

TRIP B

GEOLOGY OF ROUTE 93 FROM PINE HILL, MEDFORD, MASSACHUSETTS
TO ANDOVER, MASSACHUSETTS

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Introduction

The trip begins in the Middlesex Fells at Pine Hill, Medford. The Fells is a relatively uplifted area with up to 200' of relief. Cropping out on the Fells are the Lynn volcanics, Newburyport quartz diorite, Marlboro formation, Westboro quartzite, a volcanic breccia, and numerous dikes including the Medford diabase dike. Proceeding north, and leaving the Fells, one comes successively to the Reading granite (Dedham granodiorite ?), Salem gabbro-diorite (metalavas ?), Andover granite and associated metamorphic rocks, and the Merrimack quartzite. A generalized stratigraphic column, adapted from Emerson (1917, p. 17), Clapp (1921, p. 14-15), and LaForge (1932, p. 14-48), is shown below:

Triassic	Diabase dikes (Medford diabase dike)
Carboniferous	Andover granite Merrimack quartzite
Devonian	Lynn volcanics
Early Paleozoic	Salem gabbro-diorite complex
Precambrian (?)	Westboro and Marlboro

Portions of the Boston North, Lexington, Reading, Wilmington, and Lawrence quadrangles will be studied.

The Newburyport quartz diorite will be the first unit studied. The Newburyport is regarded as a portion of the Salem gabbro-diorite complex which includes three phases: Salem gabbro-diorite, Newburyport quartz diorite, and Dedham granodiorite. The complex is characterized by sudden changes in texture from coarse to fine and in composition from basic to acidic. LaForge (1932, p. 22) describes the unit in the following manner:

The (Salem gabbro-diorite rocks) are so intricately mixed, by both intrusion and intergradation, that it is impossible to map them separately except on a very large scale ...

No sharp lines can be drawn on the ground or in the laboratory between the rocks of these subgroups, and the inclusion of a mass of rock in one or another is often a matter of personal choice.

The origin of the rocks is still not clear particularly the changes in texture and composition. Clapp (1921, p. 21) proposed an origin for the rocks which relied on overall field relationships:

The upper part of the batholith is the most felsic... and is everywhere of granodiorite, which passes downward through quartz-diorite into gabbro-diorite, the staple rock of the batholith. This arrangement of the three sub-alkaline types accords with their respective densities, the uppermost, the Dedham granodiorite, being the lightest. It is doubtless the result of magmatic differentiation, which proceeded under gravitative control. The parent magma was doubtless basaltic and its differentiation is believed to have occurred in place through fractional crystallization.

LaForge (1932, p. 68) proposes a different variation of the magmatic crystallization hypothesis:

The differentiation must necessarily have taken place in a primary magmatic chamber that probably underlay the whole region. Gravitative fractionation may have been a considerable factor but the differentiation was also due partly to assimilation of the invaded rock. Both processes would tend to cause a progressive change in the composition of the parent magma which was basaltic at first toward the silicic end of the scale.

The rocks on the Fells have compositions corresponding generally to those of the Newburyport quartz diorite. The average rock consists of orthoclase, andesine-labradorite, hornblende and quartz with some pyroxene and epidote. The complex is dated as Early Paleozoic because it is non-conformably overlain by the Lynn volcanics which are thought to be Devonian in age.

A major portion of the Fells is composed of the Lynn volcanics. The volcanics are dated as Devonian on the basis of a lithologic correlation. LaForge (1932, p. 29) states that the Newbury volcanic complex is dated as Lower Devonian because of marine fossils (identity not specified) which were found in an intercalated calcareous shale. The Lynn volcanics resemble the Newbury volcanics in texture and composition and are, therefore, regarded as being of the

same age. At Pine Hill, Medford, which provides the best exposure of the unit, the rocks are typical pink to violet felsites with greenish phenocrysts of feldspar. The phenocrysts are generally euhedral to subhedral orthoclase or quartz. The groundmass is an intricately interlocked mixture of fine-grained quartz and orthoclase.

The Marlboro formation and Westboro quartzite as mapped by LaForge crop out on the Fells north of Spot Pond. The units as described by Emerson (1917, p. 31) are vague and poorly defined, consisting of several rock types including volcanics as well as quartzites. The exposures to be studied on this trip are generally of the volcanic type. The rocks show distinct stratification and are extremely fine grained. They are composed largely of orthoclase as determined by staining techniques. Parts of the unit may correlate with the Lynn volcanics. The unit is closely associated with a volcanic breccia (?). Unfortunately, the new road cuts are slightly to the east of the contact of the breccia with the surrounding rock.

The only other rocks occurring on the Fells are Triassic dikes. The most famous of these is the Medford diabase dike which crops out just north of Pine Hill, Medford. The dike reaches a maximum thickness of about 300' in the Pine Hill vicinity. The dike can be traced only two miles by its characteristic fine-grained feldspar weathering product. All traces of the dike are lost about 200 yards east of the highway in the woods. An interesting discussion concerning the weathering of the dike took place in the early 1930's. Some geologists such as Lane and Wolf (1932) believe the weathering is preglacial; others such as Billings and Roy (1933) believe the weathering has been post-glacial. An excellent early description of the dike was provided by Wilson (1901). The dike is essentially composed of large (6-8mm.) euhedral crystals of plagioclase (labradorite-andesine) intergrown with augite in a classic diabasic texture.

South of Route 128 rocks mapped by LaForge as Dedham granodiorite and Salem gabbro-diorite crop out. The rocks mapped as Dedham granodiorite are pink microperthitic microcline granites and syenites and are here simply described as Reading granite. The rocks mapped as Salem gabbro-diorite may correlate with dioritic rocks cropping out to the south on 128 which show definite volcanic structures. The rocks are on this basis described as metalavas. The granite is intrusive into the metalavas and is composed of microcline microperthite, plagioclase (albite-oligoclase) and quartz. The perthite is apparently of the replacement type since some of the grains are non-perthitic while others are almost completely replaced. The rock is highly fractured. Feldspar grains are commonly sheared and undulatory extinction is well developed. The surrounding metalavas show much evidence of faulting. The metalavas are composed of pyroxene, amphibole, and andesine. The texture is fine- to coarse-grained allotriomorphic granular. North of 128 the granite grades into syenite by loss of quartz.

Immediately north of 128 in the vicinity of the Ipswich River outcrops are scarce due to burial beneath a thick covering of glacial outwash. However, in Wilmington, elevations increase and outcrops of the Andover granite and associated metamorphic rocks can be studied in continuous exposure for over six-tenths of one mile. As the granite is approached, the grade of metamorphism increases. Hornblende-biotite schist, quartz-orthoclase-hornblende gneisses and migmatites are abundant. The original nature (probably sedimentary) and age of the metamorphics is not clear. The Andover granite is characterized by a white to gray color and a peculiar alternation of pegmatitic and aplitic layers. The granite is composed of microcline, quartz, muscovite and some albite. Locally biotite and garnet are abundant. The feldspar is not perthitic and there is little evidence of shearing as compared with the Reading granite. An augen texture is developed in the granite near its northern contact with the Merrimack quartzite. The granite is dated as Late Carboniferous since it intrudes the Merrimack quartzite. Clapp (1921, p. 20) states that the Merrimack quartzite is continuous with similar rocks near Worcester which were dated by fossils as Carboniferous. The Andover granite is probably close in time to the Chelmsford, Quincy and Rockport granites.

Road Log

The trip begins at the intersection of Route 93 and Route 28 at Pine Hill, Medford. Mileage begins at the first underpass on Route 93 going North. The trip will generally proceed north up the highway and then return south along the highway. Thus, we will not be required to cross the highway. Extreme caution is urged in examining the roadcuts because of the danger from falling rocks and traffic.

Mileage	Description
0.0	Intersection Rt. 93 and Rt. 28. First overpass on Rt. 93.
0.5	<u>Stop 1</u> - Outcrop of Medford diabase dike and of typical Newburyport quartz diorite. The dike shows the characteristic confinement of weathering to joint surfaces. Even near its contact with the diorite the dike is still coarse textured. Note the sudden changes in texture and in composition of the diorite. This is quite characteristic. Proceed North on Route 93.
0.9	<u>Stop 2</u> - Example of spheroidal weathering basalt

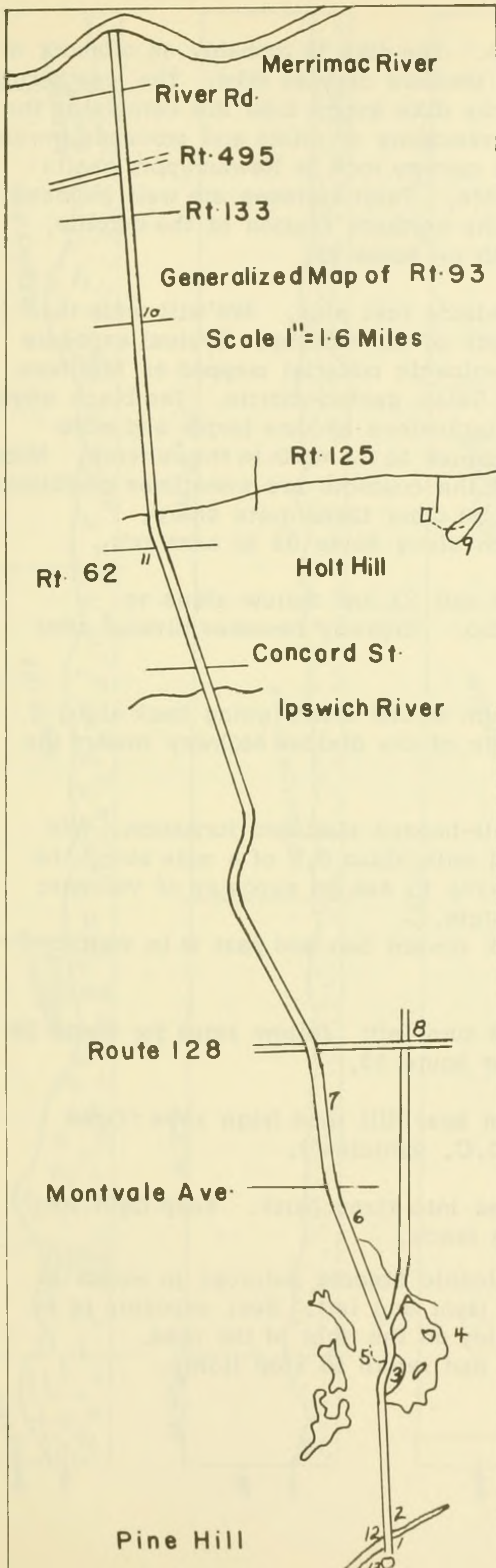


Figure 1.

Stop Locations and Descriptions

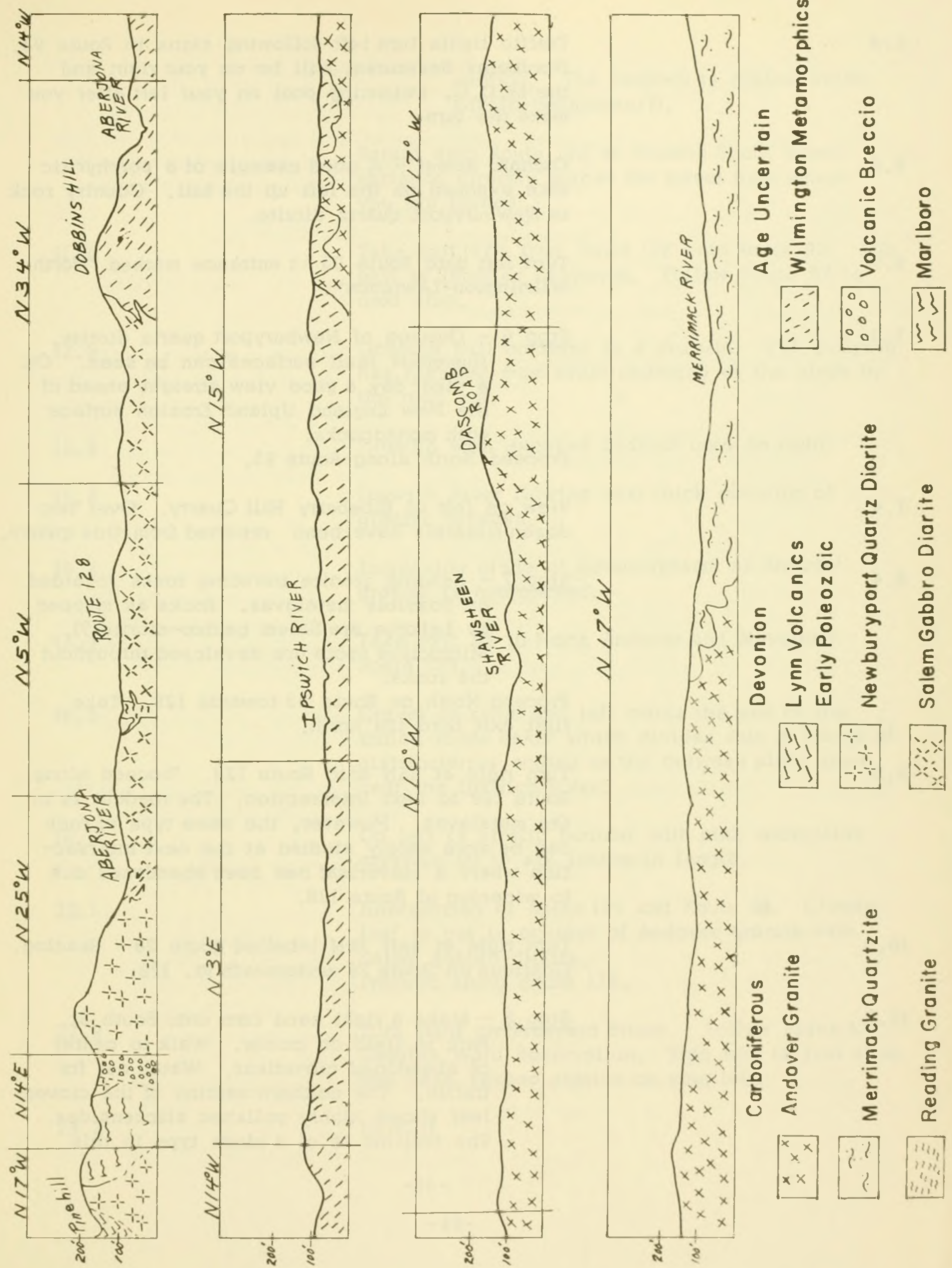
- Stop 1 - Newburyport Quartz Diorite and Medford Diabase Dike.
- Stop 2 - Newburyport Quartz Diorite and spheroidal weathering of basalt dike.
- Stop 3 - Marlboro? and Westboro
- Stop 4 - Marlboro?
- Stop 5 - Volcanic breccia well exposed in woods.
- Stop 6 - Newburyport Quartz Diorite
- Stop 7 - Reading Granite and Salem Gabbro-Diorite?
- Stop 8 - Salem Gabbro-Diorite? Intensive faulting
- Stop 9 - Lunch at Holt Hill, highest point in Essex County
- Stop 10 - Andover Granite
- If we can go to the Brox Trap Rock Quarry in the Dracut Diorite then stops 11, 12, and 13 will be omitted. The quarry is reached by continuing north on Route 93 past stop 10 to the Merrimack River and then turning left along Route 110 to Dracut.
- Stop 11 - Contact zone of Andover Granite with Wilmington Metamorphic Rocks.
- Stop 12 - Contact of Medford Diabase Dike, Lynn Volcanics, and Newburyport Quartz Diorite.
- Stop 13 - Lynn Volcanics intruded by Triassic Dikes.

dike. The dike is probably an offshoot of the Medford diabase dike. The weathering of the dike starts from the corners of the intersections of joints and proceeds inward. The country rock is Newburyport quartz diorite. Fault surfaces are well exposed in the northern section of the outcrop.

Proceed North on Route 93.

- 1.4 Stop 3 - Roadside rest area. We will walk the length of the outcrop. Typical exposure of volcanic material mapped as Marlboro and Salem gabbro-diorite. The black angular inclusions become larger and more numerous to the north in the outcrop. Note that the contacts are sometimes gradational and at other times quite sharp.
Proceed North along Route 93 to next exit.
- 1.7 Turn right at exit 22 and follow signs to Middlesex Zoo. Highway becomes divided after Zoo.
- 3.3 Make a U turn around rotary going back along the other side of the divided highway toward the Zoo.
- 3.4 Stop 4 - Well-bedded Marlboro formation. We will walk about 0.2 of a mile along the outcrop to see an exposure of volcanic breccia.
Proceed back toward Zoo and past it to traffic lights.
- 4.3 Traffic lights turn left; follow signs for Route 28 not signs for Route 93.
- 5.0 Turn right on Bear Hill road (sign says "Open only to M.D.C. vehicles").
- 5.2 Road branches into three parts. Keep right following white fence.
- 5.4 Stop 5 - Volcanic breccia outcrops in woods to the right and left. Best exposure is in valley on the right of the road.
Turn around and return to stop lights.

Figure 2. CROSS SECTION ROUTE 93 PINE HILL, MEDFORD TO LAWRENCE



- | | | |
|----------------------|----------------------------|-------------------------|
| Carboniferous | Devonian | Age Uncertain |
| Andover Granite | Lynn Volcanics | Wilmington Metamorphics |
| Merrimack Quartzite | Early Poleozoic | Volcanic Breccia |
| Reading Granite | Newburyport Quartz Diorite | Marlboro |
| | Salem Gabbro Diorite | |

- 6.4 Traffic lights turn left following signs to Route 93. Nordbergs Restaurant will be on your right and the M.D.C. swimming pool on your left after you make the turn.
- 6.6 Orchard Street - A good example of a porphyritic dike exposed on the left up the hill. Country rock is Newburyport quartz diorite.
- 6.7 Turn left onto Route 93 at entrance marked "North Wilmington-Lawrence".
- 7.3 Stop 6 - Outcrop of Newburyport quartz diorite. Numerous fault surfaces can be seen. On a clear day a good view straight ahead of the New England Upland Erosion surface with monadnocks.
Proceed North along Route 93.
- 7.4 View on left of Blueberry Hill Quarry. Over two dozen minerals have been reported from this quarry.
- 8.4 Stop 7 - Reading granite intruding rocks regarded as possible metalavas. Rocks as mapped by LaForge are Salem gabbro-diorite(?). Microcline spots are developed throughout the rocks.
Proceed North on Route 93 towards 128. Take first exit onto 128 north.
- 9.0 Turn right at 25N onto Route 128. Proceed along Route 128 to next intersection. The roadcut is in the metalavas. However, the same type of rock can be more safely studied at the next intersection where a cloverleaf has been abandoned due to widening of Route 128.
- 10.0 Turn right at exit 36N labelled Route 28 - Reading. Continue on Route 28 underneath Rt. 128.
- 10.3 Stop 8 - Make a right hand turn onto South St. Park in field on corner. Walk to center of abandoned cloverleaf. Watch out for traffic. The northern section of the cloverleaf shows highly polished slickensides. The faulting is of a block type in this

section, The bedrock is typical Salem gabbro-metalavas(?).

Return onto Route 128 at Woburn South Shore entrance directly across the street from where you are parked.

- 11.2 Take exit 37N from Route 128 onto Route 93. The exit is labelled Lawrence. Follow Route 93 to next stop.
- 12.5 Dobbins Hill on right is a drumlin. The gullying has resulted from oversteepening of the slope by the road cut.
- 12.9 Drumlin with exposed bedrock core on right.
- 15.2 Ipswich River flowing over thick covering of glacial outwash.
- 16.2 Increasing grade of metamorphism as Andover granite is approached.
- 17.4 Take exit 29 to North Andover and Haverhill Route 125.
- 18.3 Gravel on right and left marks the end of the Indian Ridge esker which divides into a series of distributaries ending in the outwash plain seen near the Ipswich River.
- 19.6 On left is erratic boulder with pink microcline crystals up to six inches in length.
- 20.1 Intersection of Route 125 and Route 28. Clover-leaf is cut in contact of Andover granite with Salem gabbro-diorite.
Proceed along Route 125.
- 22.9 Turn right on Prospect Street. Follow signs for Charles Ward Reservation. This turn is just after you pass Texaco station on your left.
- 23.2 LUNCH

Park on right for reservation. We will walk to the top of the drumlin called Holt Hill. Holt Hill is 420' high and is the highest point in Essex County. Mt. Monadnock is visible from the fire-tower on a clear day. On the adjacent drumlin, Boston Hill (385'), MIT has constructed a radar station,

Return along Route 125 to Route 93,

28.6

Left hand turn onto Route 93. Sign labelled Salem-Lawrence.

29.2

Stop 10 - Outcrop of Andover granite in middle of highway. Watch out for traffic. The outcrop illustrates the distinct alternation of pegmatitic and aplitic layers characteristic of the granite. Garnet is abundant in many of the finer-grained layers.

At the time this is written it is not known if we will be able to visit a quarry in the Dracut diorite. The quarry is of interest since nickel was once mined there. On the assumption that we will be able to visit the quarry and for those who may be able to travel there on their own, directions are given to the quarry.

31.4

Shawsheen River - a tributary of the Merrimack River.

32.0

Exit 30 to Dascomb Road. Andover granite well exposed in road cuts under highway. If we do not go to the quarry we will make a U turn here and go back along 93 towards Boston.

38.4

Cross Merrimack River and turn right at exit 34. Follow traffic circle until you come to sign for Route 110 - Lowell. Follow Route 110 along the Merrimack River towards Lowell.

42.2

Right turn at Brox Trap Rock Quarry.

Return along Route 110 to Route 93 and then south on Route 93 towards Boston.

52.7

Stop 11 - Intersection of Route 62 and 125. Con-

tact zone of Andover granite with metamorphics of uncertain origin.

57.0 Overtaken synclinal structure shown on right in tuffs and quartzites.

63.0 Stop 12 - Contact of Medford diabase dike with Newburyport quartz diorite. Slightly to the south of this contact, the contact of the Lynn volcanics with the Newbury quartz diorite can be observed. The relationship here suggests the diorite is younger than the volcanics unless overturning has occurred.

63.2 Stop 13 - Excellent exposure of Lynn volcanics cut by numerous basalt dikes.

TRIP B

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