

# The New York Times

FRIDAY, DECEMBER 2, 1983

## Story of the Eons In New York's Rocks and Cliffs

## Weekend



The New York Times / Dith Pran

Prof. Charles Merguerian, left, of Hofstra University and Leo M. Hall of University of Massachusetts, at 165th Street and Riverside Drive examining vertical section of a fold formed when African land mass drew close to East Coast eons ago.

By WALTER SULLIVAN

**T**HE most obviously dramatic features of the New York landscape are monumental skyscrapers and bridges. But rocks throughout the metropolitan area bear witness to past events grander and more awesome than anything to be seen on Earth today.

Some of these witnesses to geological eons long gone are accessible by subway or on foot. Others are within an hour's drive. Almost all can be appreciated without any special scientific knowledge. They have a tale to tell of lava pouring across the landscape, driving before it armies of dinosaurs, of vast slabs of marble pushed across the Bronx and Manhattan, of flowing ice that gouged deep grooves in the rocks of Central Park.

In the city, alongside Riverside Drive, notably at 165th Street, you can see ledges studded with garnets, tourmalines and other stones, though these are not of gem quality. The contorted folds of these ledges were produced by extreme heat and compression when the African land mass drew closer.

The most dramatic relicts of all are the Palisades, forming a mighty wall along the west bank of the Hudson River. Now that most of the leaves have fallen, they are visible for their full height from outlooks on the Manhattan shore. The Palisades were formed some 200 million years ago, when Africa pulled away from its long marriage with North America, and the modern Atlantic Ocean began to form. This great pulling apart rent the earth's crust to great depth, forming long rifts such as the Connecticut Valley and the Jersey Meadows.

Then, millions of years later, the

split penetrated so deeply that lava rose from the molten interior. Some of it, prevented from rising farther, spread sideways between layers of rock, cooling into vast underground slabs. The Palisades are the edge of such a slab, or "sill," which has been tilted up toward the east sufficiently to raise its edge above ground level. Underground, it is about 1,000 feet thick, but its upper edge, overlooking the river, has been planed off by erosion.

There are few excursions in the New York area as awesome as the descent of these cliffs via the drive at the Palisade Avenue Exit of the Palisades Interstate Parkway — the first exit north of the George Washington Bridge. This is scenery on the grandest scale. A stream tumbles down the cliff, repeatedly crossed by the road, which zigzags down to the park on the river. Last weekend, rain-swollen, it was a classic mountain torrent.

That this great slab formed underground is evident near the foot of the long hill where Interstate 80 leads west from the Washington Bridge. The rock walls flanking the highway resemble the Palisades in their towering columns and dark, uniform texture. Just before the sloping slab disappears underground alongside the Englewood Golf Course, it is crowned by reddish rock of clearly different type.

This is the layer that was severely baked as the lava intruded under it. The effect was like that of shoving a red-hot spatula into a loaf of bread, which would toast the layers both above and below the hot metal. The toasted layer beneath the sill can be seen along Henry Hudson Drive a mile and a half from the entrance, off River Road in Edgewater. The road is

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closed to vehicles for the season, but open to walkers.

## Watchung Mountains

During the great rifting, not all the lava stayed underground, as is dramatically evident in both New Jersey and Connecticut. Lava poured onto the surface, flooding large areas. Each episode produced a sea of basaltic rock like the lunar seas. Then, gradually, soil formed and life returned, only to be buried by new floods.

In New Jersey, three periods of eruption were spread over a two-million-year period. The resulting beds of volcanic rock, after having been buried by the passage of time, tilted up toward the east in the same manner as the Palisades. Their edges now form the three parallel ridges of New Jersey's First, Second and Third Watchung Mountains.

First Watchung Mountain is crossed by Route 46 at Great Notch, and Interstate 80 climbs onto its shoulder overlooking Paterson. This and the other two parallel ranges run southwest toward Somerville, forcing a wide detour by Interstate 287. Railroads in the area ride on ballast, or crushed stone, quarried from these formations. The homogeneous rock is ideal for the purpose.

Similar seas of lava poured across central Connecticut and have been tilted in the opposite direction — up toward the west — as in the Hanging Hills of Meriden and nearby Mount Higby, whose shoulder is crossed by Interstate 91. West Rock, overlooking New Haven, was intruded underground, like the Palisades.

## Manhattan Marble

Few New Yorkers realize that marble underlies much of their city. Marble, being so easily eroded, has made Manhattan an island by creating the Harlem and East Rivers. It came from a vast accumulation of tiny sea-shells that formed off the East Coast before Africa began to approach. At

that time, the North American continent was near the Equator, and the nearby ocean teemed with life.

The resulting accumulation of shells formed into limestone thousands of feet thick. The limestone was shoved far inland during the collision of the two continents. Some of it was buried, heated and compressed sufficiently to convert it into the marble deposits now quarried from Vermont to Alabama.

Some of it can be seen, forming a strangely undulating surface in Isham Park, a couple of blocks from the terminal station of the IND subway's A train at 207th Street. Beneath White Plains, this so-called Inwood marble is more than 2,000 feet thick. A sculptor would find most of it hopelessly crumbly, although some of it, which contains volcanic material, forms the east wall of Central Park near 88th Street. Since the marble is chemically similar to limestone, it is quarried in some areas for grinding into fertilizer.

East Harlem is a lowland because it rests on this marble, but to the west, Morningside Heights and Washington Heights are formed of two layers of erosion-resistant rock — Manhattan schist — which began as layered sea-floor sediment far offshore. As Africa approached, the rocks were buried so deeply that they became soft enough to be folded and refolded repeatedly. Now that they have reappeared, the complex folds are evident in many of the parks.

## Moraine and Serpentine

More than once, great ice sheets advanced as far as New York City, then paused for thousands of years, depositing great heaps of material along the front, where they melted as fast as the rock-laden ice advanced. This formed hills and ridges of rock, gravel and sand that survive as "terminal moraines."

The Long Island Expressway, for much of its length, was built along the top of such a moraine. Water from the melting ice spread vast amounts of sand and gravel to the south, forming the great apron, or "outwash plain," of the South Shore. This moraine forms Montauk Point and continues

to Block Island and beyond.

In the opposite direction the moraine continues to Staten Island, where it can be seen in cross-section at the southwest extremity of the island by turning left along the shore at the end of Hylan Boulevard. A later ice advance deposited the material that now forms the North Shore of Long Island, continuing as Orient Point, Fishers Island and beyond.

The flowing ice carried in its belly sharp rocks that carved Central Park's ledges, much as machine tools might have done. The resulting grooves, oriented to the west of north, can be seen in many parts of the city, but particularly north of the Avenue of the America's entrance to the park between the Wollman Rink on the east and the Loeb Memorial and Heckscher Playground on the west. The rock was not only deeply grooved but also polished by the ice so that the intricate folds formed a few hundred million years ago are wonderfully displayed.

Among remarkable products of the ice ages are potholes drilled into the ledges of Inwood Hill Park, west of Isham Park. Whirlpools formed by water plunging down off the ice swirled boulders violently about and carved holes large enough to hold a person. A group of these can be seen if one walks past the open meadow west of Isham Park and uphill along a walk that bears left beyond a boulder that marks the site where Manhattan was allegedly bought from the Indians.

The upheavals that produced the rocks of New York City were so great and profound that they are hard to imagine. They brought up from deep beneath the sea floor great masses of serpentine, a mineral which, when of sufficiently high quality, can be polished to form what resembles a green marble.

This rock is known as verd antique and is superior to marble in that it does not readily dissolve. The Staten Island Expressway, leading west from the Verrazano-Narrows Bridge, climbs onto a great mass of serpentine visible in the complex interchange near its summit. When the Cross Westchester Expressway was built, it, too, cut through such rock west of Rye.

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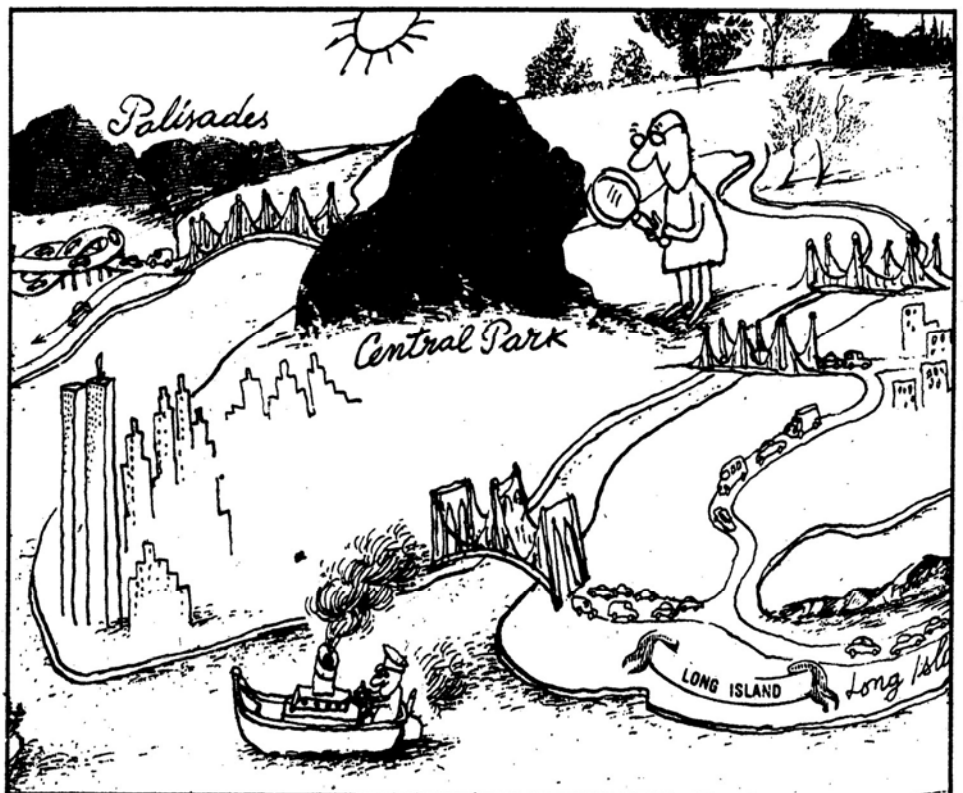
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## The City's Shoreline

New York's shoreline has largely been shaped by another geological process that can be seen in action. This is the role of waves in spreading sand to form barrier islands, like Long Beach, Jones Beach or Fire Island, and spits or hooks, like Rock-away Beach and Sandy Hook.

According to Prof. John E. Sanders of Barnard College, Fire Island, when not interrupted by human activity, grows westward a foot a month. In 110 years, it advanced five miles. During winter storms, waves tend to strike its shore from the northeast, constantly pushing the sand westward, and a visit to one of those beaches during such a storm can be an awesome experience.

A book, "Rock Trails in Central Park," published by the Greensward Foundation, is available by mail for \$5.95 from the Friends of Central Park, Post Office Box 610, New York 10021.



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