SEDIMENTARY ENVIRONMENTS IN THE NEWARK BASIN IN NEW JERSEY AND CONTIGUOUS NEW YORK

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INTRODUCTION

As Manspeizer (1988) noted "these are extraordinary times for Triassic-Jurassic researchers of the Atlantic passive margins. Extensive field studies on the African and North American plates during this past decade have yielded a wealth of new data and ideas about rift basins and the origin of passive margins, that but a few years ago would have seemed like childish speculation.

New surface and subsurface basins have been identified, fossils abound in strata that only recently were considered barren, oil exploration is being pursued actively in continental strata of the Richmond - Taylorsville, Sanford and Newark basins, Late Triassic marine strata have been identified in Georges Bank off the coast of Massachusetts, and the roles of wrench tectonics, successor basins and listric normal faults have challenged the classical view that these are simple extensional basins". "Geologic data from the Atlantic passive margins record that continental rifting of central Pangaea occurred during the Late Triassic - Early Jurassic (Liassic), and that sea-floor spreading probably began no later than the Middle Jurassic."

The Newark Supergroup is composed of Late Triassic to Early Jurassic continental sedimentary rocks and interbedded basalts that crop out in a series of elongated basins along the eastern margin of North America (Froelich and Olsen, 1985).

The following sections from Friedman, Sanders, and Martini, (1982, p.44-49) provide background on the Newark basin and their basin-filling strata.

NEWARK BASINS AND THEIR BASIN-FILLING STRATA

Since the beginning of the nineteenth century the Newark rocks of eastern North America have engaged the attention of many geologists. Perhaps more than with any other single large suite of rocks, interpretations of the Newark strata have been closely controlled by the status of ideas prevailing within the fabric of geology. In many ways the changing ideas about the Newark strata have paralleled the intellectual growth and development of the science of geology in the United States.

Throughout all these intellectual developments the Newark rocks have been linked to the Appalachians. This coupling has logically followed from the fact that the Newark rocks occur in belts which follow so faithfully the median parts of the Appalachian chain. A brief review of some salient ideas about the Newark rocks shows a large geologic literature written by several generations of investigators, many of whom clearly were torn between their ingrained geologic "beliefs" (the "geologic fabric") and conclusions contrary to these "beliefs" that arose from their field study of the Newark strata.

AGE OF THE NEWARK STRATA

The term Newark has been applied in a general way to all strata generally referred to as "Triassic." In the later part of the nineteenth century, they were designated as "Jura-Trias" (for example, Dana, 1883). Early in the twentieth century, however, this "untidy" arrangement of a formation crossing a systemic boundary was changed. Instead, the idea became popular that the Palisades "Disturbance" closed the Triassic Period. Therefore, the Newark strata, having been deformed by this "disturbance," were considered to be entirely of late Triassic age.

NEWARK BASIN FILLING-STRATA (UPPER TRIASSIC BUT MAINLY LOWER JURASSIC)

Newark-age strata unconformably overlie metamorphosed Paleozoic strata of Cambro-Ordovician age and are in fault contact with some Precambrian formations. Cobbles and boulders in Newark basin marginal conglomerates (and fanglomerates) include mostly rocks of Middle Ordovician, Silurian, and Devonian age which formerly blanketed the elevated blocks at the NW basin-margin. The thick (possibly 8 or 9 km) strata filling the Newark basin are nonmarine; they include marginal rudites, fluvial sediments, and lake deposits [most notably the massive black argillites of the Lockatong Formation, which attains a maximum thickness of about 450 m in the Delaware River valley exposures]. Interbedded with these sedimentary rocks are three extrusive complexes, each 50 to 200 m thick, whose resistant tilted edges now underlie the curving Watchung Mountains in north-central New Jersey. Boulders of vesicular basalt in basin-marginal rudites locally prove that the lava flows formerly extended across one of the basin-marginal faults and onto a block that was later elevated and eroded. The thick (300m), generally concordant Palisades sheet of mafic igneous rock is located about 400m above the base of the Newark strata.

Extension related to the breakup of Pangea and incipient rifting of North America from Africa resulted in the system of fault-bounded basins of Triassic - Jurassic age that compose the Newark Supergroup. The Newark basin is a half-graben. Sedimentation began during late Middle Carnian time and continued through the Late Sinemurian (Cornet, 1977). The basin contains fluvial, lacustrine, alluvial-fan, and playa deposits together with intrusive and extrusive basalts (Van Houten, 1969).

The Newark basin in New Jersey and contiguous New York is at present an area of active research. For a review of recent references I recommend Froelich and Olson (1984), Husch and Hozik (1988), and Olsen et al. (1996). Olsen et al. (1996), list more than one hundred references relating to the Triassic-Jurassic deposits of the Newark basin.

FIELD TRIP

Figure 1 is a physiographic map which shows the New Jersey highlands and lowlands, the Watchung Mountains, and the location of STOPS 1 and 2. Figure 2 is a profile across the Hudson River; STOP 3 examines Triassic-Jurassic strata beneath the Palisades Ridge shown in this figure. Figure 3 shows the geology and structure under the Hudson River, at the Palisades.

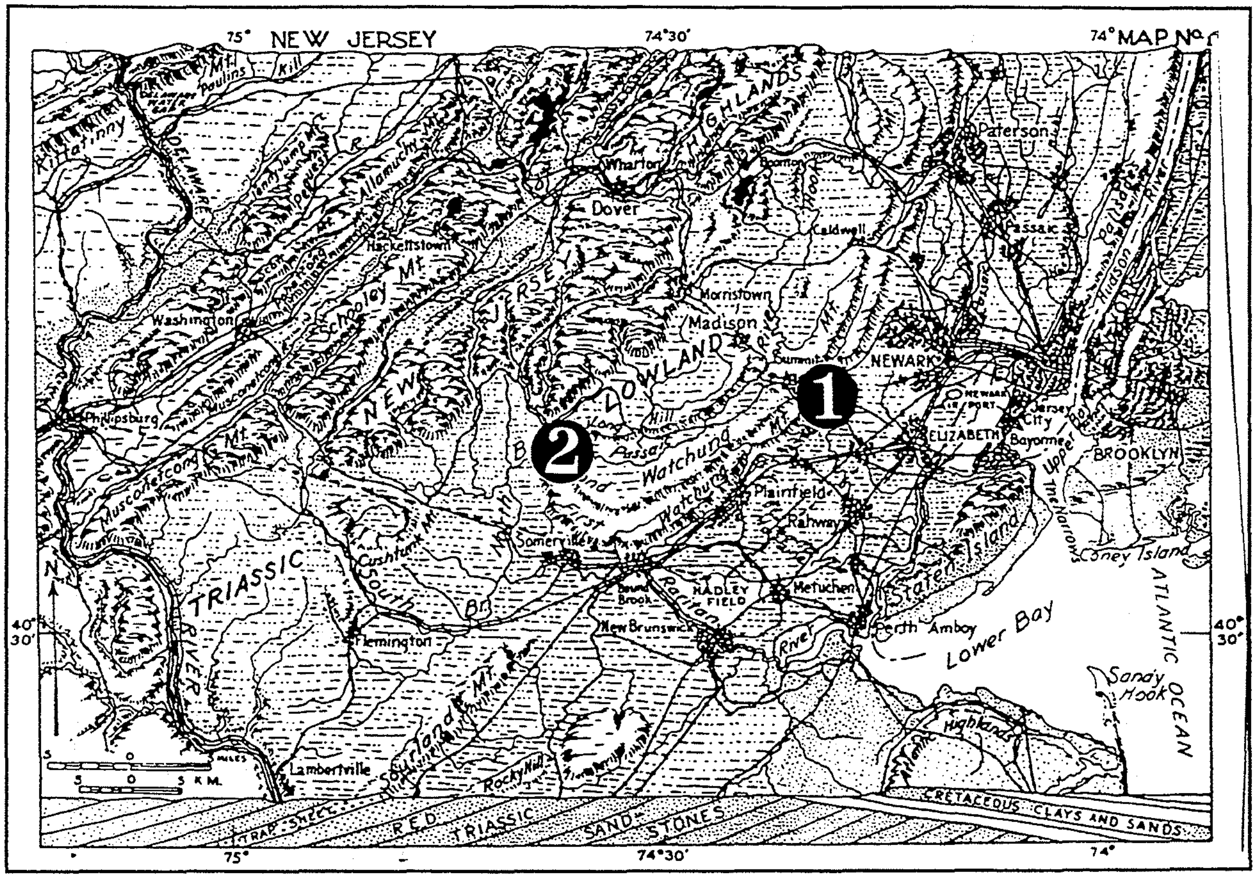


Figure 1. Physiographic map showing the New Jersey highlands and lowlands, the Watchung Mountains, and the location of STOPS 1 and 2.

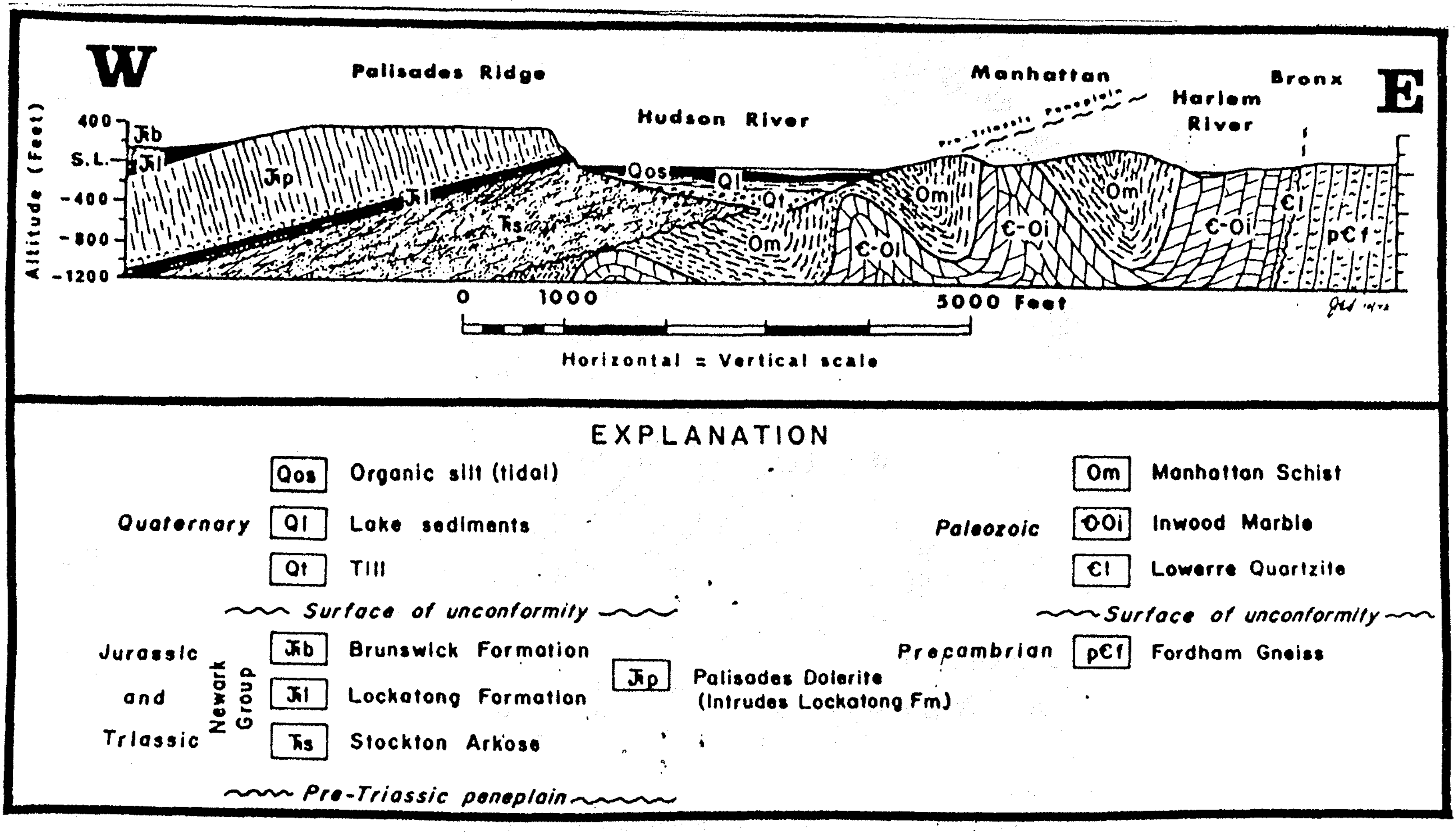


Figure 2. Profile-section across Hudson River and northern Manhattan parallel to George Washington Bridge and Cross-Bronx Expressway. (Based on C.P. Berkey, 1933; slightly modified from J. E. Sanders, 1974, Figure 3, p.11)

ROAD LOG

From the College of Staten Island head to Goethals Toll Bridge and cross Arthur Kill into New Jersey. Take Rte. 82 near Elizabeth to Rte. 24 and proceed to Summit Avenue, Summit. Exit Summit Avenue. The road log starts here.

Mileage Between Points	Cumulative	
1.1	1.1	Traffic light in Summit, head west to Ciba-Geigy Plant.
0.9	2.0	Sign: Junction 512 Union County.
0.2	2.2	At traffic light take 512 west; go to Springfield Avenue.
1.2	3.4	Bear right at traffic light (on to Springfield Avenue).

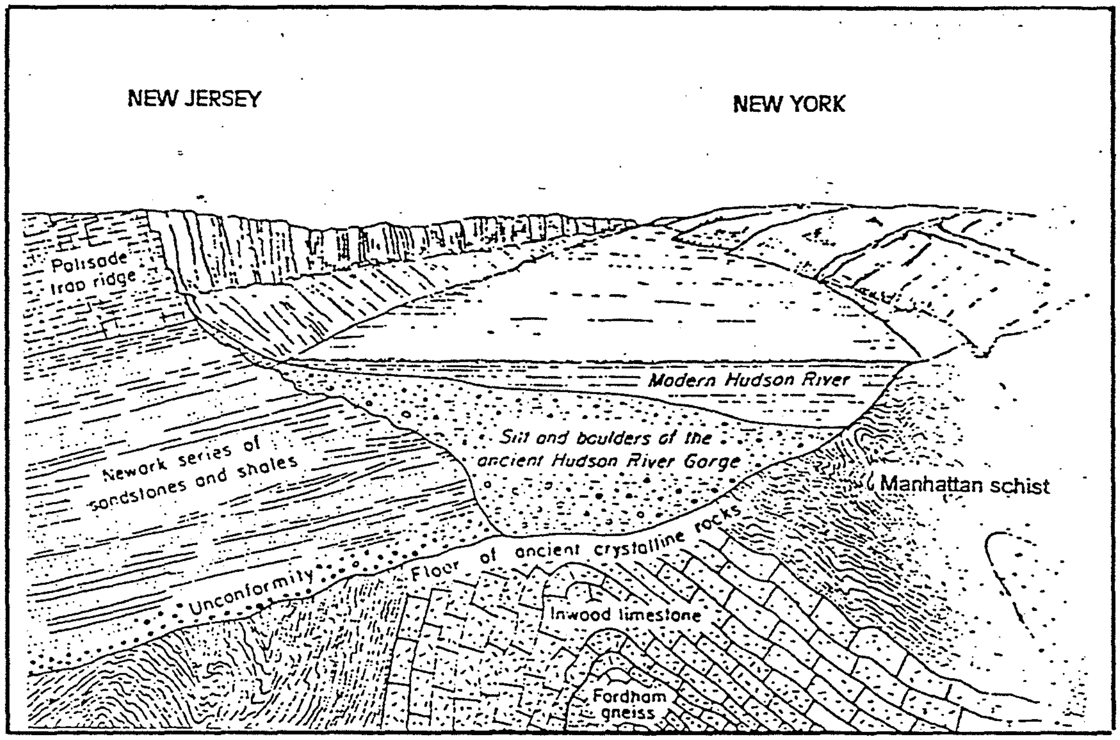


Figure 3. Geology and structure under the Hudson River, at the Palisades. (After Fig. 7 Guidebook, 61st Annual Meeting, Geol. Soc. Am.)

Mileage Between Points	Cumulative	
1.3	4.7	At traffic light take 647 south to Murray Hill, South Street.
2.2	6.9	Follow South Street south through Murray Hill, past Bell Laboratories. South Street changes to Glenside

		Road. Follow underpass and turn right and make left (south) turn into Union County Park. Continue on road in Union County Park to Parking Lot, passing the abandoned village of Feltville.
0.5	7.4	Park vehicles and walk below parking lot to STOP 1.

STOP 1. Feltville Formation of the Newark Supergroup

On north side of Blue Brook are exposed interbedded micaceous red and gray siltstones and shales with sporadic lenticular channels of quartz sandstones. These exposed strata are part of the type section of the Feltville Formation of the Newark Supergroup. Similar exposures are present an estimated 1/4 to ½ mile farther east on south side of the brook, where a tributary meets Blue Brook. In the creek bottom are numerous blocks of quartz-pebble conglomerate.

According to Paul Olsen (personal communication, 1985) the strata at this site carry abundant spores and pollen.

For stratigraphic section see Table 1. Figure 4 shows type section of the Feltville Formation exposed along ravine near Blue Lake; Table 2 provides the key for individual units.

Mileage Between Points	Cumulative	
7.6	15.0	Return to Glenside Road.
0.5	15.5	Turn left (west). Enter road to Interstate 78 West. Follow signs to Interstate 78.
1.1	16.6	Enter Interstate 78.
1.2	17.8	Note exposures of Watchung Basalt, especially spectacular columnar jointing.
9.8	27.6	Note exposures of Watchung Basalt.
0.7	28.3	Ascend road to Scenic Overlook and return to Interstate 78.
1.7	30.0	Exit 29 Interstate 287 North. Follow Interstate 287 North.
5.6	35.6	Exit road to Bernardsville, follow Route 525 North.
2.5	38.1	Enter Bernardsville.
1.1	39.2	Turn left on Route 202 West.
1.2	40.4	Turn left into Anthony Ferranti Quarry for STOP 2.

TABLE 1. LITHOSTRATIGRAPHIC TERMS FOR NEWARK BASIN

Newark Supergroup (of Newark Basin)
Boonton Formation
Hook Mountain Basalt
Towaco Formation
Preakness Basalt
Feltville Formation
Orange Mountain Basalt
Passaic Formation
Lockatong Formation
Stockton Formation

(Reproduced from Olsen, Paul E., 1980, Triassic and Jurassic Formations of the Newark Basin in Field Studies of New Jersey Geology and Guide to Field Trips, Warren Manspeizer (ed.), Rutgers University, Newark, N.J., 398 p.)

TABLE 2. TYPE SECTION OF THE FELTVILLE FORMATION AND KEY TO FIGURE 4.

Unit a		
	+4.0	Buff to red-purple feldspathic sandstone and siltstone
Unit b		
	.5 m	Green and red ripple-bedded siltstone.
	1.0 m	Gray and red limestone and siltstone beds, laminated at the base. Fossil fish abundant. In other near-by sections, this unit is black.
	1.54 m	Beds of gray and red siltstone and fine ripple-bedded sandstone with abundant roots and reptile footprints.
Unit c		
	11.0m	1 m thick beds of buff and red sandstone grading up into beds of blocky red siltstone with roots. Lower beds contain breccia of upper Orange Mountain Basalt.

(Reproduced from Olsen, Paul E., 1980, Triassic and Jurassic Formations of the Newark Basin *in* Field Studies of New Jersey Geology and Guide to Field Trips, Warren Manspeizer (ed.), Rutgers University, Newark, N.J., 398 p.)

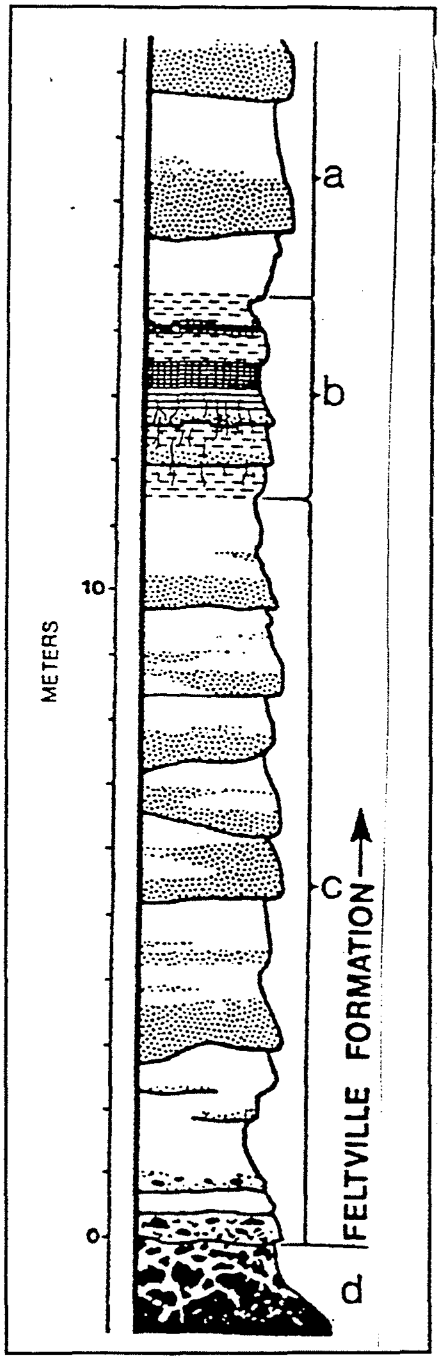


Figure 4. Type section of the Feltville Formation exposed along ravine for Blue Brookabout 1 k south of Lake Surprise in the Watchung Reservation,Union County, New Jersey (Olsen, 1980

STOP 2. Anthony Ferranti Quarry. (Permission is needed to enter this quarry. Contact Linda Kimler, Public Relations, Anthony Ferranti Quarry, 908-647-8273).

Spectacular outcrops of sandstone, siltstone, and shale of the Feltville Formation occur beneath the Preakness Basalt (see Table 1). Crossbedded sandstones show local channeling. Find sandstones with dinosaur footprints and plant fossils as well as raindrop impressions on mudcraked surfaces. Note small strike-slip faults in quarry.

Mileage Between Points	Cumulative	
0.2	40.6	Return to Route 202, turn right.
0.6	41.2	Turn right onto Route 525 South.
2.3	43.5	Turn onto Interstate 287 North.
15.6	59.1	Turn onto Interstate 80 East.
24.1	83.2	Take local exit to Palisades Parkway North via Interstate 95 (which changed from Interstate 80), exit 72 at Fort Lee.
3.6	86.8	North on Palisades Int. Parkway (PIP).
15.0	101.8	Exit PIP at NY303 (Orangeburg).
4.0	105.8	North on 303, under Thruway. Road goes uphill; cuts on L side are in Palisades dolerite.
0.3	106.1	Cuts in dolerite, both sides of road.
0.2	106.3	End of cuts in dolerite.
0.1	106.4	Highway sign Valley Cottage.
0.65	107.05	Small dolerite cut on R.
0.05	107.1	Traffic signal; turn R on Lake Road.
0.7	107.8	Wooded hill in distance on R is dip slope on W side of Palisades sill (strike NS, dip 15°W).
0.1	107.9	Jct. Belleville Rd.
0.5	108.4	Traffic signal, Rte. 9W. Cross 9W and enter Rockland Lake State Park. Rockland Lake at L.
0.4	108.8	Wooded ridge ahead is dip slope of Palisades sill.
0.2	109.0	Exposure of dolerite of sill on R; overlain by sill.
0.5	109.5	Exposure of dolerite of sill in slope at R.
0.4	109.9	Intersection; turn R on street marked "Dead End".
0.1	110.0	Barricade; passage for "Official Cars Only". Park vehicles at barrier. Walk down to old quarry and pick up trail down to shore.

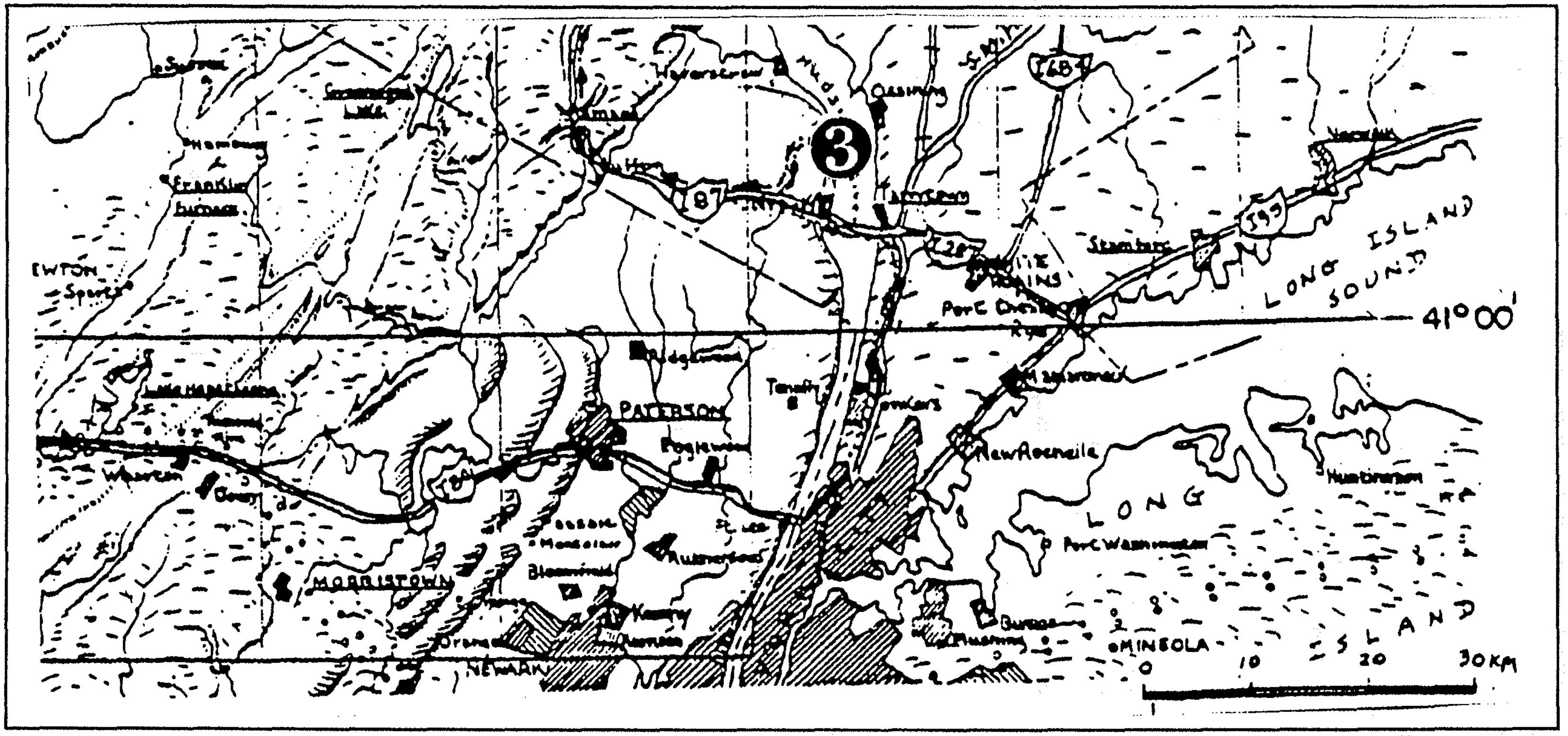
STOP 3. Nyack Landing, Upper Nyack

(SE part of Haverstraw 7 ½ minute quadrangle, along W shore of Hudson River at Long. 73°54'W, from Lat. 41°08'15" to Lat. 41°07'30"N). See Figure 5 for the location of STOP 3. Walk southward on gravel road, along floor of old quarry in Palisades dolerite. Take trail toward Hudson River from S end of quarry. Walk down to lower level and study exposures along lower trail. The level of the old quarry floor lies at an altitude of about 60 ft; the top of the cliff facing the quarry is at an altitude of 510 ft. Thus the face is about 450 ft high. The face extends downward nearly to the contact with the underlying basal Newark sandstones. The contact is not exposed but lies near altitude +50 ft. The descriptions at this stop follow Friedman, Sanders and Martini (1982).

The continuous exposure of dolerite in the face is a noteworthy display of cooling joints, which are inclined off the vertical about the same amount as the base of the sill dips westward, i.e., 12 to 15°. At this locality, no olivine zone is exposed. Farther south the olivine zone, 10 to 15 ft thick, is located about 50 ft above the base of the Palisades sill. The absence of the olivine zone here could mean one of several things: (1) This exposure includes the lower 450 ft of the sill but no such zone ever formed here; (2) This exposure does not include the lowermost 450 ft of the sill, but that much of some part of the interior of the sill lying above the lowermost 60 to 70 ft, hence the olivine zone may be present but is not exposed in the old quarry face. Alternative 2 implies that a fault follows close along the base of the face and throws down on the west by at least 70 ft.

The large institution directly opposite us on the east side of the Hudson River is Sing Sing, the notorious destination of prisoners "sent up the river" (from New York City). The wide expanse of wooded countryside between Ossining and Tarrytown is the Rockefeller family preserve, an area so large that it has been incorporated as a separate

Figure 5. Physiographyic diagram drawn by Frank P. Conant, Wesleyan University in 1930's, with major roads added by J.E. Sanders, 1980. Shows the location of Stop 3.



town (Pocantico Hills). Nobody levies local taxes on the Rockefellers but other Rockefellers!

The Croton River enters the Hudson just S of Croton Point, to the NE of us. The till exposed on the tip of Croton Point itself has been interpreted by some as a lateral moraine, but we think this till is part of a drumlin having a N-S axis. Between the till and the mainland is a sandy deltaic deposit which formed when lake water occupied the Hudson Valley to altitude about +60 ft.

The sandstones exposed in a long strike section are situated about 1000 ft above the base of the Newark Group (Upper Triassic to Lower Jurassic)(based on projection from the section at the Tappan Zee Bridge). These sandstones probably belong to the Stockton Arkose (Upper Triassic to Lower Jurassic). The strata strike N20°W and dip 12°SW (determined on base of ledge overhanging the siltstone toward the S end of the exposure). Typical Stockton Arkose is a light gray pebbly coarse rock that contains large-scale cross strata indicating water flow toward the west. Such gray rock interfingers with red siltstones and sandstones containing less feldspar (or even zero feldspar), which form the Brunswick Formation. Farther SW the Newark sequence from base upward is Stockton, Lockatong, Brunswick. Lockatong, typically a tough black argillite deposit of a former lake, is not exposed north of the George Washington Bridge; the argillite disappears by interfingering with the sandstones and siltstones of the Stockton and Brunswick.

The bluff west of the trail exposes about 20 ft of strata, of which the thickest and most persistent unit is a maroon siltstone 6 to 8 ft thick. This unit is overlain and underlain by various sandstones. At the N end of the exposure only the overlying sandstones are present. These include (upward) a coarse pebbly laminated sandstone about 1 ft thick, a laminated, reddish medium-grained sandstone, 2 to 3 ft thick, and 6 to 8 ft of coarse-grained pebbly sandstone having prominent cross strata dipping (now) 28° toward the direction of S45°W (225° true on a 360°scale). The original dip of the cross strata is about 16°. Hence these are considered to be accretion-type cross strata (in the sense of Imbrie and Buchanan, 1965), of the kind that form by the advance of "washed-out sand waves" (features transitional between the "regular" sand waves of the lower flow regime and the plane-bed condition of the lower part of the upper flow regime).

Below the siltstone unit is a bed, 1 to 1.5 ft thick, composed of greenish, poorly sorted conglomeratic arkose, almost a "pebbly mudstone." Next below is a lenticular arkose having a maximum thickness of about 2 ft.

The interbedding of the siltstones and sandstones probably resulted from the action of a floodplain meandering river. One usually tends to expect such rivers to deposit the coarse sediments in channels and the fine sediment on the floodplain. As the channels migrate, a sheet of sediment is deposited consisting of what has been termed a point-bar sequence. This sequence begins with a channel-floor lag at the base and passes upward through various deep-channel and shallow-channel deposits whose thickness equals the depth of flow in the former channel. Such sequences have been much discussed under the heading of "fining-upwards cycles" (Allen, 1965b; also Friedman, Sanders, and Kopaska-Merkel, 1992).

Closely associated with this typical channel-migration succession are deposits of natural levees and fan-like bodies of coarse sediment that spread over the floodplain from crevasses in the levees where floodwaters erode a gap through the levees. These fans have been termed splay deposits (or crevasse splays). (See summary paper dealing with alluvial sediments by Allen, 1965a).

The upper sandstones west of the trail do not seem to be part of a typical fining-upward cycle deposited by a migrating channel. The laminated, medium-grained sandstone just above the siltstone may be a natural-levee deposit and the coarse, cross-bedded sandstone next above may be a crevasse-splay (idea suggested by John Connolly). The coarse sandstone forms a series of imbricate,
overlapping lenses, the upper ones of which extend farther southward than the lower ones. Thus, instead of being incised into the siltstone as in a channel, these sands prograde over the siltstone as would the sediments of a growing fan (or the foreset beds of a delta lobe).

The sandstones underlying the siltstone are not exposed enough to be analyzed in detail. The lenticular sandstone, previously interpreted as a "double-channel" are here considered to be a depositional bedform having positive relief, a sort of longitudinal sandbar with the long axis parallel to the main direction of current flow.

At the S end of the exposure sandstone and dolerite are in close juxtaposition. The sandstone lacks evidence of contact metamorphism and the dolerite is much too coarse grained for this contact relationship to be explained as intrusive. Accordingly, J.E. Sanders interprets this contact as a normal fault which strikes about NW, is nearly vertical, and throws down on the west by at least 70 ft; this much displacement is inferred in order to drop the olivine zone out of sight. Thus, J.E. Sanders presumes that the olivine zone is present, but is not exposed.

Return to vehicles..

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