1. The cross section in your answer booklet shows the lithosphere and asthenosphere between points *A* and *B* on the map.

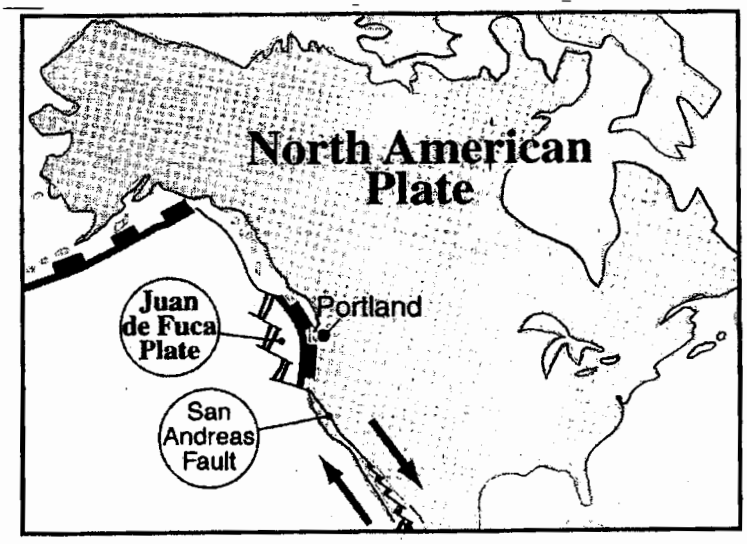
a On the cross section provided *in your answer booklet*, draw an arrow in the Juan de Fuca Plate to indicate the direction of the relative movement of the plate. [1]

b Identify the type of tectonic plate boundary that exists at the Juan de Fuca Ridge. [1]

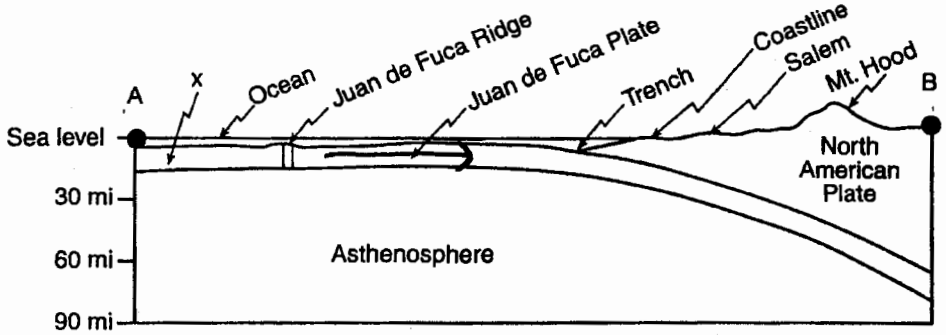
c Identify the name of the plate in the cross section labeled *x*. [1]

d How does the average earthquake depth beneath the Oregon coastline compare to the average earthquake depth beneath Mt. Hood? [1]

2. An emergency management specialist in Portland, Oregon, is developing a plan that would help save lives or prevent property damage in the event of a future earthquake. Describe *two* actions or ideas that should be included in the plan. [2]



1*a*



1*b* Divergent **plate boundary**

1*c* Pacific **Plate**

1*d* The average depth below Mt. Hood is deeper

2. (1) Improve building codes

(2) Have an evacuation plan in place

Base your answers to questions 3 through 6 on the passage and map below and on your knowledge of Earth science. The passage provides some information about the sediments under Portland, Oregon, and the map shows where Portland is located.

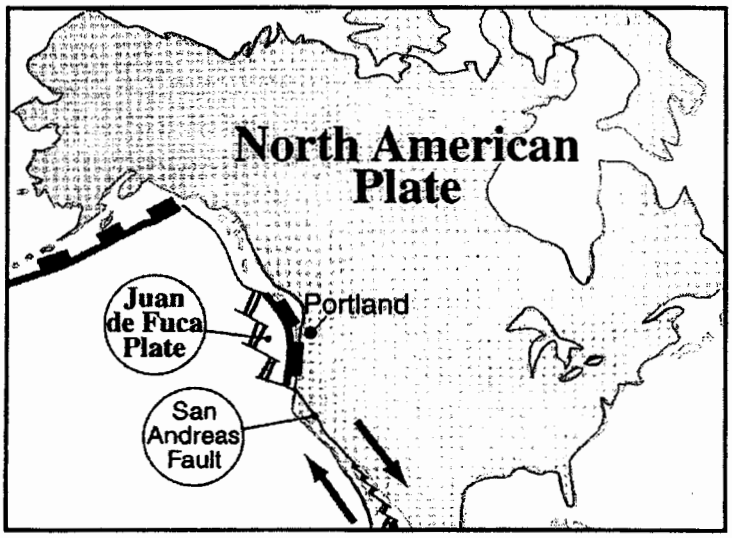
Bad seismic combination under Portland: Earthquake faults and jiggly sediment

Using a technique called seismic profiling, researchers have found evidence of ancient earthquake faults under Portland, Oregon. The faults may still be active, a USGS [United States Geological Survey] seismologist will announce tomorrow.

The research also turned up a 250-foot deep layer of silt and mud, deep under the city, which may have been caused by a catastrophic ice dam break some 15,000 years ago.

The two findings could together mean bad news, as soft sediment is known to amplify ground shaking during strong earthquakes. In the 1989 San Francisco earthquake, much of the damage to buildings was caused by liquefaction, a shaking and sinking of sandy, water-saturated soil along waterways. . . .

— Robert Roy Britt
excerpted from
"Bad sesimic combination under Portland:
Earthquake faults and jiggly sediment"
explorezone.com 05/03/99



3. Explain why Portland is likely to experience a major earthquake. [1]

4. Why is the presence of a layer of silt and mud deep under the city a danger to Portland? [1]

5. Describe one precaution that can be taken to prevent or reduce property damage in preparation for a future earthquake in Portland. [1]

6. What type of tectonic plate boundary is shown at the San Andreas Fault? [1]

3. Portland is near a plate boundary

4. The soft, unstable ground could amplify the shaking

5. Improve building codes

6. Transform

7. A seismic station in Massena, New York, recorded the arrival of the first *P*-wave at 1:30:00 (1 hour, 30 minutes, 00 seconds) and the first *S*-wave from the same earthquake at 1:34:30.

   a Determine the distance, in kilometers, from Massena to the epicenter of this earthquake. [1]

   b State what additional information is needed to determine the location of the epicenter of this earthquake. [1]

7 *a* 3000 ± 200 km km

b Two more seismic stations

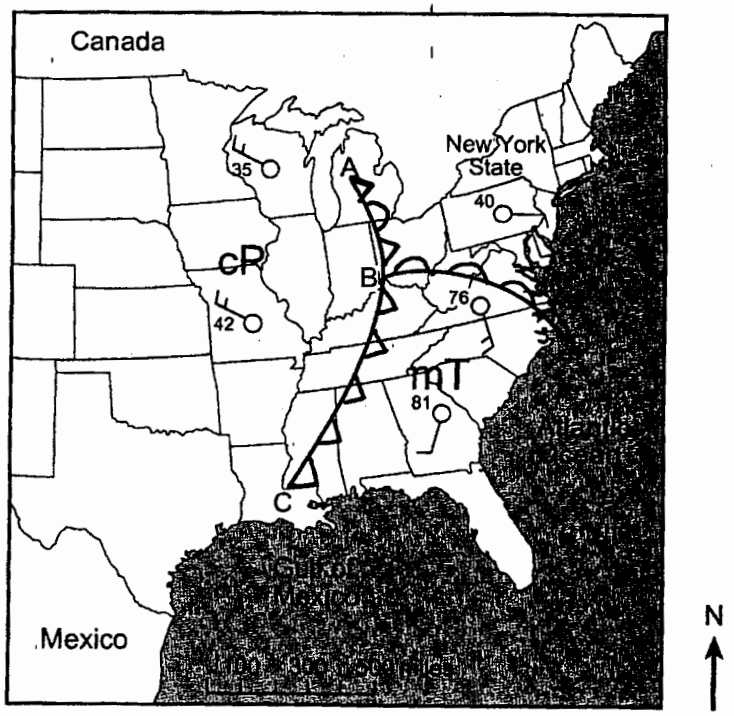
Base your answers to questions 8 through 10 on the weather map provided in your answer booklet. The weather map shows a low-pressure system over part of North America. Five weather stations are shown on the map. Lines *AB*, *BC*, and *BD* represent surface frontal boundaries. Line *AB* represents an occluded front that marks the center of a low-pressure system. Symbols cP and mT represent different air masses.

8. On the weather map provided *in your answer booklet*, place the proper front symbols on lines *AB*, *BC*, and *BD*. Place the front symbols on the correct side of each line to show the direction of front movement. [3]

9. Name the geographic region over which the mT air mass most likely formed. [1]

10. Other than low pressure, state *two* weather conditions associated with a low-pressure center. [2]

8.



9. Gulf of Mexico

10. (1) Clouds

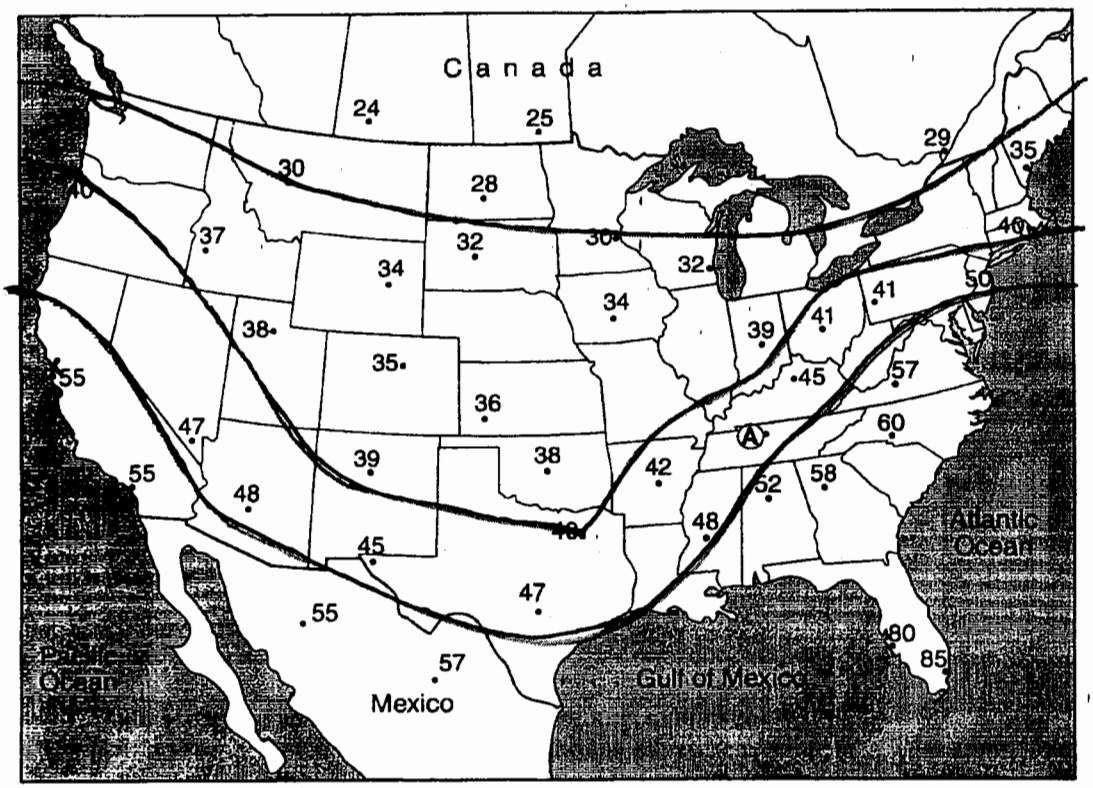
(2) Precipitation

Base your answers to questions 11 and 12 on the temperature field map provided *in your answer booklet*. The map shows air temperatures, in degrees Fahrenheit, recorded at the same time at weather stations across North America. The air temperature at location *A* has been deliberately left blank.

11. On the map provided *in your answer booklet*, use smooth, curved solid lines to draw the 30°F, 40°F, and 50°F isotherms. [2]

12. What is the most probable air temperature at location *A*? [1]

11.



30°F

40°F

50°F

12. Any temp. between 41 - 49 °F

13. The following weather data was collected at Boonville, New York.

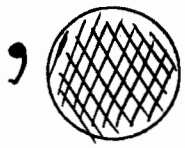
Air temperature	65°F
Dewpoint	64°F
Visibility	2 miles
Present weather	drizzle
Wind direction	from the west
Wind speed	5 knots
Amount of cloud cover	100%
Barometric pressure	996.2 millibars

On the station model provided *in your answer booklet*, using the proper format, record:

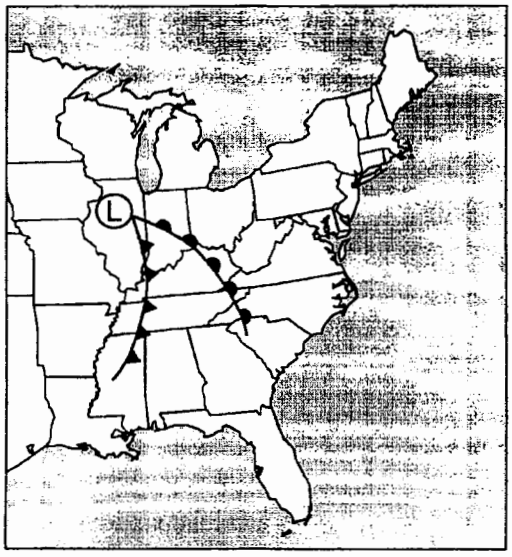
- the amount of cloud cover [1]
- the barometric pressure [1]
- the symbol for the present weather [1]

13. **Station Model**

962



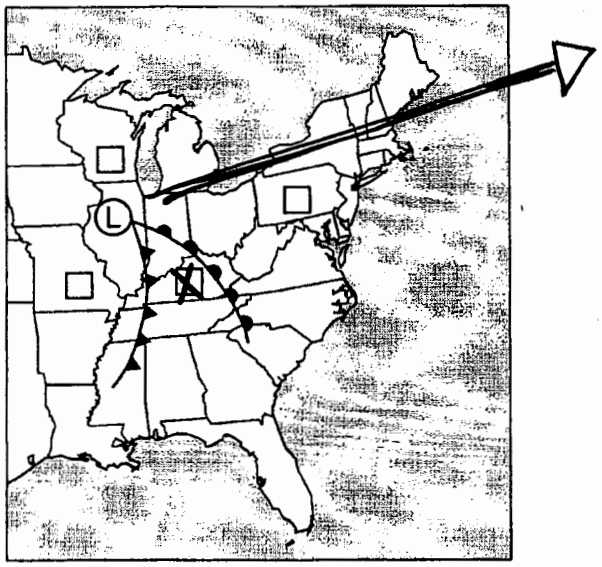
14. The weather map below shows a typical midlatitude low-pressure system centered in Illinois.



a On the weather map provided *in your answer booklet,* indicate which boxed area has the highest surface air temperatures by marking an **X** in one of the four boxes on the map. [1]

b On the weather map provided *in your answer booklet,* draw an arrow to predict the normal storm track that this low-pressure center would be expected to follow. [1]

14. *a* and *b*



Base your answers to questions 15 through 17 on data tables I and II and on the Hurricane Tracking Map below. Table I represents the storm track data for an Atlantic hurricane. Location, wind velocity, air pressure, and storm strength are shown for the storm's center at 3 p.m. Greenwich time each day. Table II shows a scale of relative storm strength. The map shows the hurricane's path.

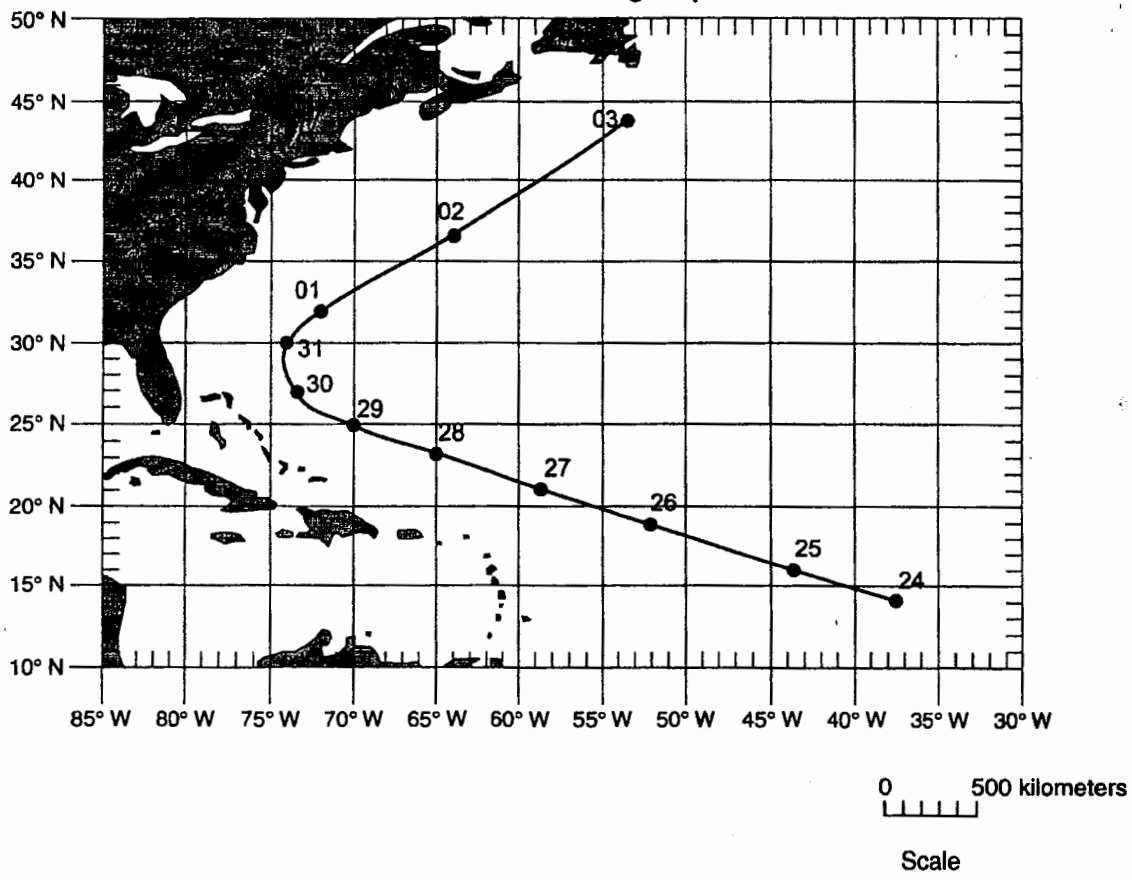
Data Table I

Latitude (°N)	Longitude (°W)	Date	Wind Velocity (knots)	Air Pressure (millibars)	Storm Strength
14	37	Aug. 24	30	1006	Tropical depression
16	44	Aug. 25	70	987	Category-1 hurricane
19	52	Aug. 26	90	970	Category-2 hurricane
21	59	Aug. 27	80	997	Category-1 hurricane
23	65	Aug. 28	80	988	Category-1 hurricane
25	70	Aug. 29	80	988	Category-1 hurricane
27	73	Aug. 30	65	988	Category-1 hurricane
30	74	Aug. 31	85	976	Category-2 hurricane
32	72	Sept. 01	85	968	Category-2 hurricane
37	64	Sept. 02	70	975	Category-1 hurricane
44	53	Sept. 03	65	955	Category-1 hurricane

Data Table II

Storm Strength Scale	Relative Strength
Tropical depression	Weakest
Tropical storm	↓
Category 1	
Category 2	
Category 3	
Category 4	
Category 5	Strongest

Hurricane Tracking Map



15. Describe *two* characteristics of the circulation pattern of the surface winds around the center (eye) of a Northern Hemisphere low-pressure hurricane. [2]

16. The hurricane did not continue moving toward the same compass direction during the entire period shown by the data table. Explain why the hurricane changed direction. [1]

17. In the space provided *in your answer booklet,* calculate the average daily rate of movement of the hurricane during the period from 3 p.m. August 24 to 3 p.m. August 28. The hurricane traveled 2,600 kilometers during this 4-day period. Follow the directions given below.

a Write the equation used to determine the rate of change.
b Substitute data into the equation. [1]
c Calculate the rate and label it with the proper units. [1]

15. Counter clockwise and Toward the center

16. Global wind patterns

17.

a Rate of change =	$\frac{\text{Change in F.V.}}{\text{Time}}$
b Rate of change =	$\frac{2600 \text{ km}}{4 \text{ days}}$
c Rate of change =	650 km/day

Base your answers to questions 18 through 20 in part on the newspaper article shown below, taken and adapted from the *Los Angeles Times*.

Volcanic Blast Shaped Earth

Study finds eruption split an ancient continent, creating Atlantic Ocean

The largest volcanic eruption in Earth's history — so powerful it split an ancient supercontinent and created the Atlantic Ocean — spewed millions of square miles of searing lava that extinguished much of life on ancient Earth.

From hundreds of basalt outcrops that rim the Atlantic coasts, scientists have pieced together evidence of the titanic eruption 200 million years ago. Researchers said that the eruption set the fractured landmasses adrift and, by wedging them apart, gradually opened the gulf that created the Atlantic — giving the map of the world the form it has today.

"This is one of the biggest things that has ever happened in Earth's history. This is a gigantic, igneous event and it all seems to have occurred in an amazingly brief amount of time."

To reconstruct the ancient catastrophe, a team of scientists analyzed basalt dikes, sills, and lavas from the New Jersey Palisades, the Brazilian Amazon, Spain, and West Africa.

By studying the chemical composition and dating the residual radioisotopes in the basaltic rocks, the researchers determined that the rocks all originated from the same eruption. Once they realized the outcrops were linked, they were able to determine that, in the distant past, the rocks all had been located together at the center of an immense continent called Pangea that once stretched, unbroken, from pole to pole.

18. Name the geologic time period when this major volcanic eruption initially opened the Atlantic Ocean. [1]

19. Scientists stated that rocks from the volcanic eruption that separated the continents are basalt. List *two* observable characteristics that are normally used to identify basaltic rock. [2]

20. Basaltic outcrops are not the only evidence of this ancient continental splitting. Describe another piece of evidence that supports the idea that the present-day continents were once part of the large ancient continent, Pangea, that split apart. [1]

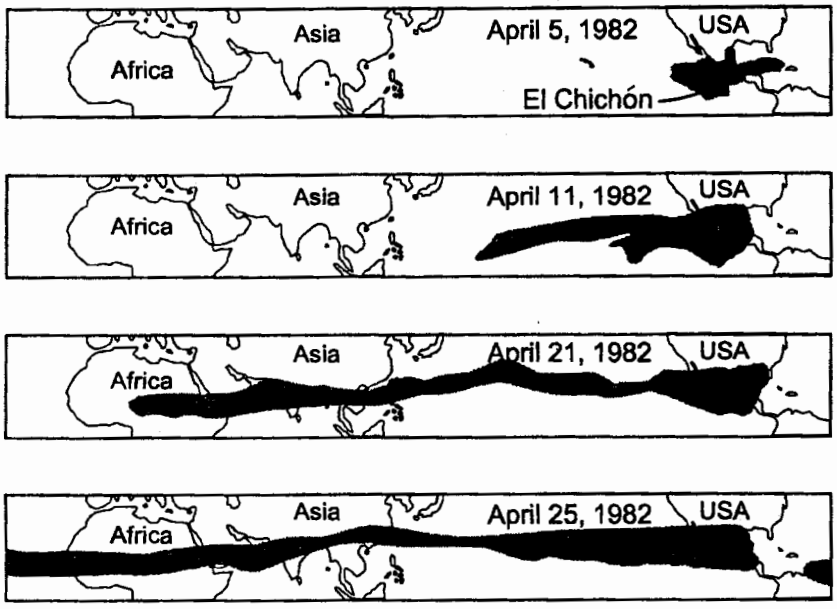
18. Jurassic **Period**

19. (1) Dark Color

(2) Sm. crystal size

20. Fit like a puzzle or Match fossils

Base your answers to questions 21 through 24 on the maps below, which show the spread of a volcanic ash cloud from the 1982 eruption of El Chichón in Mexico, as seen from weather satellites.



21. Identify the direction toward which the ash cloud spread from April 5 to April 25. [1]

22. State what caused the main ash cloud to spread in the pattern shown on the map of April 25, 1982. [1]

23. State the most likely effect of the ash cloud on the temperature of areas under the cloud on April 25, 1982. [1]

24 As the ash cloud moved away from El Chichón, some ash particles fell back to Earth.
a Describe how the size of the particles affected the pattern of deposition. [1]
b Describe how the density of the particles affected the pattern of deposition. [1]

21. West

22. Global / Prevailing winds

23. Decrease temp.

24 a The larger particles fell first, closest to El Chichón

b The denser particles fell first, closest to El Chichón

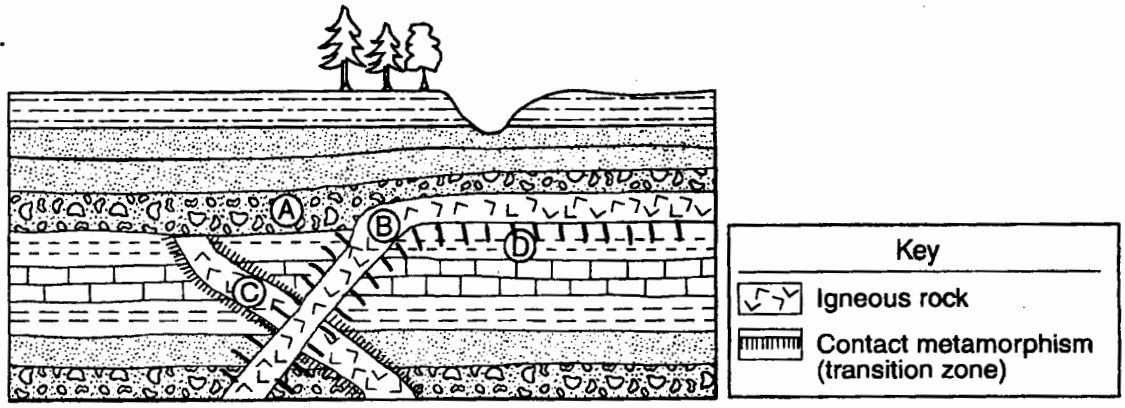
Base your answers to questions 25 through 27 on the cross section provided in your answer booklet. The cross section represents a portion of Earth's crust. Letters *A*, *B*, *C*, and *D* are rock units.

25. 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 *in your answer booklet* to indicate those rocks that underwent contact metamorphism when igneous rock *B* was molten. [1]

26. In relation to rock units *A* and *B* in the cross section, when was igneous rock *C* formed? [1]

27. Describe one observable characteristic of rock *A* that indicates that rock *A* is sedimentary. [1]

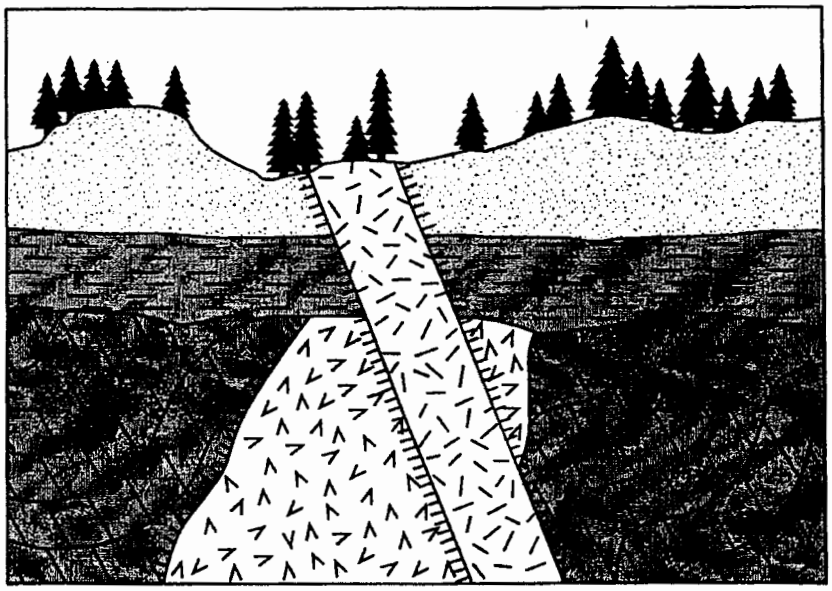
25.



26. Before both A and B

27. Particles cemented together

Base your answers to questions 28 and 29 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.

28. Explain how *each* inference is supported by evidence shown in the diagram. [3]

29. Students compared samples of the granite and basalt. State one observable characteristic other than crystal size that makes granite different from basalt. [1]

28. **Inference 1:** The basalt cuts through the shale

Inference 2: The sandstone layer is above the shale

Inference 3: Shale is deposited flat over folded limestone

29. Granite has a lighter color