An Ice Age Tour of Brookline, Massachusetts

A Brookline Rocks! Self-Guided Tour
October 23, 2021

This is a short tour of some of the key geological features from the last ice age in Brookline. There are a variety of other glacial features that can be seen in the greater Boston area and in eastern Massachusetts (e.g., terminal moraines and dunes in Cape Cod). The goal of this tour is to raise the awareness of how the local geography and terrain of the area has been shaped by the last ice age.

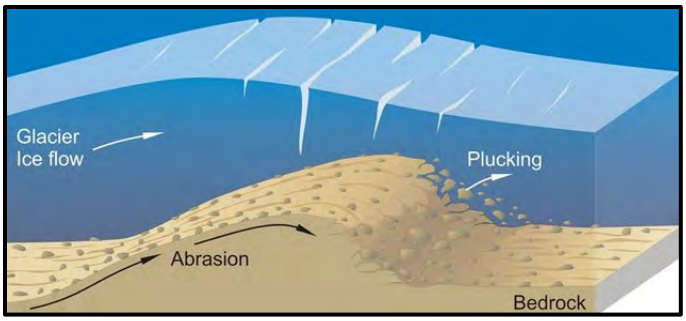
Stop 1: Glacial Smoothing

Walnut Hill Cemetery, 96 Grove Street, Brookline (42°18'18.1"N, 71°08'55.3"W)

Directions
The Walnut Hill Cemetery is located off Grove Street in south Brookline, near the intersection of Grove Street and Allandale Street. The cemetery entrance is on the south side of the road.
Enter the cemetery and park at the lot just inside the entrance.

The Walnut Hill Cemetery contains outcrops of the Franklin Park Member of the Roxbury Conglomerate. The geology of these rocks is discussed in the Brookline Tour of Avalonia, which can be found in the BrooklineRocks! self-guided tours. Here we focus on how these older rocks (ca. 558-595 million years ago (Ma) are shaped by glacial forces. The Cemetery is near Walnut Hill (east on Grove to the rotary then north on West Roxbury Parkway; the hill is east of West Roxbury Parkway).

The massive shaping forces of the Laurentian ice sheet is hard to imaging. It is estimated that, at its maximum, the ice sheet was over two miles in depth! Even at the margins of the ice, its thickness was likely hundreds of feet or up to a thousand foot thick. At this depth the weight of ice was close to 60,000 pounds. At the bottom of the glacier, there was a mixture sand, rock, ice and water that acted as a giant scouring solution, with the "elbow grease" being the tons of ice above. The "push" came from the millions of tons of ice piled up in the north. This combination smoothed the contours of the tops of rock outcrops. In some cases, stones embedded in the ice would make elongated scratches or gashes in the rock (glacial striations). As the ice flowed over such rocks, pressure would be placed on the downflow face of the rock, where rock could be pulled out of the bedrock face ("plucking"). As a result, outcrops shaped by glacial flow often show a smooth and gradual slope up to the top on what is called the stoss side, and a ragged front edge where rocks were plucked out of the cliff face on the lee side.



(Figure from: https://www.geocaching.com/geocache/GC5KMJ7_ice-age-leftovers-at-doolough?guid=492451c4-8fc9-4424-89e2-fb4ede36b979).

Leaving the parking area, follow the path to the right (Willow Ave) and stop near the outcrop to the left. One can see the smoothing at the tops of the outcrops, which often gives them an undulating appearance along the top. Note the sharp and ragged cliff face on the west and south sides of the hill.

Turn right on Beech Ave and follow the road to the south. On the left you will see a long, low outcrop, again with smoothing on the stoss side and a sharp lee side. There are many other similar features in the cemetery that together show the movement of ice from north to south

At the south end of the cemetery, where Beech Avenue meets Maintenance Road, there is a large outcrop to the right. At the base, there is a small boulder that looks like a glacial erratic (Glasses on top for scale are 5.5 inches). It is not certain that this is an erratic because stones may have been brought into the cemetery that were not naturally deposited there. The rock is granitoid and clearly too large to be part of the local conglomerate, where maximum cobble size is about a foot. An erratic is a rock that was picked up in one location, carried in the ice, and dropped out in another location. In addition, the rock has marks on top that likely reflects scoring from passing ice after its deposition from the ice. The figure at right shows a close up of this scored top. One can find other rocks in the park with glacial scratches on the surfaces.

As you drive around toward the eastern side and back toward the entrance, you will see other outcrops showing glacial smoothing. Toward the entrance and in the center of the cemetery, there is a very large boulder that has been moved and shaped by the\ ice. This is not an erratic as it is composed of Franklin Park Member conglomerate. It shows the rounding of the edges from the ice.

Stop 2: Kettle Pond, Post-Glacial Bog

Lost Pond (Arlington Road off Heath Street, 42°18'59.8" N; 71°10'17.2" W)

Directions
Exiting the cemetery, turn left on Grove Street.
Follow for 0.2 miles until the rotary. Take the first right (West Roxbury Parkway).
Go north on West Roxbury Parkway for 0.3 miles. The road will turn into Newton Street.
Continue another 0.5 miles to the next traffic circle. Take second exit (Hammond Pond Parkway).
Follow Hammond Pond Parkway 0.7 miles. At the intersection of Heath Street, turn left.
About 300 feet up the street, turn left on Arlington Street.
Follow Arlington Street to the end. Park near the entrance to Lost Pond Reservation.
Enter the reservation area and follow to the right.

Lost Pond Reservation is a quaking bog surrounding a kettle pond. A kettle pond is the result of a large mass of ice that becomes separated from the main ice flow during glacial retreat. This chunk of ice becomes buried partially or completely by sediments flowing out from the glacial front. As it gradually melts, it leaves a depression in the ground that may be filled with water. This is a kettle pond (if it does not fill with water this is called a kettle hole). The Figure below shows this formation process.

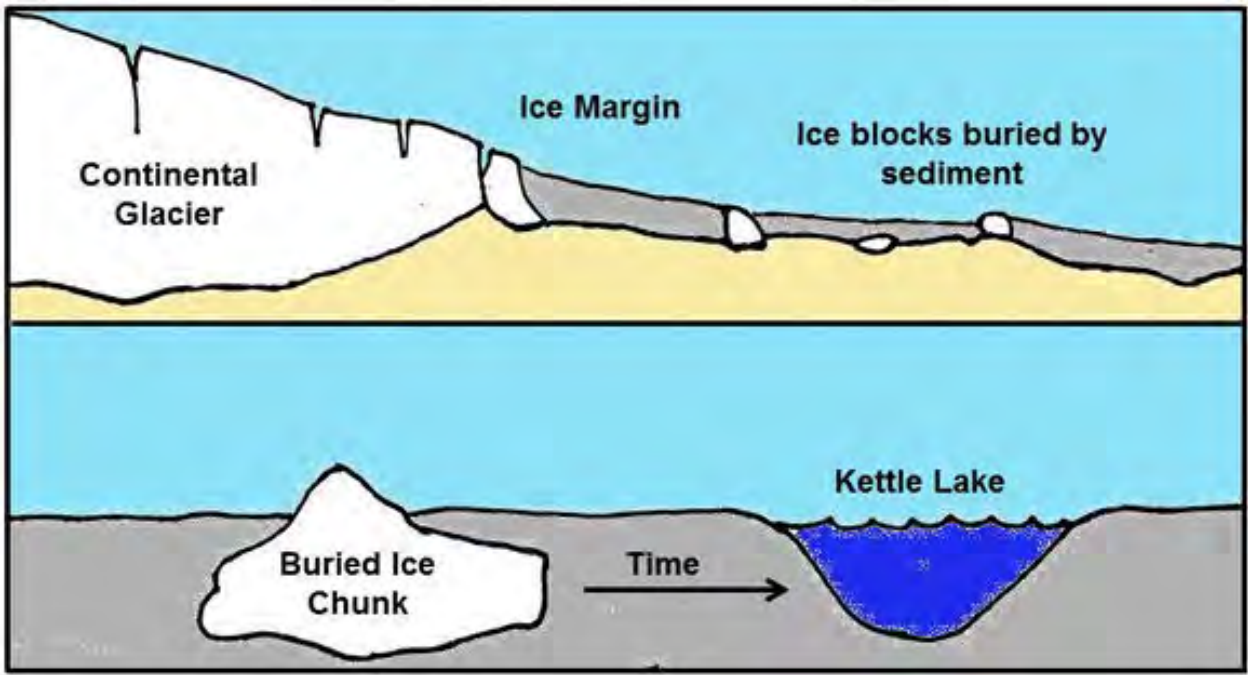


Image from: https://www.geocaching.com/geocache/GC5BGB5_a-different-kettle-of-fish?guid=c49a6b2b-3019-4fc7-97ea-90a94ece6c17.

When you enter the park area, follow the trail to the right. After a while you will see a spur trail going toward the left that leads to the pond. The trail continues on to a boardwalk. This portion of the trail is on top of a quaking peat bog. This is an unusual type of wetland for a kettle pond. Peat bogs often occur in deep glacial lakes. They are formed by the gradual decomposition of plant material in highly acidic, poorly-drained areas. In less

acidic areas, bacteria and other organisms would break down the vegetation into soil. Here, the vegetation is not fully decomposed and accumulates at the bottom of the pond area in the form of peat. Near the top, specific acid-tolerant vegetation has formed a floating mat over the water. This mat is not solid; if stepped on it “quakes” because it lies on top of water and it can collapse under additional weight of being walked on. The peat at the bottom of the kettle pond has accumulated in deposits 20-40 feet deep. This deposit provides naturalists with excellent data on the ecological history of an area as the peat preserves pollen fossils from plants that grew in the area over the last 10,000 to 15,000 years.

Figure top left: rock with glacial striations near the entrance of the trail. Top middle and left: two views of surface of quaking bog off the boardwalk area. Bottom: panoramic view of the kettle pond.

Stop 3: Kettle Pond, Glacial Smoothing, Glacial Boulders

Hammond Pond & Webster Conservation Area, Newton (42°19'21.6" N; 71°10'20.7" W)

Directions

Go back up Arlington Road, turning right on Heath Street.
At the light, turn north on Hammond Pond Parkway.
Stay on Hammond Pond Parkway 0.3 miles. You will pass under the Route 9 overpass and through a set of lights. The entrance to the Chestnut Hill Mall is on the right. Turn into the mall. You will see a parking area on the north side of the mall road next to Hammond Pond. Park there.
There are several trails that extend into the Webster Conservation Area north of the parking lot.

This is a second kettle pond in the area. Over the years, it has gradually filled with sediment washed down from the hills nearby and by decomposed plant material. Unlike the kettle pond at the previous stop, there are no peat deposits at this pond. The average depth is now only four feet. In recent decades, plant growth in the pond has been accelerated by fertilizer and wastewater from surrounding areas, increasing the growth of plants along the edge. The community has been trying to remediate some of the environmental damage caused to the pond.

Walking up into the trail running to the north, one can see high outcrops of the Brookline Member of the Roxbury Conglomerate. The shaping and smoothing force of the glaciers can be seen at the tops of these outcrops. Further up the trail (certainly up the hill as one comes to the end of one of the big outcrops) are large boulders that have been moved by ice sheet flow over these rocks. The rocks appear to be of the same type as the surrounding rock, so they are not considered erratics, an example of which we will see at the next stop.



Figure left: the downflow face of one of the cliffs at Hammond Pond conservation area shows evidence of plucking from the glacier that flowed over it. Middle: glacially-smoothed tops of one of the outcrops. Figure right: Boulder moved and rounded by the ice mass.

Stop 4: Glacial Smoothing and Glacial Erratic

Dane Park, Hammond Street, Brookline (42°19'03.2" N; 71°09'46.7 W)

Directions

Take a right out of the parking lot to the mall road and then take a left on Hammond Pond Parkway.
Follow Hammond Pond Parkway south for 0.3 miles until Woodland Road. Turn left.
Follow Woodland Road 0.5 miles. You will come to Hammond Street. Turn left.
You will see the entrance sign for Dane Park on the right. Take a right just north on Woodland Road and park on the right side.
Walk back to the main entrance of Dane Park.

Located on former estate land, Dane Park is the only passive wooded park in the town of Brookline. The rock outcroppings at Dane Park are mostly a variety of volcanic formations

from the Brighton Igneous Suite (see the Brookline Tour of Avalonia). There is an informational sign about these rocks just inside the entrance. The dating estimate shown on the informational sign (at about 600 Ma) has been updated by more recent radiological dating of a nearby sample by Dr. Margaret Thompson (2014) that established its age of deposition at 584 Ma.

Walking around the trails in the park, one can see the effect of glacial smoothing and scouring on many of the outcrops, such as the lava flow at the western end of the park near the entrance. Again, the smoothed (stoss) side of these outcrops tends to be the northern side, and the more ragged, sharper (lee) rock face tends to be on the southern sides.

Figure left: glacial activity has smoothed the tops of this gabbro deposit. Middle: An ash flow deposit show more gradual sloping on the stoss side (to the right) compared to the lee side on the left. Figure right: A volcanic deposit shows signs of glacial smoothing. Some of these outcrops show striations made by rocks embedded in the ice as it moved over the deposits.

Walk to the area identified as deposits from a lava dome or mouth of a volcano. At the southern edge, one can see glacial striations left on the top of the basalt. Toward the north at the edge of the trail, a small boulder of Roxbury conglomerate sites atop the basalt. This is a glacial erratic: a rock out of place. Due to faulting in the area, the rock in Dane Park, south into the golf course, and to the west across the street at the Beaver Country Day School, is all part of the Brighton Igneous Suite. Further south, outcrops of older Franklin Park Member conglomerate can be found. The boulder is likely Brookline Member conglomerate from the north. We can tell this because, unlike the Franklin Park Member, the conglomerate of the boulder is smaller in size (maximum diameter of the clasts is about 4 inches) and the orientation of the clasts may suggest bedding. Glaciers pulled this boulder from an area of the Boston Basin north of here and deposited it here among the Dane Park volcanics. As it is from another place, it is considered a glacial erratic. Some erratics may be carried for hundreds of miles from their place of origin and before being deposited. And while this erratic is relatively small, some are quite large. In Massachusetts, there are a number of large erratics, including Plymouth Rock.

Stop 5: Drumlins

Fisher Hill, Aspinwall Hill, Corey Hill

Directions

This is not so much a stop as a narrated drive among several drumlins in Brookline to see their distinct differences.

From the parking area on Woodland Road, turn back to Hammond Street and turn right.

Follow Hammond Street 0.5 miles to the intersection of Route 9 (Boylston Street). Turn right.

Follow Route 9 1.0 mile to the intersection with Chestnut Hill Road. Keep in the left lane to make the left turn.

Just a block in, make a right turn on Channing Road.

Follow Channing Road 0.2 miles to Fisher Hill Road, and turn left.

This will take you up over the top of the drumlin hill. If you prefer, you can turn into the parking lot at the Fisher Hill Reservoir Park at the top.

Continue on Fisher Hill Road down to Dean Road, and turn right.

Follow Dean Road for about 0.3 miles. The road will pass over the MBTA D line. Right after, turn right on Tappan Road.

Tappan Road runs along the southern side of the Aspinwall Hill drumlin.

After about 0.1 mile, turn left on Gardner Road to climb up the hill.

At the traffic circle about 0.2 miles ahead, you can turn left on Rawson Road to climb to the top of Aspinwall Hill. (To do this follow Rawson Road to Colbourne Crest, turning right, then left to Addington Hill Road).

Alternatively, one can continue following Gardner Road, which will lead you off the hill and to Washington Street. Turn left on Washington Street and head up to Beacon Street.

Go through the Beacon Street intersection. The foot of Corey Hill will be to the right.

Continue on Beacon Street 0.3 miles to Corey Road. Turn right.

Follow Corey Road for 0.2 miles to Summit Avenue, turn right.

Follow Summit Avenue up and over the top of Corey Hill. If you want, you can stop at the park located near the top of the hill.

Drumlins are hills formed by glaciers, where quantities of clay and rock were deposited in a single location. They are one of the most ubiquitous landforms generated by ice sheets. The Boston area has a relatively high concentration of drumlins (more than 200), with many of them existing in the rarer form of drumlin “swarms.”

Interestingly, the Boston Harbor Islands are part of the only drumlin swarm in the United States that intersects a coastline. Most drumlins are elongated in the direction of flow of the glacier or ice sheet that deposited it; however, in the Boston area this is not the case. As Clifford Kaye wrote in The Geology and Early History of the Boston Area: a Bicentennial Approach (U.S. Geological Survey, 1976), “Boston’s drumlins resemble a school of fish that have been frightened by a pebble falling into the water. Adjacent drumlins diverge in orientation by as much as 70°.” This likely has to do with their location toward the terminal end of the ice sheet. With a complex advance and retreat that likely occurred over thousands of years, it is likely that some drumlins were deposited and then

reshaped by later movements of ice, or that successive drumlins were deposited under different flow conditions.

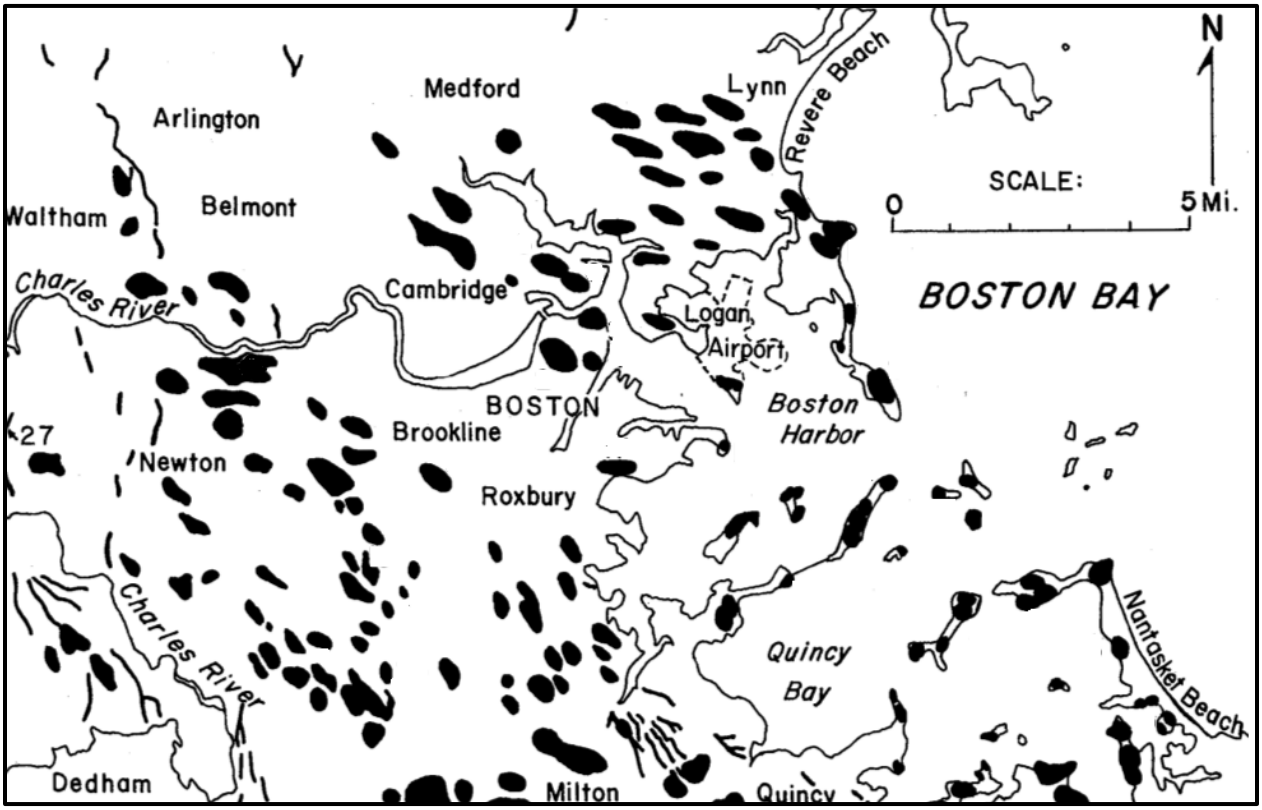
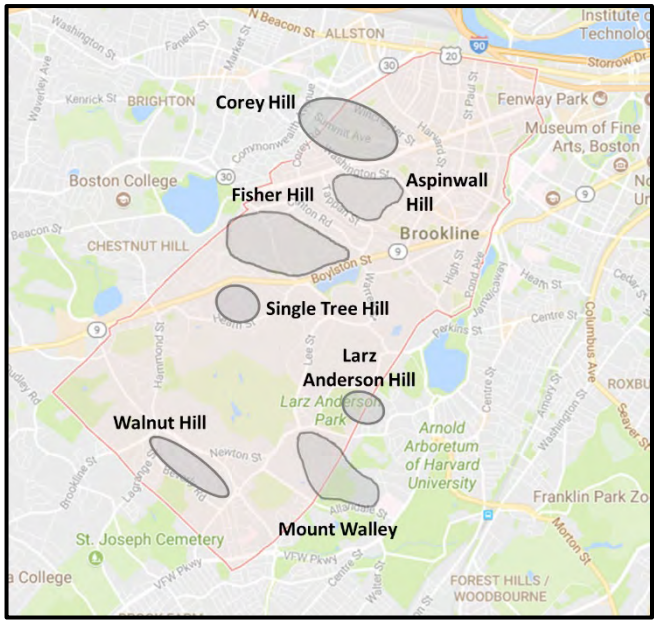


Image source: Skehan, SJ. Puddingstone, Drumlins, and Ancient Volcanoes: A Geological Field Guide Along Historic Trails of Greater Boston. Second edition. WesStone Press, 1979, p. xii.

Brookline is home to seven major hills that are drumlins: Corey Hill, Fisher Hill, Single Tree Hill, Walnut Hill, Aspinwall Hill, Larz Anderson Hill and Mount Walley. Next door in Newton is the Chestnut Hill and Mount Ida. The classical drumlin is an elongated, teardrop-shaped hill with a gradual slope up the stoss side and a sharper drop on the lee side. Some of the Brookline drumlins have this more classical shape. Larz Anderson Hill is a fine example of this, with a broad slope up from the northwest side and a rather steep drop-off on the southeast side. Others have more complex shapes. Walnut Hill has two peak areas, and Aspinwall Hill has a more comma shape. A view of all the Brookline drumlins (see Figure right) suggest a northwest to southeast movement of the ice mass that deposited these drumlins.



Drumlins in Brookline have played an important role in shaping the direction of the major roads of the town such as Beacon Street, Boylston Street and Washington Street, which navigate between these glacially-deposited hills.

In this “stop,” you have the opportunity to see three very different types of drumlins. Fisher Hill is rather broad, although longer than it is wide, and it does preserve the gradually rise on the stoss side and sharper descent on the lee side. Aspinwall is more irregular, although again the southern side (lee side away from the ice flow) is much steeper than the northern side. Corey hill may be the most classically shaped of the three drumlins, with a broad rise on the north side extending all the way to the Brighton border and a fairly sharp descent over the summit.



The gently-sloping stoss side of Single Tree Hill can be seen in these images (not on the driving tour itinerary). Erosion of the drumlin surface has exposed large boulders that were deposited in the drumlin, and are now left scattered on the surface of the hill.

Stop 7: White Cedar Swamp

Hall’s Pond Reservation (Beacon Street)

Directions
From the top of Corey Hill, head down Summit Avenue to Beacon Street. Turn right.
Just ahead, make a U turn at Marion Street and turn left going back up Beacon Street toward Boston.
Stay on Beacon Street about 0.9 miles until Hawes Street.
Turn left, go across the MBTA C line tracks, and turn left down Beacon Street.
The Amory Playground and the Hall’s Pond Sanctuary are just to the north.
Find a place to park in this area.
There is an alley that connects Beacon Street to the playground; follow the path into the playground.
The tennis courts will be on the left and the sanctuary on the right. Look for a gate to the sanctuary. Enter and make sure the gate is closed.
Follow the path to the east, keeping the pond to your left side.
After about 100 feet you will see a path going out the pond with a boardwalk.
Follow to the end of the boardwalk

Hall’s Pond Sanctuary is one of three wildlife sanctuaries in Brookline. The pond, while natural, is not a kettle pond. The area in which it is located is a wetland. A vernal pool area lies to the north and west of the pond. However, the pond harbors a secret from the end of the ice age.

As the ice receded from the Boston area starting around 15,000 to 17,000 years ago, the area near the Boston harbor was low-lying. We can see this today in Brookline, where one moves from the higher ground around the Beacon Street drumlin swarm toward the area of Hall's Pond, which is at the end of a long slope down from the drumlins. This slope can be seen looking west on Beacon Street from the Hall's Pond area. This low area of Brookline was likely an area at or below the water table. In the proceeding years after glacial retreat, plants began to pioneer this area, and in the low-lying swampy areas that included this part of Brookline and on into the Back Bay, one of the pioneering trees was the Atlantic white cedar. This is a rapidly growing tree that can tolerate relatively poor soil and wet conditions. Soon, this area was dominated by a white cedar swamp. In the aftermath of the ice age, these cedar swamps sprang up extensively along the east coast from Maine down to the Carolinas.

Cedar wood is very resinous (one of the reasons cedar is used in outdoor construction is its resistance to rotting) and acidic. The water of the cedar swamps therefore became acidic, and like at the quaking bog of Lost Pond, dead cedar trees did not fully decompose but formed a layer of peat at the bottom of the swamp. Over time this layer of peat deepened.

When the first European settlers lived in the Boston area, much of this area was wetland (either freshwater or intertidal). Over time, settlers began to cut down the cedar trees and fill in much of the wetland. In the Boston area, all the Atlantic white cedars are gone (you need to go down to Wellfleet to see such a swamp area) and much of the wetland has been filled in. But the remains of the cedar swamp still lie beneath the soil. At the end of boardwalk looking out over the pond, look down. One can see what look like oil slicks on the water, giving it a shiny coating. That is not pollution but the resin from the white cedar leaking from the peat below up into the water of the pond. It is a small reminder of how different a place Brookline was 10,000 to 15,000 years ago.

Figure left: view of Hull's Pond from the south boardwalk area. The accumulation of the white cedar resin can be seen in the foreground. Figure right: Close up of the water surface showing the oil slicks left by the white cedar resin.

References

Skehan, SJ. Puddingstone, Drumlins, and Ancient Volcanoes: A Geological Field Guide Along Historic Trails of Greater Boston. Second edition. WesStone Press, 1979.

Thompson MD, Ramezani J, Crowley JL. U-Pb zircon geochronology of Roxbury conglomerate, Boston Basin, Massachusetts: tectono-stratigraphic implications for Avalonia in and beyond SE New England. *American Journal of Science* 2014;314(6):1009-1040.