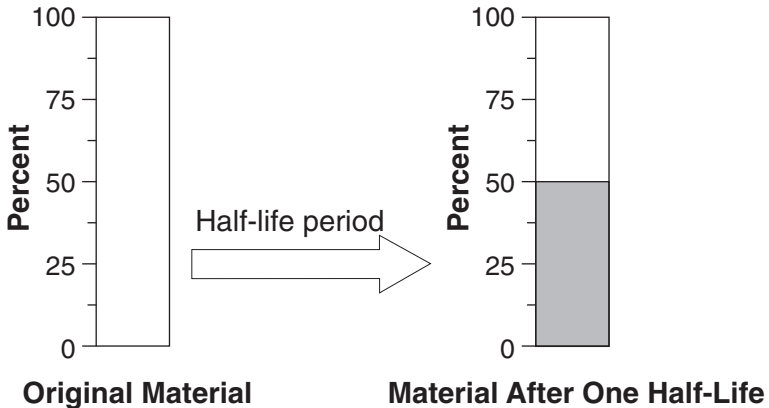






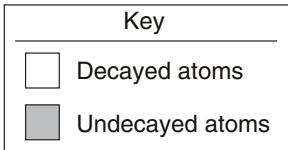
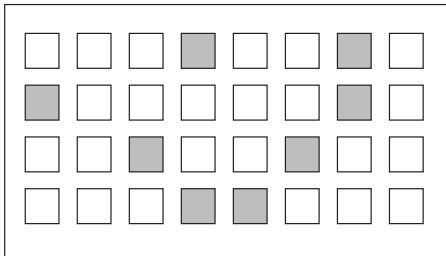
# Generalized Rate of Radioactive Decay

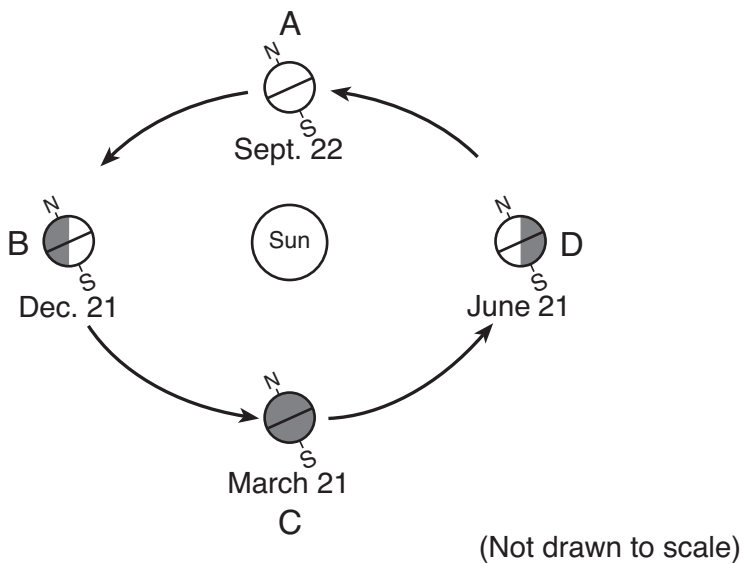


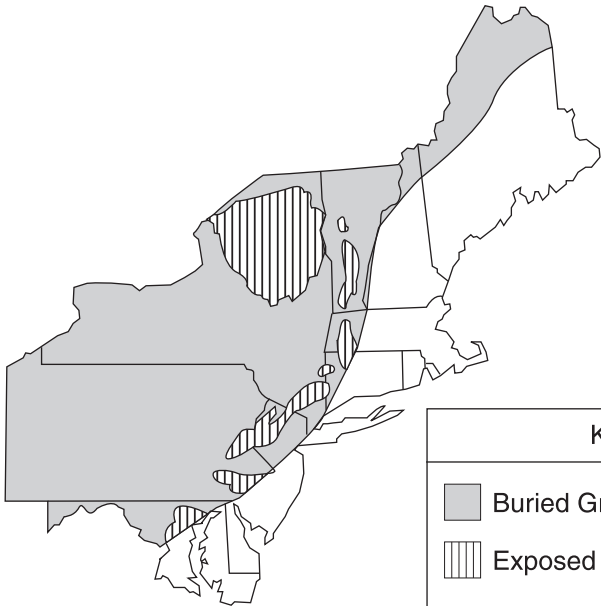
## Radioactive Decay Model





Key	
	Radioactive element
	Stable decay element







### Key

-  Buried Grenville rocks
-  Exposed Grenville rocks



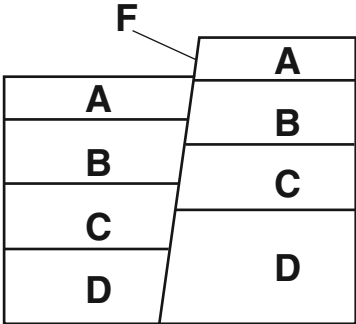
$^{87}\text{Rb}$

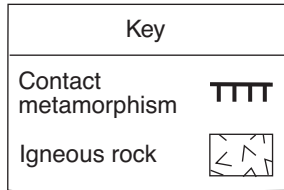
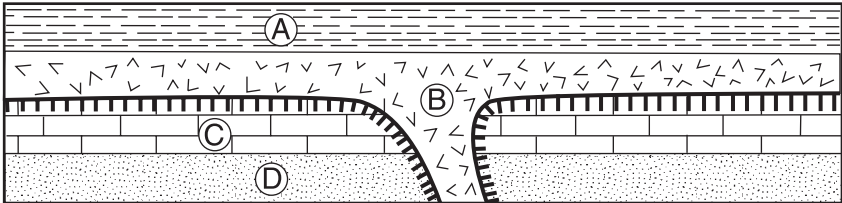
$^{87}\text{Rb}$

$^{87}\text{Sr}$

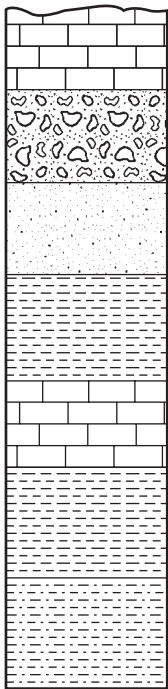
$^{87}\text{Rb}$

$^{87}\text{Sr}$





### Location X



Gray limestone

Conglomerate

Red sandstone

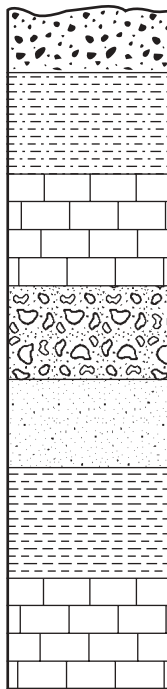
Black shale  
-containing  
trilobite fossils

Tan limestone  
-containing  
ammonoid fossils

Green shale  
-containing trilobite  
and coral fossils

Gray siltstone  
-containing trilobite  
and brachiopod  
fossils

### Location Y



Unconsolidated  
glacial deposits (till)

Brown siltstone  
-containing mammal  
skeletal fossils

Gray limestone

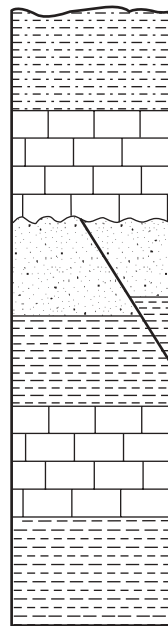
Conglomerate

Red sandstone  
-containing  
dinosaur footprints

Black shale  
-containing  
trilobite fossils

Tan limestone  
-containing  
ammonoid fossils

### Location Z



Brown siltstone  
-containing mammal  
skeletal fossils

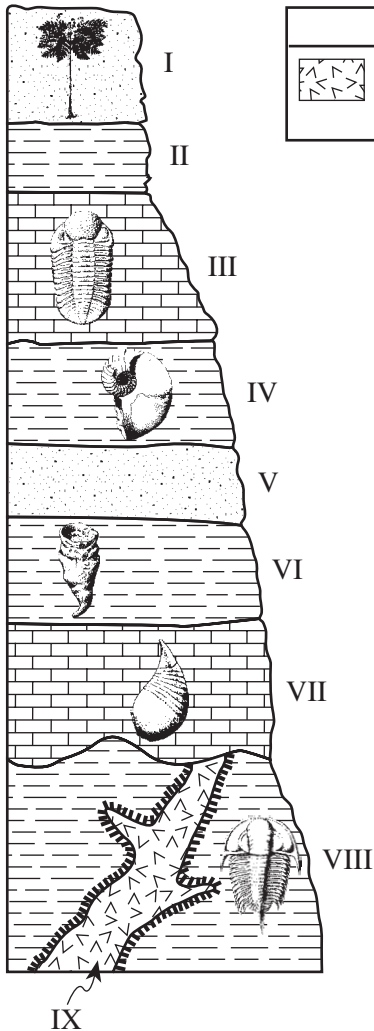
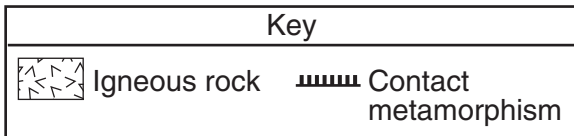
Gray limestone

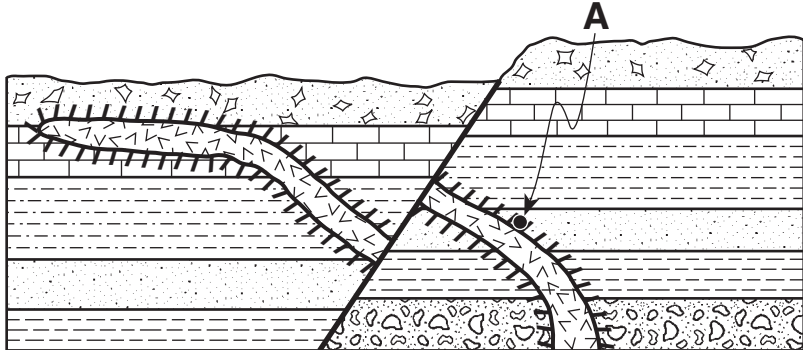
Red sandstone

Black shale  
-containing  
trilobite fossils

Tan limestone  
-containing  
ammonoid fossils

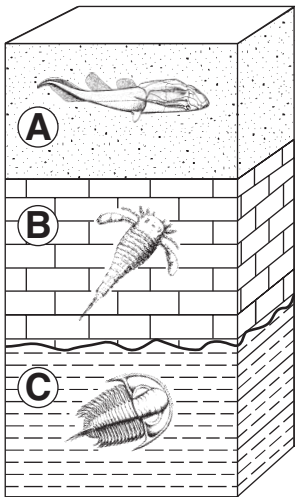
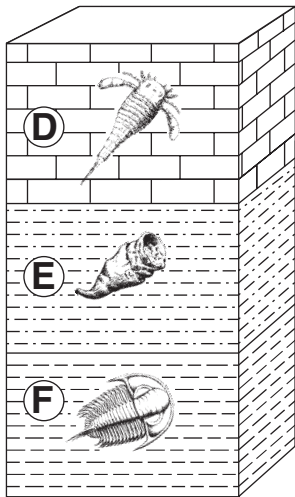
Green shale  
-containing trilobite and  
brachiopod fossils



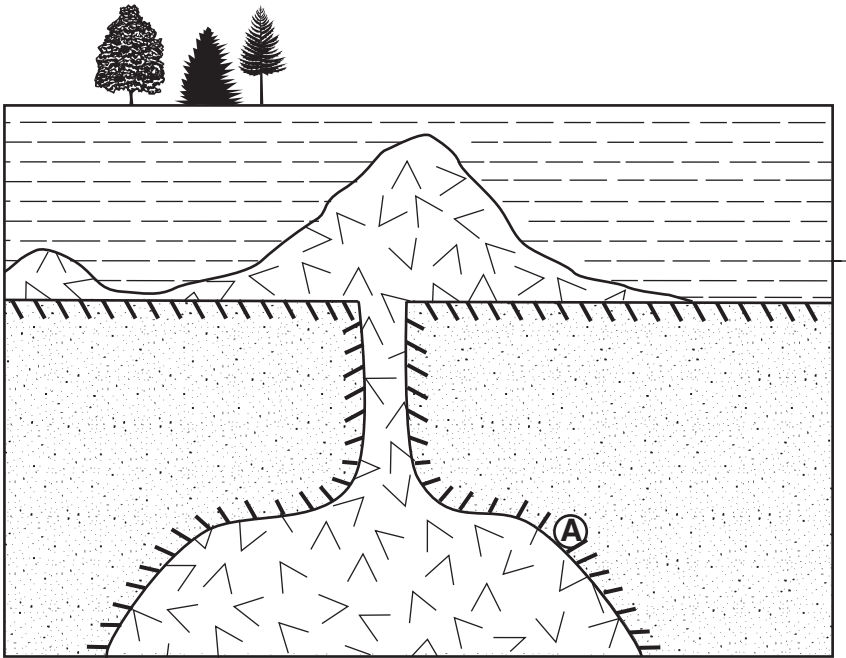


Key			
	Siltstone		Shale
	Limestone		Basalt intrusion
	Sandstone		Breccia
	Conglomerate		Contact metamorphism

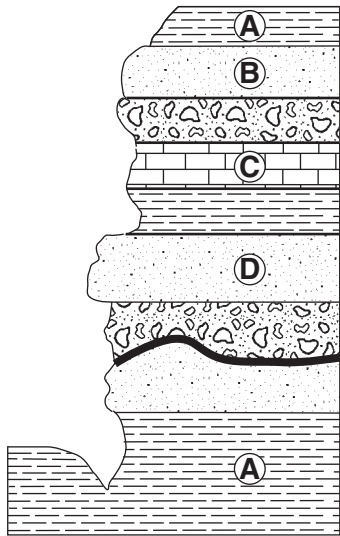
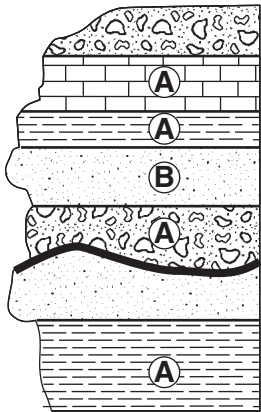
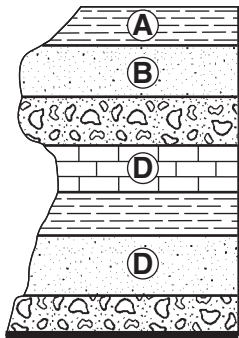


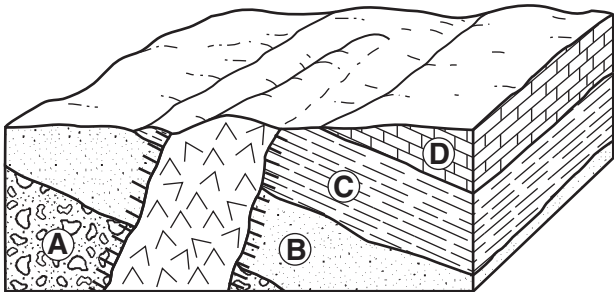
**I****II**



Unconformity

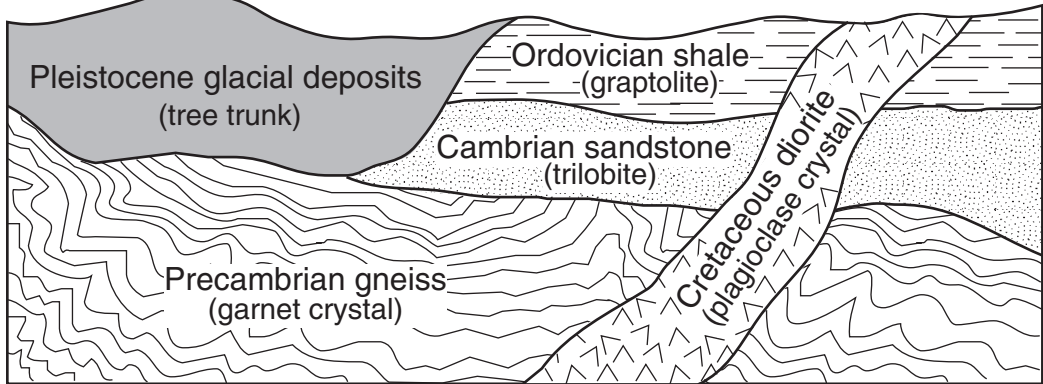


Key	
	Igneous rock
	Contact metamorphic rock
	Sandstone
	Shale



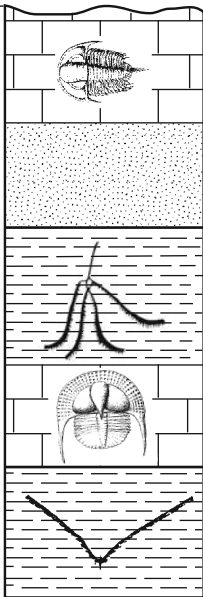


Key	
	Igneous rock
	Contact metamorphism



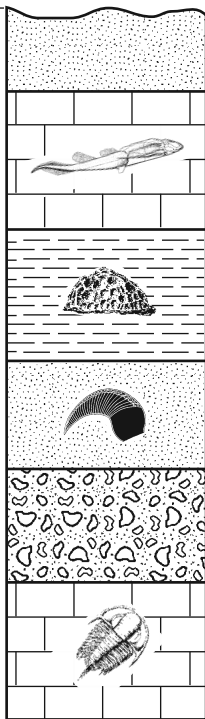
### Outcrop I

Surface



### Outcrop II

Surface



### Outcrop III

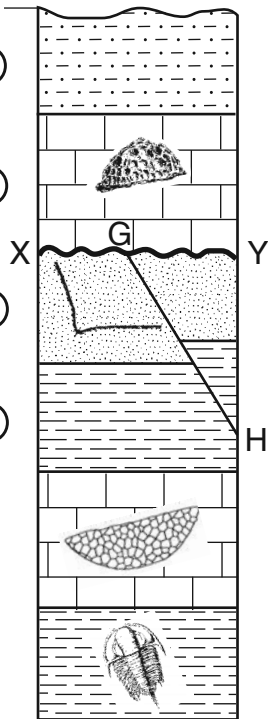
Surface

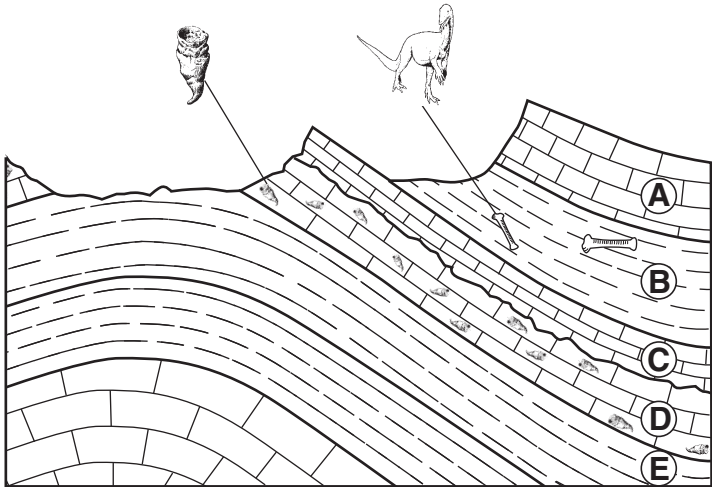
(A)

(B)

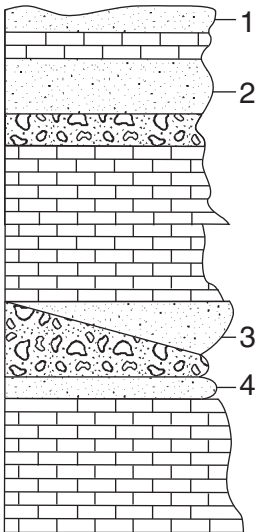
(C)

(D)

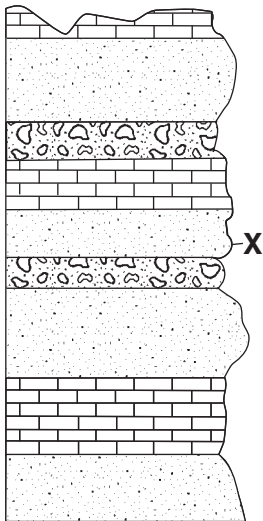




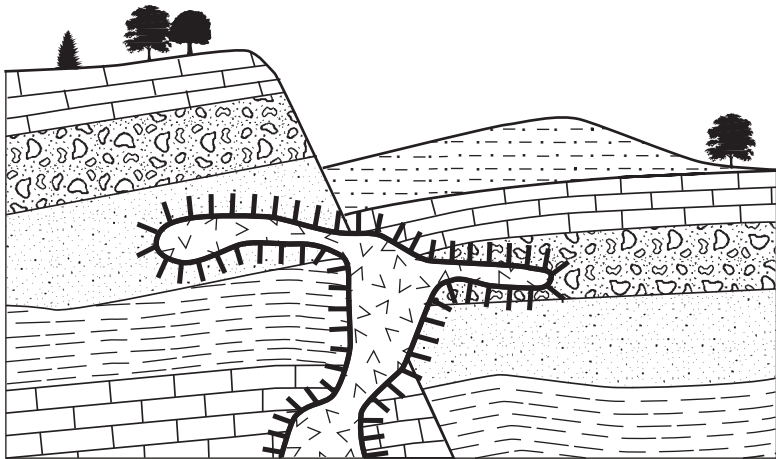
# Location A





# Location B



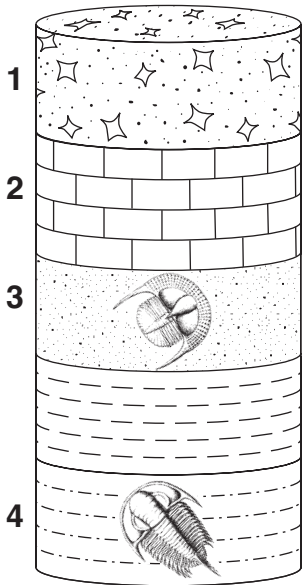




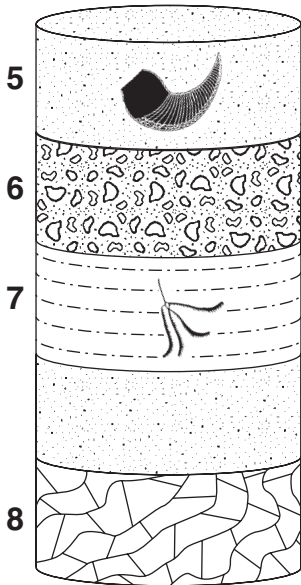
(Not drawn to scale)

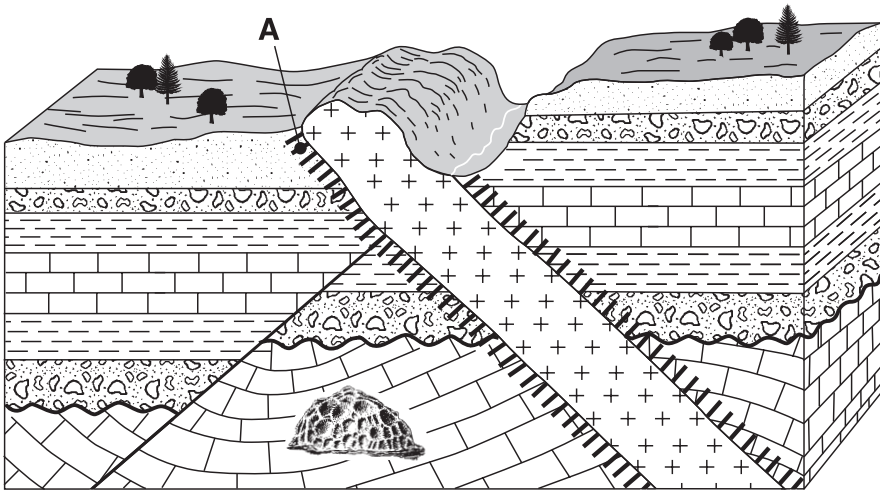
Key	
	Basalt
	Contact metamorphism

# Drill Core 1



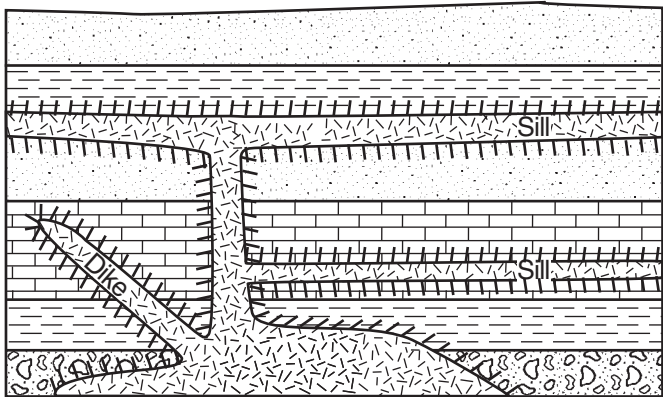
# Drill Core 2





Key	
	Rhyolite
	Contact metamorphism

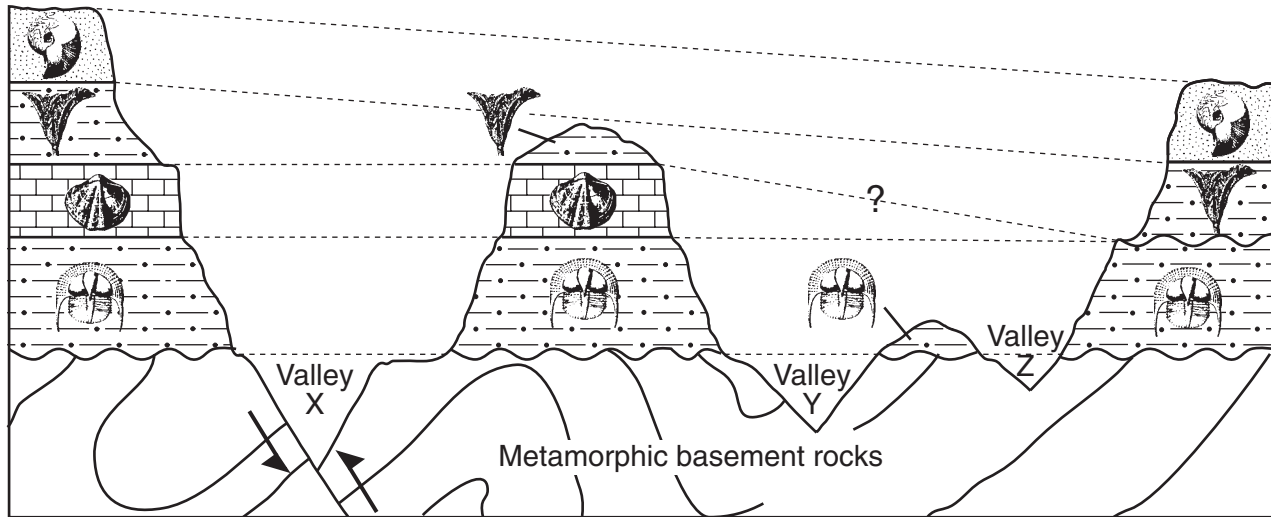
(Not drawn to scale)

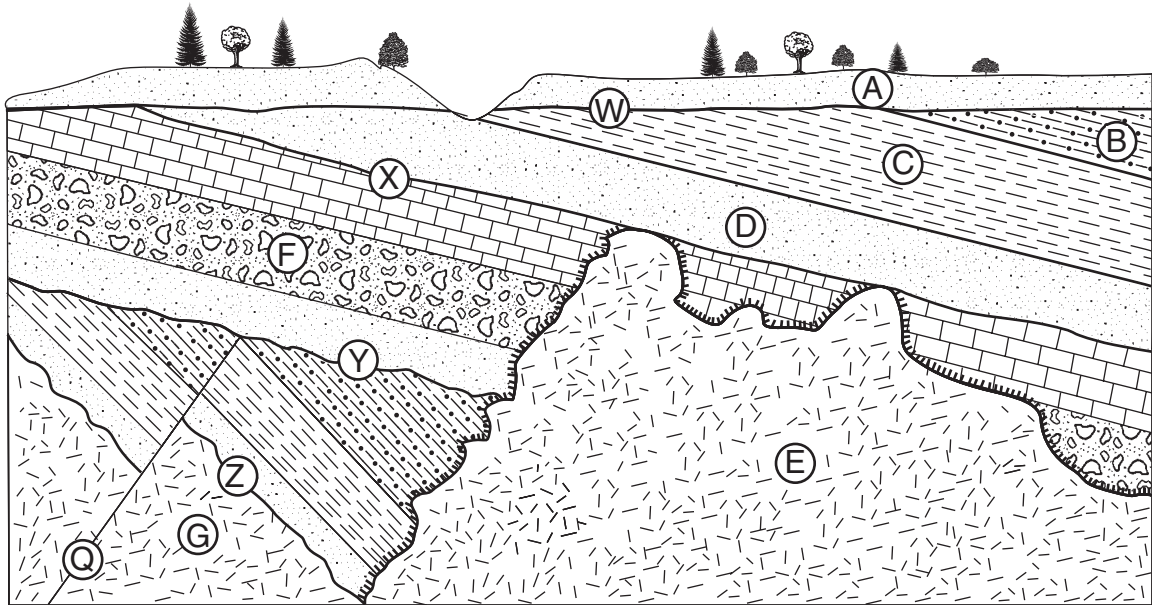


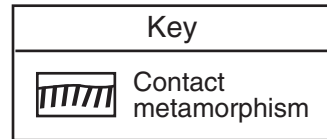
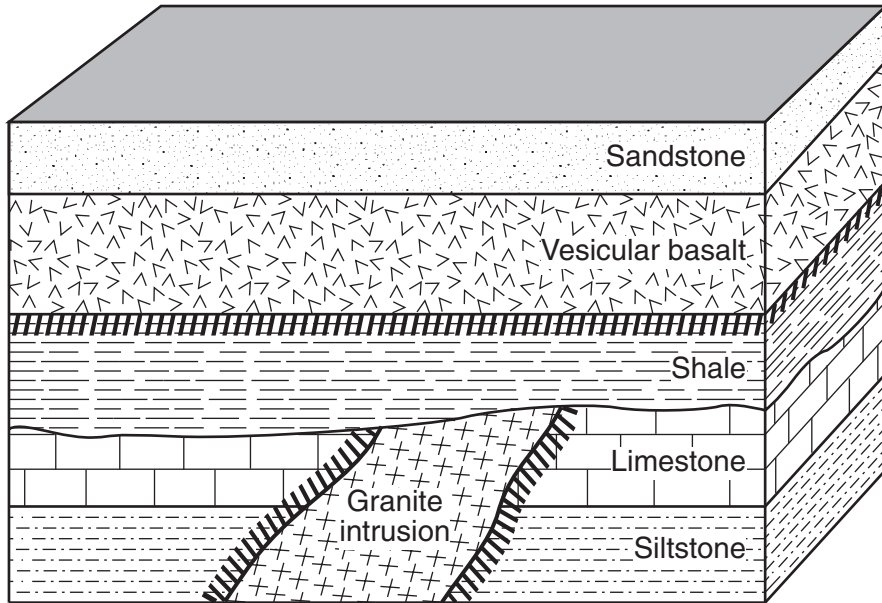
Location 1

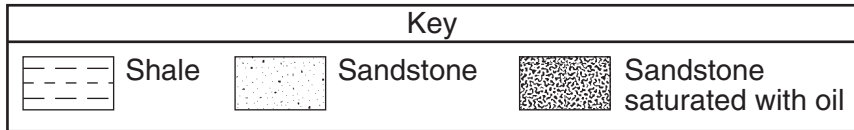
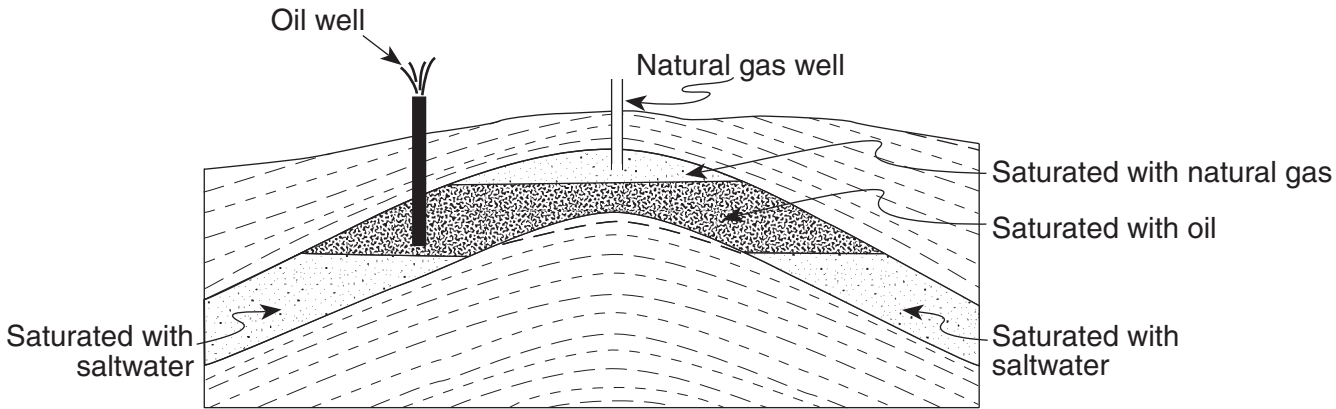
Location 2

Location 3

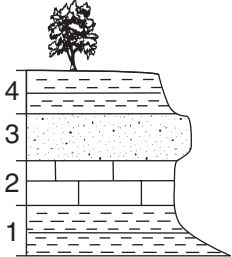




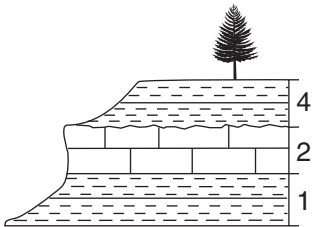




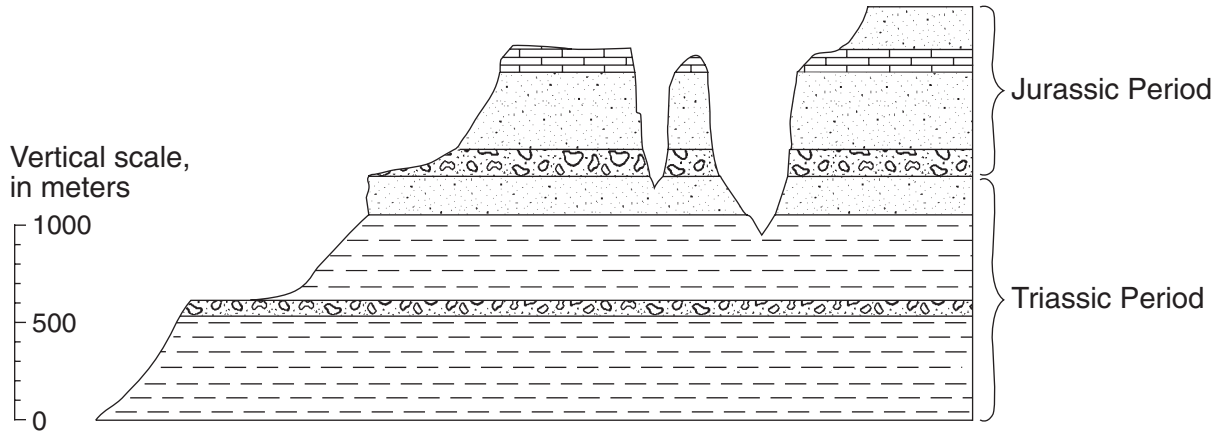


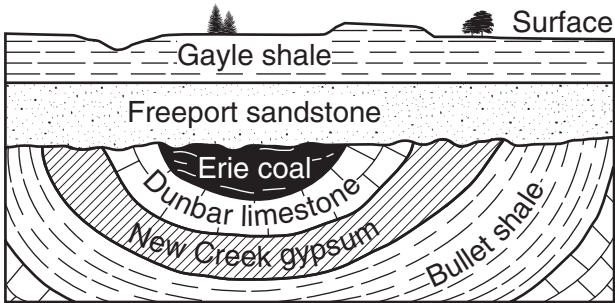


Outcrop A



Outcrop B





Surface

Gayle shale

Freeport sandstone

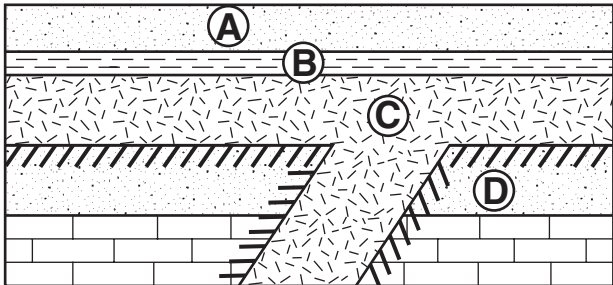
Erie coal

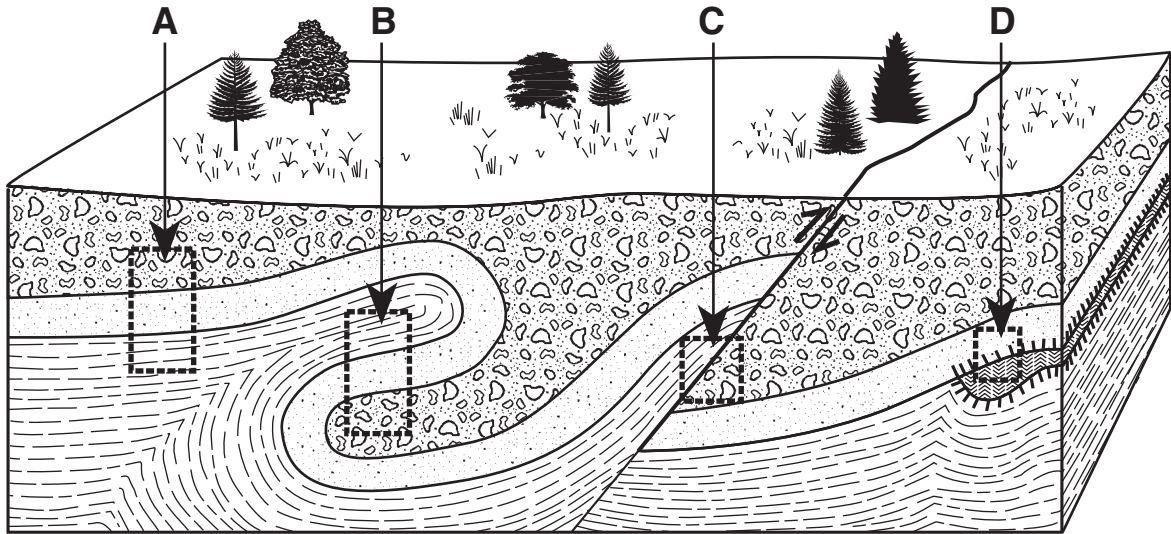
Dunbar limestone

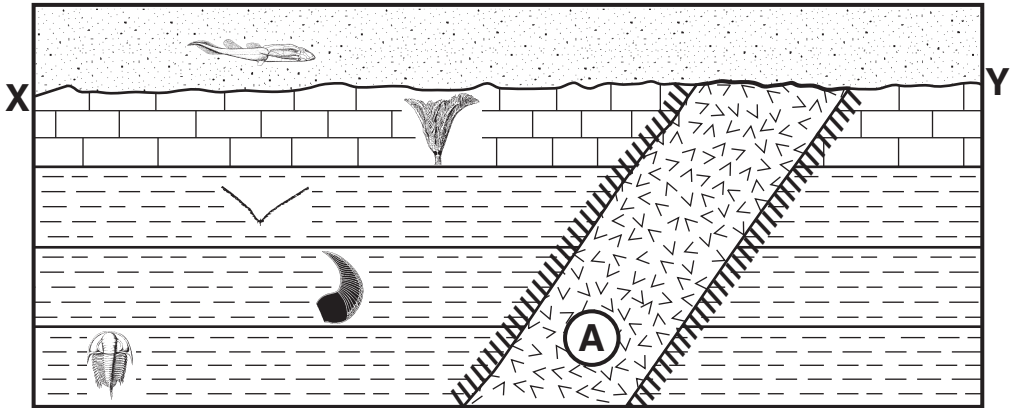
New Creek gypsum

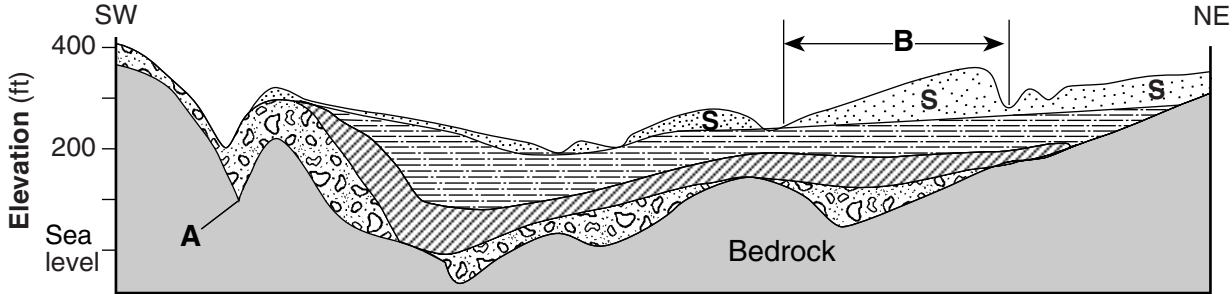
Bullet shale

Surface

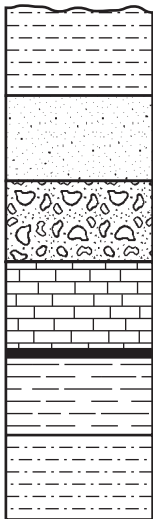








### Outcrop A



Tan siltstone

Brown sandstone

Conglomerate

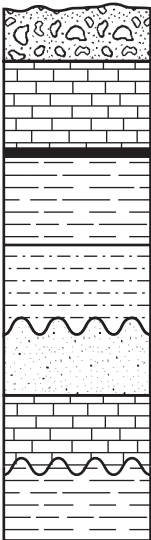
Tan limestone

Volcanic ash

Green shale

Gray siltstone

### Outcrop B



Conglomerate

Tan limestone

Volcanic ash

Green shale

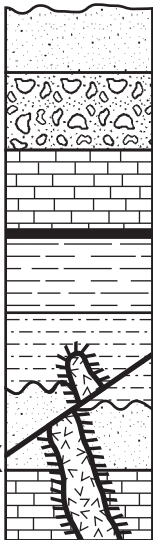
Gray siltstone

Red sandstone

Gray limestone

Black shale

### Outcrop C



Brown sandstone

Conglomerate

Tan limestone

Volcanic ash

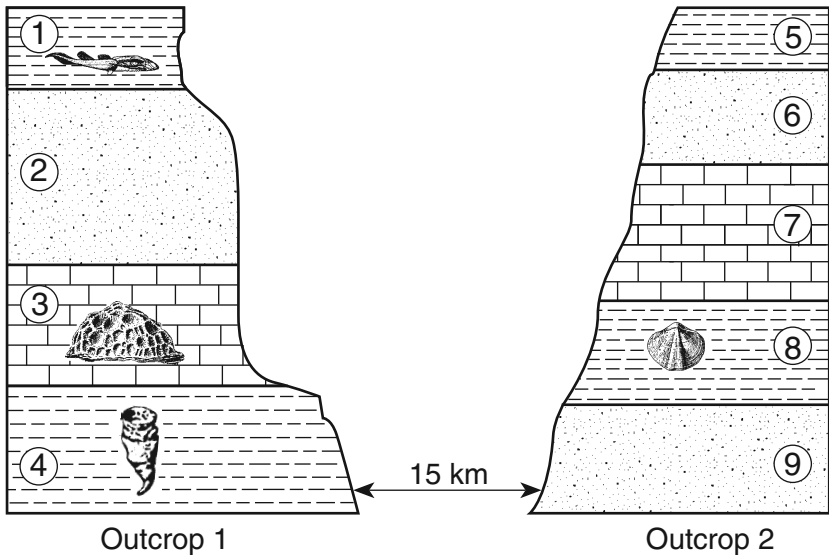
Green shale

Gray siltstone

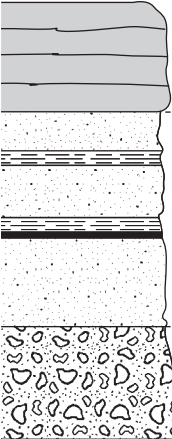
Red sandstone

Gray limestone





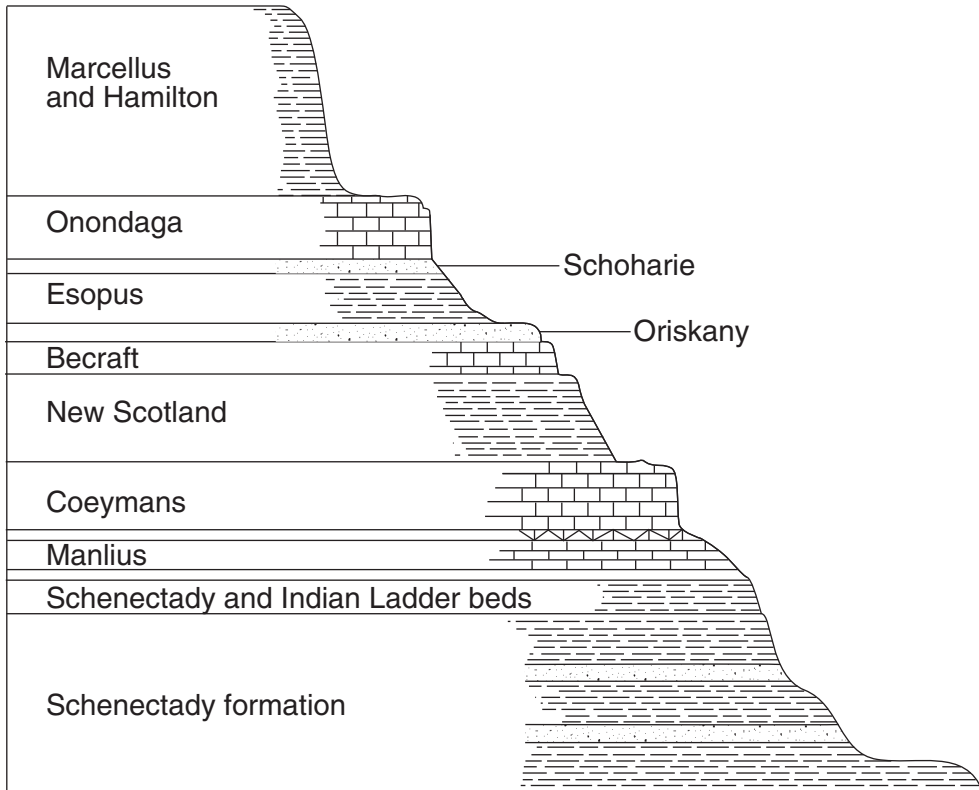
(Not drawn to scale)



Basalt  
(lava flows)

Contains  
*Glossopteris*  
fossils

Glacial (till)  
deposits



Marcellus  
and Hamilton

Onondaga

Esopus

Becraft

New Scotland

Coeymans

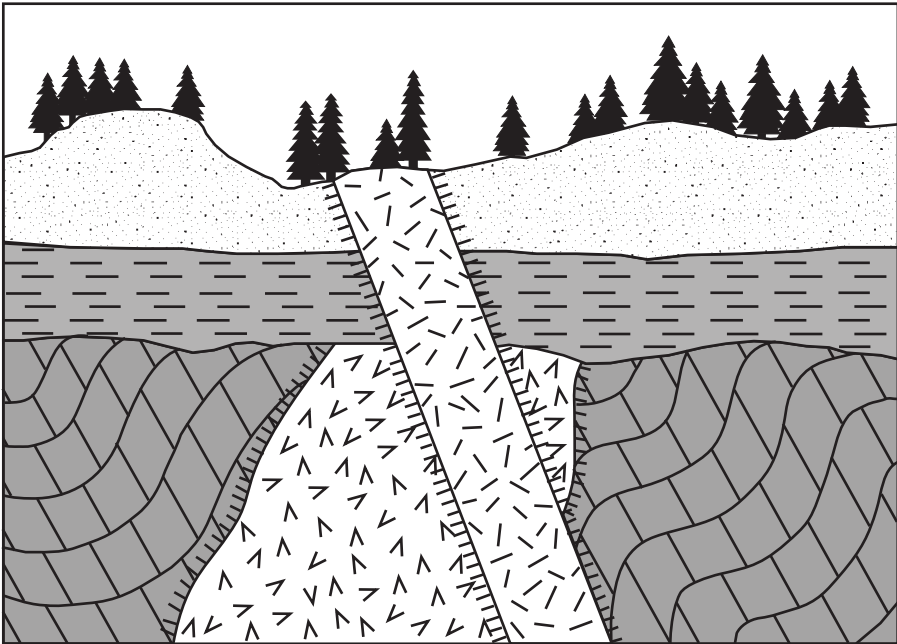
Manlius

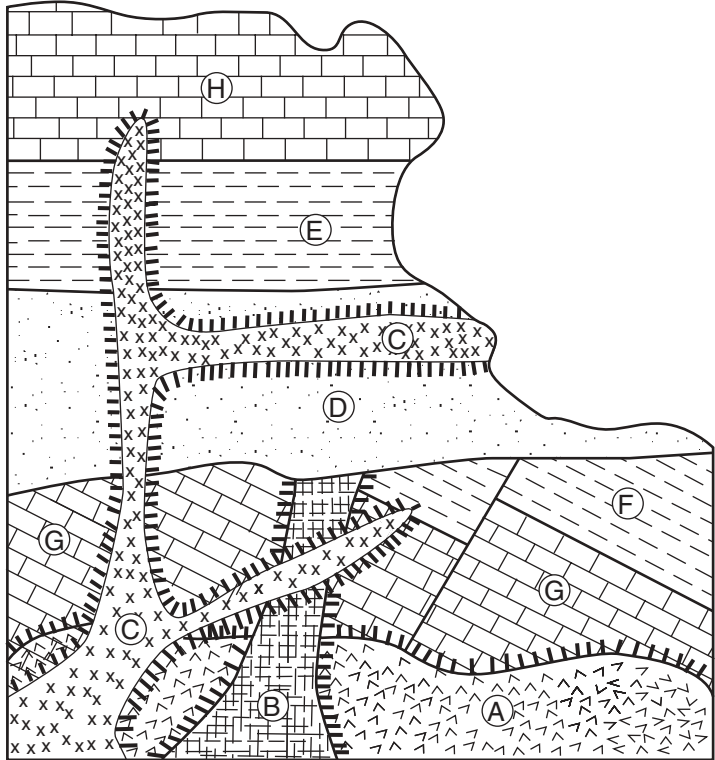
Schenectady and Indian Ladder beds

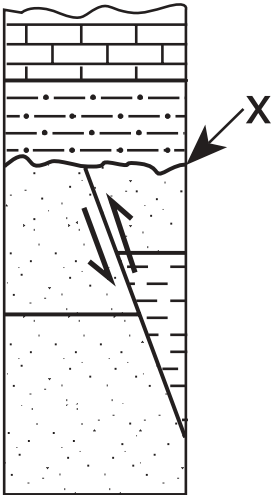
Schenectady formation

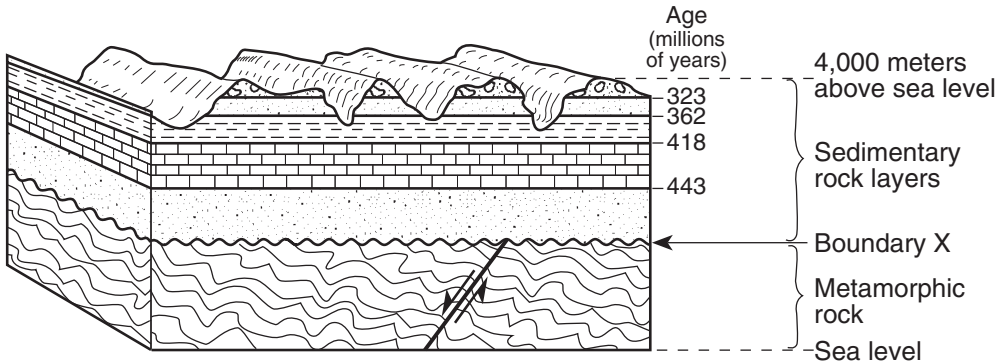
Schoharie

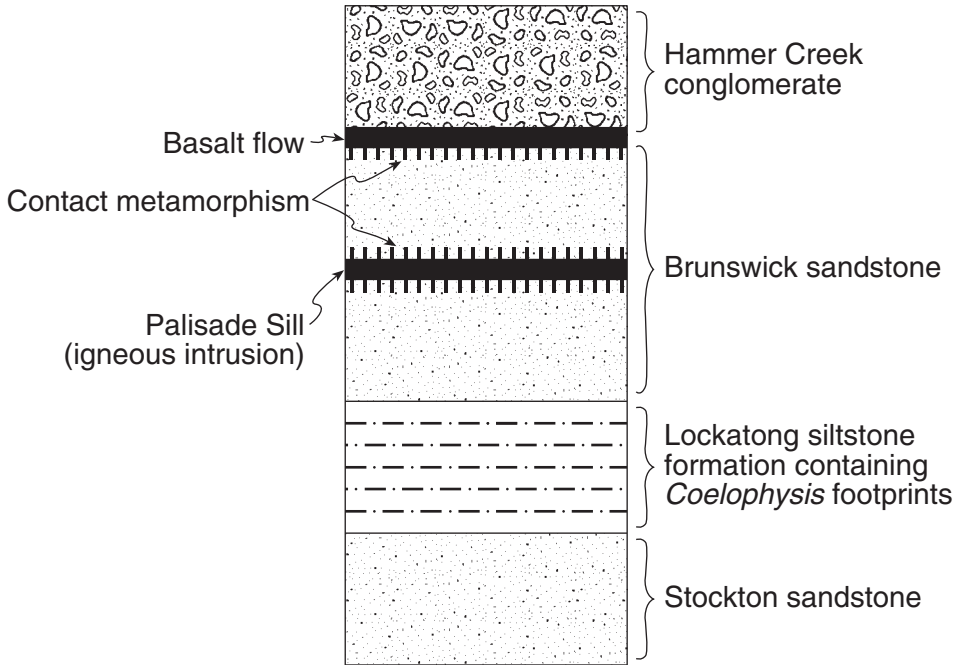
Oriskany





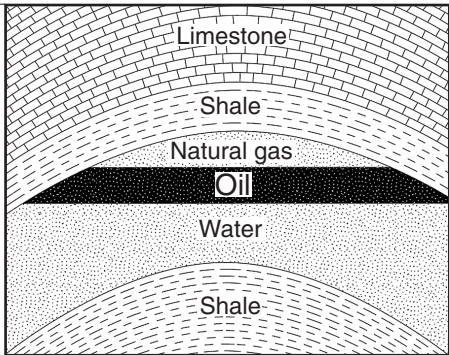




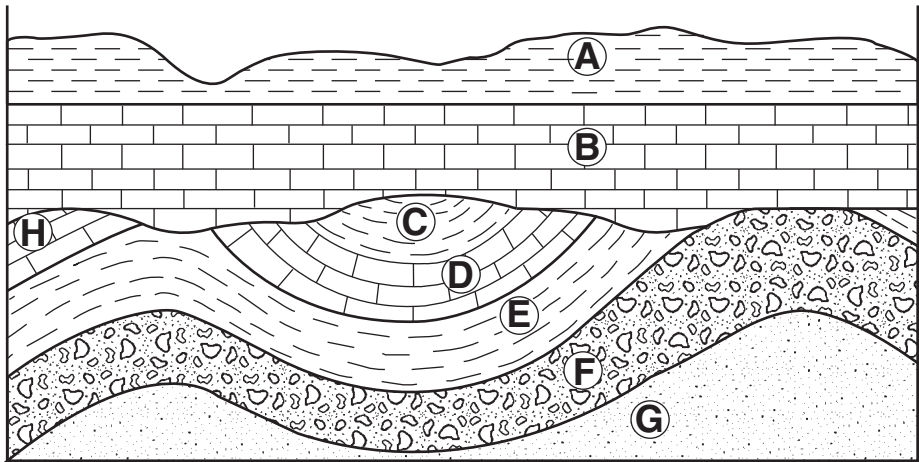


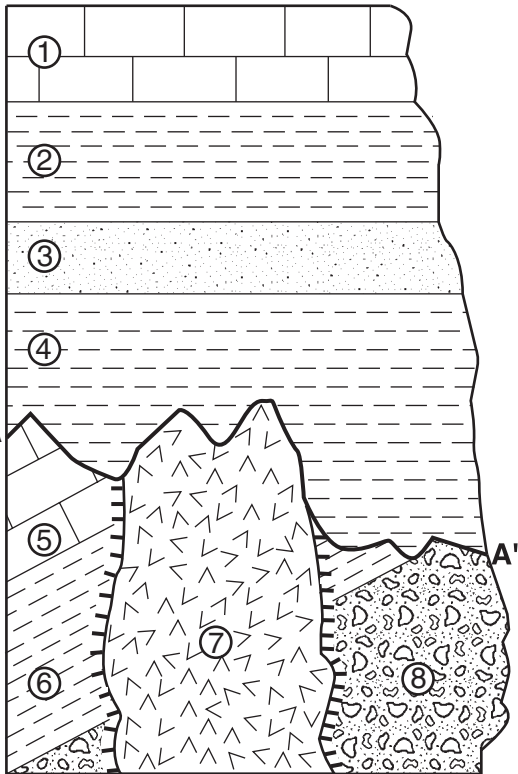


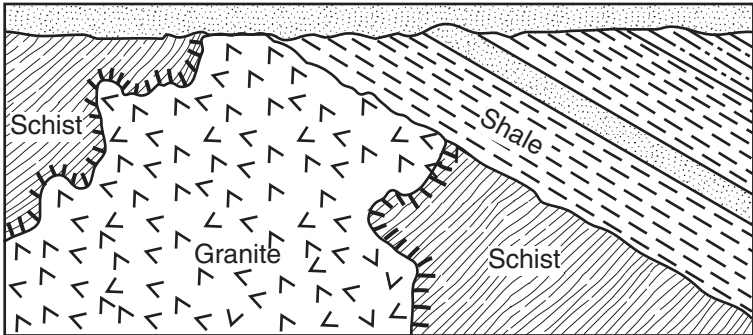
Top

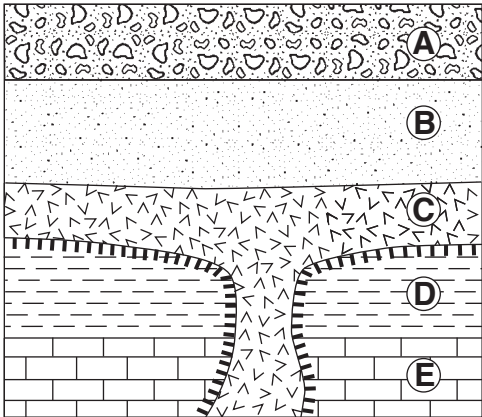


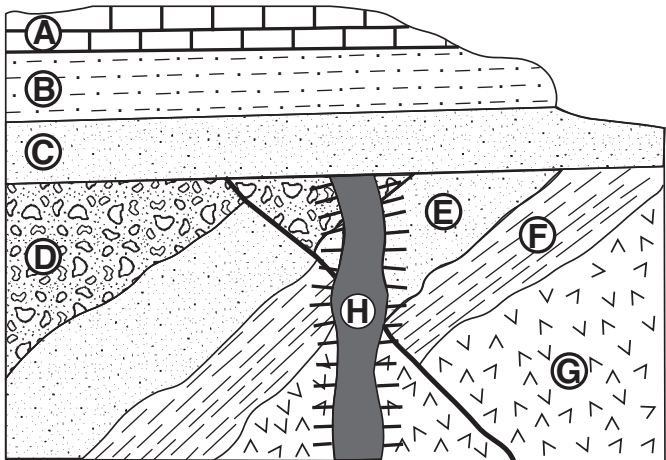
Bottom

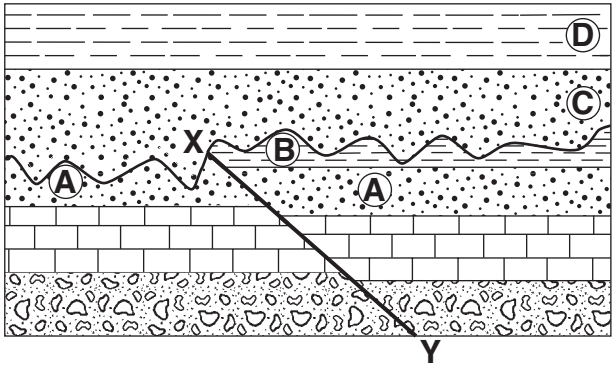


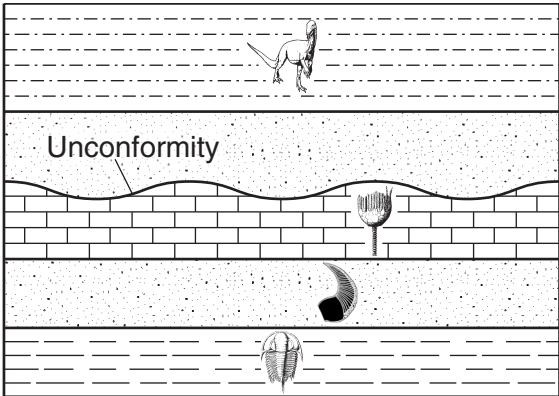






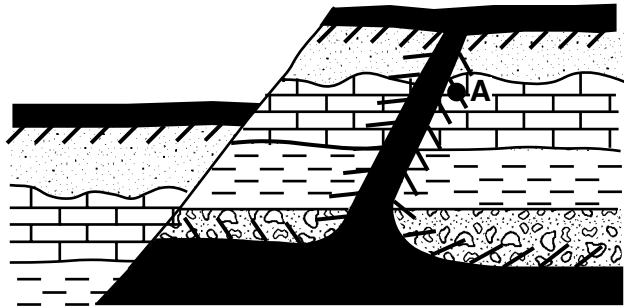






(Not drawn to scale)





### Key



Shale



Sandstone



Limestone



Conglomerate



Contact metamorphism

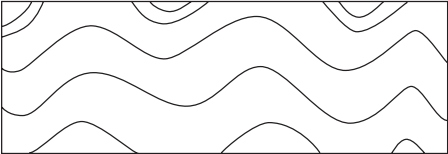


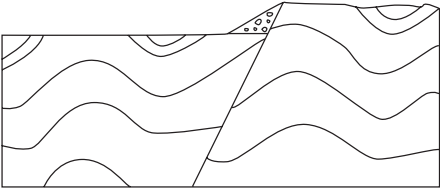
Basalt

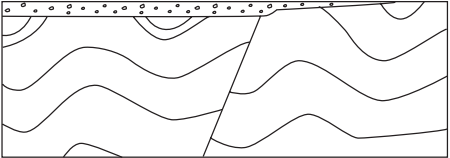
Sedimentary  
rocks

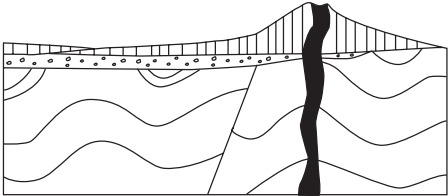
Igneous rock

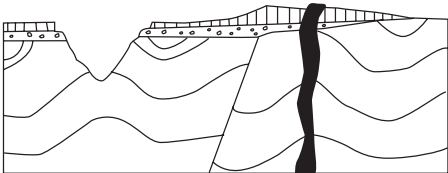




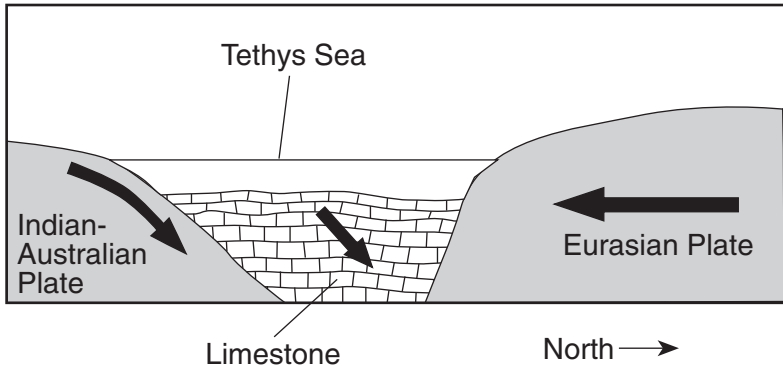


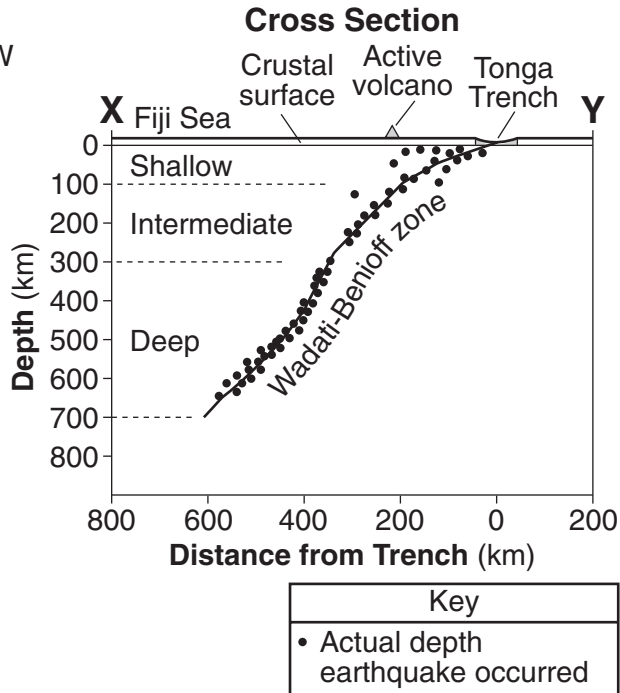
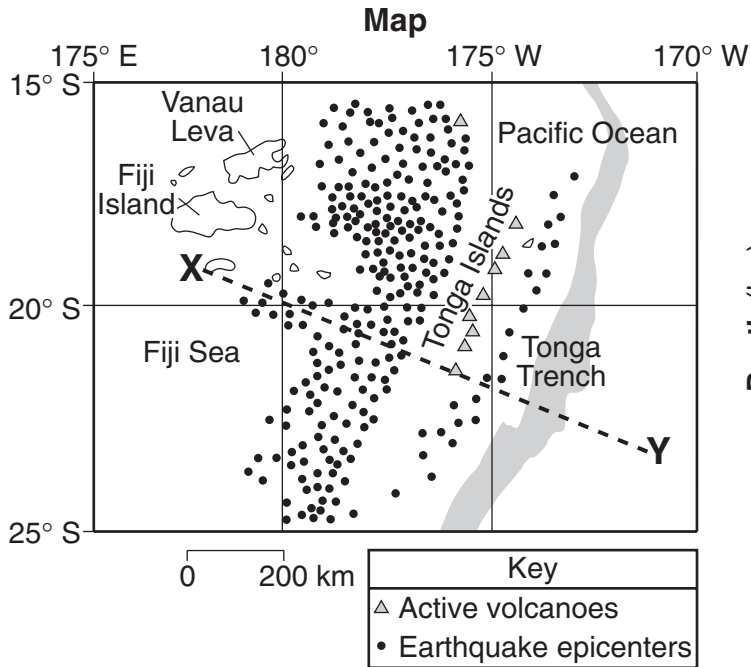


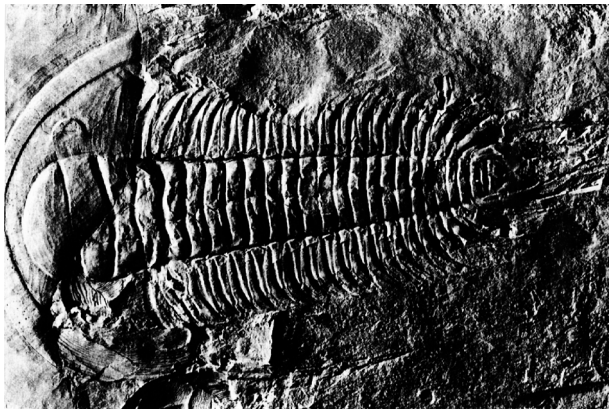


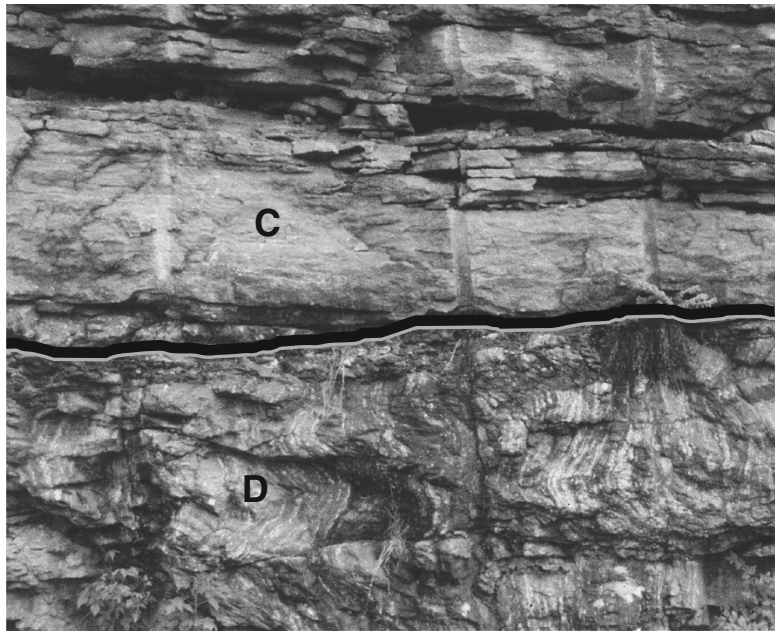


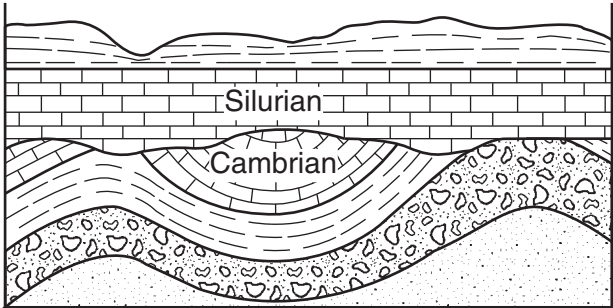
# A Portion of the Tethys Sea 50 Million Years Ago













A diagram illustrating the composition of volcanic gas emissions. A volcano on the left is shown with a large plume of dark smoke rising from its crater. This plume is divided into three distinct layers by dashed lines. The top layer is labeled 'Gas X', the middle layer is labeled 'Nitrogen', and the bottom layer is labeled 'Water vapor'. In the background, a landscape of rolling hills features several smaller volcanoes, some of which are also emitting smoke. The foreground shows a body of water with wavy lines representing ripples.

Water vapor

Gas X

Nitrogen