Deposition

TOPIC 10

How Scientists Study Deposition

How can a "mountain" of sand be created?

If you've ever been to the beach, you might have seen large piles of sand that resemble small mountains. These piles are called sand dunes, and they have a gentle slope on one side and a steeper slope on the opposite side.

You might think that water is the agent of erosion that forms sand dunes since you're at the beach. But water has little to do with it. Read the section in this topic called "Characteristic Features of the Chief Depositional Agents" to find out which agent of erosion is involved.

TOPIC

10 Deposition

Vocabulary

barrier island	kettle lake	sand dune
deposition	moraine	sorted sediments
drumlin	outwash plain	unsorted sediments

Topic Overview

The process by which sediments are released, settled from, or dropped from an erosional system is **deposition,** or sedimentation. Deposition includes the releasing of solid sediments and the process of precipitation—the releasing of dissolved minerals, hardness, or salts from a water solution to form chemical sedimentary rocks.

The deposition of sediments has many effects on people. For example, you might play on a beach or marvel at the formations in caves (which are the product of precipitation of rocks). People mine sand and gravel from wave, glacier, and stream deposits. They also mine chemical sedimentary rocks, such as rock salt, rock gypsum, and dolostone. Most people spend a large part of their lives on sediment depositional features such as beaches, flood plains, deltas, marine coastal plains, and glacial deposits, or on the sedimentary rocks formed from deposition of sediments.

Deposition is part of a series of processes that start with the formation and movement of sediments by weathering and erosion. In deposition the sediments are placed in locations where they may form beds, or layers, of sedimentary rocks. Most final deposition occurs in large water bodies (such as lakes and oceans) because running water is the most important erosional system. Before sediments reach the large water bodies, many of them are temporarily deposited in different environments by running water, wind, glaciers, or other such means. Many of these depositional environments are shown in Figure 10-1.

Memory Jogger

Recall the types of solid sediments—such as sand, silt, and clay—from the Scheme for Sedimentary Rock Identification in the *Earth Science Reference Tables.*

Factors Causing Deposition

Deposition usually occurs when the velocity, or speed, of the stream, wind, or other erosional system decreases or just stops moving. Think of a piece of paper that has been picked up by a gust of wind. The piece of paper may blow all over, but when the wind slows down or stops blowing the paper will settle or be deposited. The time it takes for sediments to be deposited—the rate of deposition—varies. The faster the rate of deposition, the less time deposition takes; and the slower the rate of deposition, the more time deposition takes. Two types of factors—the velocity of the erosional system and characteristics of the sediments themselves—affect the rate of deposition.

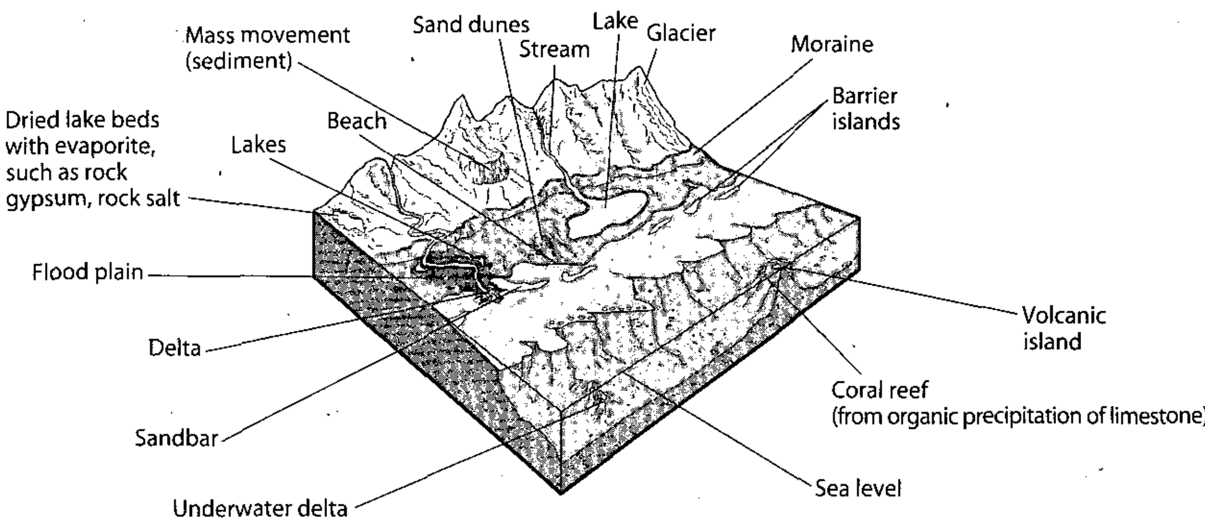


Figure 10-1. Types of depositional environments: The delta is formed from streams and the moraines from glaciers. Beaches, sandbars, and barrier islands are formed by ocean waves and longshore ocean currents. Sand dunes are formed by wind. Some sloped deposits are formed by mass movement (rock falls). Underwater deltas are formed by sediment-laden density currents.

Velocity of an Erosional System and Rate of Deposition

The faster a stream flows, the larger size sediments it can carry. Refer to the Relationship of Transported Particle Size to Water Velocity in the *Earth Science Reference Tables.* If the stream flows below a certain velocity, it will (R) deposit the sediments it can no longer carry. As an example, if a fast moving stream flowing at 350 cm/sec (78.3 miles per hour) slows down to 50 cm/sec (11.2 miles per hour) it will deposit all the pebbles, cobbles, and boulders it may be transporting. At 50 cm/sec the stream can continue to transport sand, silt, and clay-sized sediments of average density and shape. Similar relationships exist for other erosional systems.

Characteristics of Sediments and Rate of Deposition

Many aspects of the sediments themselves affect how fast they will be deposited in air or water environments. These factors include size, shape, and density, and saturation of dissolved minerals.

Size All other factors being equal, the larger sediments settle out first when wind or running water slows down. This occurs because the larger sediment particles are heavier and therefore sink faster. Very small particles, such as clay-sized particles (less than 0.0004 cm in diameter), may remain suspended in water almost indefinitely. Clay suspended in water is the "mud" of muddy or cloudy water.

Shape The shape of a particle helps determine how fast it will be deposited from wind or running water. All other factors being equal, the more rounded a sediment, the faster it will settle out. The more flattened it is, the greater its resistance—caused by friction—to deposition.

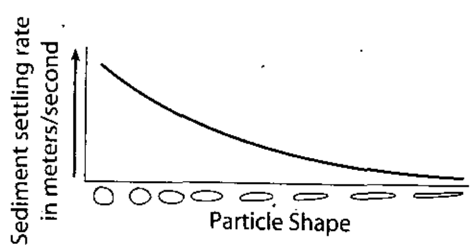


Figure 10-2. Settling rates of sediments of various shapes: **As sediments of equal volume and density become less rounded and more flattened, it takes more time for them to settle, so the settling rate decreases.**

Density All other factors being the same, the higher the density of a sediment, the faster it will settle out of air or water. If two particles have the same size and shape, the denser one will be heavier.

Saturation of Dissolved Minerals Evaporation, temperature changes, or increases in amount of dissolved minerals in a water body such as a lake, sea, or ocean may result in a saturated condition. When this happens, the dissolved mineral or minerals will settle or precipitate out of the dissolved condition and crystallize. As a result, rocks composed of one mineral, such as rock salt and dolostone, may form.

Review Questions

1. Which evidence best supports the idea that a vast inland sea once covered the Great Plains area of the United States?

(1) considerable erosion has occurred there
(2) extensive igneous intrusions are presently exposed there
(3) extensive sedimentary rock layers have been formed there
(4) numerous earthquakes occur there

2. When a river enters the ocean, sediment is deposited. Describe the change in kinetic energy of the river that leads up to this event.

3. A stream is carrying sediment particles ranging from 0.0004 to 25.6 centimeters. When the stream's velocity decreases from 300 to 100 centimeters per second, the stream will most probably deposit

(1) silt and clay
(2) sand and silt
(3) pebbles and sand
(4) cobbles and pebbles

4. The rate at which particles are deposited by a stream is least affected by the

(1) size and shape of the particles
(2) velocity of the stream
(3) stream's elevation above sea level
(4) density of the particles

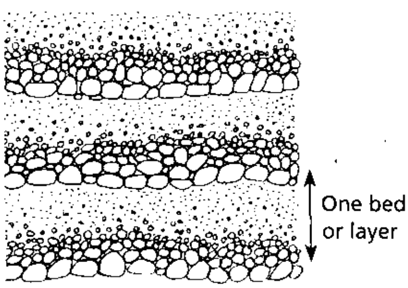


Figure 10-3. Layers of sediment with graded bedding: In each bed or layer, sediment sizes decrease from bottom to top. Graded bedding results from rapid deposition in an erosional system, such as by a flooding stream. Each bed is the result of a single flood by a stream.

Sorting of Sediments and Deposition

During deposition, sediments of similar size, shape, or density get separated or sorted by types. At any one time the majority of sediments being moved are similar in density and shape, and thus sediment size is the most common type of sorting performed by most agents of deposition. If a deposit or layer of sediment has particles that are similar in size (or density, or shape), they are considered **sorted sediments.** The greater the similarity of size, the more sorted the sediments are said to be. If sediments are very mixed in size (or density, or shape), they are considered **unsorted sediments.**

When a mixture of sediment sizes in water settles out rapidly, a horizontal bed, or layer, develops with the sediment size decreasing from the bottom to the top. Such an arrangement in a sediment layer is called "graded bedding." (See Figure 10-3.) Graded bedding is most often associated with sediment-laden density currents. These currents are most common on the sloped ocean bottoms off the coasts of continents, and on lake bottoms where flooding streams rapidly decrease in velocity when they enter.

When the velocity of a wind or water erosional system gradually decreases, such as when a stream flows into the ocean at a delta, the larger, denser, and more rounded sediments settle out first. This results in layers with horizontal sorting, in which the sediment size, roundness, and density generally decrease in the direction toward which the erosional system was moving. (See Figure 10-4.) Horizontal sorting is a major reason why most sediment deposits are sorted.

Unsorted Glacial and Mass Movement Deposits

In a solid erosional system such as a glacier, sediments of all sizes, shapes, and densities are deposited together when the glacier melts. This deposition results in the unsorted and unlayered characteristic of direct glacial deposits that cover much of New York State. (See Figure 10-5.)

When there is mass movement, such as a rock fall, landslide, or avalanche, the sediments are usually dumped together in a random deposit that is unsorted and unlayered, similar to glacial deposits. Remember the jumbled masses of ice, rock, snow, and trees that you have observed in avalanches on television. You may have observed another example—a pile of sediments at the base of a cliff along a highway.

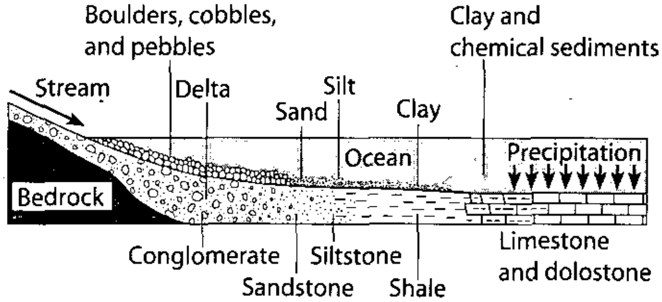


Figure 10-4. Horizontal sorting where a stream enters the ocean or lake forming a delta: The larger sediments settle first (nearer the shore). Sediments become smaller as distance from the shore increases. Precipitation nearer the shore may provide the cement for the formation of the types of sedimentary rocks indicated.

A Model of an Erosional-Depositional System

Figure 10-6 shows a side view and a top view of an imaginary stream used as a model of an erosional-depositional system. In this simple model it is assumed that the volume of discharge—water flow—is the same throughout the length of the stream.

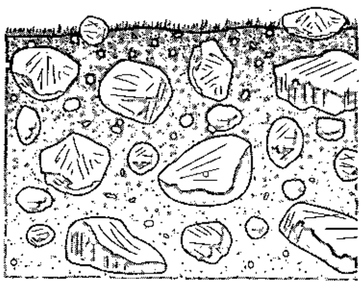


Figure 10-5. Unsorted glacial deposits: In direct glacial deposition, there is no fluid medium in which sediments can become sorted. Thus, direct glacial deposits are characterized by a random distribution of sediment sizes (unsorted) and no bedding, or layering.

Energy Transformations in the Model System

At the source, or beginning, of the stream the system has a maximum of potential energy. (See A in Figure 10-6.) As the stream flows toward its mouth, or end, potential energy is continuously being transformed into kinetic energy. (See D in Figure 10-6.) The kinetic energy is at the same time being lost to the environment in the form of heat produced by friction. Where the slope of the stream is steep, the transformation of energy occurs most rapidly, the stream has its greatest velocity, and the system has its greatest kinetic energy. Where the slope is small, the rate of energy transformation decreases, the stream slows down, and the kinetic energy of the system decreases. At the mouth of the stream, the velocity drops to zero, and the system has zero kinetic energy. Since the system has less potential energy because of its lower elevation, there has been a net loss of energy between the source and the mouth.

Erosion and Deposition in Relation to Energy Changes Wherever the kinetic energy of the system is large, erosion is the dominant process. Where the kinetic energy is small, deposition is the dominant process. Thus, erosion occurs in regions of steep slope or high discharge, and deposition occurs in regions of gentle slope or low discharge. Deposition is particularly rapid at the mouth of the stream, where the kinetic energy becomes zero. Stream velocity is faster at the outside of curves, or meanders, and slower at the inside. Therefore, erosion usually occurs at the outside of meanders, and deposition occurs at the inside.

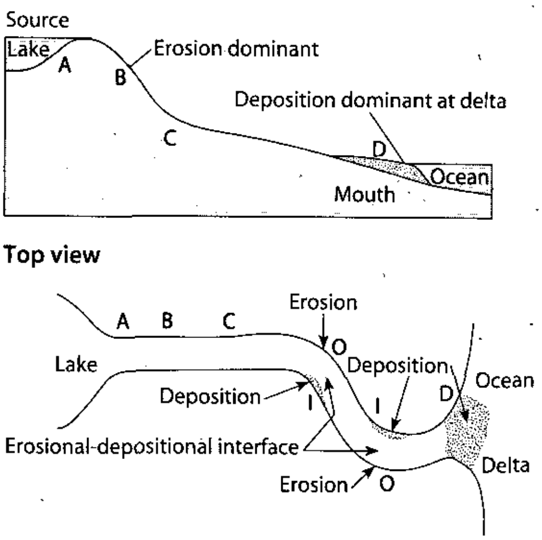


Figure 10-6. Model of a stream representing an erosional-depositional system: O indicates the outside of a curve or meander and I indicates the inside. Some deposition may occur at C, where the slope and velocity decrease. Erosional-depositional interfaces will then exist between B and C, between C and D, and between each pair of O's and I's.

If one or more tributaries were to enter a stream, this would increase the mass or discharge of water, thus increasing the potential energy of the stream. The velocity of the stream would increase, causing erosion to increase and deposition of solid sediments to decrease.

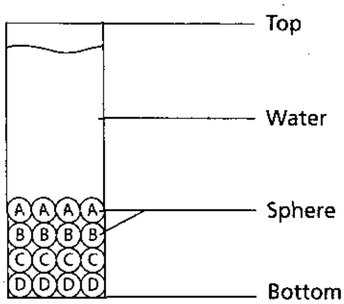
Erosional-Depositional Interfaces Since there are regions of erosion and regions of deposition along the length of the stream, an interface between an erosional and a depositional state can often be located in the system. Interfaces between erosion and deposition exist at the meanders in the model stream, and between the source and the mouth of the stream. They may also be found where changes in slope occur, as between points B and C in Figure 10-6.

Dynamic Equilibrium of an Erosional System Since all sediments picked up by the stream during erosion must eventually be deposited, the system is in a state of dynamic equilibrium. Although erosion and deposition are occurring continuously, the rate of erosion equals the rate of deposition by the system as a whole. If a flood occurs, a stream will erode—pick up and transport—more sediment, but it will also deposit an equally increased volume of sediment, thus establishing a new balance of equilibrium.

Review Questions

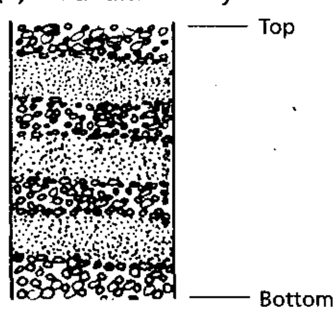
5. Small spheres that are identical in shape and size are composed of one of four different kinds of substances: A, B, C, or D. The spheres are mixed together and poured into a clear plastic tube filled with water. Which property of the spheres caused them to settle in the tube as shown in the diagram below?

(1) their size (3) their density
(2) their shape (4) their hardness



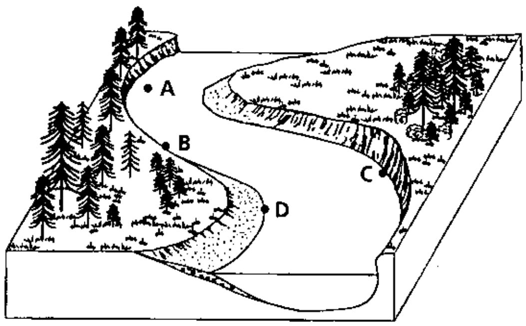
6. The following diagram represents a cross section of sedimentary deposits. Where would this type of deposition most likely occur?

(1) at the base of the shifting sand dune
(2) at the rapids in a stream
(3) beneath a large glacier
(4) in a lake fed by a stream that often floods



7. Much of the sediment that covers New York State was deposited by glaciers. Describe a depositional characteristic that these sediments should have in common.

Base your answers to questions 8 and 9 on the following diagram. The diagram shows points A, B, C, and D on a meandering stream.



8. Which material is most likely to be transported in suspension during periods of slower stream velocity?

(1) gravel (2) sand (3) silt (4) clay

9. At which point is the amount of deposition more than the amount of erosion?

(1) A (2) B (3) C (4) D

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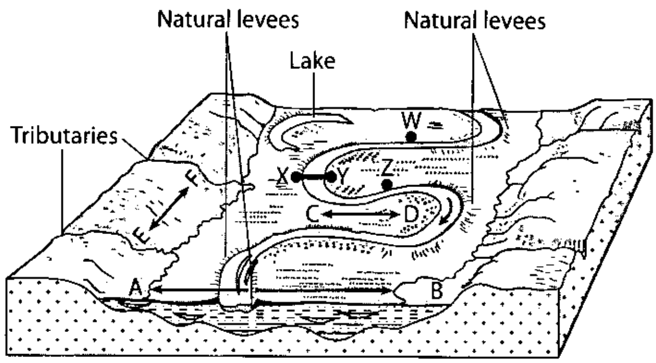
10. More deposition than erosion will take place in a streambed when the

(1) density of the rock particles carried by the stream decreases
(2) slope of the stream increases
(3) discharge of the stream increases
(4) velocity of the stream decreases

11. Which is the most probable description of the energy of a particle in an erosional-depositional system?

(1) Particles gain kinetic energy during erosion and lose kinetic energy during deposition.
(2) Particles lose kinetic energy during erosion and lose kinetic energy during deposition.
(3) Particles gain potential energy during erosion and gain potential energy during deposition.
(4) Particles lose potential energy during erosion and gain potential energy during deposition.

Base your answers to questions 12 through 14 on the *Earth Science Reference Tables* and the diagram below. The diagram represents the landscape features associated with a meandering stream. An arrow shows the direction the stream is flowing.



12. At which location is stream erosion greatest?

(1) W
(2) X
(3) Y
(4) Z

13. The lake most likely formed when a

(1) stream changed its path
(2) crater flooded
(3) cavern roof collapsed
(4) fault block subsided

14. The greatest width of the flood plain is located at

(1) A to B
(2) E to F
(3) X to Y
(4) C to D

Characteristic Features of the Chief Depositional Agents

Deposition occurs mainly by streams, glaciers, water waves and currents, wind, and mass movements. Each of these depositional agents has its own characteristic features.

Deposition by Streams

Streams make their deposits in different locations. In the stream course itself sediments are deposited on the inside of the meanders where stream

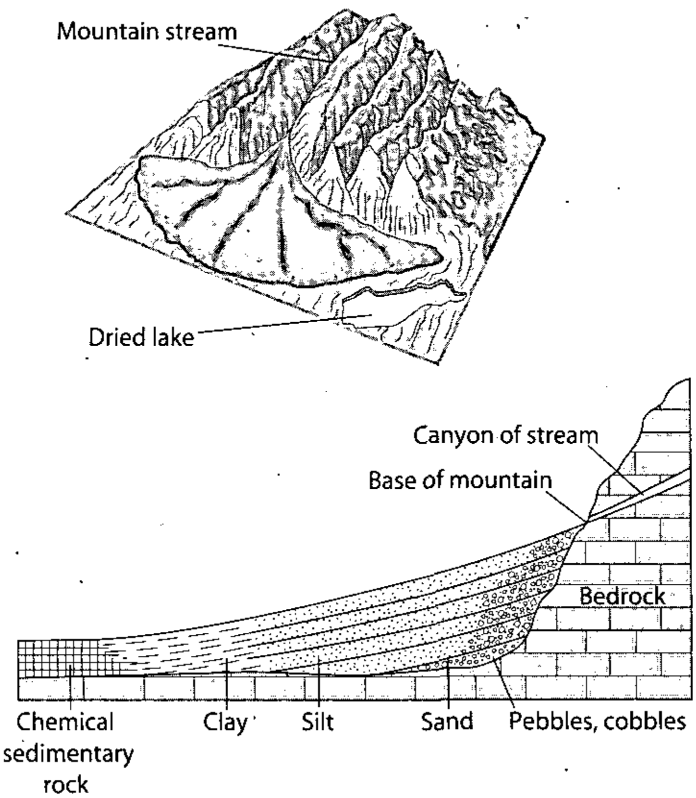


Figure 10-7. A land delta: In arid to semi-arid climates, streams flow off mountains—usually from flash floods—onto more level land and deposit most, if not all, of their sediment load. This fan-shaped deposition forms a land delta. Note the horizontal sorting of the sediment which is very similar to a regular delta, such as that in Figure 10-4.

velocity is slow. When a stream floods and overflows its banks, some of the sediment forms a mound at the edge of the river called a levee, but most of the sediment is spread over a relatively flat region to the sides of a stream forming a flood plain. Often the high velocity of a flooding stream will cut a straighter path through a meander. Depositions at the side of a stream will then separate the former meander from the main stream—forming a curved lake. The sediment that makes it to a lake or ocean will be deposited. This deposition at the end of a stream, with characteristic horizontal sorting as shown in Figure 10-4, is a delta. If there are strong ocean or lake currents, a delta may not form because the velocity of the water is not reduced enough at this location. Figure 10-7 shows the formation of a delta in arid regions.

Deposition by Glaciers

At the end of a glacier where there is a balance between melting and forward movement, the sediments it carries are just dropped in unsorted sheets or piles called a **moraine**. Figure 10-8 illustrates this unsorted, unlayered nature of direct glacial deposits. If the moraine is a thin sheet deposited from the bottom of the glacier, it is called a ground moraine. Ground moraines cover much of the northern United States including much of New York State. If the end or terminus of a glacier stays in one location for some time, the glacier builds up a pile of sediments called a terminal moraine. Parts of central Long Island, New York are the terminal moraine of the last stage of the last ice age. Moraines can also be formed at the sides of a glacier. If a glacier mounds up the ground moraine into a streamlined oval shape—something similar to the shape of the end of an inverted spoon—that feature is a **drumlin**. The drumlins indicate the direction a glacier came from by being oriented with direction of former glacial movement. Drumlins have steeper slopes pointing to the direction the glaciers came from. (See Figure 10-8.) Sometimes as a glacier melts back, it leaves blocks of ice in the terminal or ground moraine. When these blocks of ice melt, they leave behind circular depressions called kettle holes or kettles. If these kettles intersect the water tables, they will become filled with water and are then called **kettle lakes**.

Wherever glaciers melt, running water will carry sediments from the glaciers to produce layered and sorted sediment deposits when the water slows down or stops. One such feature is an **outwash plain**—a broad delta-like feature. Much of southern Long Island, New York, is an outwash plain formed by running water when the last sheets of the ice age left this region.

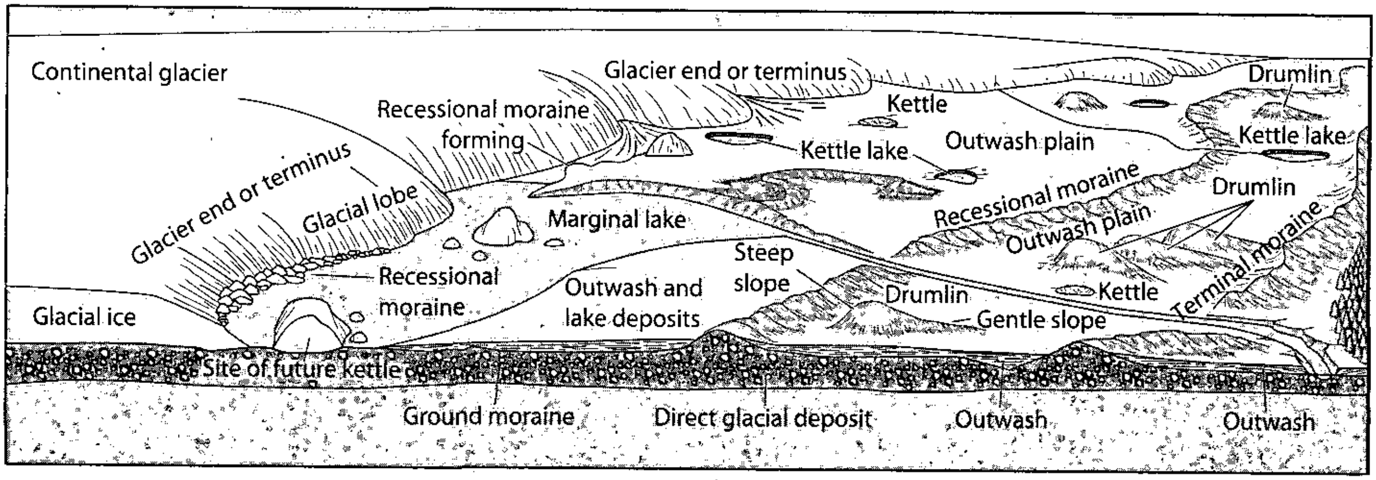


Figure 10-8. Depositional features associated with glaciers: When glaciers melt, some of the sediments are directly deposited into a single layer or small hills.

Deposition on Coastlines by Water Waves and Currents

When wind-generated ocean or lake waves slow down as they drag bottom approaching the shore, they tend to move sediment towards shore. This wave movement towards the shore often builds up a strip of sediment at the coastline called a beach. Beaches are composed of whatever sediments are available, but most beaches are composed of sand. When a shoreline has a natural or human-made projection out into the ocean—such as a peninsula or pier—sand is deposited on the side of the projection facing an oncoming longshore current. This deposition occurs because the water slows down when it reaches the projection, and the sand settles out. The side of the projection facing away from the longshore current usually gets eroded because it is not protected by the sand deposits. When the waves are more powerful, such as during storms, the beach tends to erode more and the sand is carried back into the ocean. There it is usually deposited as underwater bars parallel to the shoreline. Sand is added to these features by the longshore currents. These longshore currents transport sediment—sand—and when the velocity of the water slows, deposition creates various types of depositional features such as sandbars. If this sandbar rises above average sea level, winds will help to pile up the sediments. Then vegetation can stabilize this offshore sediment pile, creating a **barrier island**. Barrier islands are common along the east and southeast coast of the United States. (See Figure 10-9.)

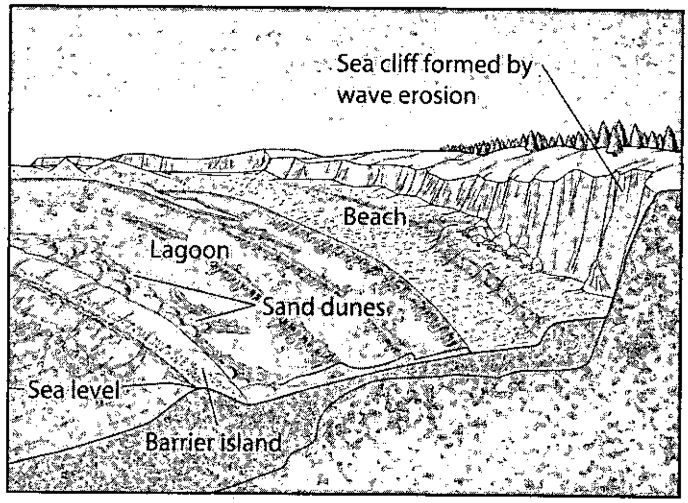


Figure 10-9. Beaches and barrier islands: Two features formed by deposition of sediments by waves and longshore currents are the beach and barrier islands. Barrier islands often protect the shore from direct pounding by storm waves.

Deposition by Wind

When wind slows down or stops, the sediments it is carrying are dropped. Because air has such a low density compared to liquid water, it usually transports and deposits only sand and smaller sized sediments. The sediments smaller than sand (silt and clay) are commonly called dust. Much of the dust picked up by wind or given to the air in volcanic eruptions—as volcanic ash—is deposited over large expanses of the land

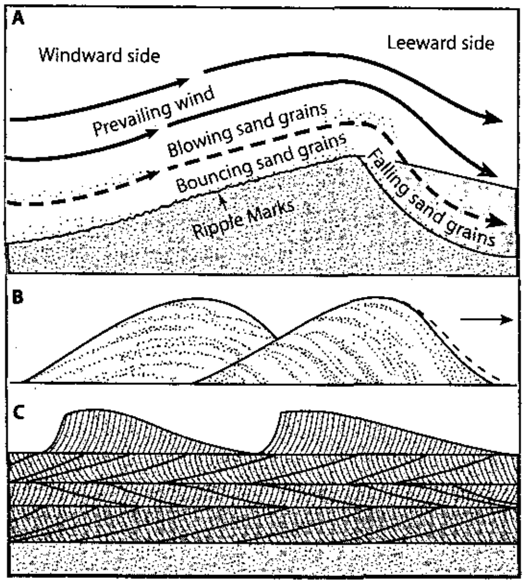


Figure 10-10. Features and movement of sand dunes: When there is loose sand, wind will bounce it along the surface and carry some a few feet into the air. When the wind slows down, it may deposit the sand in a mound called a sand dune. (A) Shows that sand dunes have a gentle slope facing into the wind—windward side—and have a steep slope on the opposite side—leeward side. Note the ripple marks on top of the sand dune. (B) Shows that dunes migrate up to a few feet a day. (C) If the winds change direction, beds of sand will cross one another at various angles producing a feature called crossbedding. Most sand in dunes is well sorted in sloping layers, and the sand grains are well rounded and have a frosted appearance.

and water environments, adding to the general sediment layer of Earth's solid surface. In rarer cases a fine-grained sediment is deposited as a soil layer downwind from large regions of loose sediment.

Sand is deposited by wind in layers or in mounds called **sand dunes.** Sand dunes can assume many shapes but generally—as shown in Figure 10-10—they have a gentle slope facing into the wind, and a steeper slope on the side the wind is blowing towards. Sand dunes migrate as a body downwind—in the direction the wind is blowing to—creating layers of sloping sorted sediment. The sand within sand dunes is usually very rounded and frosted in appearance due to numerous collisions of sand grains during erosion and weathering.

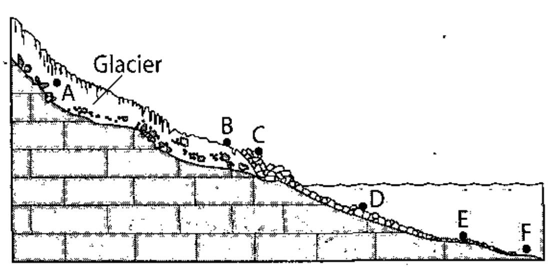
Deposition by Mass Movement

When an avalanche or other type of mass movement hits the ground and stops moving, the sediments it was transporting are deposited as a landform feature of Earth's surface. These features are usually composed of unsorted and unlayered sediments. Depending on the history of the sediments, many will not be very rounded in shape but will often have sharp sides. This is especially true if the sediments have been recently produced by frost action. The most recognizable depositional feature of mass movement is a pile of sediments that is the result of falling sediments often found at the base of cliffs.

Review Questions

15. Deltas form where
(1) a ground moraine is deposited
(2) stream velocity is reduced
(3) small streams empty into larger streams
(4) extensive ground water action has occurred

Base your answers to questions 16 through 19 on the following diagram. The diagram represents a glacier moving out of a mountain valley. Water from the melting glacier is flowing into a lake. Letters A through F identify points within the erosional-depositional system.

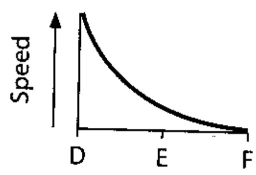


16. Deposits of unsorted sediments would probably be found at location
(1) E
(2) F
(3) C
(4) D

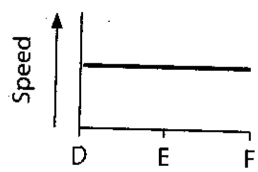
17. An interface between erosion and deposition by the ice is most likely located between points
(1) A and B
(2) B and C
(3) C and D
(4) D and F

18. The clay-sized sediment particles carried by water are most probably being deposited at point
(1) F
(2) B
(3) C
(4) D

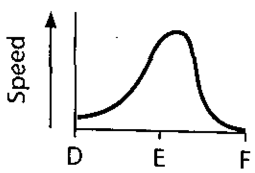
19. Which graph best represents the speed of a sediment particle as it moves from point D to point F?



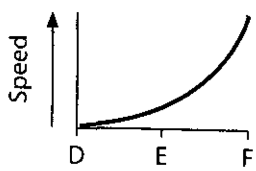
(1)



(3)



(2)



(4)

Base your answers to questions 20 through 25 on the following diagrams. Diagram I shows melting ice lobes of a continental glacier during the Pleistocene Epoch. Diagram II represents the landscape features of the same region at present, after the retreat of the continental ice sheet. Letters A through G indicate surface features in this region.

Diagram I

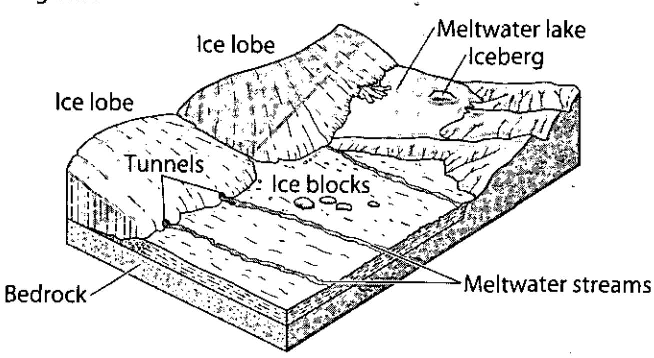
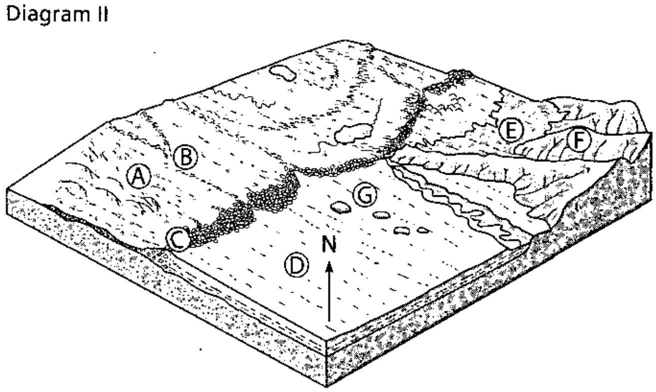


Diagram II



20. Which features in Diagram II are composed of sediment directly deposited by the glacial ice?

(1) A and C
(2) B and D
(3) C and E
(4) E and F

21. Kettle lakes are located nearest to

(1) A
(2) B
(3) F
(4) G

22. Drumlins that formed under a lobe of ice are located at

(1) A
(2) B
(3) C
(4) D

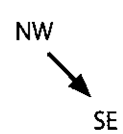
23. An outwash plain of sorted layered sediment is located at

(1) A
(2) B
(3) C
(4) D

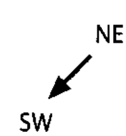
24. A moraine deposit formed at a former interface of a glacier and no glacier is located at location

(1) A
(2) C
(3) F
(4) G

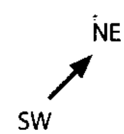
25. Which arrow best represents the directions of movement that formed the deposits shown in Diagram II?



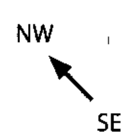
(1)



(3)



(2)



(4)

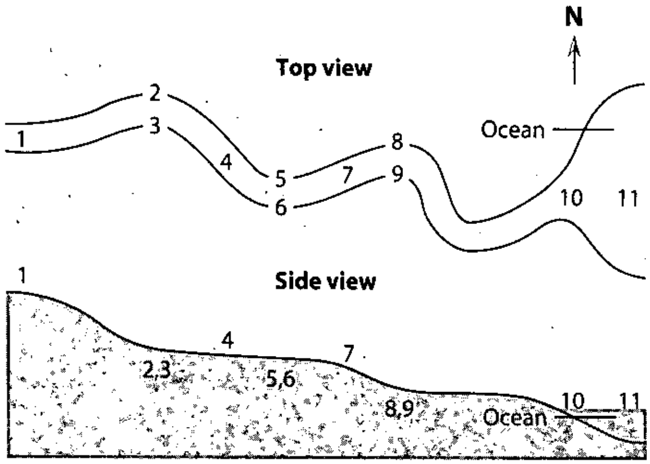
Practice Questions
for the New York Regents Exam

Directions

Review the Test-Taking Strategies section of this book. Then answer the following questions. Read each question carefully. Decide which choice is the correct answer.

Part A

To answer questions 1 through 9 refer to the following diagram, which shows the top and side views of a stream. Consider the volume of water in the stream to be everywhere the same.



1 At which place in the stream would there be the clearest interface between erosion and deposition?
(1) 1 (2) 2-3 (3) 3-4 (4) 7

2 What happens to the total amount of energy of this stream as it flows from 1 to 10?
(1) It steadily increases.
(2) It steadily decreases.
(3) It increases and decreases.
(4) It remains the same.

3 Between what two points would the most potential energy be converted to kinetic energy?
(1) 1-2 (2) 2-5 (3) 5-8 (4) 8-10

4 At which location would the most deposition occur because of loss of energy?
(1) 4 (2) 6 (3) 9 (4) 10

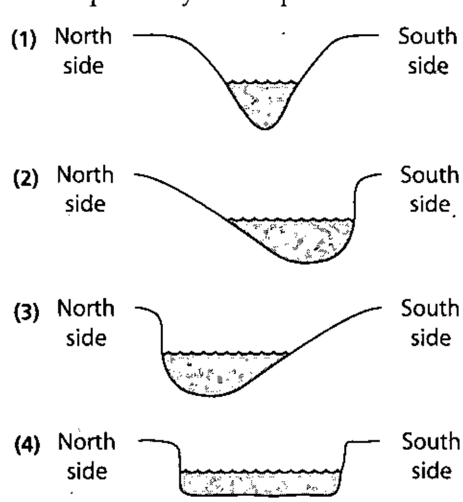
5 At which location would the stream be doing the most eroding of its side and banks?
(1) 1 (2) 3 (3) 5 (4) 8

6 If the stream is eroding as much as it is depositing between 8 and 10, the stream at this location can be said to
(1) be an interface
(2) have dynamic equilibrium
(3) be sorted
(4) have equal amounts of kinetic and potential energy

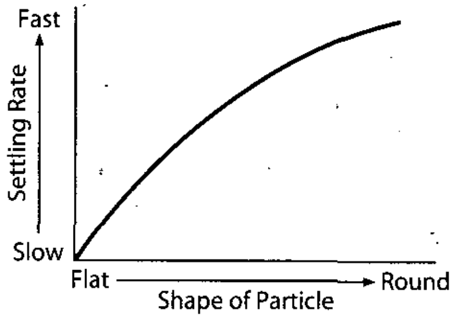
7 Which characteristic would usually decrease the most between locations 10 and 11?
(1) the amount of salt solution
(2) the size of the sediments
(3) the density of the water
(4) the depth of the water

8 As the water of the stream flows from 1 to 10, the total potential energy of the stream will
(1) increase
(2) decrease
(3) remain the same

9 An observer looks downstream from a location just above location 8-9 and draws a cross section of the streambed at location 8-9. Which diagram would probably best represent this cross section?



10 **The following graph shows the relationship between particle shape and settling rate.**



Which statement best describes the relationship shown?
(1) flatter particles settle more slowly than rounder particles
(2) flatter particles settle at the same speed
(3) all particles settle at the same speed
(4) particle shape does not affect settling rate

11 A mixture of sand, pebbles, clay, and silt, of uniform shape and density, is dropped from a boat into a calm lake. Which material most likely would reach the bottom of the lake first?

(1) sand (3) clay
(2) pebbles (4) silt

Part B

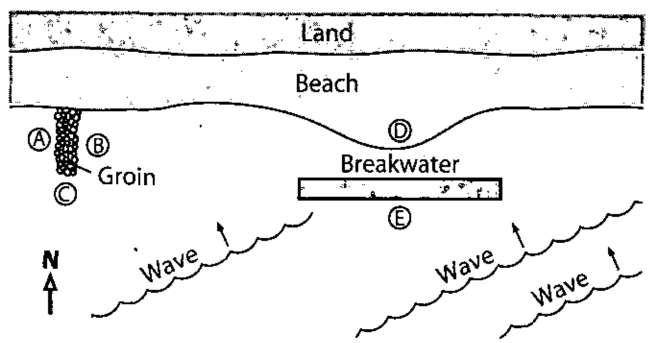
Match each of the deposition or erosional features in Column 1 with the phrase in Column 2 that best applies to that feature. Briefly describe HOW each feature forms and WHERE it forms. A CHOICE MAY BE USED MORE THAN ONCE AND SOME CHOICES MAY NOT BE USED.

Column 1	Column 2
12 outwash plain [3]	**(a)** deposited by glaciers
13 sand dune [3]	**(b)** deposited mostly by water from melting glaciers
14 offshore bar [3]	**(c)** formed by glacial erosion
15 moraine [3]	**(d)** not related to glaciation

Match each feature in Column 1 with the erosional-depositional agent in Column 2 that is chiefly responsible for producing that feature. Briefly describe how each land feature is produced. A CHOICE MAY BE USED MORE THAN ONCE AND SOME CHOICES MAY NOT BE USED.

Column 1	Column 2
16 drumlin [2]	**(a)** glaciers
17 barrier island [2]	**(b)** gravity
18 sand dune [2]	**(c)** streams
19 flood plain [2]	**(d)** waves and shore currents
	(e) wind

Base your answers to questions 20 through 25 on the diagram below, which shows ocean waves approaching a shoreline. A short wall of rocks *perpendicular to the shoreline* and an offshore structure have been recently constructed along the beach. Letters A, B, C, D, and E represent locations in the area.



20 What is the most common cause of the approaching waves?
(1) underwater earthquakes
(2) variations in ocean-water density
(3) the gravitational effect of the moon
(4) winds at the ocean surface

21 At which location will the beach first begin to widen due to sand deposition?

(1) A (2) B (3) C (4) E

22 The size of the bulge in the beach at position D will
(1) decrease
(2) increase
(3) remain the same

23 How was this beach directly formed?
(1) uplifting from an earthquake
(2) sinking of land during a landslide
(3) deposition of sediments by ocean waves and currents
(4) erosion of bedrock by ocean waves and currents

24 If sand dunes were located on the beach, they would have been formed by
(1) deposition by strong winter ocean waves
(2) erosion by mild summer ocean waves
(3) deposition by wind
(4) erosion by surf and ocean shore currents

25 Which statement best describes the ocean current that is modifying this coastline?
(1) the current is flowing northward at a right angle to the shoreline
(2) the current is flowing southward at a right angle away from the shoreline
(3) the current is flowing eastward parallel to the shoreline
(4) the current is flowing westward parallel to the shoreline

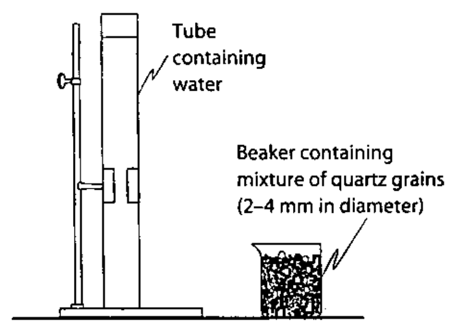
Base your answers to questions 26 through 28 on the map below, which shows the drainage basin of the Mississippi River system. Several rivers that flow into the Mississippi River are labeled. The arrow at location *X* shows where the Mississippi River enters the Gulf of Mexico.

26 The entire land area drained by the Mississippi River system is referred to as a
(1) levee
(2) watershed
(3) meander belt
(4) floodplain

27 Sediments deposited at location *X* by the Missisippi River most likely have which characteristics?
(1) angular fragments arranged as mixtures
(2) rock particles arranged in sorted beds
(3) rocks with parallel scratches and grooves
(4) high-density minerals with hexagonal crystals

28 The structure formed by the deposition of sediments at location *X* is best described as a
(1) moraine
(2) tributary
(3) delta
(4) drumlin

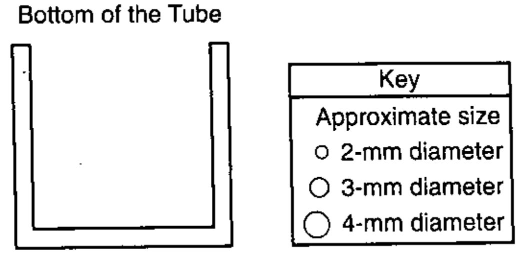
Base your answers to questions 29 and 30 on the diagram below, which shows a clear plastic tube containing water and a beaker containing a mixture of rounded quartz grains of different sizes.



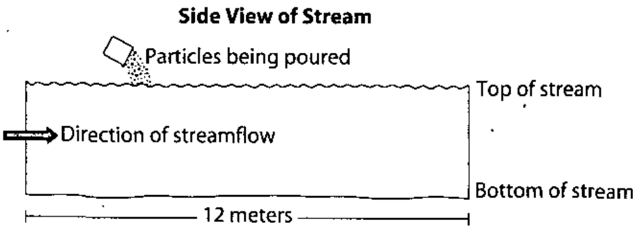
(Not drawn to scale)

29 When the rounded quartz grains are poured all at once into the tube, the grains will settle to the bottom of the tube. On the cross section provided below, draw the approximate grain sizes and pattern of arrangement of the rounded quartz grains at the bottom of the tube. [1]

Cross Section of the Bottom of the Tube

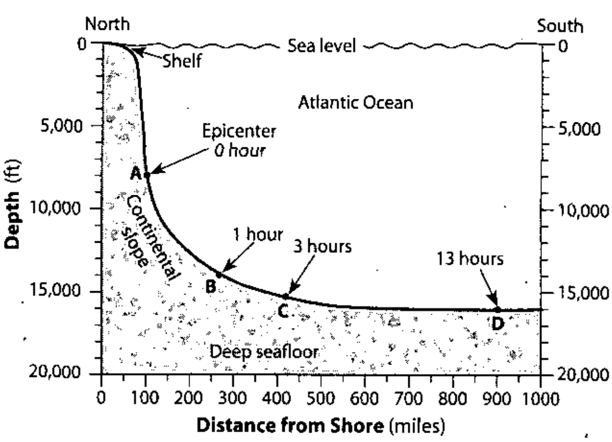


30 The side-view diagram below shows the same mixture and amount of rounded quartz grains being poured all at once into a moving stream with a depth of 3 meters.



Describe the general location of the 2-mm-diameter rounded quartz grains compared to the 4-mm-diameter rounded quartz grains as they are transported and deposited downstream. [1]

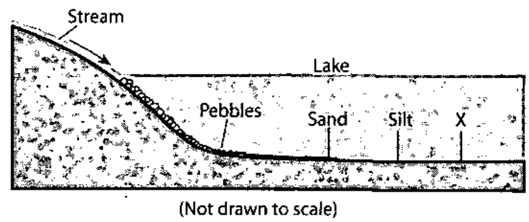
Base your answers to questions 31 and 32 on the cross section below, which represents part of the Atlantic Ocean seafloor. An earthquake occurred on November 18, 1929, triggering an underwater sediment flow. The location of the epicenter is labeled. Letters *A* through *D* indicate locations on the seafloor. Time, in hours, at each lettered location represents the arrival of the sediment flow after the earthquake.



31 Calculate the gradient of the ocean floor between locations *A* and *D* and label your answer with the correct units. [2]

32 Explain why the velocity of the sediment flow created by the earthquake *decreased* as the sediment moved from location *B* to location C. [1]

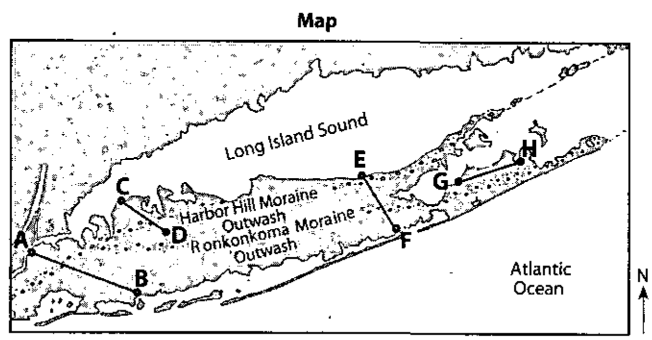
33 The cross section below illustrates the normal pattern of sediments deposited where a stream enters a lake. Letter *X* represents a particular type of sediment.



(a) Briefly explain why deposition of sediment usually occurs where a stream enters a lake. [1]

(b) Name the type of sediment most likely represented by letter *X*. [1]

Base your answers to questions 34 through 36 on the map of Long Island, New York. *AB*, *CD*, *EF*, and *GH* are reference lines on the map.



34 Which agent of erosion transported the sediments that formed the moraines shown on the map?

(1) water
(2) wind
(3) ice
(4) mass movement

35 The cross section below represents the sediments beneath the land surface along one of the reference lines shown on the map.

Along which reference line was the cross section taken?

(1) *AB* (2) *CD* (3) *EF* (4) *GH*

36 A major difference between sediments in the outwash and sediments in the moraines is that the sediments deposited in the outwash are

(1) larger
(2) sorted
(3) more angular
(4) older

Part C

37 A person finds gold nuggets near a meander, or curve, of a stream in California. Explain where in the meander area the gold nuggets were most likely found. Why is gold (density 19.3 g/cm^3) deposited at this location and not minerals such as halite (density 2.2 g/cm^3) and gypsum (density 2.3 g/cm^3)? [2]

38 You are investigating a dry stream bed at the point it once entered a lake. As you walk out into the lake bed from the mouth of the stream, you notice that the sediments below your feet become smaller. You also notice that as you dig vertically in the same location, the uncovered sediments gradually increase in size. Using your knowledge of erosion and deposition, state a hypothesis to explain both observations. [2]

39 Your friend offers the following description of sediment she observed in a V-shaped canyon on a camping trip in Arizona. "The pebbles were all piled together evenly and they were very uniform in size. They were rounded, and smooth, with almost no markings of any kind. I think that they must have been deposited long ago by a glacier." Do you agree with her inference? Cite four clear pieces of evidence to either support or refute her conclusion. [5]

Base your answers to questions 40 through 45 on the notes below written by a student during field trips to three different locations in New York State.

NOTES

Location A

Good view from this hilltop; chilly and windy. We rested to catch our breath, then collected samples. Rocks are visible everywhere. There are boulders, cobbles, and pebbles of many sizes and shapes mixed together. These surface rock fragments are composed of metamorphic rock sitting on the limestone bedrock. The teacher showed us parallel scratches in the bedrock. I saw almost no soil.

Location B

It is rocky and the streambank is steep. Where we are standing, we can see a waterfall and rapids. It is cool by the water. From the streambed we collected pebbles and cobbles—some red, some white, others a mixture of many colors. The streambed is full of rocks of all sizes. The teacher warned us to be careful of the strong stream current.

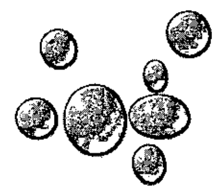
Location C

It is cool in the shade, and the rock cliff above us still has some ice on it from winter. The rocks we are sitting on have sharp edges. Rock fragments at the bottom of the cliff are the same color as the cliff. Our teacher warned us to watch out for falling rocks.

40 *a* State the agent of erosion that deposited most of the sediment found at location *A*. [1]

41 *b* State *one* observation recorded by the student that supports this conclusion. [1]

42 Some samples of sediment collected from the streambed at location *B* are shown below.



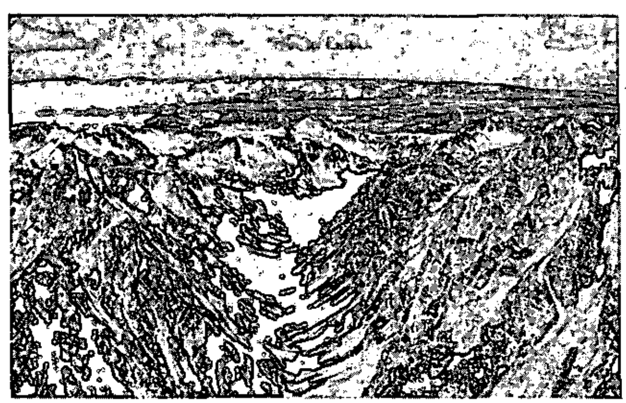
Explain why these samples are smooth and have rounded shapes. [1]

43 Explain how ice in cracks on the cliff at location C may have helped cause weathering of the bedrock on the face of the cliff. [1]

44 What agent of erosion resulted in the deposition of the rocks with the sharp edges at location C?

45 What is one feature of wind deposited sediments that would differ from rocks (sediments) deposited at locations A and B?

Base your answers to questions 46 and 47 on the photograph below, which shows a mountainous region cut by a large valley in its center.



46 What characteristic of this large valley supports the inference that glacial ice formed the valley? [1]

47 Describe additional geologic evidence that might be found on the valley floor that would support the idea that glacial ice formed this valley. [1]