

A TRIP THROUGH TIME

WELLESLEY GEOLOGIC HISTORY

Learning Goals on this Field Trip focus on student observation, discovery, and seeing connections with classroom learning.

Generate excitement and curiosity through observing rocks in the world around them

Develop a sense of scale in geology, relative size and expanse of rock formations

Identify by observation specific igneous rocks (granite and diorite as well as volcanic breccia) and the sedimentary rock Roxbury puddingstone

Through knowing how each of these rocks was formed, think about what has happened to them so we now find them at the surface

Measure a giant glacial erratic and think about the power of a moving glacier

Understand that the crust of the earth is solid rock, called bedrock.

Bedrock is usually covered by forests, meadows, houses and roads, oceans and ponds, but it is always there. Sometimes bedrock sticks up where we can see it and we call it mountains or a ledge.

Realize that these rocks were not all formed at the same time.

Some are older than others. The rocks we are seeing were all formed many many millions of years ago. Geologic time is very long

Some of these concepts are difficult for fourth graders. Don't worry. Students will be reintroduced to these concepts in ninth grade Earth Science.

Your job is to offer exposure to the concepts and most important to generate excitement and curiosity about the study of rocks and geologic history.





GEOLOGY FIELD TRIP

This is a two and one half hour field trip to geologic sites in Wellesley. While the whole class will go out at the same time, students will be divided into small groups to explore ancient rocks and glacial features found in Wellesley. They will be introduced to a sense of scale in both the size of rock formations and geologic time. See Directions for Drivers page 23.

The concept underlying this Field Trip is that by looking at a rock you can tell how it was made and something about what has happened to it since.

- 1. Devil's Slide among the oldest rocks in Wellesley, more than 600,000,000 year old. Igneous granite and diorite. Shows glacial smoothing and plucking.
- 2. Hemlock Gorge Roxbury puddingstone, a sedimentary rock laid down by streams eroding the landscape about 580,000,000 years old. Layers have been tilted. Falls and gorge cut by Charles River since the end of the Ice Age 10,000 years ago.
- 3. St. Mary's Cemetery Volcanic breccia, formed in the mouth of a volcano which erupted about 580,000,000 years ago.

Glacial formations Everyone will visit the glacial erratic. The esker and kettle hole are optional.

- 4. Longfellow Pond Esker, a glacial formation formed as the glacier retreated
- 5. Kelly Memorial Park Glacial erratics are large rocks moved by the glacier. Kettle holes are formed by the retreating glacier.

Materials:

Laminated copies of Wellesley's Geologic Time Line, Volcano at St. Mary's Cemetery, and Glacial Formations pages 18 to 22 50 foot clothesline knotted every 10 feet

Breccia

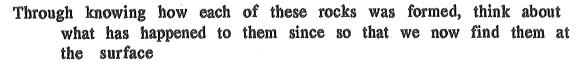
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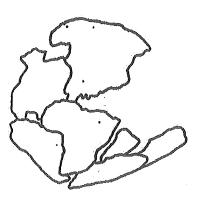
Underlying concepts:

Although these rocks were formed a long time ago, similar processes are at work now; new rocks are continually being formed and surface rocks are being weathered, eroded, and otherwise changed. Two other ways of changing rocks are glaciers and plate tectonics

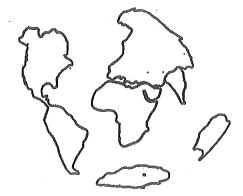
Glaciers are a mass of ice that slowly moves over the land, scraping off everything in its path and moving it like a bulldozer. Glaciers eventually melt, leaving all the moved rocks and sand scattered over the surface.

Plate tectonics describes the fact that the crust of the earth is divided into sections called plates that are moving. Some places the plates are moving apart and some places they are bumping into each other. Earthquakes and volcanoes occur at plate boundaries. Mountains are created when one plate pushes another plate so that the rocks bend and stick up. The continents ride on these plates, which include ocean floors

The interesting thing about plate tectonics for children is that after Africa and North America collided they split apart at a different place. leaving part of what was originally Africa hitched to North America. So the very oldest rocks here in Wellesley were apart of Africa when they were formed.



when continents were joined



continents today

Don't offer explanations to children, rather listen to their observations and ask questions which lead them to explore and make connections and try out their ideas. Suggested questions are given at each site.

OUESTIONS FOR DEVIL'S SLIDE

· By the rock wall:

What rocks do you see here in the rock wall? How do you know what kind of a rock it is?



Tell me how this rock (granite) was formed. How do you know that? (Depending on children's answers, you may want to ask: How fast did it cool? Can you find a rock that cooled faster or slower?)

How do you think these rocks come to be here? Naturally or moved by people? Why do you think so?

• Along the path with a view of the ledge: What do you see here? Any idea where the rocks in the wall came from? What is happening to the ledge? Any pieces of rock falling off? Why? (Weathering, erosion, tree roots)

You've learned in class how granite is formed a very long way underground. How come we can see the granite ledge here exposed at the surface? What happened to the rocks that were on top of the granite?

Anyone know what scientists mean when they say bedrock?

Look at any interesting rocks children find along the path.

• Devil's Slide: (Decision as to whether children may slide or not is made by teachers before the Field Trip.)

What do you see? Is this the same kind of rock as the ledge? How can you be sure? Walk to where pieces have broken off to find a fresh surface for identification. Anyone know the name of this rock? Diorite.

Which do you think is the oldest rock? (You will have to tell them that there is granite bedrock the other side of the diorite knob, but it is hidden by trees and the house.) Why do you think so.

Look at the shape of the diorite. Does anyone know about glaciers? As a glacier moves it pushes loose things ahead of it like bulldozer, but it can't move bedrock. So the glacier passed over the diorite smoothing and polishing it. After passing over Devil's Slide the glacier then broke off large pieces. Show students

Glaciess smooth and polish bedrock

diagram of glacial formations.

· On top of Devil's Slide:

Walk up the path to the top of Devil's Slide. Part way up notice granite bedrock under foot, abutting the diorite. Is this further evidence that molten diorite really did flow into a crack in the granite when these rocks were still deep under the crust of the Earth?

(Once on top let children discover the date and initials carved into the rock.)

What do they see up here? Look at the roots of the tree. What surprises you about this tree? What is happening to the rock? What story can they tell about what has happened to the diorite since it was formed? What is happening to the diorite now? Do they see any signs of weathering? Will any more pieces break off? Why do they think so?

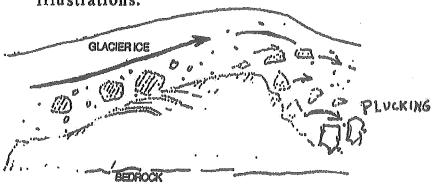
Do they realize that they are standing on a rock that was part of Africa when it was formed? Hard to think about that, but exciting. And do they realize that for millions and millions of years all continental rocks were bare, with no plants and animals living on them; all living things lived in the oceans. When they get to high school they will study more about geology.

Walk back down the path to the cars.



DEVIL'S SLIDE BACKGROUND INFORMATION

Park on Greenwood Road and walk in to Devil's Slide. First explore rocks in the wall at the entrance to the path and then observe the bedrock granite ledge to the left. Devil's slide is a diorite intrusion into granite rock. These are representative of the oldest rocks in Wellesley and formed deep underground with miles of hard rock above them. Much of the granite has been weathered away and probably scraped by the glacier. The glacier came from the northwest and was slowed down by the hard rock knob. It passed slowly over the hard diorite, smoothing and polishing the rock, then speeded up as it passed over the knob, breaking off pieces on the down side. This is called plucking. These pieces we see were broken off recently by weathering, but plucking looks the same. Where we are standing was part of Africa when the granite and diorite were formed. See following page for illustrations.

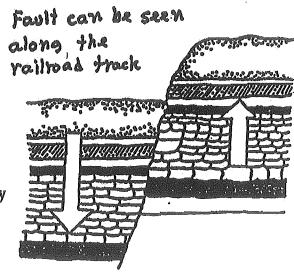


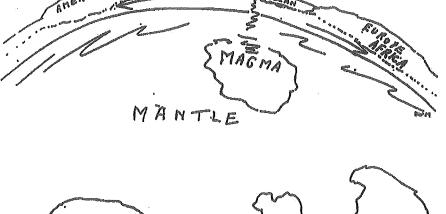
· En route in the car

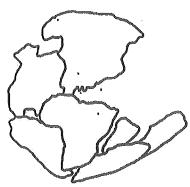
While driving point out to children the many rock outcroppings in the yards of houses north of the railroad track. Also discuss the fault line that runs through Wellesley where the railroad tracks run. Remember that when these ancient rocks were formed and when the fault occurred these rocks were part of Africa.

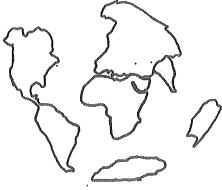
Look for the rock cliff along the railroad tracks which mark the fault line. Notice the height of the land north of the tracks and large outcroppings of bedrock in the yards of many homes.

Rocks blasted along the fault line to make the railroad bed were taken to Boston and used as fill to create the Public Garden from Charles River tidal mud flats. Did they study that when they studied Boston last year?









While driving East along Route 9 near Mass Bay College look across to the view of Boston and its tall buildings. Imagine a glacier covering this whole area taller than the buildings!!

OUESTIONS FOR HEMLOCK GORGE

You might as well take a minute to let children observe the falls.

· Walk up the slope toward the caves Look at the rocks under foot. What do they see?

Anyone know what kind of rock? How can they tell? How is it different from granite and diorite?

Proceed to the path leading down to the caves.

The caves

Before going down the path, tell children that between the path and the water there is poison ivy.

What do you see here? What about the rounded rocks imbedded in the rock? What can you tell about the history of those rocks? How does a rock come to be rounded?

Are the rounded rocks all the same size?

Why have some of the rounded rocks fallen out?

Roxbury Pullingstone

What about the rest of the rock? How can you describe this rock? Does it feel smooth or gritty? Why? Anyone know what rock it is? sedimentary sandstone.

Why are there layers? Can you tell how this rock was formed? Where was this rock formed?

What has happened to this conglomerate since? Why are the layers tilted? How come this conglomerate is at the surface?

Head back up the path. How come the level of the ground here at the top is like the level of the ground across the water? What happened here? ideas? Does water erode rock to form a channel for the river?

• Walk over to view of the aqueduct and circle back to the cars
The main reason for walking around here is to impart a sense of scale;
rock formations cover many miles, not just one little site. Roxbury
puddingstone is underfoot and visible everywhere. It is clearly seen across
the Charles. Also useful to observe the river valley erosion.

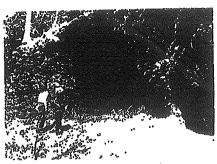
Two interesting facts may be noted:

The aqueduct used to carry water to Boston. Called Echo Bridge, it is the second largest single stone arch in America.

There is still a law on the Massachusetts books giving Native Americans the right to dry fish here on the rock outcroppings. Native Americans set fish weirs and dried their catch on the rocks for several decades after the Civil War, long after Wellesley was settled..

HEMLOCK GORGE BACKGROUND INFORMATION

Park by the old mill off the Chestnut St. ramp leading from Route 9 just past Roxbury Puddingstone is a sedimentary rock laid down by fast moving streams flowing from mountains down into the ocean. stones, both large and small, were deposited with sand to form this The base rock in which the rounded stones are conglomerate rock. imbedded is sandstone. This rock is found over the whole Boston Basin. from Blue Hill in Quincy to Prospect Hill in Waltham to Arlington Heights. was first identified in Roxbury and so named because it looked like round raisins in a pudding! Geologists know that the mountains were in Africa. these rocks were part of Africa when the sediments were laid down and subsequently compressed under the sea to form hard rock. During earth movements the puddingstone was not only exposed at the surface but tilted so the layers are no longer flat. When plate movements caused the continents to collide, the west coast of Africa bumped into North America. When the continents later separated part of Africa was left hitched to North America.



Stream-made Cave in Conglomerate at Hemlock Gorge

QUESTIONS FOR ST MARY'S CEMETERY

Before letting children out of the car, ask what kind of a place this is. How

do they think they should behave?

• Looking at the rock

How does this rock look compared with Roxbury puddingstone they saw in the caves? How are they alike? How are they different? Why aren't the imbedded rocks rounded? How does the rock feel? Sandy and gritty or smooth? How did the puddingstone and the igneous rocks feel?

Compare the differences in weathering between the rock here (volcanic breccia) and Roxbury puddingstone in the caves. Why do they think so?

Any ideas why the rock is all smoothed over? Think about the glacier and the shape of the diorite knob (Devil's Slide).

Why is there a long gouge along the side of the rock? Could the glacier have caused this? How? Sometimes hard rocks were frozen into a glacier making it like sandpaper.

Look at the colors. Is this a pretty rock?

Notice the suggestion of movement and flow in solid lava rock. Some of the pieces have been stretched by heat

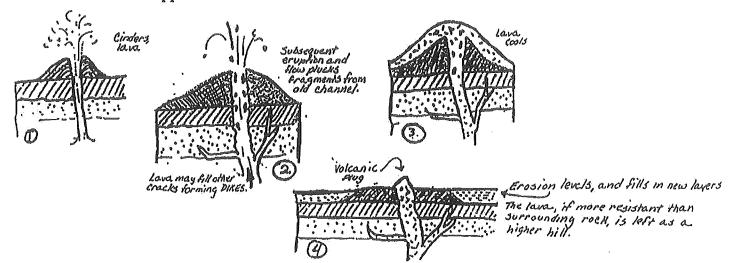
· A volcano in Wellesley?

If lava rocks come from volcanoes, how did lava rock get here? Was there once a volcano here? What has happened to it?

How did the rocks get imbedded in the lava? Any ideas? This is the chimney that fed the volcano, not the mountain itself! Pieces of bedrock broke off as the lava made its way to the surface. This is lava imbedded in the lava. The pieces have jagged edges (never rounded by water). Show students the diagram of the volcano.

How much space do they think the volcano took? Is there lava anyplace else? Point out the hill towards the street and the other direction where the roof of a school can be seen. Volcanic breccia lava is there too. Just the chimney of the volcano certainly included their school and their house!! Are volcanoes big?

What has happened that we now see this rock at the surface?



· On top of the rock

To climb on top of the rock walk around to the back and use the stone path, Allow children a minute to observe the statues. Listen to their observations and questions about what they see. Enjoy the beauty of the rock and whatever they discover.

Optional in response to questions

There are three features students may ask about: 1. There is a water erosion channel cutting across the rock made by a melting stream. 2. There is a stripe Think about the diorite at Devil's Slide being younger than of white quartz. the granite, and hardening to solid rock in a crack in the granite. they think happened here? Anybody ever find a lucky stone on the beach? How was it made? 3. Lastly some on the imbedded rocks are eroding faster than the rest of the rock. Why do they think this is so?

As time and behaviors permit, let children examine some of the headstones and make observations. Polished rock shows mineral crystals very clearly.

VOLCANIC BRECCIA BACKGROUND INFORMATION

When lava moves up through a crack in bedrock, called a chimney, to erupt as a volcano, it may break off pieces of bedrock. The lava that erupted at the surface to form a volcanic mountain here has all eroded away. here is part of the lava that never reached the surface but hardened underground with pieces of bedrock imbedded as it cooled Some rocks show signs of being stretched by the heat. It was later scrappeded and smoothed by the glacier. Other outcroppings of the chimney can be seen in the hill toward the road and near the school in nearby Needham. The chimney itself was big and the rock we see only a small part of the outcropping.

OUESTIONS FOR GLACIAL FORMATIONS



There are two very hard concepts to grasp. First is geologic time. We move here from hundreds of millions of years ago to only two million. The second concept is the formation of landforms left by the glacier.

• Glaciers and the Time Line
In dealing with the time concept, don't work too hard at it if the children are
not attending. But do mention it by showing them the time line: where
other rocks are on the line and where the glaciers are. The idea is simply to
demonstrate that geologic time is very very long.

First remind children that all the rocks they have seen so far were formed many millions of years ago. We have now moved very far in geologic time. From bare continental rocks, to when plants and animals began to live on land. Eventually the Earth went through the Age of Insects and the Age of Dinosaurs and finally to mankind. Glaciers covered many parts of the earth many times.

Nowadays there are glaciers in mountains and in very cold places like Alaska or the South Pole, but many many years ago there was a glacier here. A glacier can be a mile high, and as it moves slowly along it moves rocks like a bulldozer. Many rocks are frozen into the ice. When the weather became warmer the glacier melted and left all the rocks and sand it had moved, scattered around the landscape.

Glacial landforms can be difficult for fourth graders to understand. It is hard to imagine ice moving! But a glacier moves slowly over the land a little like Silly Putty. As it moves it bulldozes rocks and everything else in its path. And when it finally melts all those rocks it moved are left right there for us to see.

We are going to see rocks that the glacier moved and then left when it melted. We will visit an esker here and a kettle hole and glacial erratic at Stop Five. Schofield School has its very own kettle hole beside the driveway.

Do remember that students will be visiting all these topics in their ninth grade Earth Science course

QUESTIONS FOR THE ESKER

Begin this stop with the previous discussion of Wellesley's Geologic Time Line and of glaciers and the rocks they moved and left behind before starting to walk along the esker.

Looking at rocks along the path
 We are going to look at some of those rocks the glacier left behind.

Walk up the path onto the esker, looking at the rocks dropped by the glacier.

Are the rocks all the same size? The same kind of rock?

Are the edges of the rocks jagged or smooth? Why do you think so?



Stop on top of the esker where you have a good view of the ridge going in both directions.

Ask the children if they have good imaginations, because this is very hard to understand. Here they are on top of a ridge, but this is actually the bottom of a glacial melt stream!!! How can that be?

Use the diagram of glacial formations to illustrate how eskers were formed..

Imagine glacial ice above them and on both sides. They are actually in a tunnel under the ice. The stream runs through the tunnel carrying rocks of all sizes with it as a river does. Some years it is colder and the glacier stops melting, dropping all the rocks. Then it is warm again and the river flows in the tunnel on top of the dropped rocks, carrying still more rocks which were frozen in the glacier. Finally after thousands of years the glacier melts away above the tunnel and then the sides melt away leaving the rocks dropped by the melting stream as a ridge just as we see it!!!

GLACIER crevasse
ICE debris
caught in
the ice

ice walls hold in stream and water gravel gravel building up

till gravel gravel fragments stones rounded by water action

Walking the length of the esker helps to provide a sense of geologic scale, so continue along the esker until the path which leads towards the pond and thus back to the parking lot.

While walking back along the old cart path beside the pond, children may be interested in the grave marker. The Hastings family used to live on this land 100 years ago. In those days burials were often private on their own land, not always in cemeteries.

THE ESKER BACKGROUND INFORMATION

Park in the Oakland Street Parking Lot.

When the glacier began to melt streams of melt water flowed from the bottom of the glacier, carving a tunnel in the ice. Rocks of all sizes and sand were carried in the stream. Repeatedly as the weather got colder and that warmer again, the stream would stop flowing and drop its burden of rocks at the bottom of the tunnel. When the stream started to flow again it was easier to flow on top of the stream bed carving space in the melting ice. Eventually the glacier melted, , both above the tunnel and the ice walls on either side of the stream bed. The stream bed, called an esker, was then left as a ridge rising above the surrounding land. As with most streams, the ridge meanders a bit rather than following a straight line.



ECHER IN TOWN FOREST

QUESTIONS FOR THE KETTLE HOLE

Use diagram of glacial formations to illustrate how kettle holes were formed. The kettle hole is the hollow right beside the parking lot.

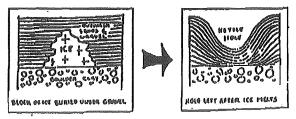
Kettle hole

Any idea why there is this round depression surrounded by dirt and rocks?

Is anyone familiar with icebergs? Well as the glacier melted sometimes great chunks of ice broke off. The melting streams flowed around the ice, depositing sand and rock particles all around it. When the chunk of ice finally melted, there was a kettle shaped hole surrounded by sand and rocks.

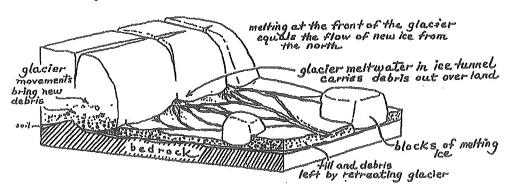
Often blocks of Ice like ice bergs brokes off from the glacier and were surrounded

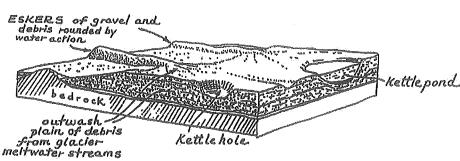
by the sandigravely and rocks of the melting gracier. When the blocks of ice melted a depression called a kettle hole was left.



GLACIAL KETTLE HOLE BACKGROUND INFORMATION

As the glacier retreated melt streams carried rocks and sand to deposit like a river delta today. Sometimes chunks of ice broke off and were surrounded by the glacial material. When the ice melted a rounded depression was left, called a kettle hole. These depressions could be large and remain today as ponds or small hollows filled with water only after a snowv winter.





QUESTIONS FOR THE GLACIAL ERRATIC

Walk up the path to the left of the woods (kettle hole) and into the woods.

Where did all these rocks along the path come from? Any ideas? After glaciers melted, what happened to all those rocks moved by the ice? Where do they think colonists got all those rocks for stone walls?

Are they bedrock or just sitting here on the ground? How can they tell?

Have they been rounded by water?



How big a rock can a bulldozer move? How big a rock do they think a glacier could move?

Explore any interesting rocks.

· Fairy rock

When you reach Fairy Rock let the children explore it at first, walking around it. What kind of rock do they think it is? Why?

What are these white bumps on the surface? Is this a rock with crystals? Anybody remember a crystal with straight sides? Does that help them discover the kind of rock? (Feldspar)

Look for a fresh surface to identify it as granite. On the far side look for a diorite intrusion.

Is it bedrock or just sitting here? Could a glacier really have moved anything so big? Are glaciers very powerful? Geologists tell us this rock was moved here from Rocky Ledges behind Bates School

Using a clothesline knotted every 10 feet have children measure the height, width, and length of Fairy Rock. What would it take for us to move this rock? Is a glacier very powerful?

There is a glacial erratic in New Hampshire that is even bigger. 110 feet long, 31 feet wide, and 55 feet high!!! Would they like to use the clothesline to measure the size of that rock, either here or back at school?



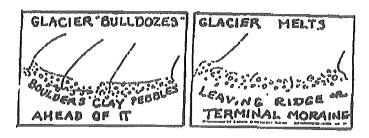
GLACIAL ERRATIC BACKGROUND INFORMATION

As the glacier advanced, moving from Canada across northern new England to Massachusetts and on to Cape Cod and Long Island, it scraped the land like a bulldozer moving everything it could. Larger rocks were heavy to carry far, and were often dropped only a few miles away. These large rocks were called erratics and the New England landscape is covered with them.



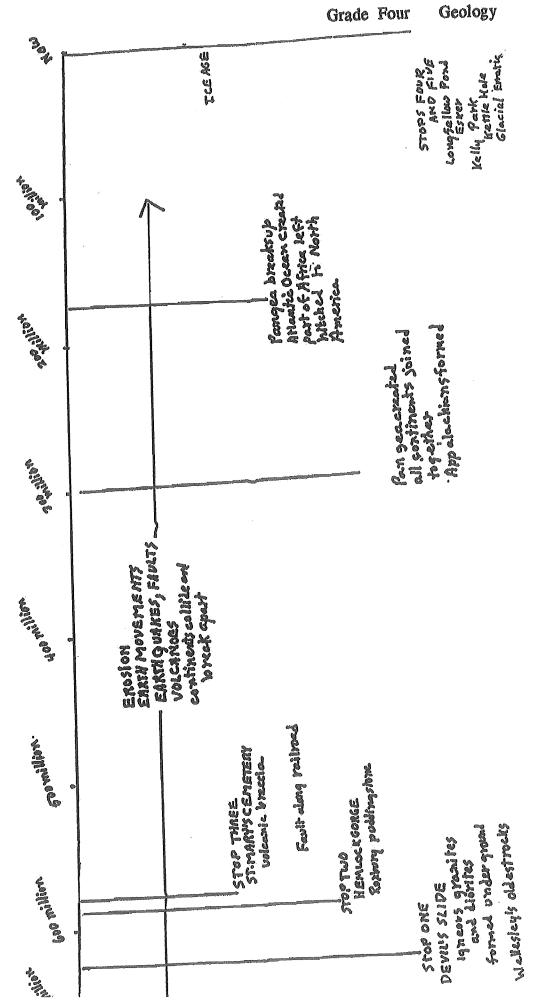
Glacial Erratic

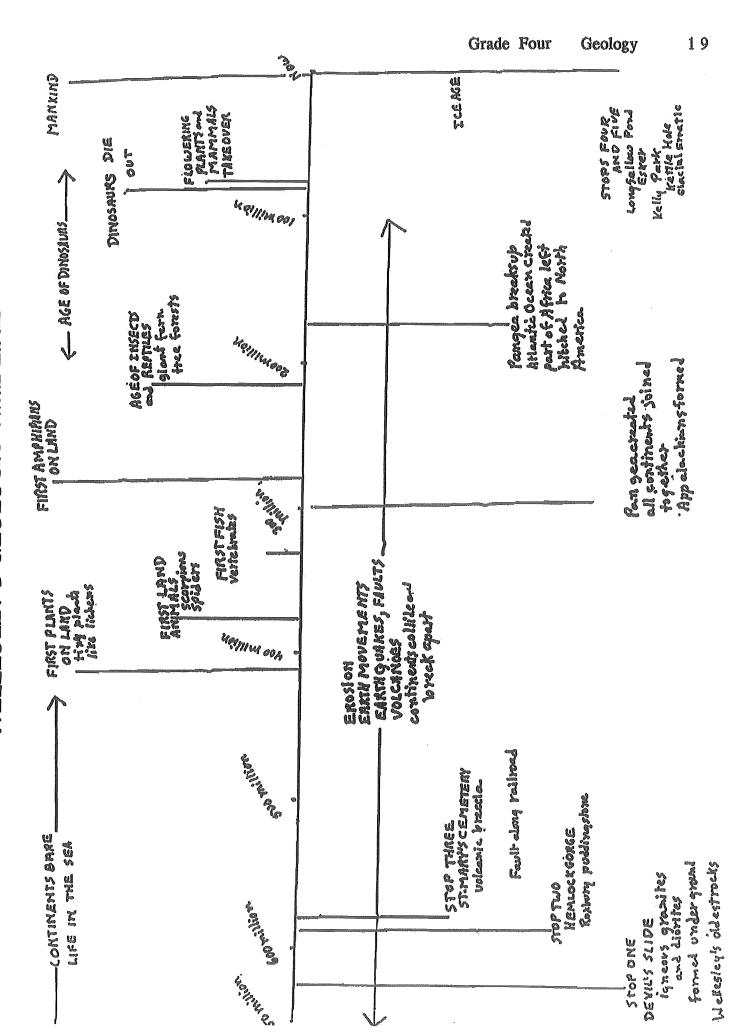
Do any of them go to Cape Cod? Cape Cod was made from all the rocks and pebbles and sand the glacier pushed ahead of it. When the glacier stopped moving all the rocks and debris it was moving was left there to form Cape Cod. Other parts of the United States such as Long Island and places in the midwest were also made by the glacier. Some rocks were simply too big to move very far, and these we call glacial erratics

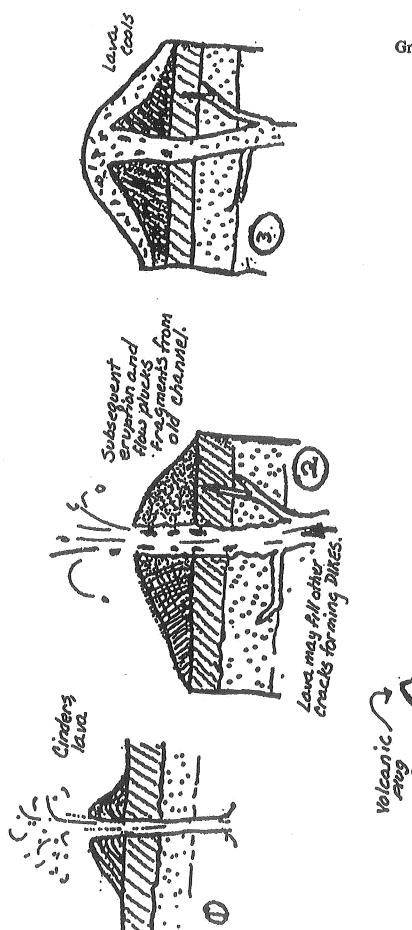


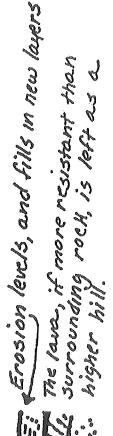
Cape Cod and Long Island are Terminal Moraines.

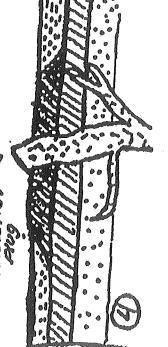
WELLESLEY'S GEOLOGIC TIME LINE



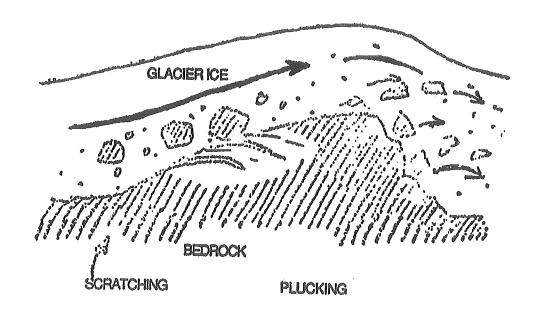








THE GLACIER MOVES ACROSS THE LAND LIKE A BULLDOZER

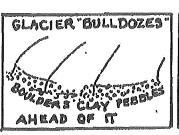


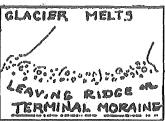
Debris laden glacial ice sheet rises up over an obstruction in the bedrock, may gouge it, pass over top, and pluck-rocks off the "downstream side" side.



Large boulders called Glacial Erratics were moved several miles and left scattered over the New England landscape. Several large erratics can be seen in Boulder Brook Reservation behind Bates School
There is a gigantic erratic in

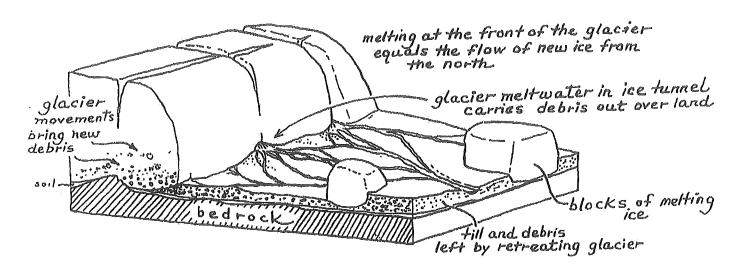
There is a gigantic erration.
New Hampshire which weighs
Bood tons. It is 110 feet long,
31 feet high, and 55 feet wide.

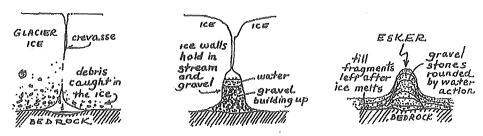




Cape Cod and Long Island are Terminal Mordines.

THE GLACIER MELTS

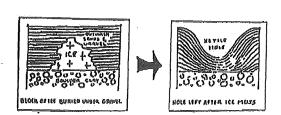


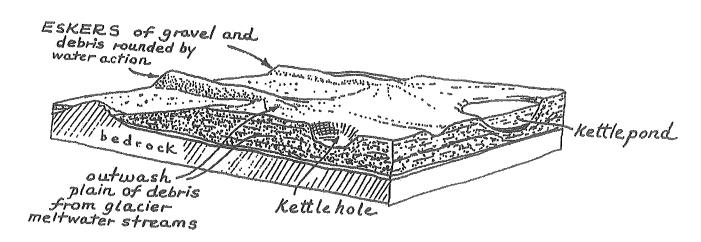


Cross Section Through an Esker

Often blocks of ice like ice bergs broke off from the glacier and were surrounded

by the sand, gravel, and rocks of the melting glacier. When the blocks of ice melted a depression called a kettle hole was left.





DIRECTIONS FOR DRIVERS GEOLOGY FIELD TRIP

Stop One Devil's Slide

From the traffic light at Washington St. and Cliff Road, turn onto Cliff Road. Drive up the hill and turn left on Cushing Road. Follow Cushing as it bears to the right and immediately turn left onto Greenwood Road. Park along the right side of the road. The path leading into Devil's Slide is on the left.

From Bates or Upham Schools, travel south on Cliff Road toward Washington St. Turn right onto Cushing Road just before Cliff goes down the hill; street on right just before Cushing is Hawthorne.

Stop Two Hemlock Gorge

Drive straight onto a dirt road (Dinsmore Rd.); turn right back towards Cliff and then again right on Cliff heading down the hill. Turn left on Washington St., past Bread and Circus, and take the ramp to Route 9 East. Follow Route 9 under Route 128. Take the next ramp Chestnut St. Almost immediately look for an old stone building and turn sharp right into a very small parking area. If no room, park as far off the ramp as you can.

Stop Three St. Mary's Cemetery

Turn left under Route 9 and immediately left again back onto Route 9 West. Exit onto Cedar St. toward Needham; take right fork onto Hunnewell St. and then turn left between two stone pillars into the cemetery. Park opposite rock outcropping with statues on top.

Stop Four Longfellow Pond

Exit turning left onto Hunnewell St. Fork right onto Oakland St. to Longfellow Pond. Park at the far end of the lot.

Stop Five Kelly Field

Exit onto Oakland St. driving right towards Route 9. Turn left on Route 9 West. Exit onto Weston Rd. toward Weston. Take a right onto Elmwood Road. Go past Wellesley Baptist Church and then into Kelly Memorial Park parking lot on your left.