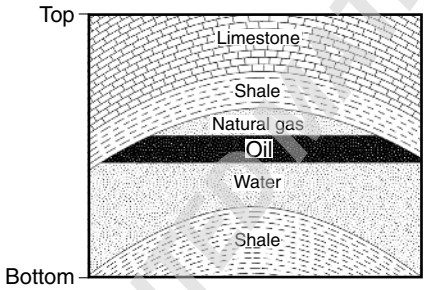
Observation and Measurement

Multiple-Choice Questions

For each statement or question, choose the number of the word or expression that, of those given, best completes the statement or answers the question.

Base your answers to question 1 on the bedrock cross section. The cross section represents part of Earth's crust where natural gas, oil, and water have moved upward through a layer of folded sandstone and filled the pore spaces at the top of the sandstone layer.

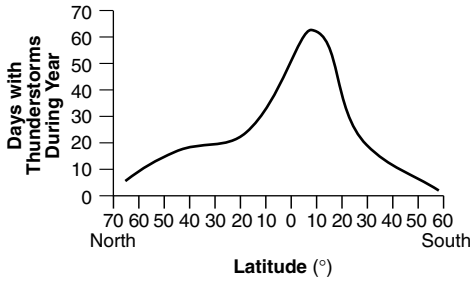


1. The final arrangement of the natural gas, oil, and water within the sandstone was caused by differences in their

(1) density.
(2) specific heat.
(3) relative age.
(4) radioactive half-life.

Correct Answer: (1) Layers of liquids and gas will arrange themselves according to their density; with the most dense materials below the least dense. It can be inferred that water is more dense than oil, which is more dense that natural gas. *(Density)*

2. The graph shows the average number of days each year that thunderstorms occur at different latitudes on Earth.



According to the graph, what is the approximate number of days each year that thunderstorms occur at locations along the 40° N parallel of latitude?

(1) 8 days
(2) 18 days
(3) 24 days
(4) 32 days

Correct Answer: (2) Starting along the *x*-axis, find 40 degrees latitude North and trace up to the curve representing thunderstorm occurrence. Trace over to the *y*-axis to find the number of thunderstorms occurring at this latitude (estimated at 18 days/year). *(Graphs)*

Base your answer to question 3 on the two tables here and on your knowledge of Earth science. The first table shows the composition, hardness, and average density of four minerals often used as gemstones. The second table lists the minerals in Moh's Scale of Hardness from 1 (softest) to 10 (hardest).

Gemstone Mineral	***Composition***	***Hardness***	***Average Density (g/cm³)***
emerald	$Be_3Al_2(Si_6O_{18})$	7.5–8	2.7
sapphire	Al_2O_3	9	4.0
spinel	$MgAl_2O_4$	8	3.8
zircon	$ZrSiO_4$	7.5	4.7

Key

Al = aluminum; Be = beryllium; Mg = magnesium; O = oxygen; Si = silicon; Zr = zirconium

Moh's Scale of Hardness
1 talc
2 gypsum
3 calcite
4 fluorite
5 apatite
6 feldspar
7 quartz
8 topaz
9 corundum
10 diamond

3. If the mass of a spinel crystal is 9.5 grams, what is the volume of this spinel crystal?

(1) 0.4 cm^3
(2) 2.5 cm^3
(3) 5.7 cm^3
(4) 36.1 cm^3

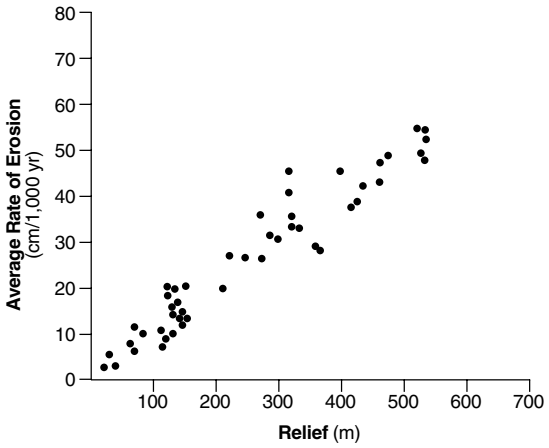
Correct Answer: (2) The density formula (D=M/V) can be manipulated to solve for V. The new formula will be $V = M/D$. To solve for *V,* divide the mass by the density. 9.5/3.8= 2.5g/cm^3. *(Density)*

4. A student determines the density of a mineral to be 1.5 grams per cubic centimeter. If the accepted value is 2.0 grams per cubic centimeter, what is the student's percent deviation (percent error)?

(1) 25.0%
(2) 33.3%
(3) 40.0%
(4) 50.0%

Correct Answer: (1) According to the Earth Science Reference Tables (*Equations)*, substitution of the aforementioned values into the equation for percent deviation yields: 2.0g – 1.5g / 2.0g = .25 or 25%. *(% Deviation)*

5. Each dot on the graph shows the result of separate scientific studies of the relationship between the rates of erosion in regions of different relief. Relief is the local difference between the highest and the lowest elevations.

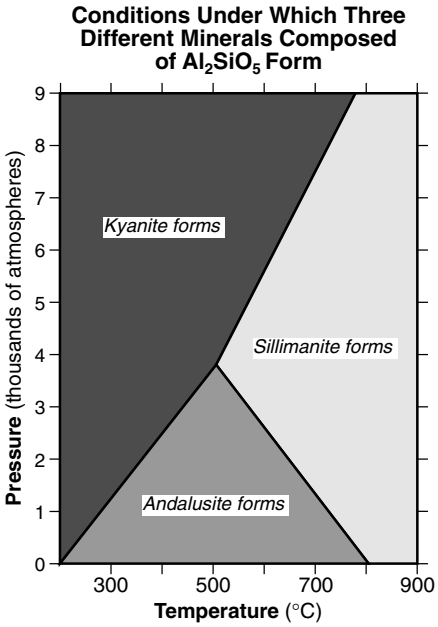


The results of these combined studies indicate that with each 100-meter increase in relief, the rate of erosion generally

(1) decreases at a rate of 10 cm/1,000 years.
(2) decreases at a rate of 20 cm/1,000 years.
(3) increases at a rate of 10 cm/1,000 years.
(4) increases at a rate of 20 cm/1,000 years.

Correct Answer: (3) As relief (*x*-axis) increases, the rate of erosion (*y*-axis) also increases. That limits your correct choices to 3 and 4. To determine the rate of increase, notice that for every 100 m of relief, the rate of erosion increases by 10 cm for every 1,000 years. For example, when relief is 100 m, the rate of erosion is 10 cm/1,000 years. When relief is 200 m, the rate of erosion is 20 cm/1,000 years. This is an increase of 10 cm/1,000 years. *(Graphs)*

Base your answer to question 6 on the graph, which shows the crustal temperature and pressure conditions under which three different minerals with the same chemical composition (Al_2SiO_5) crystallize.



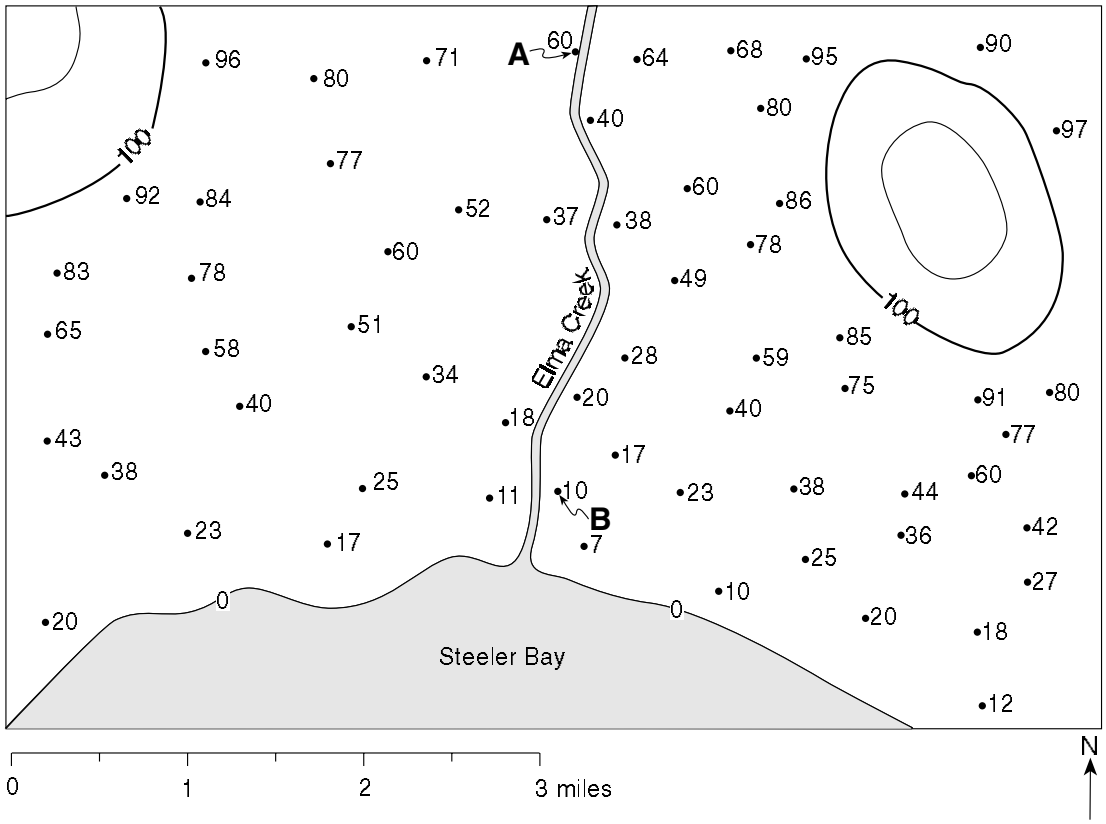
6. Under which crustal temperature and pressure conditions will andalusite form?

(1) 300°C and 6,000 atmospheres
(2) 500°C and 2,000 atmospheres
(3) 600°C and 4,000 atmospheres
(4) 700°C and 8,000 atmospheres

Correct Answer: (2) The image shows the various conditions in which andalusite will form. By extrapolating on the graph all 4 choices, you will find that 500º C and 2,000 atmospheres are well within adalusite range. *(Graphs)*

Open-Ended Questions

Base your answer to question 7 on the field map provided *here*. The map shows elevations, measured in feet, of a number of points in a certain geographic region. Contour lines have been drawn for the 100-foot and 120-foot elevations. Points *A* and *B* represent two spot elevations on the map.



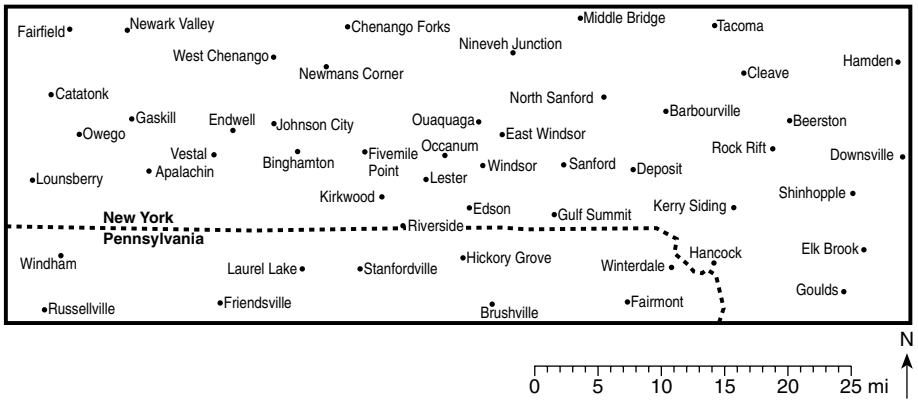
7. Calculate the gradient between points *A* and *B*. Label the answer with the correct units.

Correct Answer: Using the first page of the Earth Science Reference Tables, locate the formula for Gradient. The change in field value is the difference in elevation between points *A* (60 ft) and *B* (10 ft). That difference is 50 feet. The distance between these points is measured according to the scale at the bottom to be 2.5 miles. Subbing into the formula, the gradient is 20 feet/mile. *(Rate of Change)*

Base your answers to questions 8 and 9 on the passage that follows and on your knowledge of Earth science. The passage describes a tornado produced from a thunderstorm that moved through a portion of New York State on May 31, 1998.

New York Tornado

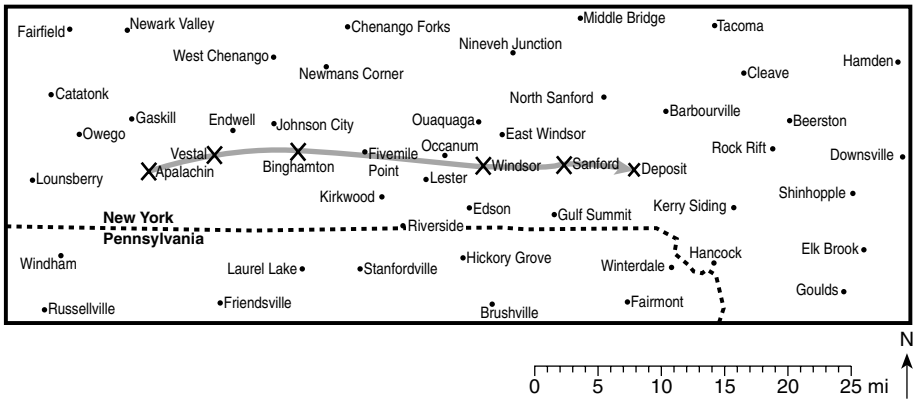
A small tornado formed and moved through the town of Apalachin, New York, at 5:30 P.M., producing winds between 40 and 72 miles per hour. The tops of trees were snapped off, and many large limbs fell to the ground. The path of the destruction measured up to 200 feet wide. At 5:45 P.M., the tornado next moved through the town of Vestal where winds ranged between 73 and 112 miles per hour. Many people experienced personal property damage as many homes were hit with flying material. At 6:10 P.M., the tornado moved close to Binghamton, producing winds between 113 and 157 miles per hour. A 1000-foot television tower was pushed over, and many heavy objects were tossed about by the strong winds. Then the tornado lifted off the ground for short periods of time and bounced along toward the town of Windsor. At 6:15 P.M., light damage was done to trees as limbs fell and small shallow-rooted trees were pushed over in Windsor. The tornado increased in strength again at 6:20 P.M. as it moved into Sanford. Some homes were damaged as their roof shingles and siding were ripped off. One mobile home was turned over on its side. The tornado moved through the town of Deposit at 6:30 P.M., creating a path of destruction 200 yards wide. The tornado skipped along hilltops, touching down occasionally on the valley floors. However, much damage was done to homes as the tornado's winds reached their maximum speeds of 158 to 206 miles per hour. The tornado weakened and sporadically touched down after leaving Deposit. By 7:00 P.M., the tornado had finally ended its 1-hour rampage.



8. On the map shown here, draw the path of the tornado and the direction the tornado moved, by following the directions.

- Place an **X** through the point for *each of the six* towns mentioned in the passage.
- Connect the **X**s with a line in the order that each town was mentioned in the passage.
- Place an arrow at one end of your line to show the direction of the tornado's movement.

Correct Answer:



Each X should be placed on each of the six towns and the line should point eastward so that it connects all six towns in the order described in the article. *(Hurricanes and Tornadoes)*

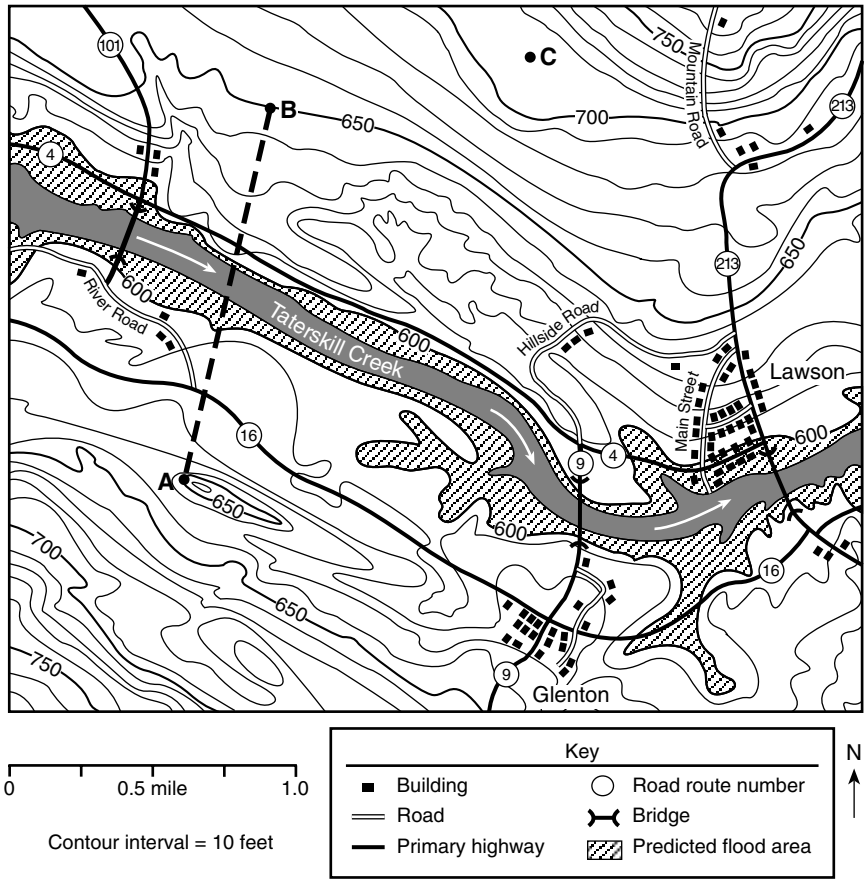
9. Calculate the tornado's average rate of travel, in miles per minute, between Vestal and Windsor, by using the equation that follows. Express your answer to the *nearest tenth*.

Tornado's rate of travel = distance between Vestal and Windsor (miles)/ Time (minutes)

Correct Answer: 0.7 mi/m By using the map provided with question 5, you can determine that the distance between Vestal and Windsor is 21 miles. According to the paragraph, the tornado hit Vestal at 5:45 P.M. and Windsor at 6:15 P.M., which makes for a difference of 30 minutes. Using the formula: 21 miles/30 minutes = 0.7 mi/m. *(Rate of Change)*

Base your answers to question 10 on the topographic map. The map shows a portion of the Taterskill Creek flowing past the towns of Lawson and Glenton. The shaded area is Taterskill Creek. The arrows in the creek show its direction of flow. Points *A, B,* and *C* are locations on the map. Points *A* and *B* are connected with a reference line.

Mercado Dam is located 32 miles upstream from Lawson. In the remote possibility of a failure of the Mercado Dam, the Taterskill Creek is expected to rise to the 600-foot contour line in the vicinity of the two towns.



10. If Mercado Dam ruptured, the first floodwater would take exactly 4 hours to reach the town of Lawson. In the space provided *in your answer booklet,* calculate the average rate of travel for the leading edge of the floodwater. Label your answer with the correct units.

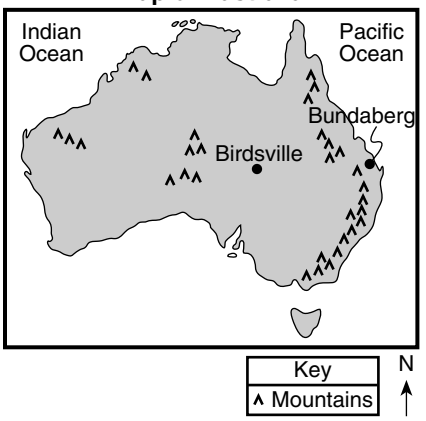
Correct Answer: Mercado Dam lies 32 miles upstream from Lawson. In the event of the dam rupturing, it would take 4 hours for floodwaters to reach Lawson. In order to find the rate at which the floodwater is traveling based on the aforementioned information: 32 miles/4 hours = 8 miles/hour. *(Rate of Change)*

Base your answers to question 11 on the map and data tables given. The map shows the location of Birdsville and Bundaberg in Australia. The first data table shows the average monthly high temperatures for Birdsville. The second data table includes the latitude and longitude, elevation above sea level, and the average rainfall in January for Birdsville and Bundaberg.

Average Monthly High Temperatures for Birdsville, Australia

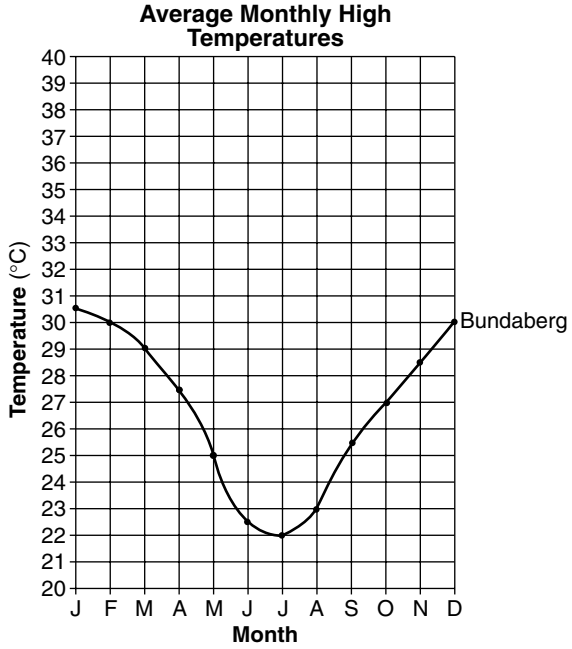
Month	*Temperature (°C)*
January	39
February	38
March	35
April	30.5
May	25
June	22
July	21
August	23.5
September	28
October	32.5
November	36
December	38

Map of Australia



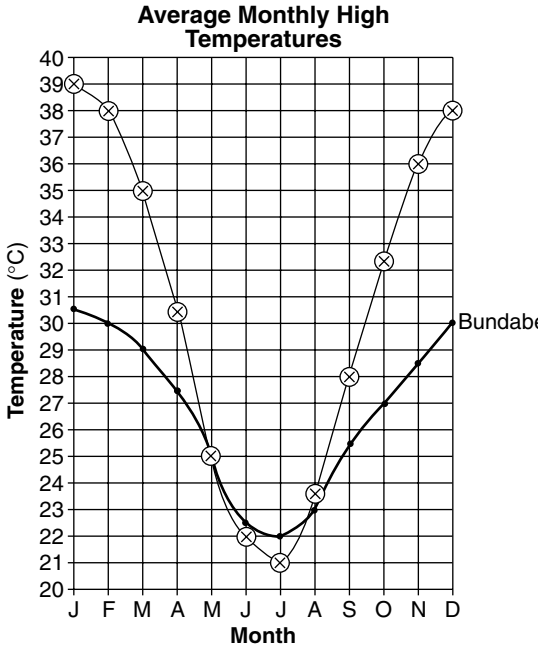
Information About Two Australian Cities				
City	***Latitude (°S)***	***Longitude (°E)***	***Elevation (m)***	***Average January Rainfall (mm)***
Birdsville	25.9	139.4	47	25
Bundaberg	24.9	152.4	14	105

11. On the grid given here, plot with an **X** the average monthly high temperatures for Birdsville, Australia. Connect the **X**s with a line. The average monthly high temperatures for Bundaberg have already been plotted on the graph for you.



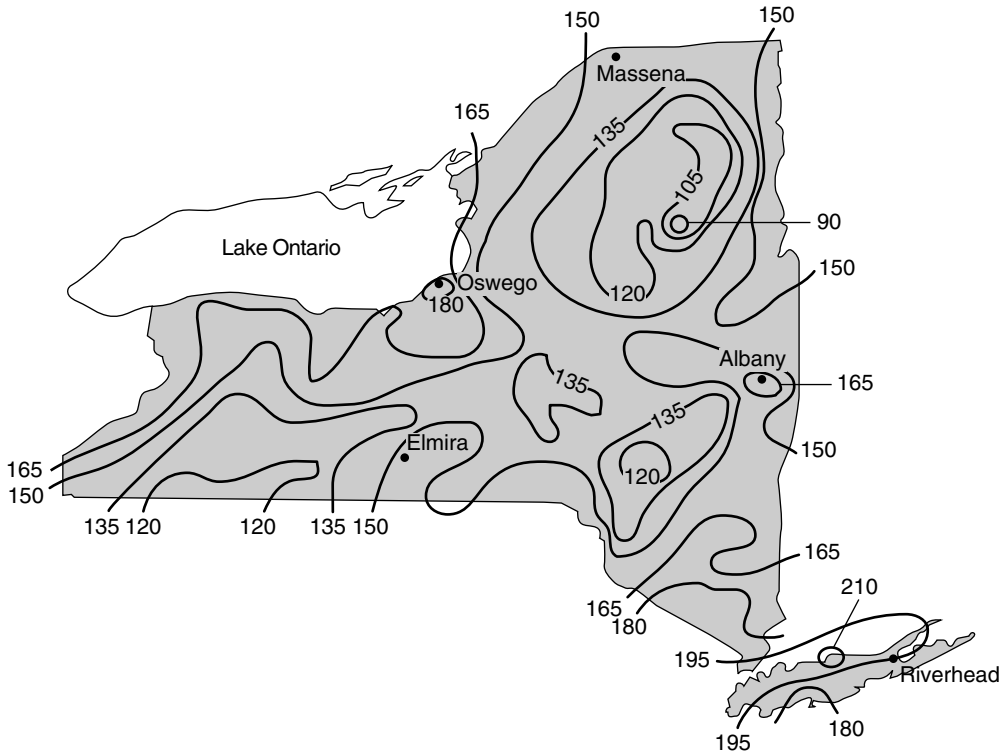
Correct Answer:

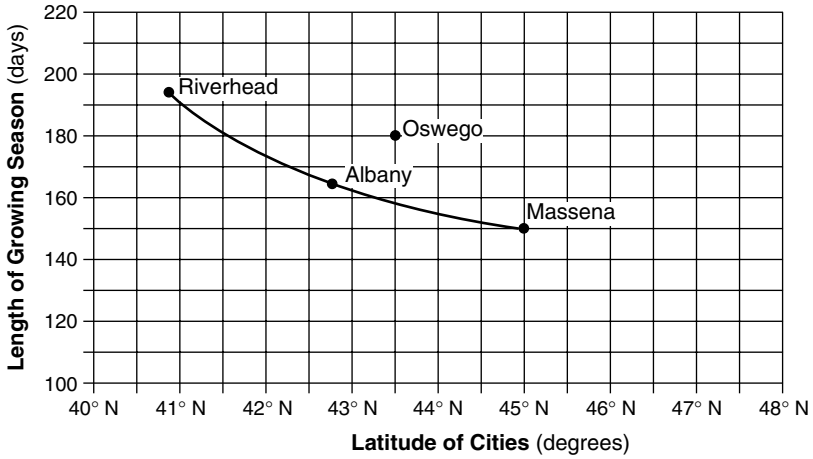
You must place at least 10 of the 12 Xs in the appropriate location (as shown here). The Xs must be connected with a line. *(Graphs)*



Base your answers to question 12 on the map, the graph on the next page, and your knowledge of Earth science. The map shows the length of the growing season in New York State, expressed in days. The growing season is the average number of days between the last frost in spring and the first frost in fall. The graph line shows the relationship between the latitudes of Riverhead, New York; Albany, New York; and Massena, New York; and the length of the growing season at these three locations.

Length of Growing Season (in days)





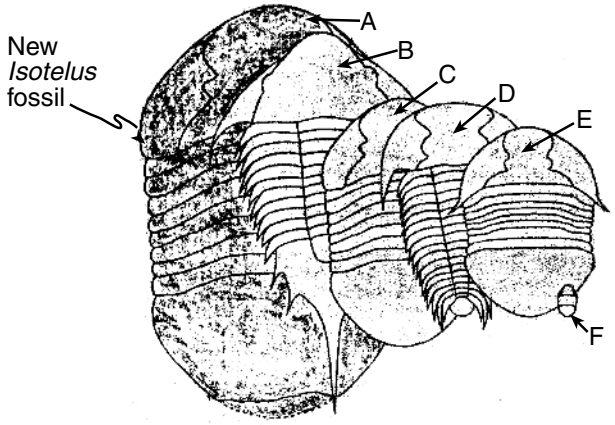
12. For Riverhead, Albany, and Massena, state the relationship between latitude and the length of the growing season shown by the graph.

Correct Answer: From the graph you can state that as the latitude (*x*-axis) increases, the length of the growing season (*y*-axis) decreases. This represents an inverse relationship. *(Graphs)*

Base your answers to question 13 on the reading passage and on your knowledge of Earth science. The reading passage provides some background information about a recent fossil discovery. The scale drawing shows the new trilobite *Isotelus* (A) fossil compared to other trilobite fossils (B, C, D, E) and a typical large trilobite (F).

The World's Biggest Trilobite

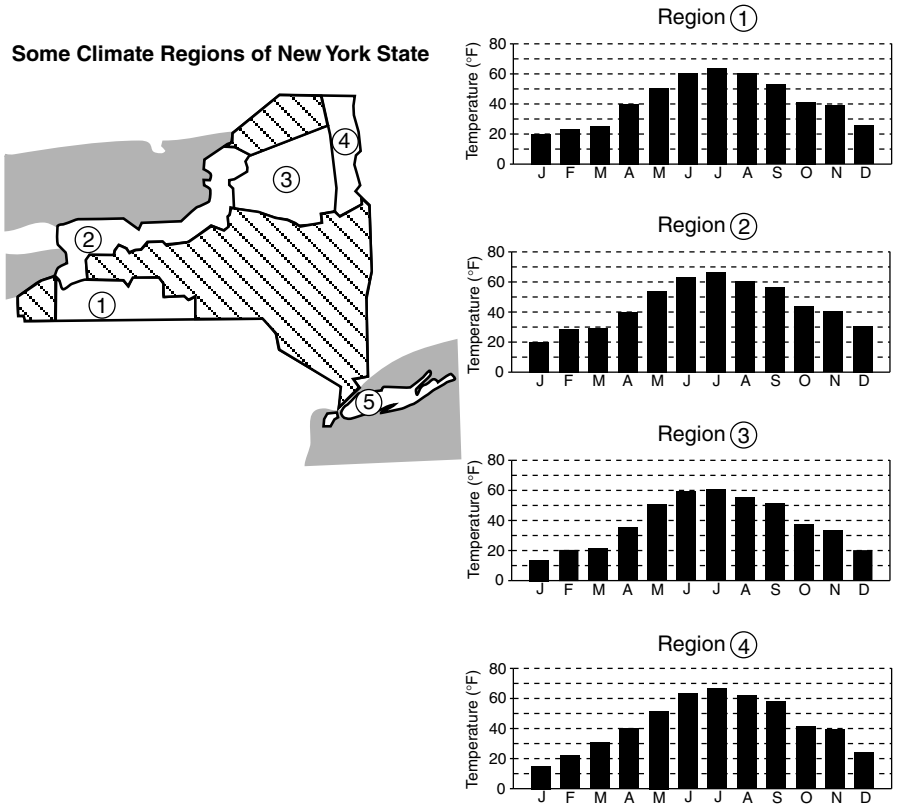
A team of Canadian paleontologists examining rock units along the shore of Hudson Bay in northern Manitoba has discovered the world's largest recorded complete fossil of a trilobite, a many-legged, sea-dwelling animal inferred to have lived during the late Ordovician Period. The giant creature, measuring 70 centimeters in length, is a new species of 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 *Isotelus* species existed just before the end of the Ordovician Period.



13. The actual new *Isotelus* fossil is approximately how many times larger than scale drawing *A*?

Correct Answer: The scale drawing (A) is approximately 5.5 cm in length. The actual size of *Isotelus* is over 12 times larger (70 cm/5.5 cm).

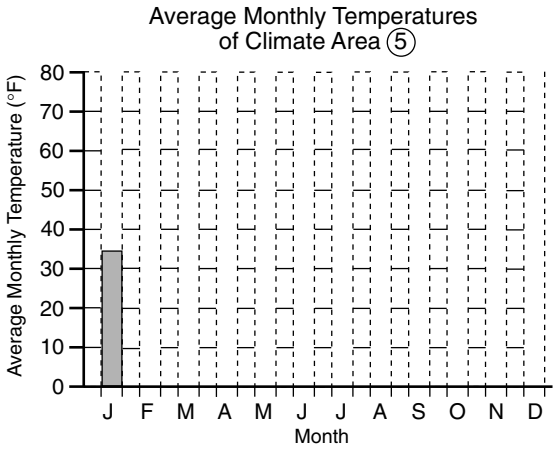
Base your answers to question 14 on the map and graphs. The map shows five climate regions of New York State. The bar graphs show average monthly temperatures of four of these climate regions.



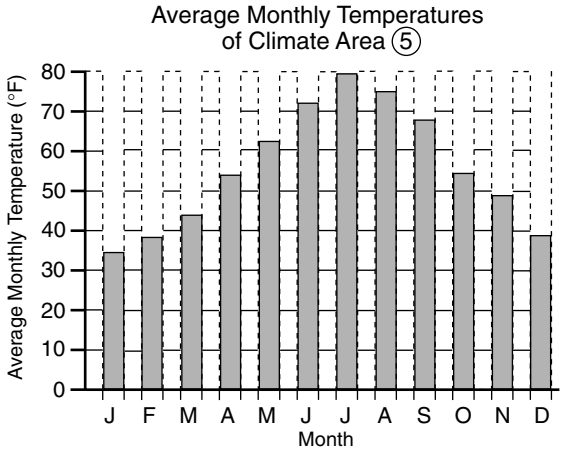
14. On the grid provided here, construct a bar graph of the average monthly temperatures provided for climate region 5. January has been completed for you.

Average Temperatures for Climate Region 5

Month	*°F*
January	34
February	36
March	42
April	52
May	61
June	72
July	79
August	74
September	68
October	55
November	49
December	39

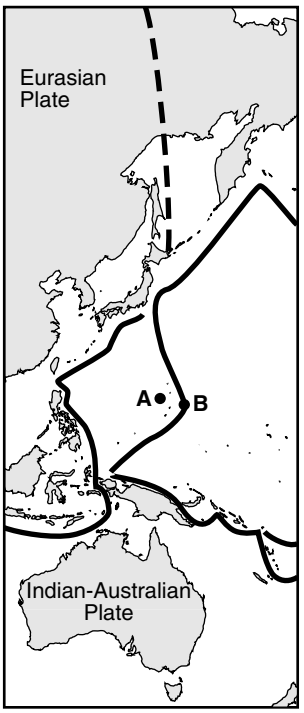


Correct Answer:



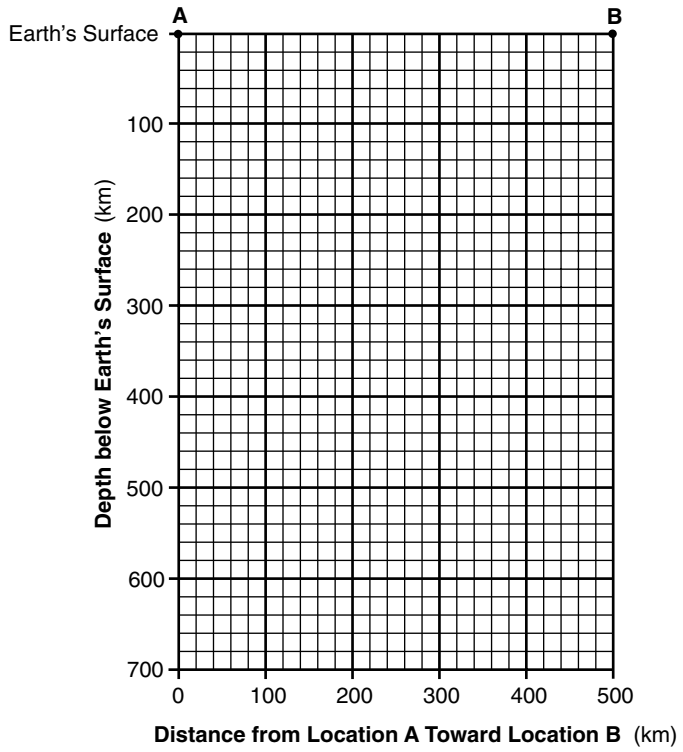
Base your answers to question 15 on the map and data table shown here. The map shows some tectonic plates and the boundaries between them. Letters *A* and *B* are locations on Earth's surface. The data table shows the depth below Earth's surface of five earthquakes measured from location *A* toward location *B*.

Map

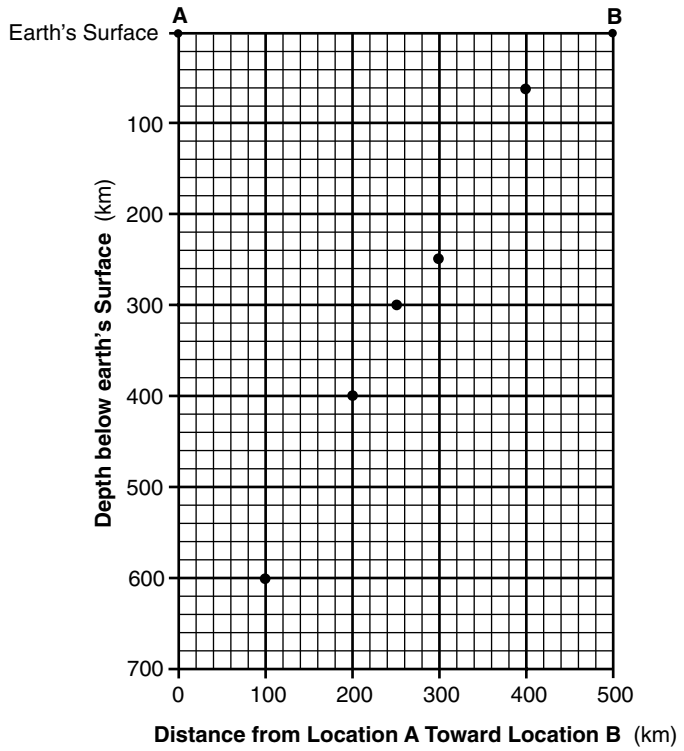


Earthquake	*Distance from Location A toward Location B (km)*	*Depth below Earth's Surface (km)*
1	100	600
2	200	400
3	250	300
4	300	250
5	400	60

15. On the grid provided here, plot the depths of the *five* earthquakes from location *A* toward location *B*.



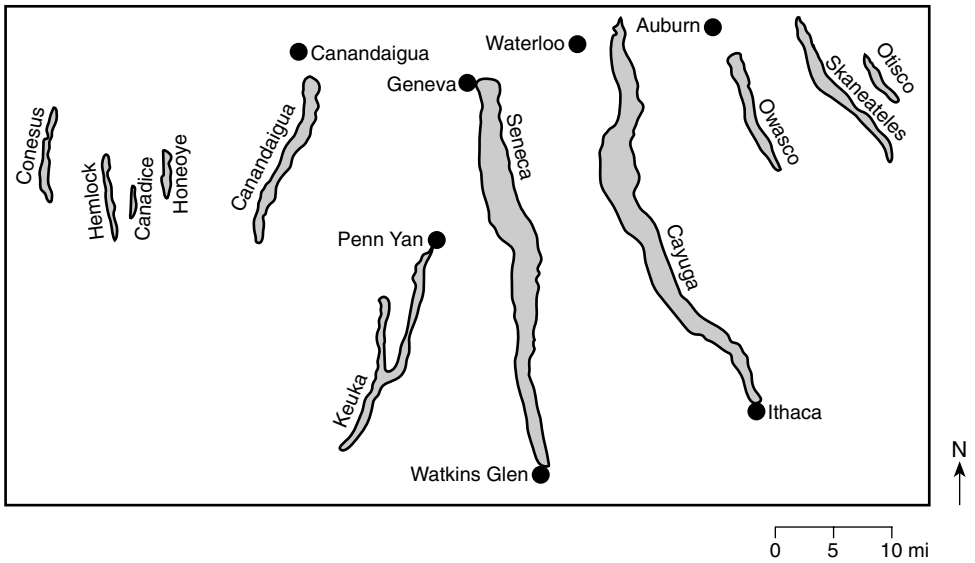
Correct Answer:



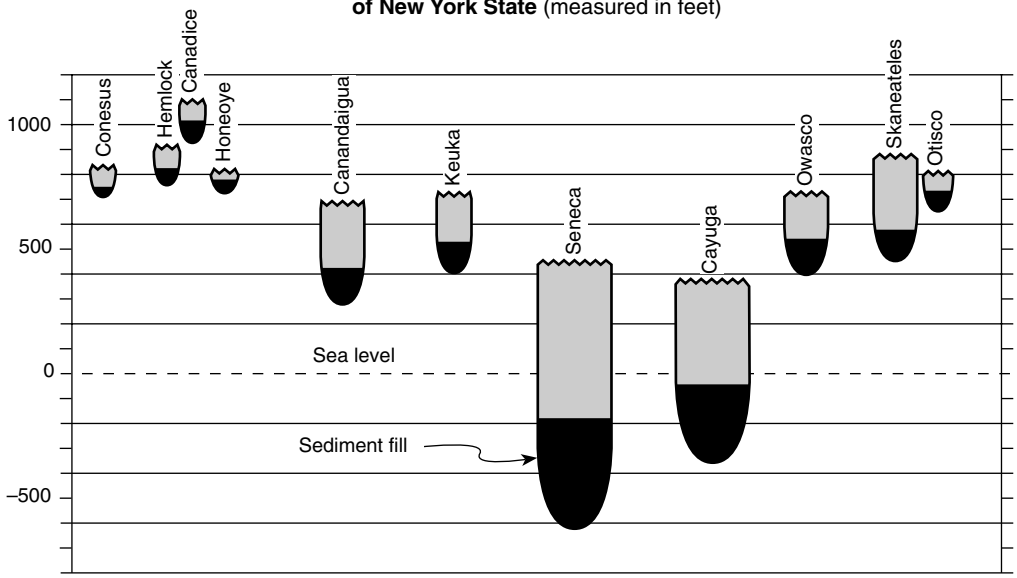
(Graphs)

Base your answers to questions 16 and 17 on the map and cross section of the Finger Lakes Region shown and on your knowledge of Earth science.

Finger Lakes Region of New York State



Elevation and Depth of the Finger Lakes of New York State (measured in feet)



16. According to the cross section, how thick from top to bottom is the sediment fill in Seneca Lake?

Correct Answer: The bottom of the fill in Seneca Lake is 625 feet below sea level, whereas the top of the fill is at an elevation of 175 feet below sea level. Taking the difference in elevations, the thickness of the fill is approximately 450 feet. *(Graphs)*

17. During some winters, a few of the Finger Lakes remain unfrozen even though the land around the lakes is frozen. Explain how the specific heat of water can cause these lakes to remain unfrozen.

Correct Answer: Water has a very high Specific Heat, meaning the amount of energy required to change the temperature of the water. According to the Earth Science Reference Tables—*Specific Heats of Common Materials*, liquid water has a heat capacity of 1 calorie/gram C°. Conversely, the other common earth materials have heat capacities that are much lower, meaning the temperature will change more readily.