Geology of Newton

by James W. Skehan, S.J. and Catherine W. Barton

Introduction

The City of Newton lies at an elevation ranging from 300 feet above sea level in the southeastern part of the city to 10 feet in the northeastern part.

Geologically Newton lies within the so-called Boston Basin (Fig. 1), which in turn is a tiny structure in the Appalachian Mountain chain. We refer to these as "mountains" in the geological sense even though the high mountain landscape (as high as the Swiss Alps today) which once characterized this region has long since been beveled by erosional processes.

The Boston Basin is bounded on the north by the Lynn Fells or Upland, on the south by the Blue "Hills and on the west by the higher terrain of Needham, Waltham, Wellesley and Weston. The boundary between the rocks to the north and west is a northerly and westerly dipping thrust fault called the Boston Border Fault (Figs. 1 and 2). The Blue Hills are bounded on the north by a high angle reverse fault. The net effect of such faulting is to have moved the older rocks to a position on top of and therefore to a higher elevation than the younger rock sequence of the Boston Basin.

The History of the Development of the Boston Basin

Bedrock Geology

The rocks of Newton belong essentially to a single sequence of volcanic and sedimentary deposits formed during Devonian time or about 350 to 400 million years ago. The sedimentary rocks consist of the Roxbury Conglomerate or "Puddingstone" and the Cambridge Argillite or Slate (Fig. 3). The Brighton Volcanics are distributed throughout the approximately 5000 foot thick sequence of sediments and represent a variety of volcanic products. The youngest rocks of the bedrock sequence are dike rocks, which are earthquake fissure fillings which may be as young as 150 million years. Elsewhere in the Boston Basin these rocks rest upon the Mattapan Volcanics. Just outside the Boston Basin region there are rocks as old as approximately 600 million years, the Dedham Granodiorite. This igneous rock has not been encountered within the Boston Basin. It is likely however that the sedimentary and volcanic rocks just referred to have been built upon this older foundation. Deep drill holes in Newton therefore would be likely to penetrate the Mattapan Volcanics and the Pre-Cambrian foundation of Dedham Granodiorite.

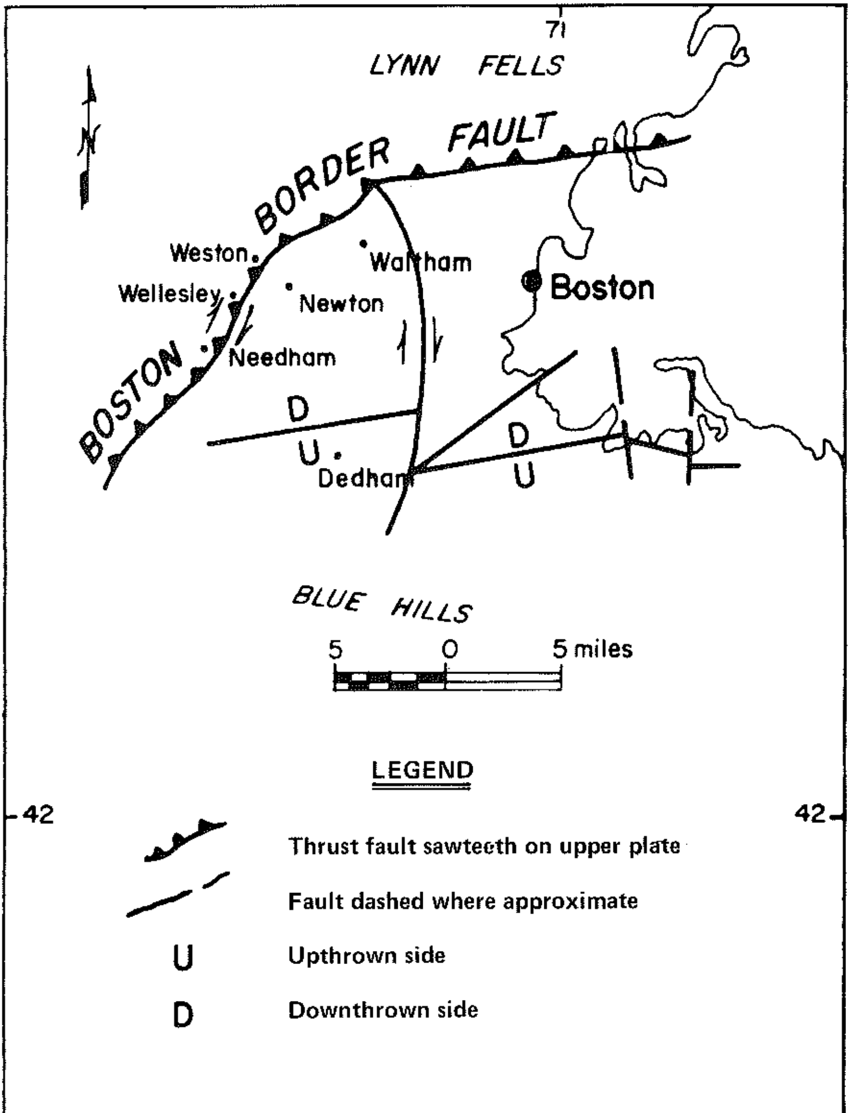


Figure 1. Location of Newton with respect to the Boston Basin, (adapted from Skehan, 1969)

We may visualize the deposits of the Boston area some 350 to 400 million years ago as consisting of gravels, sands and muds which were being deposited beneath the ocean just east of a chain of high mountains which then occupied the New England area.

The Roxbury Conglomerate was deposited at the foot of high mountains by streams which washed sediment down the mountains and out to sea. Generally speaking heavier cobbles and pebbles rapidly settled out of the water and came to rest relatively close to the mountains of east central Massachusetts.

Some structures in the Roxbury Conglomerate suggest that at least part of the "Puddingstone" deposits represent submarine slides which moved down the gentle ocean bottom slope as submarine landslides coming to rest in deeper water. Such landslides were possibly triggered by earthquake activity associated with volcanism and related faulting activity. Such slide masses would be capable of producing a good deal of erosional scouring of the ocean floor and would produce slump structures such as are seen in Figure 8.

Sand and clay deposits of the Cambridge Slate undoubtedly represent those finer grained materials which were able to be transported greater distances. As one might expect, the Slate and the Roxbury Conglomerate consequently show a close association (Fig. 2). The interfingering of the Slate and the Roxbury Conglomerate suggests alternations in the rhythm of transportation of particles. of varying sizes during the long periods of time in which these deposits were formed.

While the sediments were being deposited, volcanic activity was taking place chiefly in that part of the basin of deposition where the conglomerate was being deposited. Also volcanic ash deposits are found in the slate of Cambridge and Somerville. The surface distribution of slate, conglomerate and volcanics in the Newton area is shown in Figure 3. A modern analogue of the Boston Basin may be the Tyrrhenian Sea which is the basin of deposition for coarse to fine gravels washed from the alpine mountains of the North. Nearby, volcanic activity is apparent on the Italian mainland and on the island, Ischia, offshore.

The folding and faulting of the Boston Basin rocks resulted from mountain building forces, which pushed the alpine mountains of east-central Massachusetts in an easterly direction. This thrusting produced faults such as the Boston Border Fault and folds such as the Shawmut anticline of Newton (Fig. 2). These structures were developed when blocks of the earth's crust were squeezed together.

Glacial Geology

The youngest deposits within the Boston Basin region including Newton are of glacial origin (Fig. 4). There is a great variety of forms and types of such deposits. These consist generally of "hardpan" which was deposited directly where the rock fragments (till) fell out of the ice as it melted, or deposits which were formed under the ice (drumlins). Such drumlin deposits are elliptical in shape and their long axes show the

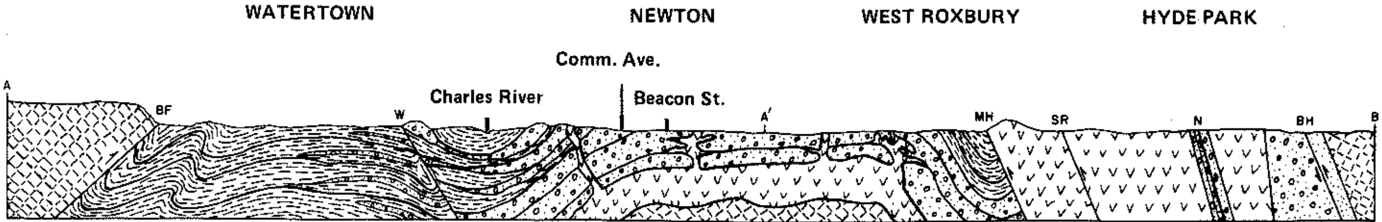
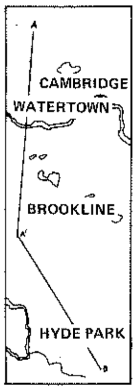


Figure 2a. Cross section which passes through Newton showing the geology and structure of the area. (adapted from Billings, 1929)



0 2 miles

LEGEND

Thrust fault thus indicated:

BF	Northern Border Fault
W	Watertown
MH	Mt. Hope
SR	Sally Rock
N	Neponset
BH	Blue Hills

- Cambridge Slate
- Roxbury Conglomerate
- Mattapan and Brighton Volcanics
- Milton Quartzite
- Dedham Granodiorite

Figure 2b. Map showing the location of the section line in the Boston Basin. (from Billings, 1929)

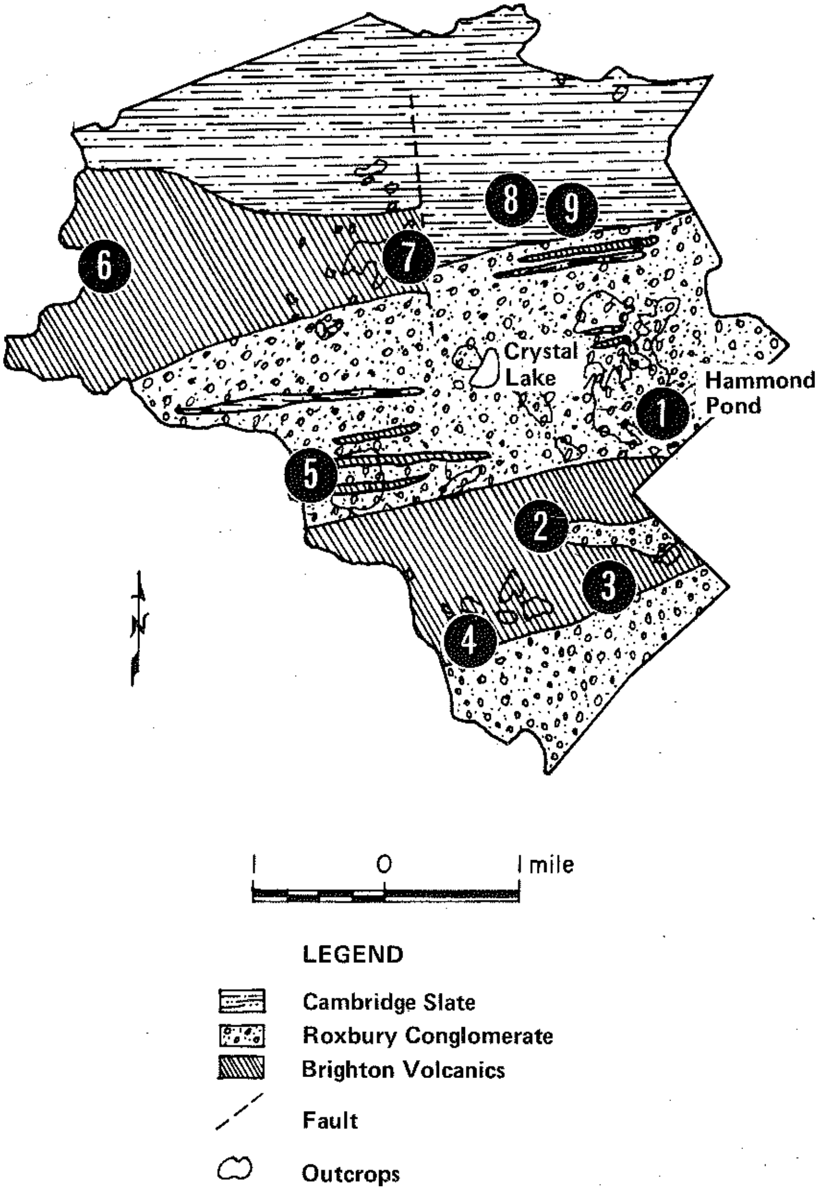


Figure 3. Generalized Bedrock Geology of the City of Newton, Mass. (after Bell, 1948), Gielisse (1959), and LaForge (1932).

NOTE: **2** indicates Geology Field Trip stops mentioned in text.

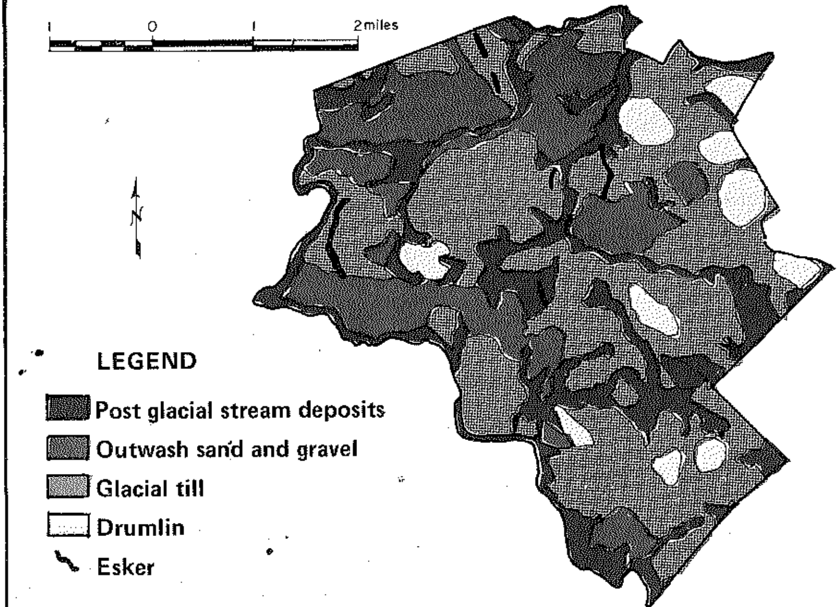


Figure 4. Map of surficial glacial deposits in Newton. (adapted from LaForge, 1932)

direction of movement of the glacier. Such deposits are represented in Oak Hill, Bald Pate Hill and many others (Fig.4).

Another major land form and natural resource consists of layered glacial deposits which have been deposited by meltwater from the glacier. These esker deposits may have formed as crevasse fillings or as sub-glacial stream deposits. Such outwash deposits are found in Edmands Park, Waban, Auburndale, Newton Centre, Newtonville, and Cutler Park in Needham. Outwash plain deposits were laid down in front of the melting glacier by a meandering stream produced by the melting glacier.

Finally the alluvial deposits consist of post-glacial sediments developed in the 14,000 year period since the glacier receded from New England. Such sediments are swamp deposits including peat and certain stream deposits.

Geology Field Trip

A series of nine field locations, or stops, has been chosen to facilitate firsthand study of examples of Newton's bedrock geology and the forms which glaciations has superimposed on and around the rock outcrops.

These stops are either on land in public ownership or are so located that permission to observe the formations will not be necessary. They are convenient for bus tours or for smaller group or individual visits.

Beginning at Stop 1 in Chestnut Hill, the stops follow a clockwise sequence westerly, then northerly, then easterly, and end up at the slate outcrop at the campus of the Newton College of the Sacred Heart.

Stop 1. Hammond Pond Reservation

Access to parking lot is from Hammond Pond Parkway just off Boylston Street (Route 9).

Features to be seen:

1. Roxbury Conglomerate crops out throughout the Reservation. The conglomerate contains quartzite, granite and felsite pebbles which are rounded to sub-rounded in shape.
2. Outcrops of sandstone embedded in the conglomerate can be seen along the east side of Hammond Pond Parkway or along the bend in the main path in the Reservation. a) differences in grain size between the conglomerate and the sandstone. b) layering of the sandstone.
3. Jointing in the conglomerate (Fig. 5). In some locations it can be seen that the joints cut right through some of the pebbles as well as the matrix of the conglomerate.
4. Trees growing in joints in the conglomerate in the hemlock grove on the west side of the Reservation. As their roots grow larger, more and more pressure is applied to the rocks and eventually this pressure splits the rocks apart (Fig. 6).

5. On top of the large cliff at the entrance to the Reservation by Stearns parking lot, you may see glacial grooves and a perched glacial erratic (Fig. 7). Perched boulders can also be found in the formation around the hemlock grove.
6. Pieces of amygdaloidal lava can be found on the hill at the left of the MDC pathway as one goes toward Hammond Pond Parkway.

Webster Conservation Area (south)

West of Hammond Pond Parkway and south of the MBTA track. Park at Temple Mishkan Tefila.

1. This area is best known for its Roxbury Conglomerate fissure caves --known locally as Gooch's Caves.
2. Contacts of Roxbury conglomerate with sandstone can be found in the high formation about 400' north, of the Temple.

Webster Conservation Area (north)

West of Hammond Pond Parkway and north of the MBTA track. Off the southbound lane of the Parkway. Enter the pathway about 600' south of Beacon Street.

1. To the right of the path are thick sandstone ledges alternating with Roxbury Conglomerate. This large sandstone formation may be a sand bar deposited in a stream. Ripple marks such as are made by water may be seen.
2. Note very long, almost vertical joint toward the westerly end of the sandstone ledges. One of the best examples of a joint in Newton (Fig. 5).

Corner of Beacon Street and Bishopsgate Road

Park along Beacon Street or walk from the Webster Conservation Area. Note the sandstone beds contorted in tight "hairpin" folds. The sandstone slumped while the layers were still soft (Fig. 8).

Stop 2. Near Newton South High School

Outcrops of the Brighton Volcanics occur extensively in the wooded area across Brandeis Road from the school. From the first set of parking lots north of the school and to the left (east) of Brandeis Road, a path leads to a break in the fence and up the hill. The outcrops form two steep cliffs, one low, and the other higher which are separated by a rather flat bench.

Important features of the upper cliff are:

1. The rock itself is a fragmental volcanic material, certainly pyroclastic and probably a welded tuff. The rock is characteristic of a near vent deposit.
2. The rock is felsic rather than mafic and has a blocky fragmental character. The blocks range from fine ash to blocks inches to feet across.

3. Collapsed, possibly recrystallized pumice and lapilli make up most of this deposit, although amygdular lavas may constitute a certain part of the volcanic sequence. These rocks are white and rather plastery in appearance.
4. Amygdules or gas hole fillings and small lapilli can be seen in the felsite along with some vug quartz.
5. The "nubbles" which can be found at certain spots may be subaerially deposited volcanic bombs or lava droplets which initially solidified as glass beads and have since undergone recrystallization. Notice the differential weathering here.
6. Farther toward Route 9 from the "nubbles," numerous quartz veins can be found which extend in varying directions indicating that these veins may perhaps all radiate out from a single source. These veins were fissures filled by quartz solutions.
7. At certain points a definite foliation or lamination of the volcanic rock can be seen. This is interpreted as a layering probably developed as the tuff or the ash accumulated on the flanks of the volcano. This type of layering is characteristic of the early formed ash deposits of Surtsey Volcano, in Iceland as the island was being built up by eruptions above sea level.

Important features to notice on the middle bench: Large perched boulders, glacial erratics, are of Roxbury Conglomerate. Some deformed pebbles can be noticed in the conglomerate.

The conglomerate contains rounded to subrounded pebbles of quartzite, granite and felsite (Fig. 7).

Features on the lower cliff: Notice the red color of the rock which is a welded rhyolite tuff. There is a second Brighton Volcanics outcrop along the west side of the school.

A number of features can be observed on this hill, including the fragmental nature of the volcanic rocks, perched glacial erratics and a distorted quartz vein.

Stop 3. Oak Hill

Drive up Ober Road which runs off Brookline Street. Oak Hill is a drumlin (elevation 291') which was formed by glacial action as described generically above.

Notice:

1. Sandy till in the outcrop at the top of the hill.
2. Rocks of varying sizes from sand to cobble size intermixed in the till.
3. These rocks are of varying compositions and textures.
4. As you walk down the road a bit you can see the Blue Hills, which form the southern border of the Boston Basin in the distance.
5. From the top of Oak Hill you can look across to Bald Pate Hill (elevation 302'), another drumlin. Note the typically rounded elliptical shape of the hill.

Stop 4. Outcrops Along Nahanton Street Across From The Charles River Golf Course And Farther West At The Kendrick Street Bridge Over The Charles River

The outcrops are road cuts. Parking is difficult. The rock consists of the Brighton Volcanics.

1. Excellent examples of mineralization. Well-formed crystals can be seen. Please do not remove crystals.
2. Minerals which can be found in veins: Chlorite Quartz Calcite Pyrite/Chalcopyrite Hematite
3. Small fragments of red felsite are present in the rock.
4. Differential weathering.

Stop 5. Hemlock Gorge DCR Reservation At Newton Upper Falls

Access to the west (Needham) side of the Charles River at the Gorge from Route 9 eastbound lane is by turning right at Ellis Street and proceeding to the signal at Chestnut Street-Elliot Street intersection. Turn right onto Elliot Street. Cross bridge over the river. Turn right onto Reservoir Street and park at the Sudbury Aqueduct pathway which leads to the famous Echo Bridge over the river.

To the left of the aqueduct path is a large outcrop of boulder conglomerate. Notice that the pebbles in the conglomerate are stretched (Fig. 9).

Nearer the level of the River is a cave formed by running water.

Other features to be noticed:

1. Erosion of the Gorge by running water.
2. Boulders up to 1 foot long in the conglomerate.
3. Development of close-spaced mineralized fault fractures in pebbles and boulders indicative of a fault zone nearby.

Access to the east (Newton) side of the Charles River is from Ellis Street. Two or three cars can be parked on the Reservation below the Echo Bridge abutments. Walk down toward the ramp leading off Route 9. Circular dam just below Route 9 viaduct. A dike of basalt can be seen above the Circular dam. The dike has microscopic vugs in it. On the north side of Route 9 on the Wellesley side of the Gorge is an intrusive contact of basalt into conglomerate. The southernmost building of Wellesley Office Park is located just above this feature.

Sullivan Avenue at Elliot Street, Newton Upper Falls Walk a short distance from Hemlock Gorge up Sullivan Avenue from Elliot Street and observe at the right in a conglomerate cliff, half of a pothole formed as smaller pebbles were rotated in a weak spot in the conglomerate by swiftly flowing water when the gorge was being cut.

Stop 6. Rocky Mountain --Large Outcrop Overlooking Route 128

The rock is composed of the Brighton Volcanics. Park at the Recreation Road bridge over the Charles River along the spur from northbound Route 128 which leads to the Massachusetts Turnpike entrance and to Route 30. Walk south to the railroad overpass over Route 128. This railroad spur is all but abandoned. Climb the hill to the left of the railroad.

Notice:

1. Glacial grooves and striae at the top of the outcrop. The rock has been glacially polished at the left of the path leading to the summit. Amygdules which are now filled with epidote and calcite can be seen at the summit.
2. "Roche moutonnee" features, caused by glacial plucking at the south side of the hill and polishing of the rock surfaces on the hill may be observed.
3. The Auburndale Esker can be seen to the east behind the Grove Street apartment development (Fig. 10). The Grove Street Hills formerly occupied the present site of the Woodland Golf Course. They were excavated during the 19th Century for fill in the Back Bay area of Boston.
4. The fault-line marking the western border of the Boston Basin can be discerned to the northwest above the Massachusetts Turnpike Tollgate and below the red roofed Wachusett Reservoir control station in Weston just west of Route 128.
5. Some mineralization is apparent in tension gashes and veins.
6. The blue and purple color of the Brighton Volcanics which form Rocky Mountain.
7. On the southern end of the summit, look for examples of the difference between quartz and calcite crystals. The calcite crystals have been weathered more since they are soluble in water whereas the quartz crystals are not.
8. Look for a pink feldspar-bearing vein on the side of the summit toward the MBTA terminal.
9. There is a single porphyry rock at the left of the path on the first rise toward the summit. Feldspar crystals are embedded in the matrix.

Stop 7. Claflin School

On Lowell Avenue north of Commonwealth Avenue and south of Hull Street. The school is well above street level on a rocky bank. The face of the bank below the school shows a fine display of glacial scratches, grooves, and chattermarks (Fig. 11). The parking lot at the rear of the school is on the site of a former quarry cut into the Brighton Volcanics.

Stop 8. Edmands Park

A small esker can be seen to the right as you enter the park from Blake Street. A trail leads back into the park (Fig. 13) and then along the top of the esker. Note the sandy soil and the steep sides of the esker as you walk along its "back".

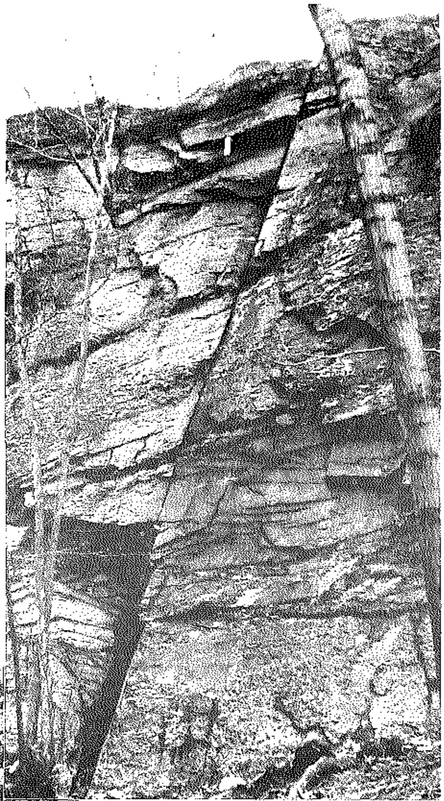
Stop 9. Newton College Of The Sacred Heart

A small isolated, conspicuous outcrop of laminated Cambridge slate can be seen on a large lawn close to the driveway off Colby Street (Fig. 12).

Notice the strike and dip of the outcrop. There is also a very small fault which can be seen in the northeast edge of the outcrop, offsetting layers formerly continuous.

This kind of slate is found elsewhere in a number of places in northern New England. A similar slaty ledge has been observed behind a house at Annawan Road and at 59 Tamworth Road both in the Waban section of Newton.

Figure 5. Jointing fracture in the Roxbury Conglomerate in Webster Conservation Area.



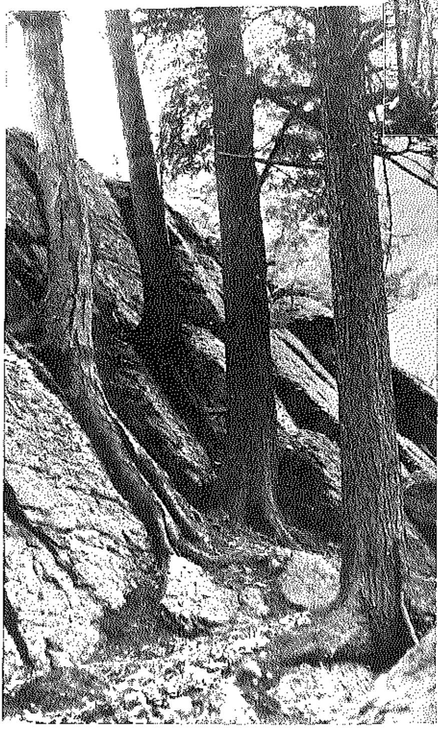


Figure 6. Trees growing in joints in Hammond Pond Reservation.

Figure 7. (top) A large perched boulder in Hammond Pond Reservation.

Figure 8. (bottom) "Hairpin" folds in fine-grained sandstone near 8 Bishopsgate Road.

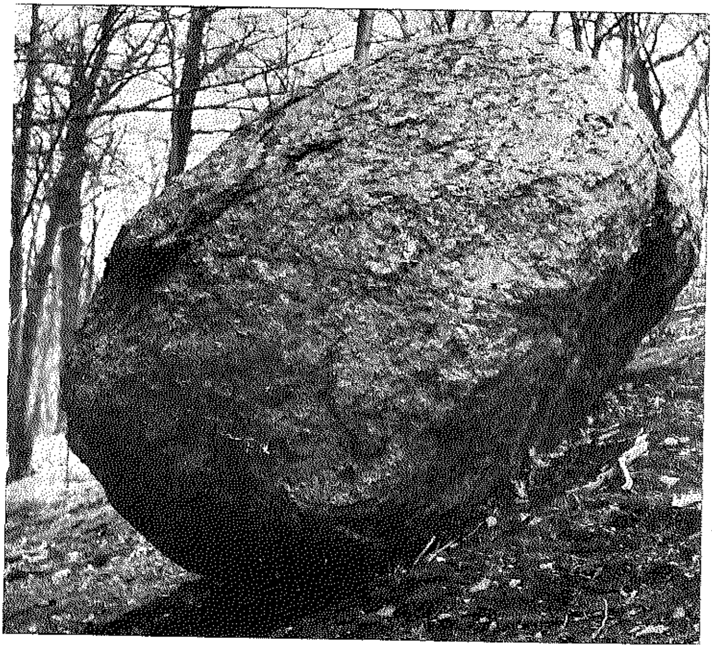
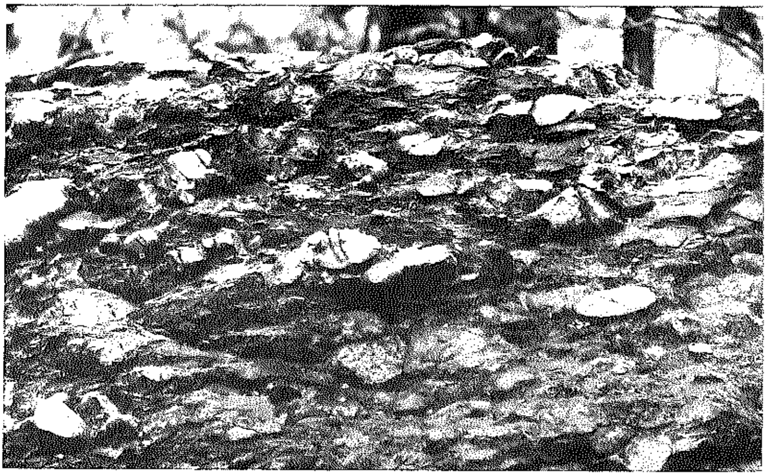


Figure 9. (top) An outcrop of Roxbury Conglomerate at Hemlock Gorge. Notice the stretched pebbles.

Figure 10. (bottom) A view of the Auburndale Esker from the Woodland Golf Course.



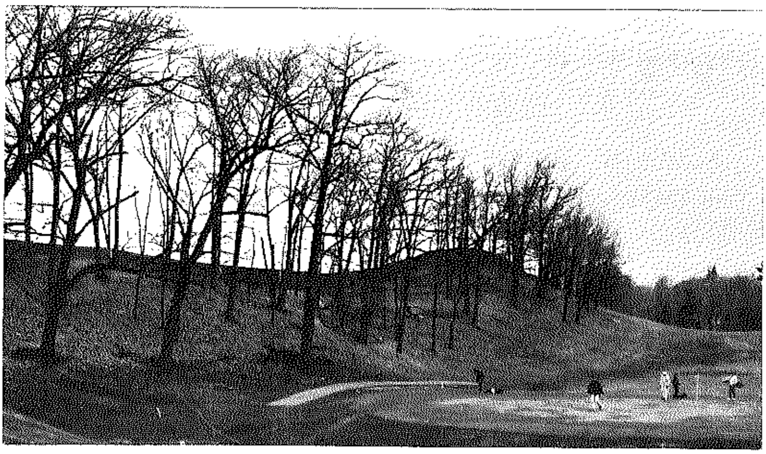
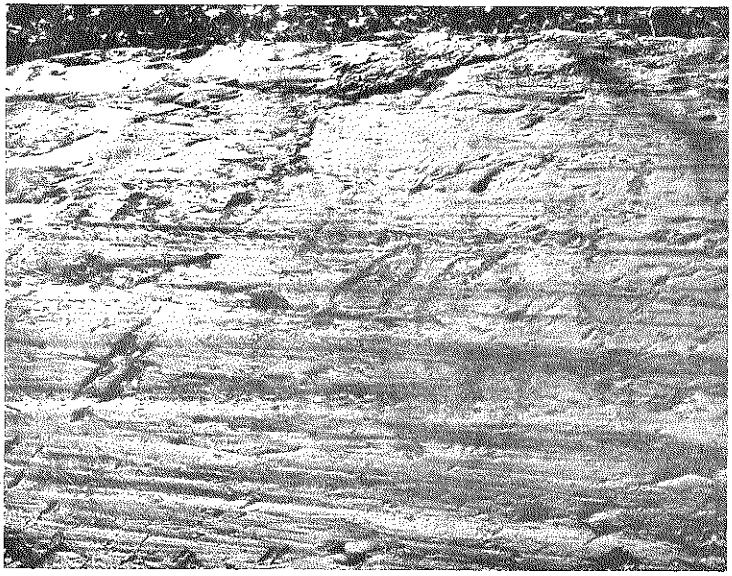
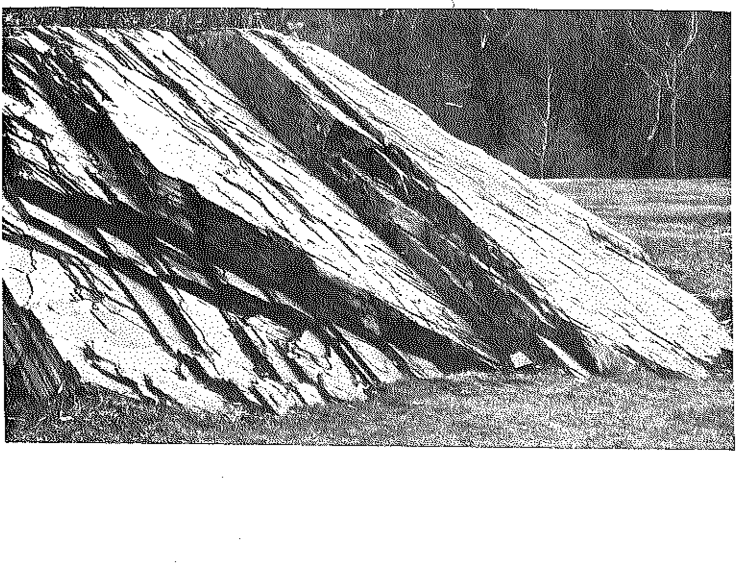


Figure 11. (top) Glacial scratches, grooves and chattermarks at the Claflin School play area.

Figure 12. (bottom) An outcrop of Cambridge Slate on the campus of Newton College of the Sacred Heart.





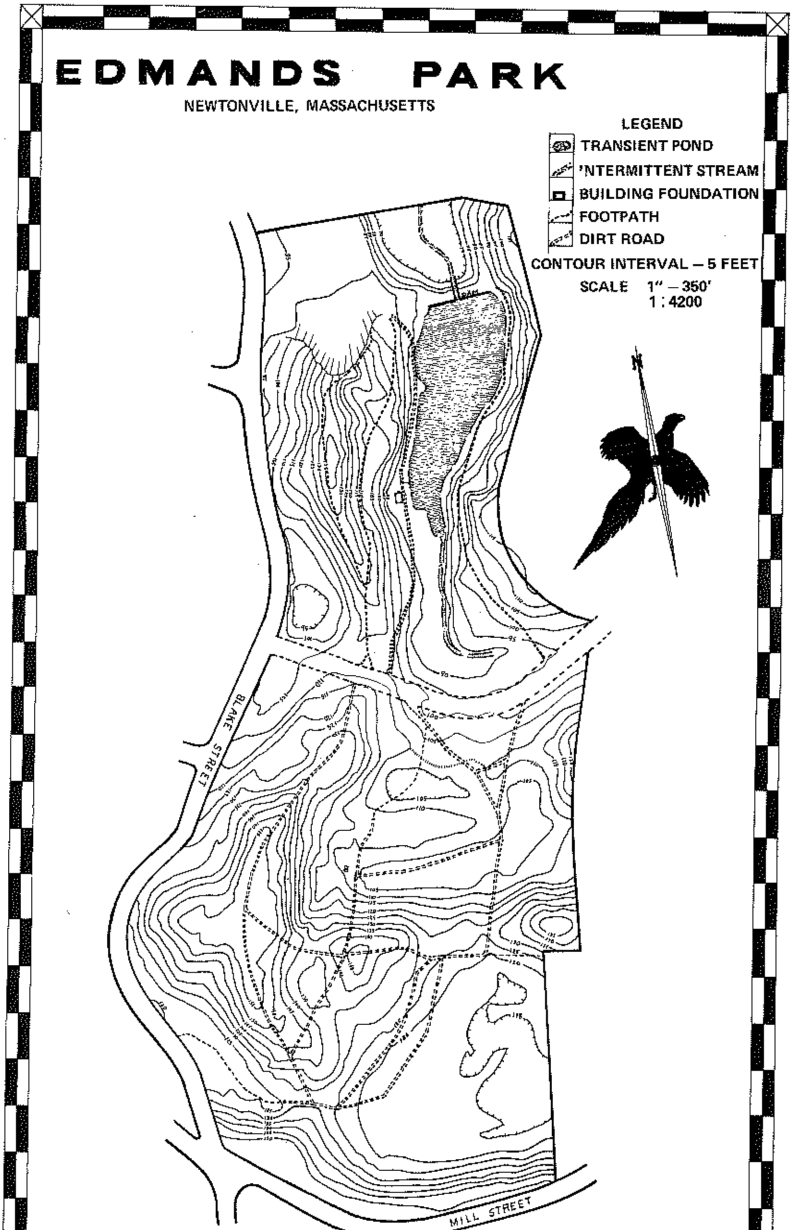


Figure 13. Edmands Park - Diagram by D. DeWolf and the Cabot School Fifth Grade Class of 1968.