WANDERING THE WATERSHEDS: HACKENSACK MEADOWLANDS

by Michael J. Passow

The Hackensack Meadowlands contain both highly developed and wilderness environments, and as such rank among the most interesting locations to "Wander the Watershed." One can paddle through a tidal marsh viewing at snowy egrets and great blue herons one moment, then look up to see overpasses on the New Jersey Turnpike and Giants Stadium with 70,000 fans while a jet overhead roars down toward its landing at Newark Liberty Airport! Geologically, the Meadowlands result from more than 200 million years of deposition, erosion, and human alterations. It is an oasis of peace and quiet, fascinating environmental features, and a pollution-abatement success story, all within the greatest metropolis in the world!

Geological History

The Meadowlands lie within the Newark Basin, also known as the Newark Lowlands province, a Late Triassic-Early Jurassic sedimentary feature with several igneous extrusions and intrusions, including the Palisades along the west shore of the Hudson River. First studies of the region date back to the earliest days of geology in the 1830s, yet new techniques within the past decade have revealed much about the history of the region. These include a set of deep drillings by the LDEO Borehole Group and Rutgers University.

Olsen (1980) introduced the discussion by noting:

> Far from being the consequences of the last gasps of the Appalachian Orogeny, Late Triassic and Early Jurassic Newark Supergroup basins formed in dynamic association with the opening of the Atlantic Ocean. In addition, Newark Supergroup rocks, once thought to be nearly barren of fossils, are now known to be exceptionally rich in organic remains, replete with plants, invertebrates, and vertebrates spanning some 35 millions years of the Early Mesozoic. Finally, long periods of unusually continuous deposition coupled with an abundance of laterally extensive stratigraphic 'marker' beds makes this deposit ideal for studying time-facies relationships and evolutionary phenomena. These recent discoveries have focused new interest on Newark strata.
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> The Newark Basin is the largest of the exposed divisions of the Newark Supergroup, covering about 7770 km^2 and stretching 220 km along its long axis. The basin contains the thickest sedimentary sequence of any exposed Newark Supergroup basin and correspondingly covers the greatest continuous amount of time.

Olsen defines the Newark Supergroup as:

> … "the predominantly red clastics and volumetrically minor basaltic igneous rocks exposed in 13 major and 7 minor elongate basins preserved in the Piedmont, New England, and Maritime physiographic provinces of Eastern North America….The rocks of these basins … unconformably overlie (or intrude) Precambrian and Paleozoic rocks. They are in turn overlain by post-Jurassic rocks of the Coastal Plain, Pleistocene deposits, or recent alluvium and soils…."

> Precambrian and early Paleozoic rocks of the southwestern prongs of the New England Upland ["Manhattan" Prong and "Reading" Prong or, locally, "Hudson Highalnds"] border the Newark Basin along its northeast and northwest margins. The southeastern and southwestern portions of the Newark Basin overlie and are bordered by Paleozoic and Precambrian rocks of the Coastal and Piedmont Provinces. Newark Basin sediments rest with profound unconformity on basement rocks and mostly dip 5^{o} - 25^{o} to the northwest.

For an earlier guidebook, Van Houten described this region as:

> …preserved in a southwest-trending basin that reaches from Rockland Country, New York, to northeast Lancaster County, eastern Pennsylvania. This is the largest of six major (and several minor) Triassic rift valleys in a sinuous belt more than 1,000 miles long, from Nova Scotia to North Carolina (and in subsurface as far south as Florida).

> The Newark Basin is the largest of three lobes (Newark, Gettysburg, Culpepper connected by narrow corridors in a 300-mile arcuate tract from southeastern New York to northeastern Virginia. It is about 40 miles long and a maximum of 32 miles wide….

Extruded or intruded through the sedimentary layers are several igneous rock formations. These include the Watchung lava flows (formally described by Olsen as the Orange Mountain Basalt, Preakness Basalt, and Hook Mountain Basalt), and diabase intrusions, the largest of which form the Palisades. A smaller intrusion in the Meadowlands has been extensively quarried, but still forms a prominent landmark on any paddle through the Meadowlands. It is variously known as Rocky Hill, Snake Hill, and Laurel Hill, and is now the site of a Hudson County Park and common launching site for canoeing and kayaking trips.

The sedimentary rocks consist mainly of shales, sandstones, and conglomerates. Earlier studies divided these into the Stockton, Lockatong, and Brunswick formations, but recent work by Olsen and others now separates the Brunswick into three formations separated by the basalt flows. Further details of the rocks may be found in the references.

In summary, we can generally say that great stresses associated with the breakup of Pangaea in the Early Mesozoic produced a series of basins into which sediments were eroded from adjacent higher areas. Many were rich in iron, giving the distinctive reddish color. Such oxidation and the fossil evidence indicate that these basins were generally shallow, or even terrestrial. In many places, “fossil raindrops” preserve a record of brief showers falling on moist muds, through which worms or other burrowing organisms left churned-up tracks. One of the earliest dinosaurs, *Clepysaurus (Rutiodon)*, was discovered in 1910 during a field trip of Columbia geology students about half a mile south of where the George Washington Bridge was later built, and is now on display at the American Museum of Natural History.

Gradually, the sediments were eroded southeasterly as the Atlantic opened and the Coastal Plain formed. There is evidence that changes in sea level during the later Mesozoic and Cenozoic alternately covered and exposed the region, and probably deposited sediments over the early Mesozoic rocks.

The next interesting part of the Meadowlands story involves the Hudson River, which now flows several kilometers to the east on the other side of the Palisades ridge. But closer examination of the area has revealed remnants of meandering streams that crossed a flat surface (sometimes called the “Schooley Peneplain”). These can be traced to the ancestral Hudson River, which apparently cut through the Palisades at the Sparkill Gap, west of the Tappan Zee region some twenty km north of the George Washington Bridge. These streams eroded softer rocks that may have been deposited as part of the Coastal Plain inundations as the Atlantic opened, exposing and eroding the harder Triassic and Jurassic rocks. Many diagrams illustrating the sequence of events during the Mesozoic and Cenozoic are included in De Lotto (1973) and the other references used in preparing this account.

Using borings made for various construction projects in the Meadowlands, it became possible to identify two pre-glacial rivers flowing in a southerly direction through what is now the Meadowlands, beds of the ancestral Hudson River (Widmer, 1964). At some point in time, a small stream eroding northward along the base of the Palisades broke through the sediments and “pirated” the Hudson River, allowing it to follow a more direct route to the ocean. Subsequently, the Hudson eroded its existing bed, and the more westerly river beds were abandoned.

With the advance of the Pleistocene ice sheets, the area was covered by continental glaciers more than 800 meters thick. But this was close to the limit of their extent, and much of the materials they transported were left as the terminal moraine when the ice started to melt, or was strewn over the region as erratics. The terminal moraine formed a dam blocking the meltwaters, and in what became the Meadowlands a long, narrow lake formed. Glacial Lake Hackensack apparently extended more than 30 km northward from the area near where Newark Airport is now into Rockland County. Clay and other sediments deposited on the lake bottom covered the ancient river beds and other rocks, beginning the formation of the Meadowlands. To the west behind the terminal moraine lay the even-larger Glacial Lake Passaic, the remnant of which is the Great Swamp.

In the 1920s when clay from these glacial lake deposits were mined in Little Ferry for ceramics and other uses, geologists counted more than 2000 varves, layers that

formed in the annual freezing and melting as the Ice Ages ended. At some point, the terminal moraine "dam" broke and Glacial Lake Hackensack emptied. Sea level rose as water once in the glaciers melted and returned to the ocean, and the region gradually became the swampy, tidal Meadowlands. More information about the changes as the Wisconsin glaciation ended and the Holocene began are provided by Averill et al. (1980.)

Interesting "windows" into the region's life as the Ice Ages ended and post-glacial warming began have been in the form of two mastodont skeletons discovered in the area. During construction of Interstate-80 in the early 1960s at the edge of Hackensack, two schoolboys accidentally found a tooth. Subsequent excavation by paleontologists uncovered a partial skeleton. In February 1974 during clearing of Dwarskill Creek leading into the Oradell Reservoir near the junction of Closter, Harrington Park, and Northvale, another skeleton was discovered and excavated. Both now belong to the Bergen Museum, which is in the process of re-opening at Bergen Mall. [Note: If you look carefully in Fig. 7 of Averill's article, you will see him pointing out some features to me during the excavation.]

Agron (1980) provides an excellent overview of the Meadowlands environmental geology, and this article is strongly recommended. Additional selected field trip guidebook articles about the geology of this region are provided at the end of this account.

Human Intervention

The Lenni Lenapes and other Native Americans survived for many centuries through lifestyles based on hunting and gathering the animals and plants occupying the region in post-glacial times. The first Europeans to settle were the Dutch, beginning around the 1630s. They began to utilize their ditch and dike building strategies to modify the environment into farmland, just as they had done in their native Holland.

When the English took control from the Dutch in the 1660s, many of the early settlers remained and continued to farm the area. During the early 18th Century, copper was discovered in the Mesozoic rocks on the western edge of the Meadowlands in what is now Lyndhurst, and one of the first steam engines in North America was imported to drain water seeping into the mine. Copper from this region was used to make brass and bronze fittings during the Revolutionary War.

In November 1776, Washington led his forces in the Retreat Across the Jerseys after the Battle of White Plains that ended at Valley Forge. When all his troops had crossed the river, Washington's forces burned the "New Bridge" at River Edge and took all the boats at Little Ferry, thus stymieing the British forces trying to catch them. The following month was the famous crossing of the Delaware and victory at Trenton on Christmas Eve. But perhaps without the delay provided by the barrier of the Hackensack River, events might have turned out quite differently.

Through the 19th and 20th Centuries, various attempts were made to develop the marshy areas, but the subsurface geology generally frustrated such efforts. Modern technology allowed construction of the Meadowlands Sports Complex, with Giants Stadium, the Continental Arena, and Meadowlands Race Track. Fortunately, much of the region still remains wetlands. The Meadowlands today still consists of about 7,000 acres of wetlands, some ten times the size of Central Park in Manhattan.

In the late 19th and early 20th Centuries, the red sandstones along the eastern edge of the Meadowlands were extensively quarried to supply basic materials for the "brownstones" so common in parts of Manhattan and Brooklyn. The diabase was also extensively quarried at many places along the Palisades and at Rocky Hill. Around the turn of the 20th Century, various Womens Clubs led the efforts to end these mining activities and created the Palisades Interstate Park, stretching north of Fort Lee into Rockland.

Industrial plants at the edges of the marshes, however, continued to discharge great amounts of toxic heavy metals and other pollutants until stricter environmental laws passed beginning in the 1970s required greater attention to the impact of their actions. Some companies shut down their operations in this sensitive region, but others continue to have detrimental affects. The damage they inflicted on water quality and wildlife still remains, although definite signs of positive progress exist. More birds and other predators inhabit the marshlands, indicating reduced levels of pollution.

The Hackensack Meadowlands Environmental Center, part of the New Jersey Meadowlands Commission, provides educational and recreational programs about the Meadowlands region (http://www.meadowlands.state.nj.us/ec/environment_center.html). They offer a variety of school and public activities featuring the Meadowlands, working together with such groups at Hackensack Riverkeeper (www.hackensackriverkeeper.org).

Hydrology

At its northern end, the Hackensack is strictly a freshwater stream, supplied by rain and runoff through many small tributaries draining westward down the Palisades and eastward from its divide with the Passaic. Since the late 19th Century, parts of the upper Hackensack have been dammed and used as water supply. The largest of several water bodies is the Oradell Reservoir, and also include Woodcliff Lake, Tappan, and Lake DeForest in Rockland County.

South of the Oradell dam, the river is tidal, with a range of more than a meter. In places along its banks, the river alternately exposes and covers mud flats on which live crabs, mussels, and other organisms. Marsh reeds, bog plants, and vegetation form islands in much of the rest of the area, providing a habitat for a variety of fish, waterfowl, muskrats, and other organisms. Within the Meadowlands can be found both freshwater and salt marsh environments.

The tidal patterns are available at www.nos.noaa.gov, and should be consulted before planning a paddle. In many parts of the Meadowlands, the water may drain out fairly quickly, stranding the unwary wanderer in a vast muddy tract within sight of deeper waters. More information about the Hackensack watershed is available through the EPA's "Surf Your Watershed," http://cfpub1.epa.gov/surf/huc.cfm?huc_code=02030103, and related websites from the U.S. Geological Survey and other sources that may be linked through the EPA site..

The Hackensack Meadowlands Environmental Center (http://www.meadowlands.state.nj.us/ec/environment_center.html), operated by the New Jersey Meadowlands Commission (http://www.hmdc.state.nj.us/) serves as the focal point for educational programs about the region. They provide a great variety of school and public activities featuring the Meadowlands, working together with such groups at the Hackensack Riverkeeper (http://www.hackensackriverkeeper.org/).

References:

Agron, S.L., 1980, "Environmental Geology of the Hackensack Meadowlands," in Manspeizer, W., ed., *Field Studies of New Jersey Geology and Guides to Field Trips.* 52nd Annual Meeting of the New York State Geological Association, Rutgers University-Newark. pp.215 – 242.

Averill, S.P., et al., 1980, "Environmental Geology of the Hackensack Meadowlands," in Manspeizer, W., ed., *Field Studies of New Jersey Geology and Guides to Field Trips.* 52nd Annual Meeting of the New York State Geological Association, Rutgers University-Newark. pp.159 – 186.

De Lotto, Sister Doris, 1973, "An Overview of the Hackensack Meadowlands from Its Geological Beginnings to the Present." St. Louis University Geography Department, Masters Thesis.

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Van Houten, F.B., 1969, "Late Triassic Newark Group, North Central New Jersey and Adjacent Pennsylvania and New York," in Subitzky, S., ed. *Geology of Selected Areas in New Jersey and Eastern Pennsylvania and Guidebook of Excursions.* Geological Society of merica and Associated Societies Annual Meeting, Atlantic City, NJ.

Widmer, K., 1964, *The Geology and Geography of New Jersey.* Van Nostrand Co., Princeton.

Additional Field Trip Guidebook articles concerning this region

[Note: Over time, many of the locations described in these articles no longer exist, but the geological information is still of use.]

New York State Geological Association 40th Annual Meeting (1968, Queens College) Guidebook to Field Excursions

"The Triassic rocks of the Northern Newark Basin" by E.L. Savage;
Road log by F. B. Van Houten, E. L. Savage

New York State Geological Association 47th Annual Meeting (1975, Hofstra University) Guidebook to Field Excursions

"Structure and Form of the Triassic Basalts in North Central New Jersey"
by M. Sichko, Jr.

New York State Geological Association 68th Annual Meeting (1996, College of Staten Island) Guidebook to Field Excursions

"Sedimentary Environments in the Newark Basin in New Jersey and Contiguous New York" by Gerald M. Friedman

The Geology of North America Volume I-2 The Atlantic Continental Margin: US, Edited by R. E. Sheridan and J. A. Grow, Geological Society of America, 1988.

"Late Triassic-Early Jurasic synrift basins of the U.S. Atlantic margin" by W. Manspeizer and H. L. Cousminer, pp. 197 – 216.

"Mesozoic and Cenozoic magmatism" by J. Z. de Boer et al., pp. 217 – 241.

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