STREAM TABLE INVESTIGATIONS

Laboratory Manual for the Earth Science Stream Table

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HUBBARD
Scientific

STREAM TABLE LABORATORY MANUAL

INTRODUCTION

The Stream Table has been developed to provide a means of exploring and discovering geologic principles and processes. Since it is difficult to be in the field to view every type of geologic feature, and very few processesproceed at a rate that can be witnessed, the Stream Table can be a most important laboratory tool in the study of physical geology. The Laboratory Manual outlines numerous investigations relating to stream processes, coastal features, glaciation, and structural processes. The experiments involve observations and the recording of data from which conclusions may be drawn regarding the geologic concepts and their application in nature.

CONTENTS

ACKNOWLEDGMENTS

Many of the investigations prepared by Gregory Beckway for the Stream Table Laboratory are based on original Stream Table investigations developed by Maurice Schwartz for the Earth Science Stream Table Study Guide published by Hubbard Scientific, Inc.

EXPERIMENT 1
LIFE HISTORY OF A STREAM

Introduction

Almost everyone has had the opportunity to see several different rivers in his lifetime. Maybe you have been able to notice striking differences between them. Did you every wonder why one river follows a straight course while another contains numerous curves, or why one river has a smooth channel floor and the next contains many falls and rapids? In this laboratory exercise we will observe some of these differences between streams and determine what conditions might cause them.

Materials

- stream table
- string (1/2 to 1 meter in length)
- small cork
- stop watch
- ruler
- protractor
- colored sand
- clear plastic drawing overlay
- colored grease pencils

PART 1 — YOUTH OF A STREAM

Make sure both water output valves are closed before plugging in the power cord. Place the plastic stream deflector beneath the outlet nozzle at the head of the channel. Fill water in the lake, at the lower end of the stream table, to a depth of 1 1/2". The depth can be determined by adjusting the drainpipe 1 1/2" above the bottom.

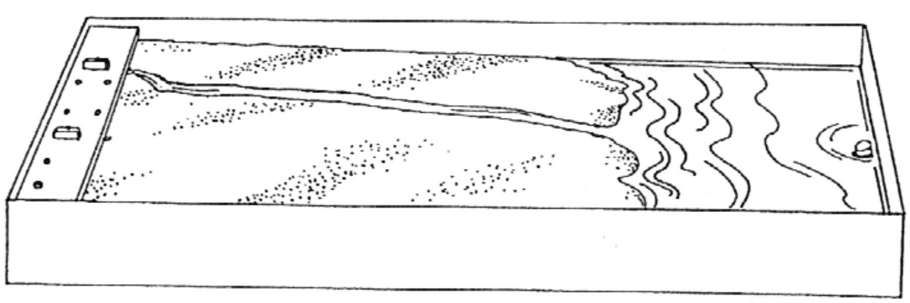
Open the valve and allow the water to flow moderately onto the deflector and drain down the valley.

Place the acrylic **grid** over the edges of the table and trace the borders of the stream onto it. Trace the edge of the valley after every 5 minutes using a different colored pencil each time. At frequent intervals sprinkle colored sand into the stream and examine its movement.

Take a piece of string 1/2 meter in length (1 full meter if possible) and stretch it alongside the stream. Place a cork in the stream at the upper end of the string and, using a stop watch, determine the nearest tenth of a second the length of time it takes the cork to travel one meter. Do this three times and place the results in the proper spaces of Chart 1. Determine the average velocity in cm./sec. and add your results to the chart.

Make an overhead drawing of the river in the space marked Diagram 1. First, use your ruler to measure the depth of the stream in centimeters at the head, center, and mouth, and enter the results of Chart 1. Next, place the clear plastic overlay on top of the stream table and trace the borders of the stream channel with a colored grease pencil. Measure in centimeters the width of the stream at the head, center, and mouth, and again enter your results on the chart. Take three readings.

Use the measurements to find the average width and depth. Determine there form ration for the head, center, and mouth. (Form ratio for each location equals depth divided by width.) Next, determine the form ratio for the whole stream by dividing the average depth by the average width.



High End

Low End

Chart 1

	SEC. REQ. FOR CORK TO GO 1 M.	STREAM VELOCITY CM./SEC.
READING NO. 1		
READING NO. 2		
READING NO. 3		
AVERAGE READING		

LOCATION	WIDTH (CM.)	DEPTH (CM.)	FORM RATIO (DEPTH/WIDTH)
HEAD			
CENTER			
MOUTH			
STREAM AVERAGE			

CHART 1

PART 2 — EARLY MATURITY OF A STREAM

Using the single inlet hose at a moderate rate of flow, allow the water to run for approximately 10 to 15 minutes down the youthful stream valley formed in PART 1.

Take three velocity readings following the same procedure described in PART 1. Notice the changes which have occurred and make another overhead drawing in Diagram 2. Place a clear plastic overlay on top of the stream table and trace the channel borders with a different colored pencil.

Again take width and depth readings for the head, center, and mouth of the stream and again find the form ratio for each of these locations and for the entire stream. Place all of these results on Chart 2.

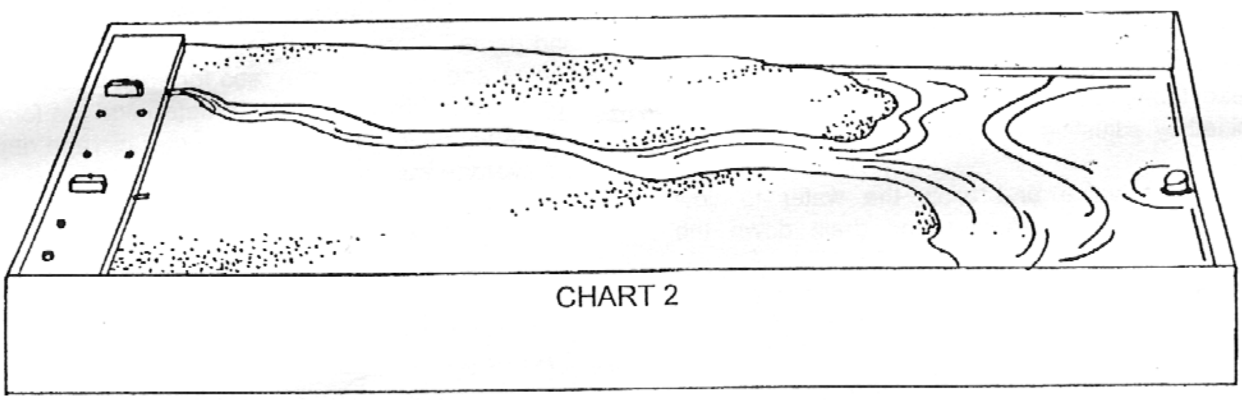
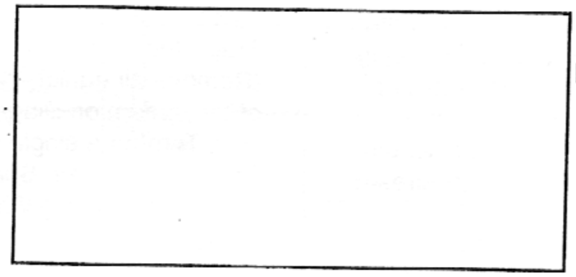


CHART 2

	SEC. REQ. FOR CORK TO GO 1 M.	STREAM VELOCITY CM./SEC.
READING NO. 1		
READING NO. 2		
READING NO. 3		
AVERAGE READING		

LOCATION	WIDTH (CM.)	DEPTH (CM.)	FORM RATIO (DEPTH/WIDTH)
HEAD			
CENTER			
MOUTH			

High End



Low End

DIAGRAM 2

Questions

1. Did the stream change its form ratio at all places at the same rate? Might it be possible for the lower regions of a stream to be in a different stage of development from the upper regions? Explain.

2. What was the change in the form ratio of the stream as it advanced from youth to early maturity? Explain.

3. From your observation of the stream table, which stage of development in the life history of stream is the shortest? Why?

4. Why does the stream begin to meander in early maturity?

5. How would you be able to distinguish a youthful stream from a mature one on a topographic map?

6. What is the lowest level or base level to which the stream on the stream table can be cut?

7. Why do most youthful streams have a V-shaped valley?

8. How does headward erosion occur in nature? Why can't this be demonstrated on the stream table in PART 1 and PART 2?

9. Explain how a flood plain is formed.

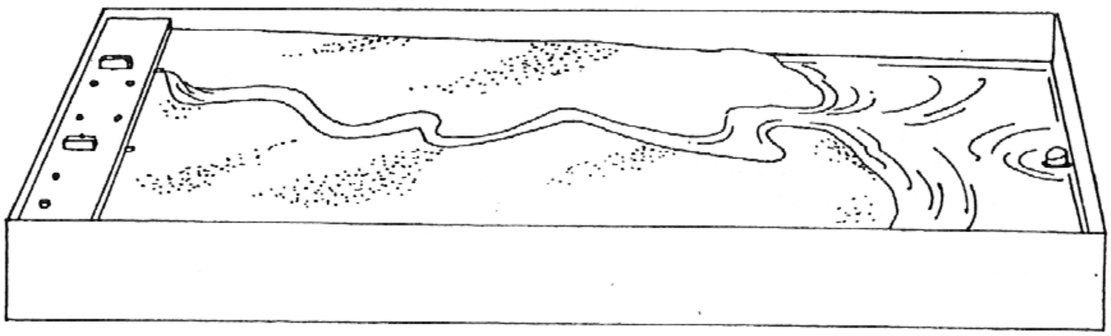
PART 3 — FULL MATURITY OF A STREAM

Smooth the sand into a gently sloping plain. Form a deep, narrow, sharply meandering depression along the entire length of the sand. (The meanders should be reverse curves.)

Before starting the water, measure the length, depth, width, and angle of valley sides of the stream channel at random locations.

Place your results in the proper spaces on Chart 3. Trace the channel sides on the clear plastic overlay. (Remove all earlier markings.) Draw an overhead view of the stream on Diagram 3.1.

Turn on a single inlet nozzle at a moderate rate of flow for 2 minutes. Sprinkle a pinch of colored shavings in the water, noting where they move fastest. Watch for



any circular paths in the movement of the particles.

Measure the depth, width, and length of the stream and the angle of the valley sides at the same location as your earlier measurements. Trace the channel outline on the overlay in a different colored pencil, and draw another overhead view in Diagram 3.2.

Again turn on the flow of water until a meander cutoff occurs. (If necessary, increase the rate of flow.)

Let the water run several minutes after the cutoff occurs, watching for any change in flow through the cutoff meander. Again measure the angle of the valley sides and the width, depth, and length of the stream channel. (When measuring the length, measure along the new stream course.) Draw an overhead view of the stream in Diagram 3.3 and again trace the outline of the stream on the overlay.

High End

Low End

DIAGRAM 3.1

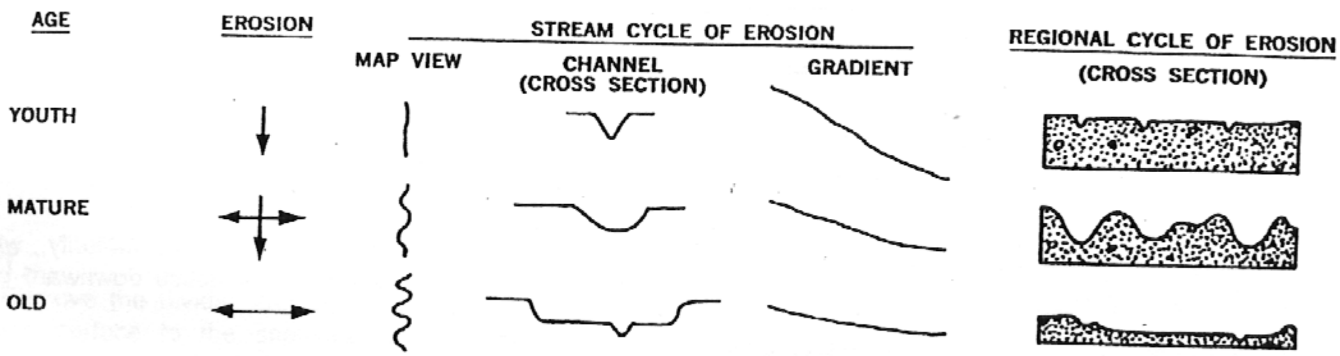
DIAGRAM 3.2

DIAGRAM 3.3

	SEC. REQ. FOR CORK TO GO 1 M.	STREAM VELOCITY CM./SEC.
READING NO. 1		
READING NO. 2		
READING NO. 3		
AVERAGE READING		

	WIDTH (CM.)	DEPTH (CM.)	LENGTH (CM.)	VALLEY SIDE ANGLE
BEFORE STARTING				
AFTER 2 MINUTES				
AFTER CUTOFF				

CHART 3



Questions

1. From your observation of the stream table, what is a good indication that the valley width, as originally carved, was too narrow?

2. Occasionally, small eddies may be found in the bends of a meandering stream. Why don't these develop potholes in the stream channel?

3. Rivers are often used as political boundaries. Why isn't this a good idea in the case of a fully matured stream?

4. Explain why, in times of flooding, the safest spot is often on the very banks of the river.

5. If you were going to buy property and two identical lots were offered, one on the inside of a meander and one on the outside, which would you invest your money in? Why?

6. Explain why a cutoff occurs and how this will shorten the stream channel.

7. Was the current of your model stream fastest along the inside bank of the meander or along the outside bank? How does varying current velocity relate to the further growth of meanders?

8. What was the path of the water in the stream channel immediately after the cutoff occurred? How did this change after several minutes?

9. Why are old-age rivers very rare in nature?

10. After the stream has reached maturity, what conditions might again produce active downward cutting of the channel?

EXPERIMENT II

DELTA FORMATION

Introduction

Most of us have heard of the odd-shaped landforms known as deltas, which form at the mouths of many large rivers. A cursory glance at an atlas shows that deltas are of many shapes and sizes, and often do not develop at all. This exercise will reveal some of the factors which determine the size and shape of deltas and will also illustrate some principles about the carrying capacity of streams.

Materials

- stream table
- wave generator (or paddle)
- 2 plastic base sheets (12" x 18")
- clear plastic divider
- ruler
- clear plastic drawing overlay
- colored grease pencils

PARTS 1 AND 2

Set the rate of flow of one nozzle to **gentle** and the other to **heavy.** Mold the sand into a smoothly sloping surface down to the shoreline and carve two straight channels the length of the sand. Divide the stream table with the clear plastic divider. Place one 12" x 18" sheet of plastic flush against the foot of each channel. Directing the gentle flow down one channel (PART 1) and the heavy flow down the other (PART 2), allow the water to run for exactly 5 minutes, forming a delta on each base sheet of plastic.

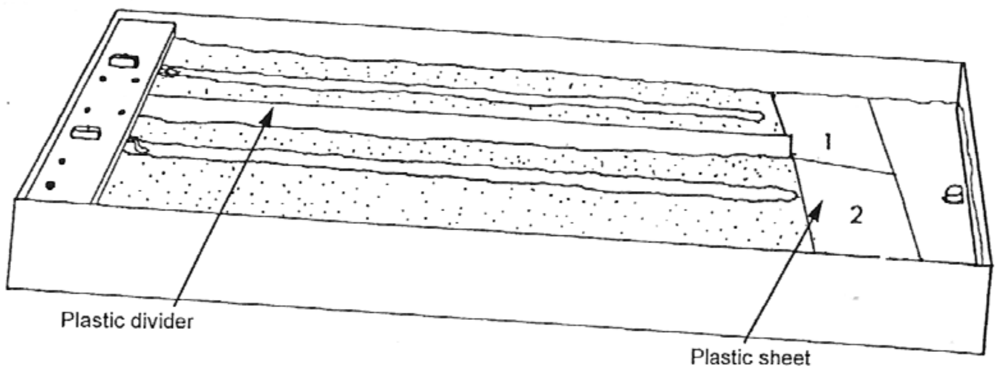
PROCEDURE

Measure the length of each delta at its longest part and the width at its widest part.

Measure the angle of the forset beds of each delta. Trace the outline of both deltas on the clear plastic overlay with grease pencilll, labeling each with corresponding number from the chart.

Make an overhead diagram of the deltas in Diagrams 1 and 2.

Carefully lift both base sheets of plastic with their sand deltas from the stream table. Drain excess water. Weigh each delta and record on the chart.



PART 3

Remove the divider and again form a smoothly slopping surface to the shoreline. Carve only one channel in the center and place a single base sheet of plastic at the foot. Use 1 nozzle at a heavy rate of flow. (If possible, the same rate as for PARTS 2 and 4.) Place the wave generator at the end of the stream table and direct the waves at 90° angles toward the shore. (Or use a paddle to generate waves in the same manner.) Follow the same procedure described in PARTS 1 and 2.

PART 4

Set the conditions of your stream table exactly as in PART 3. Remove the wave generator and attach a piece of tubing with a y conector to the heavy rate of flow nozle. Attach two pieces to the y connector, run one hose parallel to the shore beneath the water surface to produce a current. Place the other branch of hosing at the head of the channel.

Use the same heavy rate of flow as in PART 3 and allow to run for exactly 5 minutes. Again follow the procedure from PARTS 1 and 2.

PART 5 — Growth of a Delta

Shape the sand into a smoothly sloping surface down to the shoreline. Carve a narrow channel from one of the nozzles, along the entire length of the sand.

Adjust the standpipe to a height of 2 inches and fill the lower end of the table with 2 inches of water.

Direct a heavy flow of water down the channel for 30 seconds, then turn it off. Place the grid over the delta that is formed, and make an overhead drawing of it. Trace the stream distributaries if any have formed.

Direct another heavier flow of water down the channel for 2 more minutes and make another overhead drawing. Allow another flow for 5 minutes, then make a final drawing.

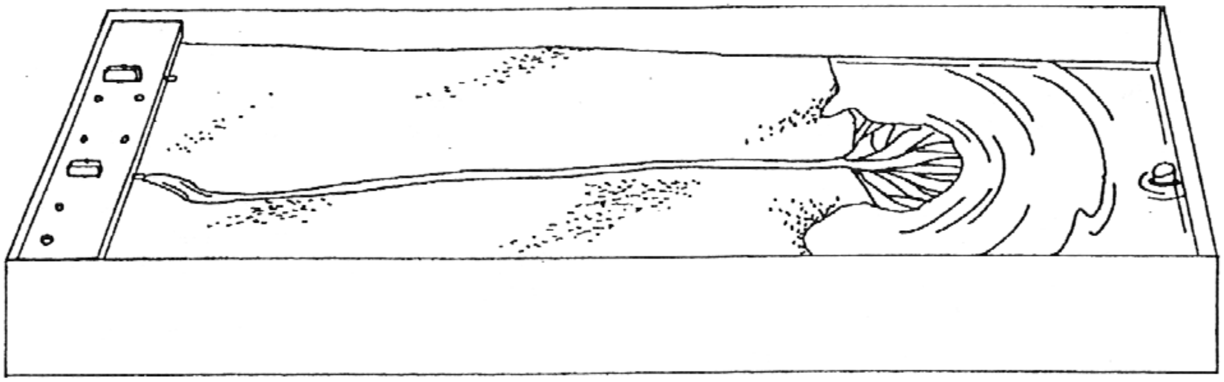
OBSERVATION

The water body will check the speed of the stream, and its load will be deposited. The channel will extend through the deposits into the water body. After a while, as deposits accumulate, distributaries break through the channel walls.

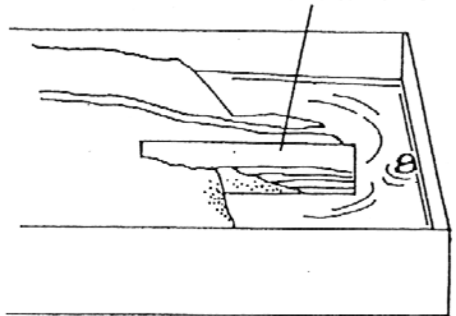
The first drawing should show one small lobe of sand extending into the water.

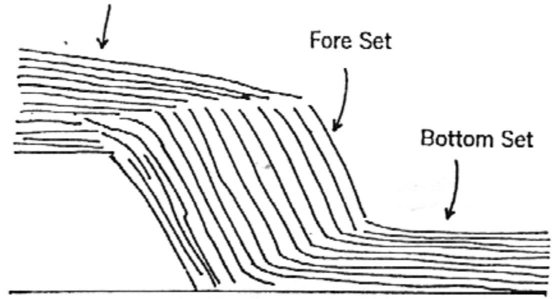
The second drawing should show a better developed delta, with several overlapping lobes and two or more distributaries, or distributary scars.

The third drawing should show a delta, nearly semicircular in shape, with many distributary scars. formerly occupied by the streams.



PART 6 — Cross Section of a Delta





PROCEDURE

Reshape the sand as in Part 5 and carve a narrow channel from one of the outlet nozzles to the shore. Insert the clear plastic **divided** vertically into the sand at the end of the channel so that it extends out into the lake.

Direct a heavy flow of water down the channel, periodically adding sand of different colors into the channel. Allow a well-developed delta to form. Stop the water and remove all the sand on one side of the plastic **divider**. Observe the cross-section as seen through the plastic divider.

OBSERVATIONS

In cross section, the delta reveals three distinct beds: the top set, fore set and bottom set beds. The top set beds are composed of sand deposited on the delta's surface. The for set beds consist of sand which has slid or rolled down the front slope of the delta. (The angle of these beds is dependent upon the angle of repose of the materials in water.) The bottom set beds are the most difficult to see. They consist of finer sand washed out in front of the advancing deltas.

Questions

1. Which activity, PART 1 or PART 2, produced the larger delta by weight? State the relationship between the volume of a stream and its carrying capacity.

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2. Why are large boulders often found moved downstream after flooding?

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3. Why does the stream continually change its path across the delta? What are these dividing and shifting streams across a delta called?

4. Explain why deltas make such rich and productive farm land.

5. Describe the difference in the delta formation between PART 2 and PART 3. What does this indicate about the effect of wave action on the formation of a delta?

6. Describe the difference in the delta formation between PART 2 and PART 4. What does this indicate about the effect of currents on the formation of a delta?

7. Name at least four conditions which will affect the size and shape of deltas.

8. Using a map, examine the Mississippi delta and draw two conclusions as to why it is so large.

9. In your experiment did the angle of the fore-set beds change from delta to delta? What general conclusion about the material can you draw from this?

EXPERIMENT III

ALLUVIAL FANS AND TALUS CONES

Introduction

Two landforms which are often confused by students due to their similarity in shape are the talus cone and the alluvial fan. A cursory glance does show many similarities; however, a closer look at these two features in this laboratory exercise will reveal many differences as well.

Materials

- stream table
- 1 cup of dry fine sand and small pebbles
- protractor
- ruler
- clear plastic drawing overlay
- colored grease pencils

PART 1

Construct a steep cliff in the sand the width of the table. Form a stream bed terminating at the cliff on one side of the stream table, and notch in the cliff on the other side. Smooth the sand into a flat plain sloping gently away from the base of the cliff. (The two features may optionally be separated by the use of the clear plastic divider).

Direct a single inlet nozzle at a moderate rate of flow down the stream bed. At the same time gently pour one-half of the cup of sand mixed with small pebbles through the notch in the cliff. Turn off the water. Place the clear plastic drawing overlay over the stream table and trace both the alluvial fan and the talus cone.

Diagram the two overhead views in the places provided on Diagram 1. With the protractor, measure the angle of the talus cone and the alluvial fan. Include the position or positions of the stream across the fan. Measure the radius of both features, placing a ruler from the apex to the farthest point of deposit. Enter the data on the chart.

PART 2

Again turn on a single inlet nozzle and let the water run for approximately 15 minutes, while gently pouring the remainder of the sand and pebbles through the notch. Turn off the water and trace a new outline of the features on the overlay. Also make an overhead drawing of both features on Diagram 2. (Note how close the fan is to a half-circle.) Again measure the angle and the radius of both the talus cone and the alluvial fan. Enter you data on the chart.

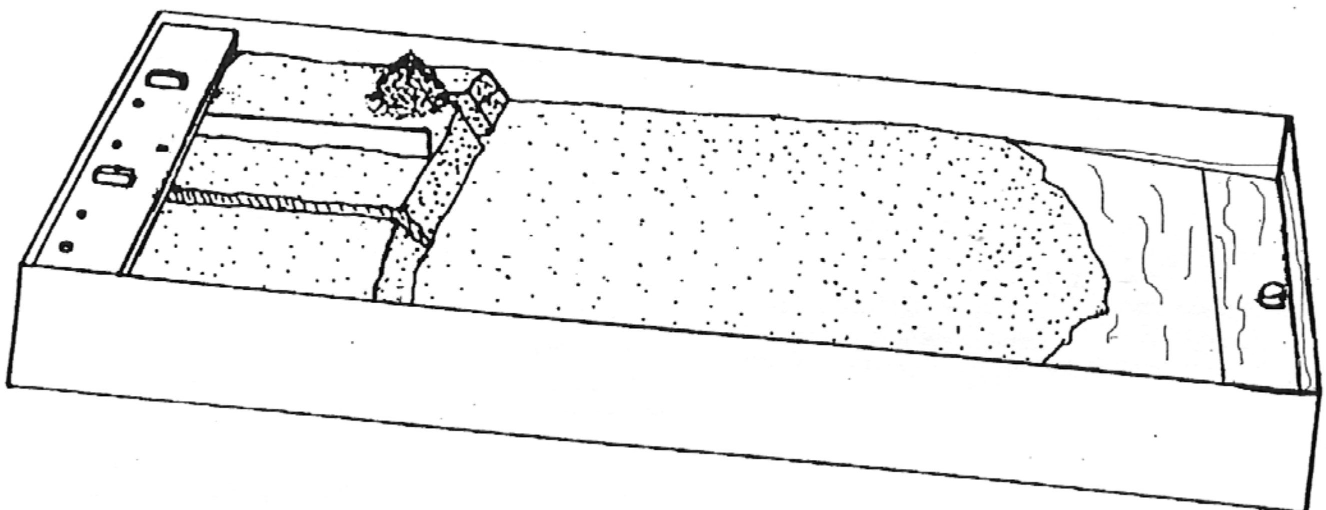

FIGURE F

ALLUVIAL FAN	TALUS CONE

CHART 1

ALLUVIAL FAN	TALUS CONE

CHART 2

	ALLUVIAL FAN		TALUS CONE	
	READING NO. 1	READING NO. 2	READING NO. 1	READING NO. 2
ANGLE OF SLOPE				
RADIUS				

Questions

1. What accounts for the difference in slope between the two landforms?

2. Did the slope of the alluvial fan noticeably change from the first to the second measurement? Will this trend continue as the cliff is worn down?

3. Was the stream's channel stationary across the fan? What other feature demonstrates a similar phenomenon?

4. Did the slope of the talus cone noticeable change from the first to the second measurement? What does this suggest about dry particles of this?

5. Using your knowledge of deposition by running water, describe the sorting which would occur if the particles in the alluvial fan were of various sizes.

6. Does the relative positioning of the particles for a talus cone differ from that of an alluvial fan?

7. In what type of climate are alluvial fans and talus cones most often found? Why?

8. Why does an alluvial fan often act as a storage reservoir for water?

9. Explain the reason for the difference in slope between talus cones and the forset beds of a delta.

10. Explain why alluvial fans develop.

EXPERIMENT IV
EROSION BY WATER

Introduction

All of us have, at some time or another, seen or been caught out in a heavy rainstorm. A casual inspection of the muddy sidewalks afterward is proof enough that erosion has occurred. If you have ever parked your car on an uncovered soil surface during a heavy rain, you have noticed a splash erosion. Drops of muddy water might be found as high as several feet up the side of your car. If may not be clearly understood just how great an erosion force this splatter effect is. This laboratory exercise is designed to illustrate some of the factors which affect and control erosion.

Materials

stream table with rainmaker
clear plastic divider
dried grass
tube of colored sand
eyedropper
grease pencils

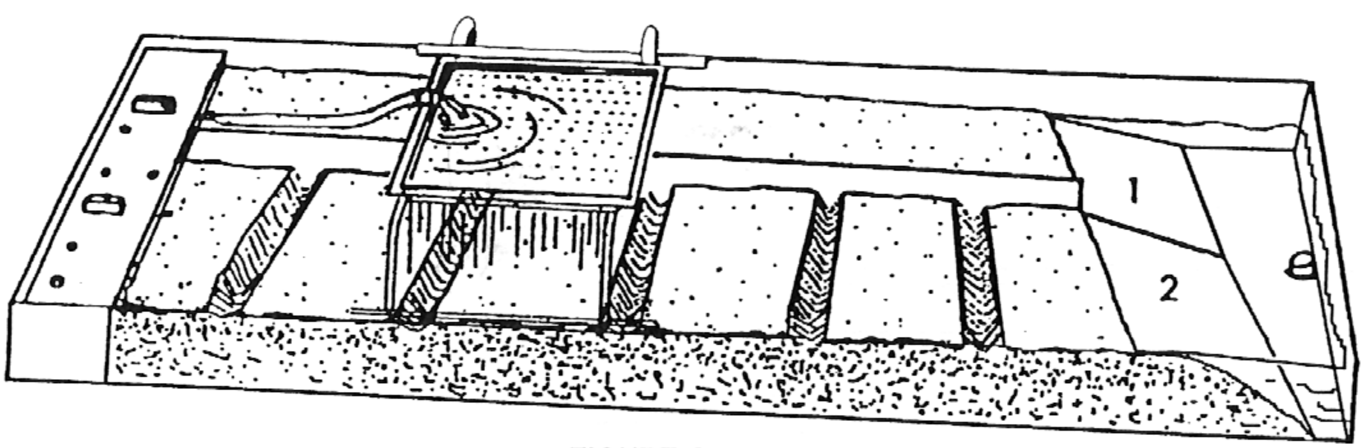

FIGURE G

PART 1 — SPLASH EROSION

Place one plastic sheet on the floor and draw a small circle 2 cm. in diameter in the center with a grease pencil. Gently pour dry colored sand into a cone, just filling the circle. Clean away all excess particles. Using an eyedropper, release 10 drops of water from a height of approximately 10 cm. onto the pile of sand. Using as a radius the distance of the farthest splashed particle from the center, draw a circle in grease pencil and label it 10 cm.

Wipe all sand clear and repeat the operation at an elevation of 30 cm., labeling the new splash circle 30 cm. Follow the procedure again at a height of 1 meter and label.

Using the other plastic sheet and the eyedropper, release one drop of ink from a distance of 10 cm. Move to a different spot on the plastic and release a drop from a height of 20 cm. Drop another drop of ink from a height of 50 cm. Note the results. Compare the radii of the ink blots. Compare the distances from the drop's point of impact to the farthest splattered droplet.

PART 2 — CONTOUR PLOWING, TERRACING, GRASS WATERWAYS

As shown in FIGURE G, form a smoothly sloping sand surface down to water. Divide the stream table with the clear plastic divider. On one side of the partition, carve transverse trenches while leaving the other side flat. Carefully place one piece of plastic at the foot of the smooth slope and one piece at the foot of the contoured slope. Make sure both pieces are flush against the sand and sides of the stream table.

Run the water at a heavy rate of flow through the rainmaker onto the smooth slope for 3 minutes. Next direct the water onto the contoured slope for 3 minutes. Weigh the eroded material from each piece of base plastic, placing the results on the accompanying chart.

Next, as shown in Figure H, reshape the sand into a smooth slope and again divide the stream with the plastic divider. On one side of the partition shape 5 terraces with a very slight inward slope. On the other side of the partition place a covering of dry grass. (Shake before using to remove small pieces.) Again place collecting sheets at the foot of the two slopes. Direct water through the rainmaker at the same rate of flow for 3 minutes on each side. Weigh the eroded material from each piece of plastic. Place the data in the proper space on the chart.

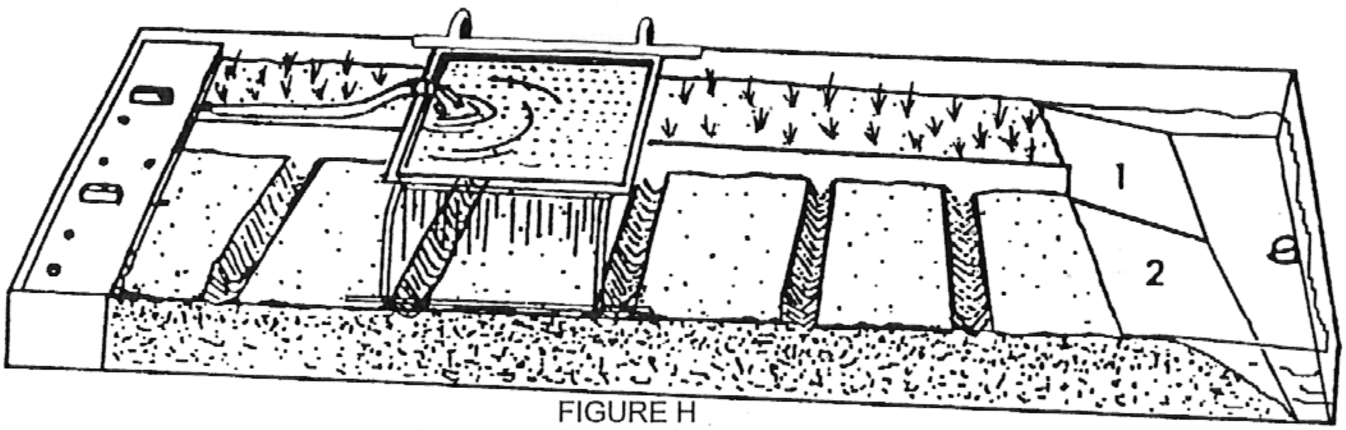

FIGURE H

	SMOOTH SLOPE	CONTOURED SLOPE	TERRACED SLOPE	GRASS SLOPE
WEIGHT OF ERODED MATERIAL				

CHART

Questions

1. Over which of the surfaces was there the greatest amount of erosion?

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2. Why do contoured slopes, grass slopes, and terraced slopes reduce erosion?

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3. Name three ways in which a grass cover protects the soil. (Remember, soil particles are different from sand, in that they cluster into aggregates.)

4. If we laid grass over the terraced slope, what effect might this have on the rate of erosion?

5. Why were the particles spread further from the center with increased elevation in the splatter-effect demonstration?

6. Considering that soil is clustered into aggregates with large openings between each particle, how might splash erosion greatly accelerate runoff?

7. If we were to double the size of the particles in the stream table, how would this affect the rate of erosion? Why?

8. In the splash erosion demonstration, it was shown that the splatter effect was much greater when drops were released from 1 meter than from 10 cm. If this increase continued at the same rate, a raindrop falling from the atmosphere would have the energy to move sand grains hundreds of feet. Explain why this doesn't happen.

9. Provided the same quantity of rain falls, which of the following conditions, A or B, is more conductive of soil erosion and why? (A) High-intensity rain for 20 minutes; (B) low-intensity rain for one hour.

10. Why should man be so concerned with soil erosion?

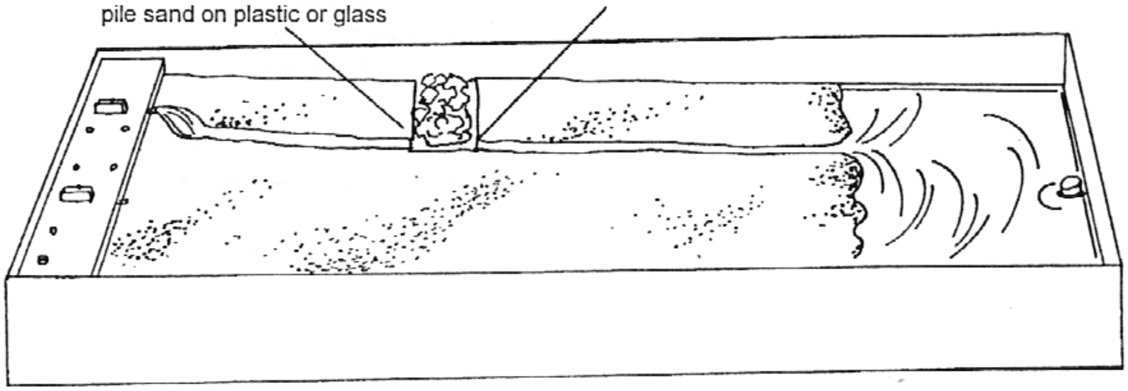
EXPERIMENT V
MASS WASTING

Introduction

Loose earth materials that lie on a slope move downward under the force of gravity. Sometimes the movement is slow and imperceptible and sometimes, rapid. Ice or water between particles often aid movement..

PART 1 — ROCKSLIDE

A rockslide is a rapid, downhill movement of a large rock mass along a smooth, inclined bedding plane or fault. The rock begins to slide as a consolidate nit, but usually it disintegrates before coming to rest as an accumulation of disordered rock debris. Rockslides can cause devastation if they occur in a populated region.



PROCEDURE

Smooth the sand into a gentle slope and carve a narrow channel from one of the outlet nozzles along the entire length of the sand. Construct a steep hill on one bank of the channel. Place the plastic *waterfall* over the hill with its open end resting in the stream valley. Pile wet sand on the *waterfall* at the steepest possible angle.

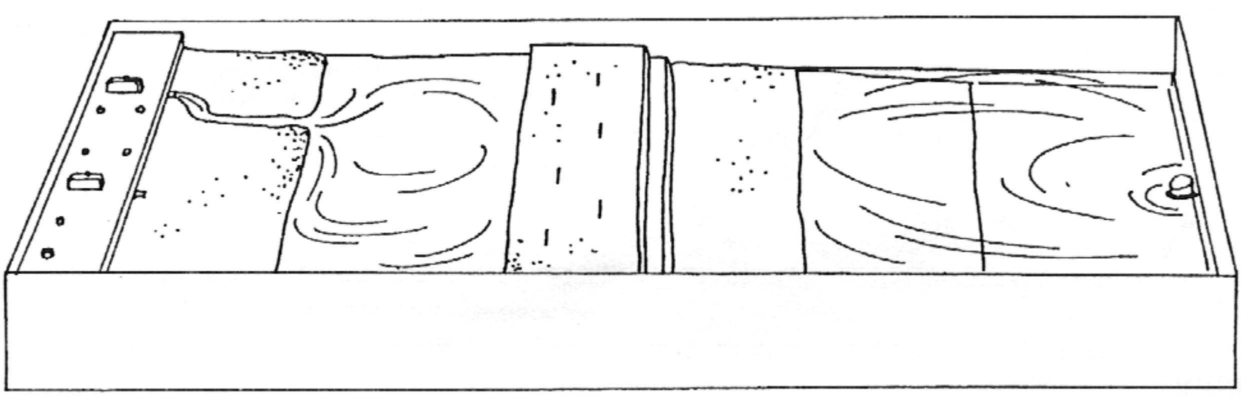
Open the outlet nozzle and allow a gentle flow of water down the channel. After some time, a landslide will occur.

OBSERVATIONS

As the stream removes the sand at the bottom of the slope, the sand above the channel slides down the plastic, which represents a bedrock surface.

If conditions are right, the landslide will dam the stream. Water will accumulate behind the dam as a lake. When the lake rises to a certain level, the stream will shift forming a new channel.

PART 2 — SLUMP



Slumping, sometimes called earthflow, is the collapse of a wet, steep slope in a series of steps, above a basal protruding accumulation of debris or a "toe". When the slope surface is composed of rock, or fairly consolidated earth, whole blocks may slump with a backward rotating motion along a curved slip plane.

PROCEDURE

Construct a broad sand ridge across the stream table and terminate it in a steep slope. Level its top and measure its width. Plant tooth picks vertically in the top near the edge. Draw a side view.

Direct a moderate flow of water behind the ridge until the water level nears the top of the ridge. Keep refilling as the water level drops. Be careful not to allow the water to overflow the ridge. After the first slump occurs, measure the width of the ridge and make another drawing.

After several more blocks have slumped measure the width of the ridge again and make a third drawing. Are the toothpicks in the slumped blocks still vertical?

OBSERVATION

The sand will slump in blocks along planes of stress, and the width of the ridge will decrease. The slumping is accompanied by a backward rotation which causes the toothpicks to slant toward the ridge.

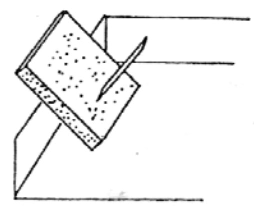
PART 3 — SOLIFLUCTION

Solifluction occurs only in subarctic climates. It is the slow flow of melted surface soil over the permanently frozen permafrost layer below.

PROCEDURE

Fill a large pan with sand to a depth of at least two inches. Saturate the sand completely with water and place a ruler vertically in it at one end. Place the pan in a freezer and allow the mixture to freeze overnight.

Remove the pan and read the depth of the sand as shown on the ruler. Place the container against the side of the *stream table* at an angle of 45°, with the ruler extending into the table. Observe the results as the layer of sand and water mixture at the surface melts. Measure the depth of the sand after approximately one-half of it has melted

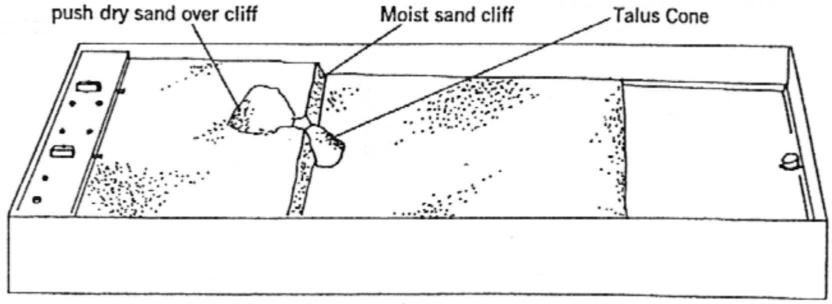


OBSERVATION

The melted water cannot soak into the frozen sand beneath so it forms a fluid mixture with the sand, and flows slowly down the slope. This process is called solifluction. After solifluction has continued for some time the depth of the sand will be greater at the foot of the slope than in the middle of the slope.

PART 4 — TALUS CONE

The products of the mass wasting of cliff faces may tumble down to accumulate as talus cones at the foot of the cliff. The larger fragments tend to come to rest at the base, while the smaller ones remian closer to the top of the cone. Cones form at the end of ravines, which channel the rockfalls to a single location.



PROCEDURE

Form a steep cliff with a large notch in the edge. Smooth the sand flat away from the cliff. Mix some small pebbles in a cup of fine sand. Pour the mixture down the notched cliff until a well developed cone forms.

OBSERVATION

The cone will develop into its characteristic fan shape. It will reveal particle sorting as the pebbles roll to the periphery.

Questions

1. Explain how weathering aids mass wasting.

2. Explain how mass wasting aids weathering.

3. Cite examples of how mass wasting often works in conjunction with the active agents of erosion.

4. Why are the results of mass wasting less noticeable in the eastern part of North American than in the western parts?

5. Explain how a crack of thunder can produce enough of a stimulus to trigger the movement of tons of rocks.

6. Why was the angle of slope of the conical pile of sand reduced with each pounding?

7. Why might freezing and thawing produce a slow downward creep of a hillside?

8. In PART 4, explain why movement of the mass began with the mere addition of water.

9. Why is a mudflow more potentially dangerous to humans than an earthflow?

10. Explain how freeze and thaw play an important part in earth flowage in the tundra climates. (Hint: Permanently frozen ground blocks infiltration of water.)

EXPERIMENTS VI
WATERFALLS AND RAPIDS

Introduction

Waterfalls have long been recognized as one of the most beautiful features of nature. However, they are very important from an economical standpoint in that they furnish great sources of electrical power. The steep slopes necessary for waterfalls are a result of various physical factors such as faulting, hanging valleys left by glaciers, or unequal weathering and erosion, and demonstrate why one waterfall moves progressively upstream and another erodes into a series of rapids.

Materials

- stream table
- plastic waterfall
- ruler
- clear plastic divider
- toothpick

PART 1

Form a steep cliff along the entire with of the stream table. Divide the stream table with the clear plastic divider. One side of the cliff bury the plastic waterfall just beneath the surface of the sand, allowing at least 2 cm. of sand beneath the waterfall and the floor of the stream table. (The plastic waterfall represents-a resistant layer of rock.) Form two stream beds down the entire length of the stream table, one on each side of the partition.

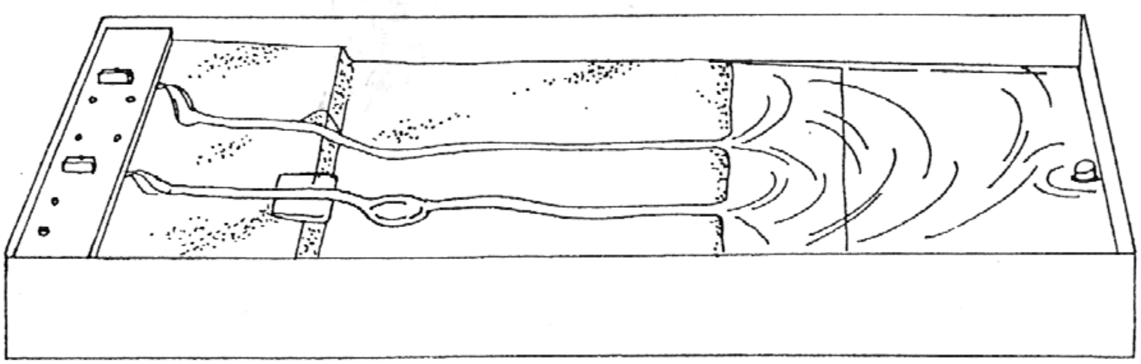
Using a single nozzle, allow the water to run down the stream bed without the hidden plastic waterfall until the cliff has eroded to a gentle slope (several minutes).

Next, direct the flow of water down the other stream bed until the hidden plastic model is exposed and a plunge pool is well developed. Drop colored sand into the plunge pool to determine the motion of the water. Stop the flow of water and measure the depth of the pool,placing your results on the chart.

Insert a toothpick vertically from the lip of the waterfall into the plunge pool. Remove the plastic waterfall and note the undercutting of the cliff. Measure the length of the plunge pool ahead of the toothpick and behind it. Add the data to the chart.

PART 2

Replace the plastic waterfall in the same position as before. Attach a piece of plastic tubing to one of the nozzles and hold the inlet hose 15 cm. above the plunge pool for several minutes to simulate a higher waterfall. Repeat the procedure for taking measurements of the plunge pool and add the data to the chart.



	LENGTH OF POOL TOOTHPICK BACKWARD	LENGTH OF POOL TOOTHPICK FORWARD	DEPTH OF POOL
WATER FALLING ( ) CM.			
WATER FALLING 15 CM.			

Questions

1. Why are waterfalls characteristic of youthful streams and rarely found in mature streams?

2. Describe the movement of the sand particles dropped into the plunge pool. Why is this important in the erosion of a waterfall with a top layer of resistant rock?

3. Explain how a waterfall with a cap layer of resistant rock works its way progressively upstream. How and why is this different from a waterfall flowing on homogeneous rock?

4. What happened to the plunge pool when the hose was held at a height of 15cm? Why?

5. Explain why falls usually last for only a small fraction of the stream's life history.

6. At what time of year do the waterfalls in North America contain the most erosive power? Why?

7. After much of the Atlantic Coast was uplifted, a line of waterfalls in the streams flowing eastward—a fall line—developed along the point of contact between the Appalachians and the newly emerged continental shelf. What does this tell us about the relative hardness of the Appalachians and the emerged shelf? Explain thoroughly, including the types of rock involved.

8. Why can waterfalls be used as sources of power?

EXPERIMENT VII
WATER TABLE

INTRODUCTION

If you have ever been camping, you may perhaps have used a hand pump to obtain your water. It probably took several pushes on the handle of the pump to bring water to the surface, but when it arrived it gushed forth heavily. If you had pumped long enough, however, you would have found that it took more and more effort to bring the water to the surface, until finally the flow stopped altogether. Upon returning to the well some time later, even though there had been no precipitation, it would have again been possible to pump water to the surface. What is the explanation for this phenomenon? We shall seek the answer to this and other questions about ground water in this exercise.

Materials

- stream table
- artesian well tube
- 3 funnels
- 6 100 - ml. beakers
- large beaker or glass aquarium
- 100-ml. graduate
- coarse sand, fine sand, soil
- stop watch
- rubber tubing (60 cm.)
- grease pencils
- clear plastic tube

PART — GROUND WATER

Push the standpipe to its lowest elevation and allow all the water to drain from the lower end of the stream table. Moisten the sand and smooth it in a slope to the standpipe. Form a lake bed in the upper part of the slope; a lowland, a hill, and a basin at short distances from each other down the slope. Dig out a small circular column of sand near the base of the hill and insert a plastic tube almost down to the floor of the stream table. The tube represents a well. The edge of the sand should terminate in a sharp line on the dry floor of the stream table.

Open one inlet nozzle and allow the water to fill the upper lake basin. Be sure not to overflow the basin. Note the time. Keep refilling the lake as its level goes down. Watch for changes in the lowland well and the small basin.

Observe and record the level of water in the well after two-minute intervals by dipping a stick into the well and noting the level on the stick. Note the time when water begins to issue at the edge of the sand.

Measure the distance from the lake basin to the edge of the sand. Calculate the velocity of the water through the sand.

PART 2 — PERMEABILITY DEMONSTRATION

Set three funnels side by side with a beaker placed beneath each funnel. Insert a wad of cotton in the neck of each funnel. Place coarse sand in the first funnel, fine sand in the second, and soil in the third. Fill all to the same level. Fill three separate beakers with 50 ml. of water. (Or less, depending upon the size of your funnels.)

With a stop watch determine the length of time it takes the water to drain through each funnel. Measure the amount of water in each beaker below. By subtracting the amount left in each beaker from the original 50 ml., the amount of water trapped between the particles as capillary water can be determined for each funnel. Enter you findings on chart 1.

The water level in the beaker, the water flowing down the neck of the funnel, and the water trapped around the particles in each funnel can be equated respectively with the ground water table, ground water, and capillary water held in place by surface tension.

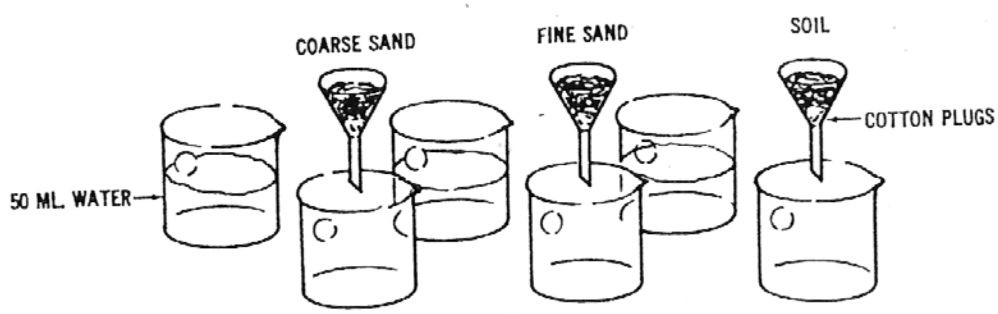


FIGURE Q

	TIME	AMOUNT OF PERCOLATED WATER	AMOUNT OF CAPILLARY WATER
COARSE			
MEDIUM			
SOIL			

PART 3 — CAPILLARY ACTION

A simple demonstration of capillary action can be shown by pouring coarse sand into a tube, closed at one end with a piece of cloth, and placing this end into a beaker of water just beneath the water surface. Mark the height of the water in the tube at 10-second intervals, using a grease pencil. Remove the tube from the water when the height of the column has become stationary (several minutes). Repeat the procedure using fine sand, marking the height of the water with a different colored grease pencil. Compare the tubes, noting the differences, and record your findings on Chart 2.

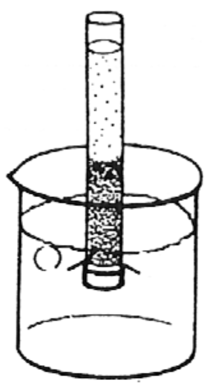


FIGURE R

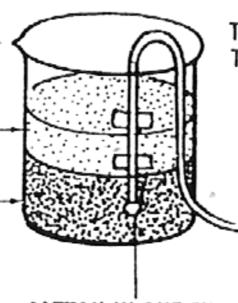


FIGURE S

Time Sec.	10	20	30	40	50	60	70	80	90	100	110	120
COARSE SAND HEIGHT												
FINE SAND HEIGHT												

PART 4 — BASE FLOW

An illustration of a cone of depression and base flow can be demonstrated with a large beaker or glass aquarium and approximately 60 cm. (2 ft.) of rubber tubing. Insert a loose wad of cotton into one end of the tubing. Tape this end to the side of the beaker near the bottom, allowing the tube to extend over the lip of the beaker. Place about 10 cm. (4 in.) of water-saturated fine sand into the beaker and cover it with another 8 or 10 cm. of fine, dry sand. (The sand should be clean and of uniform particle size.)

Begin to siphon the water from the sand, noting the way that the water table drops. Watch for base flow filling the cone of depression. Relate these results to the problem considered in the introduction.

Questions

1. What happened in the lowland formed on the stream table in PART 1? Why?

2. Did the water in your well flow out at the surface? If so, why? If not, why not?

3. List as many factors as you can which affect the height of the water table in nature.

4. What is the flow of water emerging from the base of the sand known as?

5. Answer the question posed in the Introduction, using the results of your siphoning of the well in PART 1 and the cone of depression principle covered in PART 4.

6. If we double the size of the particles in the stream table, would the experiment in PART 1 have occurred at a faster rate or a slower rate? Explain.

7. From what you have discovered about artesian wells, explain why many artesian wells are found in the area east of the Rockies.

8. Why is artesian well water usually very pure?

9. In PART 2, which type of material had the greatest permeability? Why?

10. In PART 2, which type of material had the greatest capillary water remaining? Why?

11. Provided that all other conditions are equal, under which of these surfaces would the water table be highest: fine sand, coarse sand, sandy soil, clay? Why?

12. Name two ways in which a rock may be highly porous with a very low permeability.

13. What conditions must prevail for ground water to produce underground caverns?

14. Distinguish between a perched water table and a true water table.

15. Why does the temperature of spring water fluctuate very little from season to season?

EXPERIMENT VIII
SHORELINES

Introduction

If you've ever gone swimming in a large lake you probably have noticed that as you entered the water the depth became greater until you reached a certain distance from the shore. As you continued to move outward, the water became more shallow for a short distance and then deeper again. Maybe you have wondered about this as well as why there are often steep cliffs along the shore, or why the rocks on the beach have such rounded edges. This exercise will answer these and many other questionsabout shoreline development.

Materials

- stream table
- wave generator
- ruler
- protractor
- colored sand
- toothpicks
- clear plastic drawing overlay
- colored grease pencils

PART 1 — NATURAL SHORELINE

Form the sand into a steeply sloping (from 30° to 45 °) mound across the center of the stream table. From the base of this mound form a shallow offshore shelf. Raise the water level to a height one-third of the distance from the top of the mound. Place the wave generator at the end of the stream table and direct waves toward the shore at a 90° angle.

Watch for the notch being cut into the shoreline. Examine the form and growth of the abrasion platform.

When the platform appears to have stopped enlarging, turn off the wave generator (after about 10 minutes) and placing the plastic drawing overlay above the shoreline, trace the form of the sea cliff and abrasion platform with colored grease pencil. Draw a side view of the stream table in Diagram 1. Measure the angles of the sea cliff, abrasion platform and shoreface terrace and place the results on the chart.

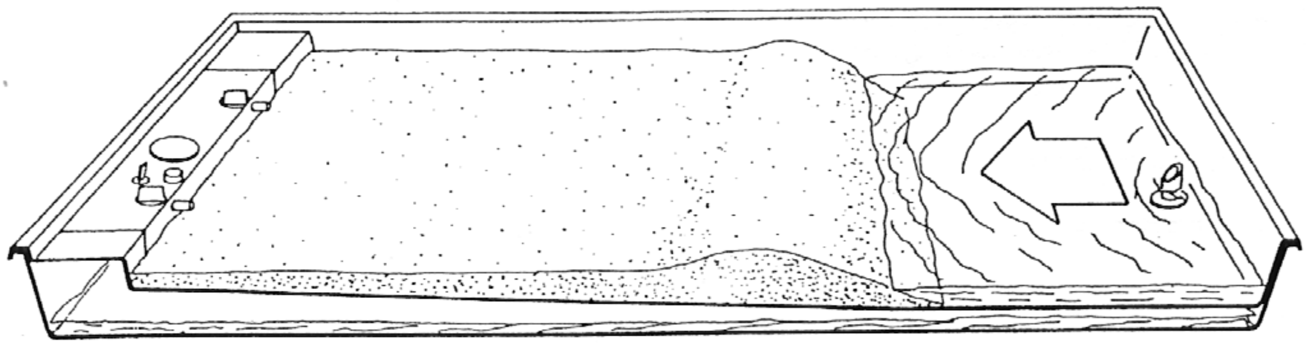


FIGURE T

PART 2 — ELEVATED SHORELINES

Drain the water to a level near the lower portion of the sand mound. When the water has quieted, insert several toothpicks perpendicularly along the line of contact between water and land.

Turn on the wave generator. For the first 3 minutes, at 30-second intervals, measure the distance from one of the toothpicks to the new sea cliff developing. Observe whether this distance is the same for the other toothpicks.

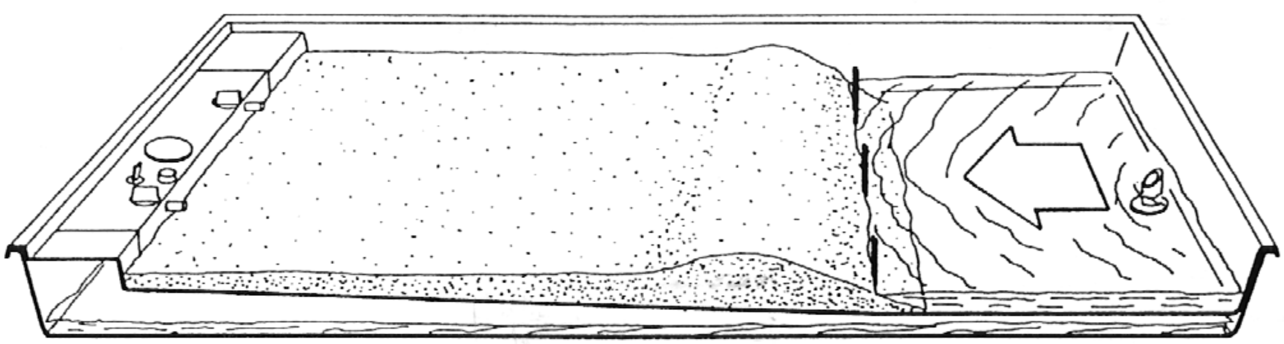


FIGURE U

DIAGRAM 1

DIAGRAM 2

Sprinkle colored sand on the abrasion platform and examine the particle movement. Direct the waves from an oblique angle, observing the particle movement.

Turn off the wave generator after a well-developed sea cliff has been formed (20 minutes). Trace the new sea cliff and abrasion platform on the plastic overlay in a different colored pencil. Again draw a side view of the stream table in Diagram 2. Measure the angles of the new sea cliff, abrasion platform, and the shore-face terrace. Place all the data on the chart.

	ANGLE OF SEA CLIFF	ANGLE OF SHOREFACE TERRACE	ANGLE OF ABRASION PLATFORM
FIRST SHORELINE			
SECOND SHORELINE			

TIME	DISTANCE TO SEA CLIFF
30 SEC.	
1 MIN.	
1½ MIN.	
2 MIN.	
2½ MIN.	
3 MIN.	

CHART

Question

1. Why are sea caves, arches, and stacks formed on a natural shoreline when they were not produced on the stream table?

2. How are the sides of the tank affecting the development of the shoreline?

3. How does the angle of the shoreface terrace compare with the angle of the forset beds on a delta? Explain.

4. Why is the abrasion platform nearly flat?

5. Explain the movement of the particles on the abrasion platform while the waves were approaching at 90° angles. How is this particle movement related to the building of a wavecut terrace and wavebuilt terrace? On which side of the toothpicks did each of these features form?

6. Explain how a sea cliff, much higher than the incoming breaking waves, is eroded. (Remember the formation of the notch.) How is this similar to the erosion of a waterfall with a layer of resistant rock?

7. Determine the change in the water level of the stream table without taking water depth readings.

8. Offshore bars sometimes form barrier beaches. What change in the region is necessary to effect this conversion?

9. Why is the material eroded from the face of the sea cliff important in further erosion?

10. Why does a trough and an offshore bar develop at the base of the shoreface terrace on the stream table?

11. From your observation on the erosion of a sea cliff, explain how a guyot is formed.

12. With the wave generator directed at the shore from an oblique angle, explain the particle movement. What is happening to the shore? Had there been a bay along the shore, explain what might have happened.

13. From your timed measurements of the distance from the toothpick to the sea cliff, when was the speed of erosion greatest, and why?

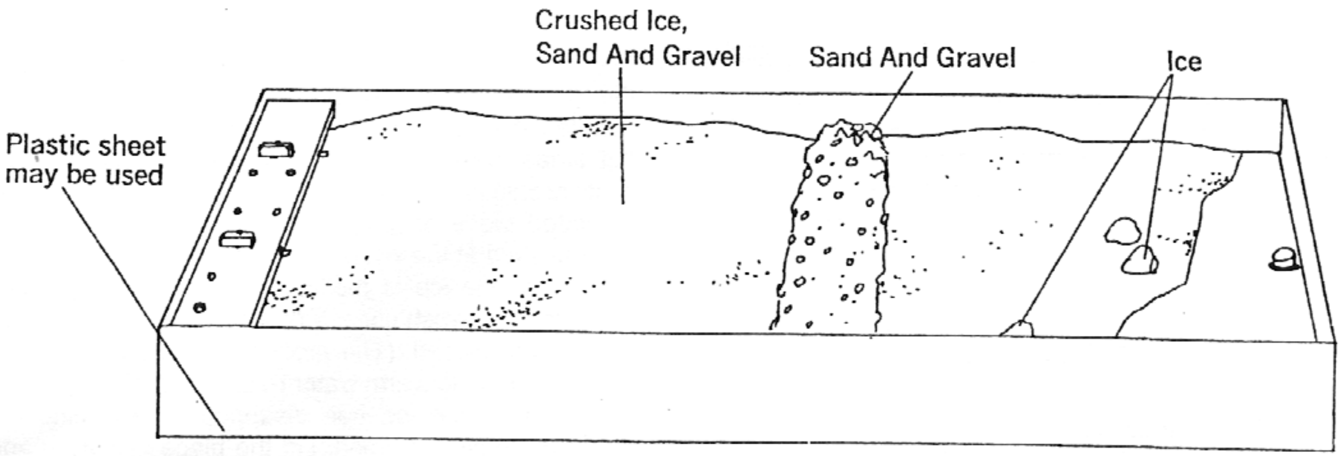
14. A series of elevated shorelines indicates a relative fall of sea level or elevation of the land. List as many conditions as you can which might produce such changes.

15. What would you expect to find on a submerged slope after a relative rise of sea level in several stages? Would the time it took for these changes to occur change your answer?

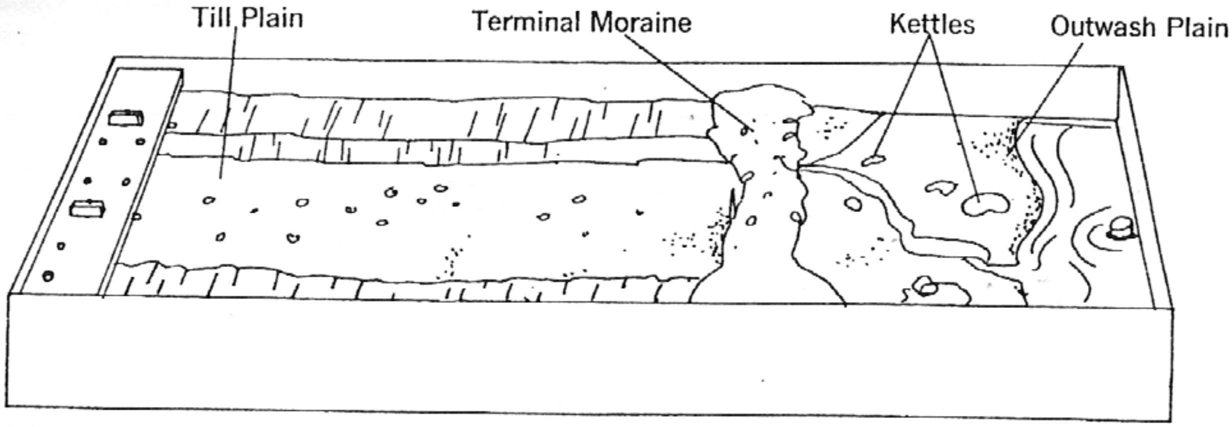
EXPERIMENT IX
GLACIERS

Introduction

Glaciers have left their mark on much of both North America and Europe. Many names for their erosional and depositional features have been given. This exercise is designed to show not only what these landforms look like but also how they develop and why they appear as they do.



BEFORE GLACIER MELTS



AFTER GLACIER MELTS

Materials

stream table
large bag of crushed ice or snow
discarded garden hose (2-3 ft. long)
bag of gravel and stone

Part 1 — PROPERTIES OF ICE DEMONSTRATION

An excellent introduction into the study of glaciers lies in a brief look into the properties of ice. Several of these demonstrations should be prepared in advance.

(A) On each of two ice cubes place a small square of hard board. On ice cube place a heavy weight. On the other, a light weight.. Observe that the cube with the heavy weight on it melts faster than the cube with the light weight.

(B) One can either gather snow after it falls or make it by directing the blast from a carbon dioxide fire extinguisher or cartridge into a deep freeze. The change from snow to granular ice can then be demonstrated. Pack the snow tightly in your hands. As the snow is compacted, it will change from tiny, flaky snow crystals to granular ice which is similar to firn. After further packing the mass will resemble compact ice (providing it is not too warm).

(C) To demonstrate the character of ice, perform two experiments. First strike ice with a hammer. It will shatter. Second, freeze an elongated bar of ice approximately 18" x 1" x 2" . (You may use aluminum foil to make a tray of the proper size.) Remove the bar from the tray and while keeping it at freezing temperature in the refrigerator, suspend it at both ends. Place a weight in the middle of the bar. After a few hours the bar of ice will bend but will not spring back to its original shape after the weight is remove.

(D) Suspend a bar of ice at both ends in a refrigerator or deep freeze where the temperature is at or below freezing. Loop a wire around the center of the block and hang a weight from the wire. The wire will be seen to "eat" its way down through the block of ice. The water produced by melting under pressure of the wire will refreeze above the wire.

(E) To demonstrate the expansion of water when it freezes, fill a small screw-top jar to the very brim. Carefully screw the cap on, allowing as little air as possible into the jar. Put the jar in a pan and place in the refrigerator. Remove after several hours and note the broken Jar.

(F) A simple demonstration of the plucking action of ice is to put one end of a dry sponge into a cup of water and place it in the freezer. Remove after several hours and examine how the ice and sponge are bound together. Melt the block of ice slightly to remove it from the cup and try to tear the sponge from it. Notice how the sponge tears apart, leaving some of its substance trapped in the ice.

PART 2 — GLACIAL DEPOSIT

Acquire crushed ice or snow in advance of the demonstration. Form a broad U-shaped valley with shallow bottom, placing a ridge of sand across its mouth. Cut a short piece of garden hose in half lengthwise, placing one half with the convex side

Pile crushed ice on and behind the ridge, mixing small the glacier. After the ice has melted for about 10 minutes, partially bury ice cubes or chunks of ice in the flat areas downgrade from the valley. Direct a single inlet nozzle at a gentle rate of flow through the extended piece of garden hose, while lightly pouring colored sand at the entrance to the "tunnel."

While the ice is melting, watch for the development of an outwash plain. Examine the spots where ice cubes were placed. (The process may be speeded up by gently pouring warm water over the crushed ice.)

After all the ice has disappeared, examine the different moraines formed. Lift the piece of hosing and note the sinuous ridge of colored sand formed. Examine the surface of your end moraine.

Questions

1. What property of ice is demonstrated by exercise A?

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2. From your observation of exercise B, explain the vertical composition of a glacier.

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3. Why does glacial ice move plastically near the base and tend to fracture near the surface?

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stones and gravel in with the ice. A heavier concentraion of gravel should be distributed along the border of upward on the floor of the valley in a meandering path.

4. In exercise D, why did the water above the wire refreeze?

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5. Why is the expansion of water demonstrated in E important in nature?

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6. Why is plucking action, as demonstrated in F, so important in glacial erosion?

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7. Why is glacial terrain often referred to as "knob and kettle?"

8. Much of Wisconsin is covered by ground moraine while much of Illinois is covered by outwash plain. Why? Should this make Illinois better for crop farming than Wisconsin? (Re-examine both features on the stream table.)

9. Describe the development and structure of an outwash plain. Why is it often marked with depressions?

10. How do the deposits of a moraine differ in composition from those of an outwash plain?

11. Why does the center of a valley glacier move faster than the sides?

12. Why is the formation of moraines different on the stream table than in nature? (Re-examine how the gravel and ice were concentrated.)

13. Explain how it might be possible for the path of an esker to be related to the slope of the land.

14. All of the glaciers in the United States are found in the western mountains. Why is this so?

15. How does a glacier acquire its load?

SUGGESTED ADDITIONAL ACTIVITIES

HEADWARD EROSION

This physical process is easy to illustrate on the stream table. Form a smooth slope of sand at a high elevation and gently pour water along the top of the slope. Notice how sheet erosion changes to rill erosion near the center and gully erosion near the base. Increased pour-ing increases the size of these gullies.

SEA MOUNT

Form a small round island surrounded by water, with its top not more than one inch above the water surface. Turn on the wave generator and watch how the upper portion of the island is planed off by the waves.

DRAINAGE PATTERNS

The headward erosion demonstration also illustrates dendritic drainage. Water poured on top of a round hill will produce a radial drainage pattern. Devise other simple demonstrations to produce rectangular, parallel, and trellis patterns. The clear plastic overlay can be used to trace and compare these patterns.

906

STREAM TABLE INVESTIGATIONS

TEACHER ANSWER SUPPLEMENT

BY
GREGORY BECKWAY

EDITED BY
MAURICE SCHWARTZ

HUBBARD
Scientific

ANSWERS

Experiment 1 — Parts 1 and 2

1. (A) No. The form ratio should have changed first and fastest near the mouth of the stream, becoming wider and more shallow. (B) Yes. Since the fastest changes are occurring near the mouth, often a stream may exhibit characteristics of old age in its lower regions, mature characteristics in its central portion and youthful characteristics in its upper regions.

2. The denominator (width) should have become larger while the numerator (depth) should have become smaller, causing the fraction to become smaller.

3. Youth is the shortest stage in the life history of a stream. Since the land is high above base level, the stream flows swiftly down the steep gradient and, due to its greater erosive capacity at these speeds, quickly cuts a deep, narrow channel. As the gradient becomes less, the velocity becomes less and changes occur at a slower rate.

4. In early maturity the stream has cut its channel near base level, decreasing the gradient and the speed of flow. Active downcutting has been greatly reduced and the stream is deflected easily by irregularities in the channel, causing the beginning of lateral planation and a meandering stream.

5. In a youthful stream, the contour lines will be closely spaced down to the stream channel and will point more sharply upstream. Early mature streams will be distinguished by meanders and the development of a flood plain with widely spaced contour lines indicating gentle slope. The stream course has begun to meander but is relatively straight in comparison with later stages.

6. The lowest level to which the stream on your stream table can cut is the level of water in your stream table.

7. Youthful streams possess a V-shaped valley due to the great downward cutting of the stream channel produced by its steep gradient. Mass wasting along the valley sides causes a widening toward the top and the resultant V shape.

8. Water flowing off the land after a rain follows the natural contour of the land and flows toward the low places which form gullies. With every additional rainfall these gullies collect more and more water which widen and deepen the channels. As they grow in size, they become collecting channels for the drainage of an ever-increasing area. Parts 1 and 2 of our experiment cannot illustrate headward erosion due to the fact that the water has not been distributed evenly over the stream table. (See Suggested Activities.)

9. As the stream enters maturity, its slope and velocity become less and it loses its ability to override obstructions. It is therefore deflected against its bank, causing erosion of the valley sides and further deflection. The meandering continues, cutting on the outside and depositing material on the inside, until the valley floor has been worn wide enough to be called a floor plain.

Experiment 1 — Part 3

1. Your measurement of the width of the stream should show a rapid widening from the first to second measurement. Since streams adjust their form to the gradient or slope, this clearly indicated the width was too narrow.

2. Meandering streams usually move slowly. They do not possess the energy to cut deeply into the channel or to carry the stones used as tools for cutting.

3. Cut-offs often occur in a fully matured stream. Land on the inside of a cut-off meander would be located on the opposite side of the new boundary.

4. When a stream overflows its channel, the greatest amount of sediment is dropped at the very edge of the bank due to the water's sudden loss of velocity. This builds a natural levee, the highest spot being at the edge of the bank.

5. The lot on the inside of the meander is the wiser investment. The stream is cutting on the outside of the meander causing a loss of land, while it is depositing sediment on the inside, increasing the size of the land area.

6. Meanders grow in size as they actively cut on the outside of the bank and deposit on the inside slightly down stream. As these bends become more winding, occasionally the stream will cut through a bank to another portion of the stream, separating the meander from the main stream. The stream no longer takes the path through the large broad loop, but flows through the cutoff, a much straighter path.

7. The water moves the fastest along the outside of the meander. This provides the energy needed for lateral planation.

8. The water should have followed both the new and old channels simultaneously moving through the newer channel at a greater velocity due to the greater slope. After several minutes, damming of the cutoff meander should produce a greater blockage of flow and eventually an oxbow lake.

9. In order for a river to develop into old age, land and sea conditions must remain stable for great length of time. This seldom occurs in nature.

10. Either a drop in sea level or an uplift of the land would produce renewed downward cutting of the channel forming an entrenched meander.

Experiment II

1. Activity 2 will produce the larger delta. Other conditions being equal, as a stream's volume increases, its carrying capacity also increases.

2. Boulders can be moved during times of flooding due to the greater volume of the stream and its resultant increased carrying capacity.

3. As the river deposits its load, it fills its own channel, causing the river to shift to a new position where the cycle again occurs. These dividing and shifting streams are called distributaries.

4. The fine sediments of a delta make rich soil for farming. The availability of water for crops and the smooth topography, easy for plowing, are also favorable factors.

5. Activity 5 will produce a smaller delta. Wave action has the affect of reducing the speed at which deltas form and also altering their shape, depending upon the angle at which they approach and their size.

6. Activity 6 will produce the smaller delta, curving away from the flow of the current. Currents carry the deposited sediments from the mouth of the stream, reducing the delta size. Currents combined with waves are often responsible for the many different shapes of deltas.

7. (1) Amount of sediment carried by the stream; (2) amount of wave action at the mouth of the stream' (3) presence of a coastal current; (4) instability of sea level; (5) instability of land elevation.

8. (1) It is a large river heavily laden with sediments. (2) It is well protected by land from the strong effect of ocean waves and currents.

9. The angle of the forset beds will remain constant at about 24. This is the angle of repose for sediment in a water medium.

Experiment III

1. The alluvial fan will have less of an angle than the talus cone due to the fact that talus cones assume the angle of repose for dry sediment of this particle size, while alluvial fans assume the angle of repose for water-laid deposits.

2. The slope will gradually become less. As the cliff is worn down and the alluvial fan is built up, the fan will be distributed to an ever increasing area, decreasing the slope.

3. No. It shifts position much the same as on a delta.

4. The slope of the talus cone will remain constant from the first to second reading at 35 to 38. This suggests that the angle of repose for dry particles of this size lies somewhere between 35° and 38°.

5. The heavier particles would be dropped first due to the decrease in slope, with the finer particles being carried further down toward the base of the fan.

6. The particles of a talus cone will be sorted in just the opposite manner from those of an alluvial fan, with the finer particles near the top and the larger particles rolling and sliding toward the base.

7. Alluvial fans and talus cones are most often found in semi-arid and arid climates respectively. Talus cones and alluvial fans are both encouraged by the accumulation of loose weathered soil and rock in high regions. This occurs best in hot dry areas as a result of the great physical weathering. The collecting of this material at the base of a slope forms a talus cone. The pickup and deposition of this material by running water at the base of a slope produces an alluvial fan.

8. Alluvial fans collect and store water due to the sudden decrease in flow of water across the unconsolidated material of the fan, allowing for the easy percolation of water.

9. Talus cones assume the angle of repose for dry particles and alluvial fans assume the angle of repose for particles in a water

mixture.

10. Alluvial fans are a result of a heavily loaded stream flowing down a steep slope at a high velocity emerging onto a more gentle slope where the stream's load is deposited.

Experiment IV

1. The greatest amount of erosion will occur over the smooth, uncovered slope.

2. Grass, contours, and terraces all slow the speed of the water, therefore reducing its erosive capacity.

3. Grass not only slows the speed of the water, but binds the soil with its roots and provides a cover protecting soil aggregates from splash erosion.

4. Grass will assist the terracing in providing even less erosion over the slope.

5. The kinetic energy of the falling drops was increased with greater elevation, providing more power to "splatter" the sand.

6. Soil aggregates promote easy infiltration of water and less runoff due to the large openings between the aggregates. Splash erosion breaks up the aggregates, clogging the pores and increasing the amount of runoff.

7. Doubling the size of the particles would increase the rate of infiltration, thus reducing the amount of runoff. As the amount of runoff decreases, the amount of erosion by water decreases.

8. Raindrops fall only a short distance until they reach their terminal velocity, or the speed at which the friction of the air equals the weight of the raindrop. Therefore, after drops have been released from an altitude at which they reach this terminal velocity, a further increase in altitude will produce no change in their speed or erosive capacity.

9. A. Greater amounts of water are concentrated on the land due to the greater intensity and lesser amount of time for infiltration. This greater volume of runoff has a greater erosive capacity.

10. Without soil, the world couldn't feed its growing population. Rich soil takes great lengths of time to produce but can be destroyed in a relatively short period of time.

Experiment V

1. Weathering breaks rock into smaller pieces, reducing the cohesion of the mass. If these smaller particles lie on a slope where the force of gravity acting on them is greater than the force of friction holding them in place, mass wasting will occur.

2. Bedrock on gentle slopes often has partial protection from weathering due to its cover of weathered rock. On steep slopes, weathered rock is continually being removed by mass wasting, exposing the bedrock to the constant action of physical and chemical weathering.

3. Youthful rivers cut steep channels, which are subject to mass wasting. The products are in turn transported by the river. A glacier flows in steepens mountain valley sides, collecting the products of mass wasting on its surface. Shorelines are eroded by a notch cut deep into the sea cliff, in which case the slope becomes too great and mass wasting occurs. Waterfalls are often worn back through undercutting by the plunge pool and consequent mass wasting of the cliff, the products of which are transported by the stream. Numerous other examples can be cited.

4. The eastern portion of the U.S. receives more precipitation, encouraging the growth of vegetation which helps to hold the soil in place.

5. Particles will remain at rest on a slope where the force of friction is greater or equal to the force of gravity. Thunder may jar the particles, momentarily reducing the friction and allowing the force of gravity to cause a downward movement. As these particles increase in momentum, they crash against other rocks, causing a chain reaction.

6. The pounding momentarily reduced the friction, allowing the force of gravity to cause movement downslope.

7. The growth and melting of ice crystals produces a disturbance which acts in conjunction with the force of gravity to produce down-slope creep.

8. Water acted as a lubricant, reducing the force of friction holding the mass in place.

9. Earthflows move slowly but mudflows, due to their greater amount of water, sweep in torrents down steep slopes, occasionally causing great destruction.

10. Spring thaw of the surface cover of ice and snow produces meltwater which cannot infiltrate the permanently frozen subsoil. This water saturates the uppermost layer of soil, producing a slow flowage of soil on slopes.

Experiment VI

1. Only a youthful stream has a steep enough gradient to produce the downward cutting necessary for development of waterfall.

2. The sand particles followed a tumbling rotation. Particles at the base of a waterfall follow this motion, cutting away at the adjacent rock. This produces an ever-steepening over hang, which breaks off, falling into the plunge pool when the stress becomes too great.

3. Waterfalls with a resistant cap rock erode by the process mentioned above, with the greatest amount of erosion, occurring at the base of the water fall. Waterfalls produced on homogeneous rock have great erosion where the waterfall flows over the lip. This allows the cliff to be worn down.

4. The plunge pool will increase in size as a result of greater force exerted by the falling water.

5. Their great erosive capacity does not permit their long term existence.

6. Spring. Most streams in the U. S. contain a higher volume of water as a result of increased precipitation and melt-water. This greater volume flowing over a fall has a greater erosive capacity.

7. The fall line reveals that the sedimentary rocks of the emerged continental shelf are softer than the metamorphic rocks of the Appalachians.

8. The kinetic energy of the falling water produces great quantities of raw power.

Experiment VII

1. The lowland will become saturated with water, forming a small swamp, due to the fact that the ground level is at or beneath the level of the water table.

2. Whether the water flows out at the surface depends on the amount of hydrostatic head produced.

3. (A) Amount of rainfall; (B) permeability of the rock; (C) porosity of the rock; (D) amount of evaporation of water from the surface; (E) slope of the surface.

4. A spring.

5. The pumping of the well produces a cone depression, the well becoming dry when the cone moves below the depth of the well. Base flow refills the cone slowly, which enables water to be pumped to the surface.

6. Faster. The permeability of our particles would be increased, which would in turn increase the rate of subsurface water movement or base flow.

7. The dipping sedimentary beds slope away from the Rockies, producing a hydrostatic head for groundwater.

8. It is well filtered as it flows through the small rock openings.

9. The water will penetrate fastest through the coarse sand due to the larger openings between the particles.

10. The fine sand will hold the greatest amount of capillary water as a result of the greater surface area of the particles and the larger number of contact points.

11. Coarse sand will allow the greatest infiltration of water and thus produce a higher water level.

12. Rocks may have large pores which are closed. Rocks may have very small pores with the openings so small as to not allow easy penetration.

13. The subsurface rock must be water soluble and there must be ample precipitation.

14. A perched water table results from ground water blockage by an impervious layer of rock elevated above the normal level where filling of the pore spaces will occur.

15. Groundwater is not affected by fluctuation in surface temperatures due to its depth beneath the surface.

Experiment VIII

1. Caves, arches and stacks result from the differential erosion of the various rocks of a shoreline. Our stream table sand is a homogeneous mixture.

2. Deflection of the waves from the sides of the tank are causing the waves to approach the shore at different angles.

3. Both angles will be the same (approximately 24"). This is the

angle of repose for sediment in the water medium.

4. The abrasion platform represents the depth at which the approaching waves can laterally plane back the sea cliff.

5. The action of the sand particles is a back-and-forth movement to accommodate the swash and backwash. The swash cuts into the sea cliffs, building the abrasion platform or wave-cut terrace and the backwash deposits much of the detrius to form the wave-built terrace. The wave-cut terrace will be found on the sea-cliff side of the toothpick and the wave-built terrace will be located on the seaward side.

6. Rock fragments are thrust against the base of the sea cliff by the swash, cutting an ever-deepening notch. When the stress becomes too great, bedrock falls or slumps on the abrasion platform, being ground up and used for further tools or supplying the shoreface terrace. (To compare this with the erosion of a waterfall, turn to answer 2, Experiment VI).

7. This can be done by measuring the difference in height of an old and new shorelines.

8. Either a raising of the land mass or a lowering of sea level.

9. This eroded bedrock furnished the rocks used as tools for further erosion by the waves.

10. The trough is formed by the collapse of the approaching waves and is a zone of great turbulence. The bar formed seaward is a result of deposition by the waves as they are slowed in their shoreward movement.

11. Guyots were planed off by waves in much the same way as sea cliffs. (See Suggested Activities.)

12. The movement of the particles will approach at an oblique angle and will return in the normal downslope direction. The shore is experiencing beach drifting. Had there been a bay along the shore, a bay-mouth bar would have formed.

13. The greatest changes will occur at the start, when the waves exert their greatest force against the land mass.

14. Land: folding, faulting, upheaval or subsidence. Sea: change in ice caps, change in basin form or shape.

15. A fast series of sea-level rises develops submerged terraces. A slow overall rise leaves no terraces, only an eroded slope.

Experiment IX

1. Demonstration A illustrated that the melting point of ice is determined by pressure as well as by temperature. The higher the pressure the lower the melting point.

2. Flaky snow covers the surface of a glacier. Under the layer of this light snow granular snow can be found. With increased depth and pressure, firm or neve is found, below which lies true glacial ice.

3. The greater the pressure on the ice, the greater the tendency of plastic flow. Near the surface there is less pressure and the ice is more brittle.

4. Pressure was no longer being applied at that location, allowing the meltwater to refreeze.

5. Water seeps into cracks and crevasses of rock, expands when it freezes, and splits it not smaller pieces. This is a form of physical weathering known as ice wedging.

6. Water flows into the openings of bedrock and refreezes, binding the rock mass to the glacier. As the glacier moves this bound-up rock is "plucked" or dragged loose from the remaining bedrock.

7. The glacial terrain is marked by many hills and closed depressions formed by the flowing of meltwater through the moraine and the melting of ice chunks.

8. Outwash plains are composed of finely sorted material evenly laid down by glacial meltwater, forming beautiful farm land. Ground moraine is till, laid down directly by the glacier, and contains many large rocks and depressions. Drainage is poor and the land is difficult to plow.

9. Meltwater, flowing from the glacier, emerges onto the land in streams. These streams deposit their load into a series of alluvial fans which form the outwash plain. Depressions are formed by the melting of remaining blocks of ice.

10. Moraines consist of unsorted till of a great range of sizes while outwash plains are composed of finely sorted drift usually of less size range.

11. The sides of a valley glacier are slowed by friction against the valley walls.

12. On our stream table we had to "cheat" by placing more debris along the perimeter of the ice. In nature, moraines are formed by the standstill of a glacier, releasing its load as till.

13. Eskers are deposited within the glacier where the slope of the stream producing them may be unrelated to the slope of the land over which they are deposited.

14. The mountains of the west provide the only location in the U.S. above the snow line due to their great height.

15. A glacier acquires its load by plucking and scouring and by mass wasting of material onto its surface.

TIPS FOR BEST RESULTS

1. Ask for volunteer students to run through the experiment after school the day prior to the experiment. Have these students do the molding of the sand for the next day's experiment. It is best to have only two people shaping the sand at once.

2. Involve as many students as possible into each experiment. Assign "jobs" to the students at the beginning of the class period. Two students can be used in taking measurements, others can be drawing on the clear plastic overlay, while another can be recording the results on the board for the rest of the class. One student should be appointed to be in charge of the water level in the reservoir. The amount of water needed varies depending upon the amount of sand being used, and the rate of flow. Different students can be appointed to perform the parts marked "Demonstration".

3. Make sure no student working with the sand is allowed to touch the electrical connections.

4. All exercises can be worked into an hour period with proper planning, the only exception being Exercise I, which requires Parts 1 and 2 for one period and Part 3 for a second period.

5. Questions at the end of each exercise make excellent homework assignments.

6. Some background information should be supplied before starting each exercise. Be careful not to reveal the information which the students will be discovering for themselves.

7. The sand should be moderately moist prior to each exercise unless specifically stated otherwise. The stream table should be drained when not in use. Raise the large upper section to the maxim level and push the sand to the upper half of the stream table. Shape it smoothly down to the floor.

8. When measuring angles of small slopes with your protractor, extend a ruler from the slope parallel to it and measure the angle of the ruler.

9. Snapshots can be taken of the stream table which provide a good permanent record of the results.

10. Landforms developed on your stream table can be correlated with geology models, overhead transparencies, topographic maps of similar features, videos and films, or field trips.

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