FLUIDS-PRESSURE

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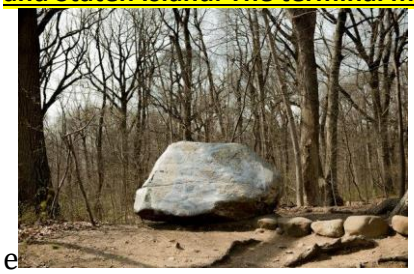
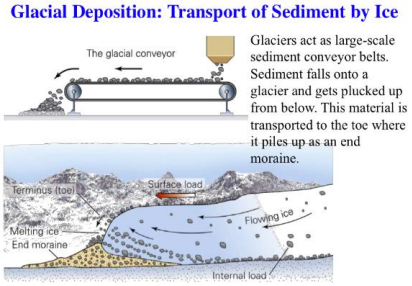
HOW THE ICE AGE SHAPED NEW YORK

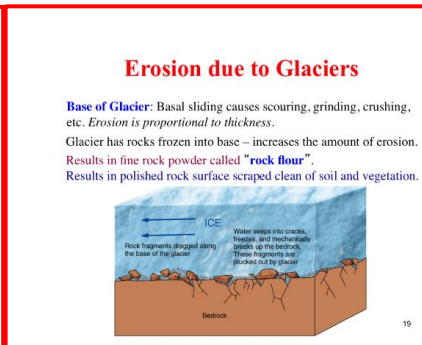
At the start of the last ice age, 2.6 million years ago, a sheet of frozen water formed atop North America that kept expanding and thickening until it reached a maximum depth of roughly two miles. At its southern edge, the vast body deposited tons of rocky debris — from sand and pebbles to boulders the size of school buses. Then, some 18,000 years ago, the planet began to warm and the gargantuan sheet of ice began to melt and retreat. **Today, the southernmost edge of that frozen expanse is marked by a line of rubble that extends across the northern United States for thousands of miles. The largest deposits form what geologists call a terminal moraine. The intermittent ridge runs from Puget Sound to the Missouri River to Montauk Point on Long Island**, forming the prominence that supports its old lighthouse. The ancient sheet of ice also left its mark on a very modern phenomenon: New York City. The ice over Manhattan would have buried even the tallest skyscraper and was so heavy that it depressed the underlying bedrock. As it melted, giant boulders embedded deep within its flanks landed throughout what became the city. Many are still visible in Central Park, unlikely obelisks scored by time.

But the island was the last hurrah, and **the mammoth sheet of ice ended immediately to the south, in Brooklyn, Queens and Staten Island. The terminal moraine,** the mounds of rubble left behind, form much of their high ground.



Boulders like this one in Forest Park in Woodhaven were deposited by the ice sheet as it retreated. They are called erratics.





At Umpire Rock in Central Park, overlooking baseball fields, the geologist noted places where glacial ice and rubble had carved massive grooves, wider than a human body. Yet the rock's overall surface was quite smooth. The reason, Mr. Horenstein said, was that ages of glacial abrasion had acted like sandpaper. "Kids can slide down the rocks," he said of many Central Park outcroppings.

Umpire Rock in Central Park, whose distinctive grooves were formed by glacial ice and rubble.

INTRODUCTION: Under any fluid there is pressure(P = F/A. = ρ g h = [mass density][gravity][depth]) .2000 ft. ice had pressure on Manhattan's rocks(as seen at left}. Thus, the rocks surface were scraped smooth.

QUESTIONS: (a) ρ_{ICE} = 916.7 kg./m,^{3} , g = 9.8 m./s.^{2}, 0.305 m./ft., Find metric pressure under 2000 ft. of ice?, (b) Convert metric pressure in N/m.^{2} (PA) to ft./in.^{2}?, (c) Find pressure under 2000 ft. of ice in units of lb./ft.^{2} & Tons/ft.^{2}?

HINTS: 1.45 X 10^{-4} psi/PA, 2000 lb./ton, 144 in.^{2}/ft.

ANSWERS: (a) 5.48 X 10^5 PA, (b) 794.6 psi, (c) 114,422 lb./ft.^{2} or ~57.2 Tons/ft.^{2}

COMMENT: ~60 tons/ft.^{2} grinds rock smooth with no trouble.

Throughout the park are places where the retreating ice had dropped giant boulders that geologists call erratics, after the Latin word errare, to wander. By definition, the boulders differ in composition from surrounding rocks. Some of the park's erratics sit perched atop flat rocks, looking at times like alien monuments. **Current estimates put the ice's thickness there at roughly twice the early calculations — not 1,000 feet, but closer to 2,000 feet, and possibly more.** The forward edges of glaciers can be inclined or sheer, like a cliff. Mr. Horenstein said geologists believe the local face was sheer. Its precipitous edge shed not only tons of rocky debris but gargantuan blocks of ice. The ice's overall weight was so immense that it depressed the bedrock of the New York City region — and then, following the sheet's retreat, the rocky depths slowly rebounded. Mr. Horenstein said the rise is calculatedat more than 150 feet.