

Contrib. A.S. Warthin Jr.

EXCURSION OF THE NEW YORK STATE GEOLOGICAL ASSOCIATION

IN THE NEW YORK CITY REGION

May 12th - 13th, 1933

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COLUMBIA UNIVERSITY

(Note: Much of the region is described in Guidebook 9, New York City and Vicinity, by C. P. Berkey, G. I. Finlay, R. J. Colony and others, to be issued by the International Geological Congress, Xvith session, Washington, 1933. The following guide has made use of the material in that guidebook.)

INTRODUCTION

The region to be visited in this excursion is one including parts of several geological and physiographic provinces (see Figure 1). The first stops are to be made adjacent to the Highlands of the Hudson, where the resistant crystalline rocks of the Reading prong of the New England Upland have been dissected by the superimposed Hudson River. Northwest of the Highlands, these crystalline rocks are in faulted contact with the folded Paleozoic sediments of the Hudson Valley extension of the Folded Appalachians. The Catskill Mountains farther northwest are the northern end of the Appalachian Plateau.

East of the Hudson River from Peekskill to New York City, the meta-sediments lie in the Manhattan Prong of the New England Upland that terminates on Staten Island, New York City. To the west of the Hudson is the Triassic Lowland margined on the east by the Palisades, the river occupying a subsequent valley in the underlying, gently westward-dipping, relatively non-resistant basal Triassic sediments.

The geologic column and history of each of these parts of the region will be treated separately as the route traverses each area.

ITINERARY: NEWBURGH TO PEEKSKILL

The first of the route maps (Figure 2) shows the course of the excursion from Newburgh to New York City. The first stops are on the northwest border of the Highlands at Snake Hill and Cornwall. The section in this district includes an older series of crystalline gneisses and Schists, the Pochuck, that have been intruded by younger granites such as the Storm King and Canada Hill granites; these rocks are Pre-Cambrian.

In some localities they are unconformably overlain by the Cambrian Poughquag quartzite (600 feet thick), the Cambro-Ordovician Wappinger limestone (about 1000 feet) and the Hudson River phyllite (a few thousand feet thick). Along the route of the excursion, the sediments are in fault contact with the Pre-Cambrian crystallines

Stop 1. Snake Hill is just southwest of Newburgh along State Highway 32. The locality has an outlier of resistant Pochuck gneiss that is an isolated remnant of a once-continuous crystalline mass that was overthrust northward from the Highlands upon the Hudson River beds (see Figure 3). This overthrust was cut later by a normal fault that transects the eastern side of the Hill and brings the Hudson River beds in contact with the older Wappinger limestone on the east.

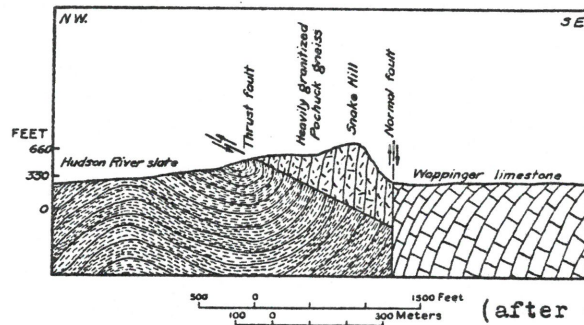


Figure 3. Section through Snake Hill.

Thus there are two faults in the section. The older overthrust might be from the evidence in this section of Taconic (post-Ordovician, pre-Silurian) age; deformation of this age is known east of the Catskill Mountains at Kingston. But from the fact that similar faults in the immediate region affect Devonian sediments, it is inferred that the thrust on Snake Hill is post-Devonian. This faulting may have occurred in the Acadian disturbance (immediately post-Devonian) or the Appalachian revolution (post-Permian). Inasmuch as there are no sediments younger than Devonian in eastern New York north of the Highlands, it is not possible to learn with assurance which period of deformation is represented; perhaps both affected the region. The faulting is thought to have occurred in the Appalachian revolution.

The fault that cuts the gneiss on the east side of the hill is believed to have occurred in the Palisade disturbance (post-Triassic) because similar normal faults of that age occur south of the Highlands.

Stop 2, southwest of Cornwall-on-Hudson

is a locality where a thrust fault similar to that at Snake Hill brings the crystalline rocks over the Hudson River phyllites.

Between stops 2 and 3, the latter at the east end of Bear Mountain Bridge, north of Peekskill, the crystalline rocks of the Highlands are passed in many exposures. Most are of the granites of the Storm King and Canada Hill formations. At stop 3, the Canada Hill granite has been intruded by younger pegmatite dikes.

The course of the Hudson River through the Highlands is believed to be that of a stream superimposed on the crystalline rocks from a cover of sedimentary rocks that has been removed. Recent studies suggest that Cretaceous sediments once transgressed the area, and that the ancient Hudson that flowed consequently on the plain that was exposed with the retreat of the Cretaceous sea was "let down" on the "barrier" of crystallines. The less resistant sediments have been removed, but the more resistant granites and gneisses remain as the Highlands of the Hudson.

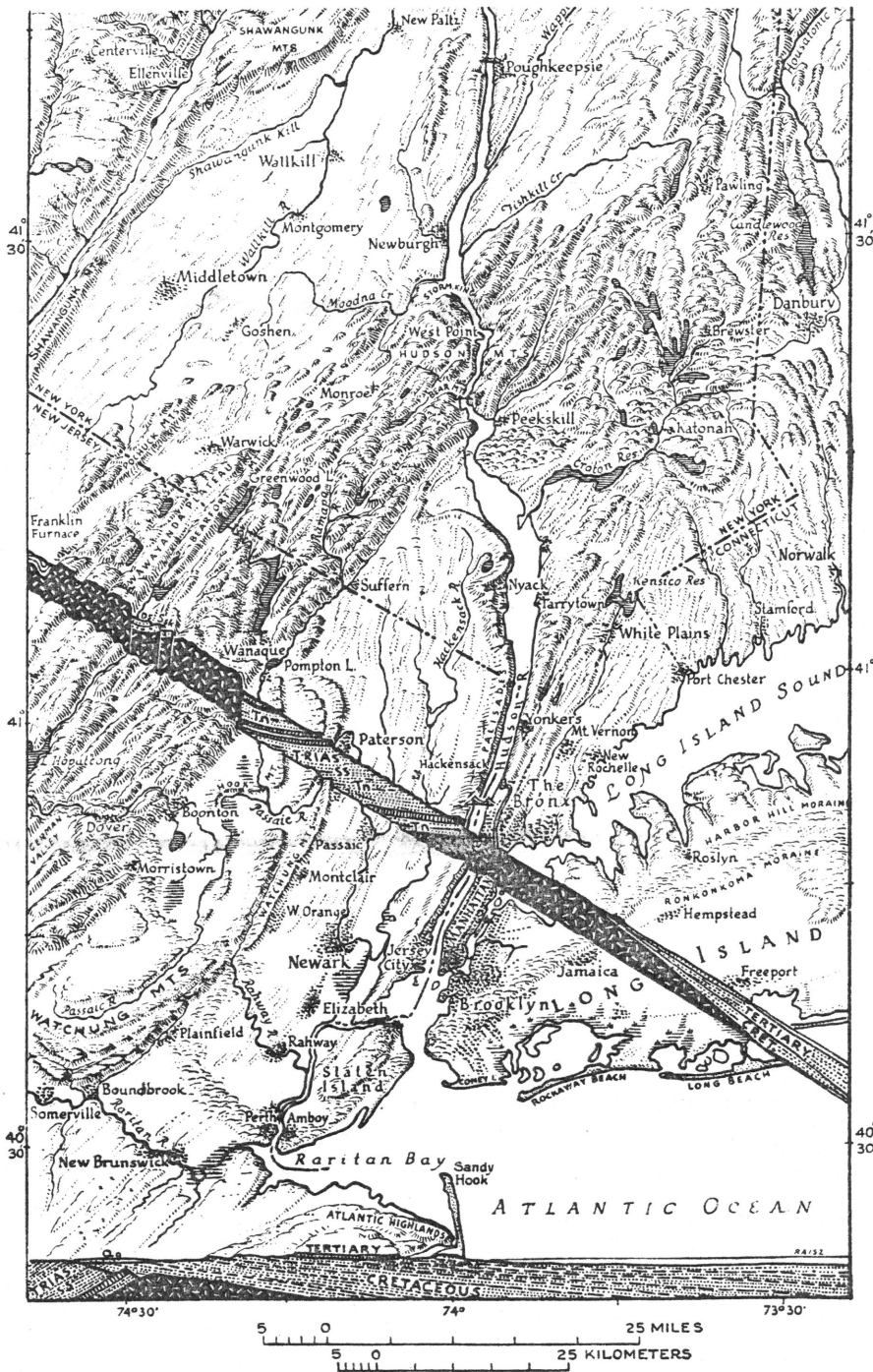
Below the Highlands, the river has become adjusted to the resistance of the belts of rock that it traverses. This subsequent drainage will be discussed more fully in connection with the stop on the top of the Palisades at Edgewater (stop 7).

lit-par-lit injections and dike-like and sill-like intrusions that commonly 60 per cent of it is igneous. The thickness is unknown. The overlying Inwood marble is a massive, strongly-bedded, coarsely-crystalline magnesian limestone, the upper part of which is generally impure and micaceous. It is about 700 feet thick in New York City. The formation is locally cut by pegmatite dikes, but as a whole is quite free of igneous matter. The contact with the Manhattan schist is a transitional one with interbedding of the two sorts of rock.

Figure 1. Block Diagram of the region from Newburgh to New York City (by Raisz after Berkey).

From Peekskill to New York City the route traverses a region underlain by the crystalline Fordham gneiss, Inwood marble and Manhattan schist; the formations will be examined in Manhattan and The Bronx, New York City. They are believed to be of Pre-Cambrian age, though some have thought the younger two to be of early Paleozoic age.

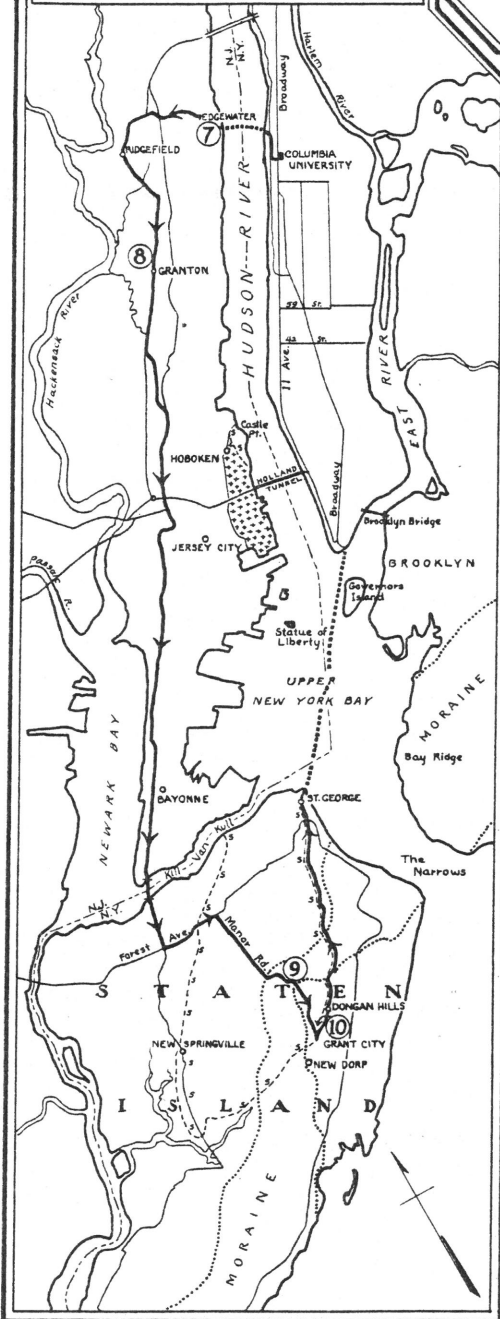
The Fordham gneiss is typically a black and white banded, quartzose and granitic gneiss, in places schistose, and so thoroughly impregnated with pegmatitic and granitic matter in the form of



# FIGURE 6 ROUTE MAP EDGEWATER TO STATEN ISLAND

Scale 0 1 2 3 4 5 Miles

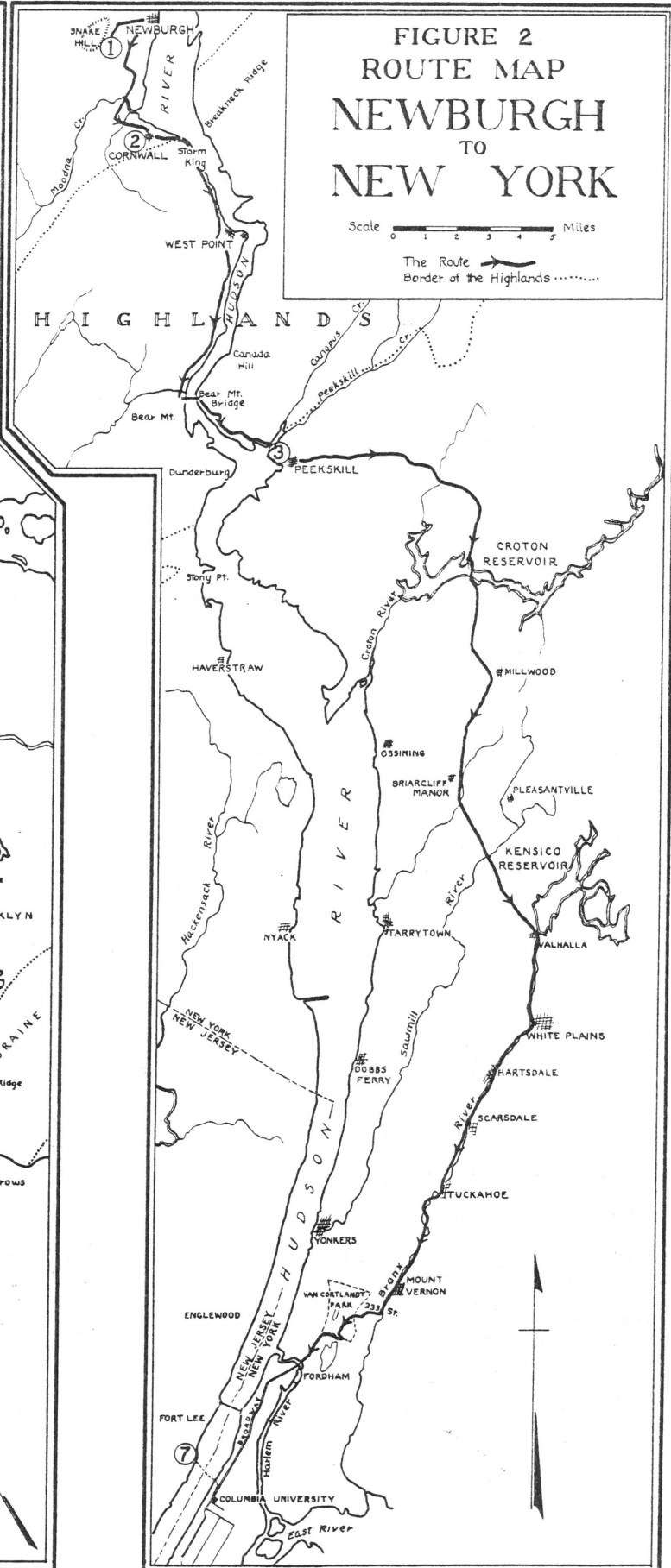
- The Route
- Other Roads
- Ferries
- Margin of Serpentine
- Margin of Terminal Moraine
- Manhattan Schist in New Jersey



# FIGURE 2 ROUTE MAP NEWBURGH TO NEW YORK

Scale 0 1 2 3 4 5 Miles

- The Route
- Border of the Highlands



(3)

4239

The Manhattan schist is a dark, streaked, strongly micaceous, coarsely crystalline, markedly foliated rock, locally carrying large quantities of quartz, feldspar and garnet, and exceeding 3000 feet in thickness. It is filled with irregular masses of pegmatitic material and pegmatite dikes and contains a few layers of hornblende schist that are believed to represent metamorphosed sills of basic igneous rock intruded prior to the foliation of the rock.

This series of crystalline rocks is believed to have had the following history. Fine clastic sediments, shales, were deposited in a sea; the source of the materials and character of the underlying rocks are unknown. These shales were succeeded by limestones and later by more shales, the three constituting the darker part of the Fordham, the Inwood and the Manhattan. Basic igneous rocks were intruded into these sediments during or after their deposition (and are now represented by the hornblende schists).

These sediments were buried under a thick cover of since-removed sediments, and the region was affected by the intrusion of large quantities of granitic material that thoroughly permeated the shaly beds; these include the light-colored injections in the Fordham. The intrusion was accompanied by or followed by intense regional metamorphism that folded incompetent beds and produced a crystalline, foliated lithology.

Subsequent to this deformation, later igneous rocks were intruded along joints and planes of weakness; and are now represented by the undisturbed pegmatites that will be seen along Harlem Speedway in Manhattan. The time of the deformation cannot be determined with assurance, but the foliation presumably was developed in Pre-Cambrian time, for similar foliated Pre-Cambrian rock lies beneath Cambrian quartzite north of the Highlands.

The rocks had been eroded and peneplaned prior to the deposition of the late Triassic sediments. The later history of the region will be discussed subsequently.

#### ITINERARY: MANHATTAN AND THE BRONX

On reaching northern Manhattan, the cars will be parked near the Dyckman Street station of the Interborough subway system, and the group will transfer to buses.

Stop 4, at an excavation southeast of the plaza at the east end of the Washington (181st Street) bridge over the Harlem River in The Bronx, is an exposure of the characteristically lit-par-lit injected and contorted Fordham gneiss, the oldest formation in the city. The route then will pass exposures of the same formation to the north as far as 207th Street bridge. The subsequent valley in westward-dipping Inwood marble is an arm of the sea that has been

deepened to make it navigable.

Stop 5, at 204th Street and Nagle Avenue, Manhattan, is an excavation in these westward dipping Inwood marble beds; a large pegmatite dike cuts across the structure. From an examination of quartzitic beds above the west face of the excavation, one gains an impression of the more competent character of such strata. The surface of the hill is strewn with boulders of glacial drift, and the marble has locally disintegrated to sand. The varying resistances of the beds have produced miniature subsequent monoclinical ridges and valleys on the weathered surfaces.

Stop 6, along the Harlem Speedway, is beneath the same Washington bridge that was crossed earlier in the afternoon. The schist is the Manhattan, and in addition to the pegmatitic material permeating the formation, there are remarkably parallel pegmatite dikes that dip gently to the west. These undisturbed pegmatites reach a thickness of ten feet, and frequently show in the finer crystalline texture of their periphery the effect of having been chilled by cooler wall rocks. The east end of Figure 5 gives a section such as that across the Harlem River from stop 6 to stop 4.

The buses will return to Dyckman Street. Dinner will be held at the Faculty Club, Columbia University (see inset, Figure 4), at 7:00. The University may be reached from Dyckman Street subway station by taking the downtown train to 116th street; Times Square and Pennsylvania Station are farther south at 42nd and 32nd streets, respectively.

If it is desired, the cars may be driven west to Riverside Drive, and southward to the Columbia University district to be garaged; there are a number of garages east of Broadway south of 125th street.

The Faculty Club is at 117th Street and Morningside Drive.


#### ITINERARY: PALISADE DISTRICT

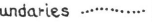
Saturday morning, May 13th, will be devoted to a study of the rocks of the Triassic Lowland across the Hudson River in New Jersey. The cars will leave the University at 9:00 in the morning, and cross to Edgewater on the 125th Street Ferry. Ascend to THE TOP of the hill and park cars on the right, then walk down hill to the hairpin turn on the highway. The group will convene at this point, stop 7, at 9:45. If it seems advantageous, the cars may be driven directly to the Palisades from the garages.


Be Conscious of the fact that you are on a main travelled road. Don't be careless.


# FIGURE 4 ROUTE MAP OF MANHATTAN


Scale 0 5000 Feet


The Route 

Geologic Boundaries 

Faults 

Fordham Gneiss 

Inwood Limestone 

Manhattan Schist 

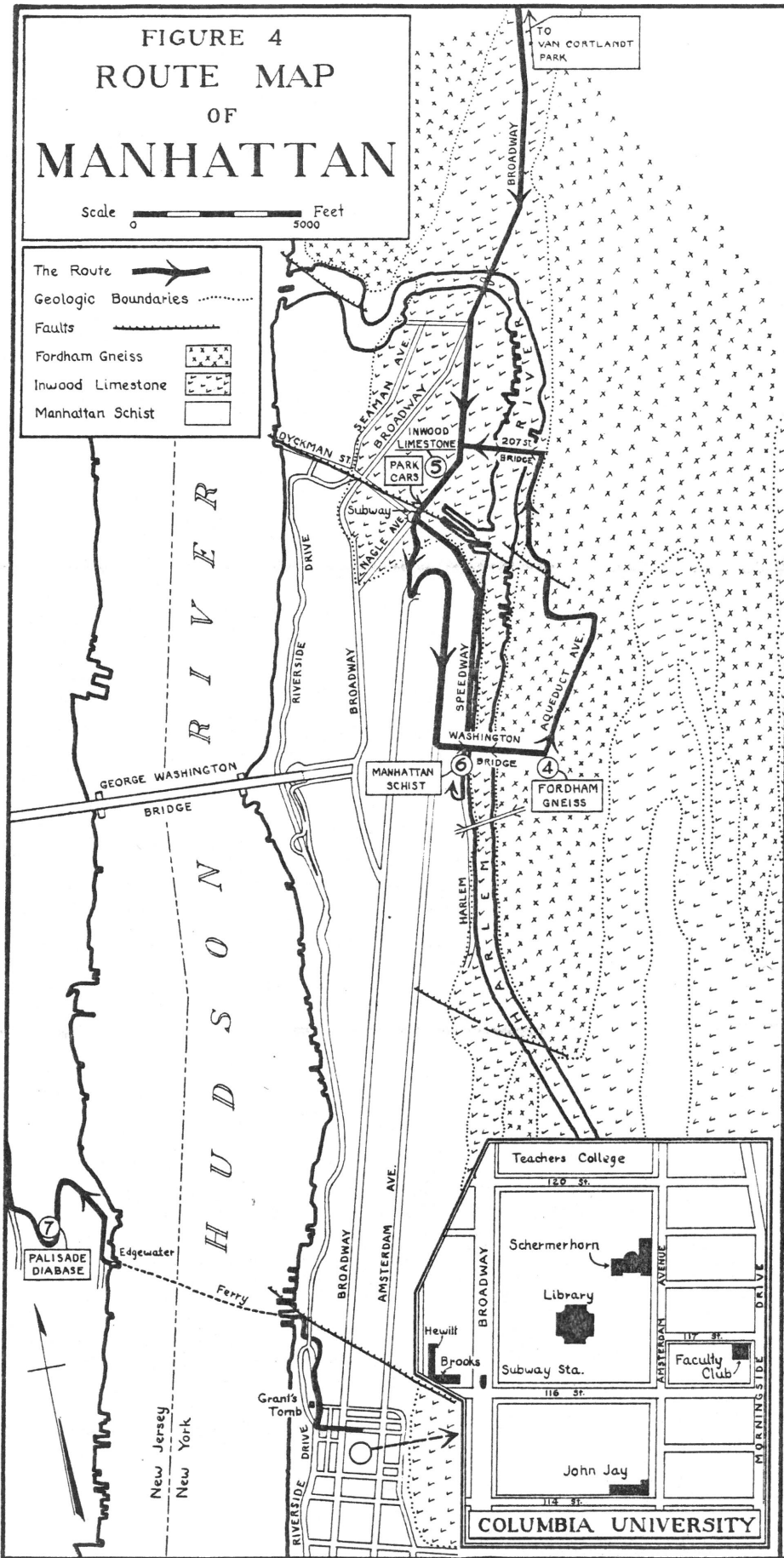
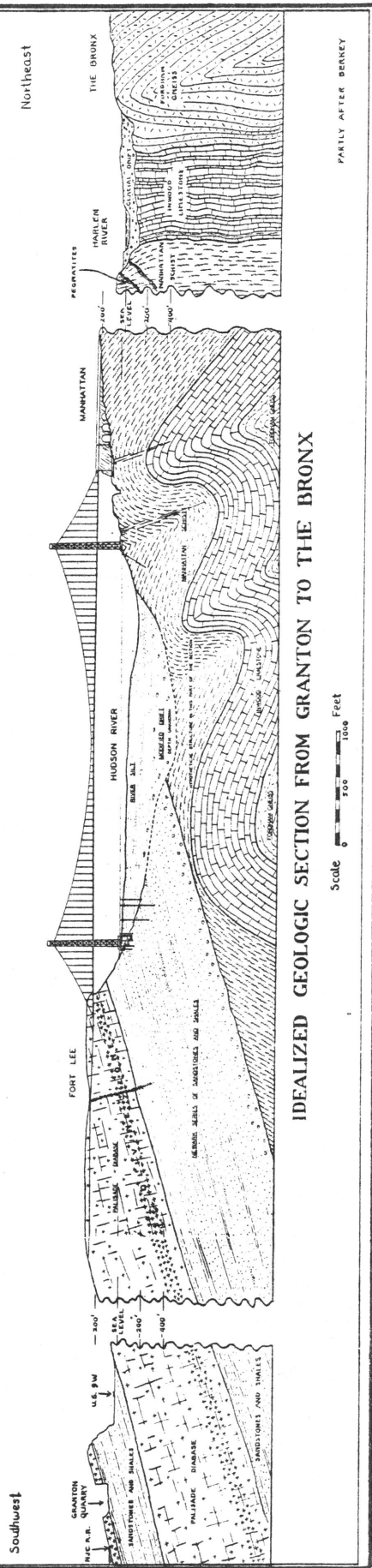


FIGURE 5



IDEALIZED GEOLOGIC SECTION FROM GRANTON TO THE BRONX

Scale 0 500 1000 Feet

Stop 7. Hairpin turn on State Road above Edgewater, New Jersey. (See west end of Figure 5). The first concern will be with the Palisades diabase. This sill was intruded into the lower part of the Triassic Newark sediments in latest Triassic or early Jurassic time. It is about 700 feet thick at Edgewater, and overlies a few hundred feet of reddish arkosic sandstones that rest unconformably on the crystalline rocks such as occur in Manhattan, though the contact is beneath the river. These are the basal sediments of the Stockton formation at the base of the Newark series. The sediments and included sill dip gently to the west at an angle of about seven degrees. The river occupies a subsequent valley along the weak belt of the basal Newark sandstones with the resistant crystalline rocks on the east and the diabase on the west.

After the intrusion of the magma that was to form the diabase, the first parts to be cooled must have been those adjacent to the intruded sediments; at the lower contact, not exposed at this stop, the igneous rock is of extremely fine texture. Later, there were certain minerals such as olivine that crystallized from the magma while the most of it was still fluid. These minerals, being heavier than the surrounding liquid, settled toward the bottom and formed a layer in the sill above the first cooled part adjacent to the chilled bottom contact. The rest of the magma continued to crystallize until finally the coarser-textured center of the intrusive body was bordered below by the olivine concentrate and extended upward to the first chilled upper part of the mass.

Thus there is an olivine zone of varying thickness that can be recognized along the face of the Palisades, and this zone being composed of more readily weathering rock forms a terrace that is evident along the rock. Spheroidal boulders may be seen forming as a result of the weathering along joints that cut the rock. Small normal faults may also be recognized with downthrown side to the east. The columnar structure of the diabase is also apparent, and being at right angles to the cooling surface, the joints tend to dip at an angle of seven degrees from the vertical and toward the east.

From the top of the hill, one gains a fine view of the city of New York, which is built in its higher parts on a peneplane, the Fall Zone peneplane, that dips gently to the southeast beneath a cover of Cretaceous sediments on Long Island. The older peneplane on which the Triassic was deposited is largely obscured by the buildings on the east side of the Hudson, but as one looks northward beneath the new George Washington Bridge he can project the basal Newark sediments and Palisade sill to the level of the top of the Palisades and upper Manhattan and conceive of a belt of non-resistant rocks that has been reduced by the river; see Figure 5, west end.

The Hudson River is a drowned river, a long arm of the sea that occupies this subsequent valley. The ancient gorge has been filled with sediments that may have a depth of as much as a thousand feet at New York City.

Following the peneplanation of the crystalline rocks during early Triassic time, a great series of fluvial and lacustrine sediments, perhaps exceeding 20,000 feet in thickness, was deposited to the east of the Appalachian mountains that had been folded and elevated at the end of the Paleozoic. Lavas were extruded and buried in these sediments and are represented in the Orange and Watchung mountains to the west of the region that we traverse. And at the same time, intrusions such as the Palisades sill and a higher sill that will be examined at Granton were intruded into the sediments. During or following Triassic time, normal faults broke the sediments into a series of blocks that were tilted gently to the west. These block mountains were reduced and peneplaned before the Late Cretaceous (Gulfian), for sediments of that age mantle the peneplane to the south. With the withdrawal of Cretaceous seas, consequent streams took courses on the gently sloping plain that had been formed; the ancient Hudson was one of these. With further uplift of the region, the superimposed river took a course that is not the present one, but one which breached the Palisades near Sparkill, New Jersey, and passed southward to the west of the present Palisades ridge in the Hackensack River region. More recent erosion along the weak lowest Newark sediment belt has resulted in the capture of this ancient Hudson's headwaters and the diversion of the water through the present course.

From the top of the Palisades, the route proceeds westward to Ridgefield and southward along the east side of the Hackensack Meadows to Granton. About a half mile from the top of the Palisades, west of where the street car tracks cross the state road, the route crosses a small subsequent valley along one of the fault zones that have displacement down to the east. The road then descends the long dip slope on the back of the Palisades sill to the Hackensack River valley eroded in Newark non-resistant shales. South of Ridgefield, a prominent hill comes in view on the right of the road.

Stop 8. Belmont-Gurnee Stone Quarry, Granton, New Jersey. This hill has been formed because of the resistance of a sill intruded into the sediments at a little higher horizon than that of the Palisades sill; this intrusive mass is of small lateral extent.

The large quarry on the west face of the hill displays the contact of the igneous rock, essentially a basalt, with the underlying sandstones and shales of the Newark series. The contact can be more readily examined

farther to the north in the quarries. The black shales contain the only abundant fossils that occur in the New York city region, specimens of the ostracod-like crustacean, *Estheria ovata* Lea (see Figure 7.), about a third of an inch in length; they abound on some of the bedding planes. From the top of the hill, one can see the Watchung and Orange mountains far to the west, cuestas of westward dipping Triassic extrusive rocks. To the southeast, rising in the meadows, is Snake Hill (another one!), an intrusive, stock-like igneous mass.

The route follows southward to Hudson Boulevard, and continues along this road through Jersey City and Bayonne to the Kill van Kull bridge to Staten Island, New York City.

#### ITINERARY: STATEN ISLAND

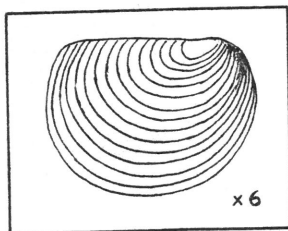
The route follows Forest Avenue and Manor Road to Todt Hill Road.

Stop 9 is on the top of the terminal moraine of the Wisconsin glacier of Pleistocene age west of Dongan Hills. To the left, the moraine swings eastward across the narrows at the lower end of New York Harbor to form the backbone of Long Island. The barrier beaches of Coney Island and Rockaway Beach are on the south margin of the island. In the foreground, outwash plains extend into a small driftless area that will be visited next. The plain beyond is bordered toward us by a sea cliff; it is presumably underlain by Cretaceous sediments, for the drift to the south contains Cretaceous plant fossils; none of the Cretaceous is exposed on Staten Island. But a cross the lower bay in the distance is Sandy Hook projecting northward from the Cretaceous and Eocene sediments of the Atlantic Highlands. The terminal moraine continues southward on the right.

Continuing on the road to Grant City, a quarry in the Staten Island serpentine will be evident on the right, and farther along, the serpentine is exposed on each side of the road. The route continues to the Richmond Road and turns sharply to the left.

Stop 10, west of the Richmond Road in Grant City, gives a good exposure of the Staten Island serpentine. The weathering of this rock has produced limonite; locally this iron-bearing rock was an important source of iron in earlier days. The serpentine has been formed as a result of the alteration of basic igneous rock, perhaps basalt. Occa-

Figure 7.  
*Estheria ovata* Lea  
(after Jones)



sionally the serpentine contains minerals that have survived from the earlier history. The formation is of pre-Cambrian age, and is intrusive into the Manhattan schist, although none of the schist occurs on Staten Island. The contact has been well exposed at Castle Point, in Hoboken, New Jersey, and there have been exposures on Manhattan, though all are now obscured. The Staten Island serpentine is thus an alteration product of a youngest Pre-Cambrian formation in the New York City area.

This concludes the excursion. We have made rather brief examination of each of the geologic formations that comprises any considerable part of the New York City region.

From this point, New York City may be reached by continuing northward on Richmond Road to Saint George; the ferry trip from there to the Battery gives one of the finest views of the skyline of the lower part of the city. A more direct route to points up-state is to return by way of Kill Van Kull bridge to Hudson Boulevard, and continue northward on United States Highway 9W from Ridgefield.

A few of the more important papers that deal with the geology of the region are the following:

- Balk, R. Structure and Correlation of the Metamorphic Rocks of Southeastern New York: National Acad. Sci., Proc., Vol. 18, pp. 618-630 (1932)
- Balk, R. The Cortland Series: Neues Jahr., Beilage Bd, 52, .Abt B, pp. 243-308 (1927)
- Berkey, C. P. Geology of the New York City (Catskill) Aqueduct: N. Y. S. M., Bull. 146, Berkey, C. P. and Rice, Marion. Geology of the West Point Quadrangle: N. Y. S. M., Bull. 225-226.
- Colony, R. J. Some Problems of the Schunemunk Area: N. Y. S. M., Bull. 267, p. 26 ff.
- Fettke, C. R. The Manhattan Schist of Southeastern New York: N. Y. Acad. Sci., Annals, Vol. 23, pp. 193-260 (1914)
- Holzwarsser, F. Geology of Newburgh and Vicinity: N. Y. S. M., Bull. 270.
- Johnson, D. W. Stream Sculpture on the Atlantic Slope: Columbia Univ. Press (1931).
- Lewis, J.V. Palisade Diabase of New Jersey: American Jour. Sci., 4th ser., vol. 26, pp. 155 - 162 (1908)
- Merrill, F. J. H. and others. New York City Folio: U. S. G. S., Folio 83 (1902)
- Sharp, Henry S. A pre-Newark Peneplane and its bearing on the origin of the Lower Hudson Valley: American Jour. Sci., 5th ser., Vol. 18, p. 509ff (1929).

Guidebook 9, International Geological Congress, Washington, 1933 (by C. P. Berkey, R. J. Colony, G. I. Finlay and others).