Thickness and Depositional Settings of Surficial Deposits in New Jersey

Introduction

Surficial deposits are unconsolidated sediments that overlie bedrock, weathered bedrock, and Coastal Plain formations. They include sediments laid down by rivers, glaciers, ocean currents and waves, wind, and movement of soil and rock on hillslopes. Surficial deposits in New Jersey are as much as 10 million years old, but are more commonly less than two million years old. They are as much as 400 feet thick in a few areas but are less than 25 feet thick over most of the state where there are deposits. The thickness of surficial deposits (fig. 1) is based on thousands of wells and borings, field observations, and geophysical surveys, compiled in the course of geologic mapping. These data are provided on 1:24,000-scale surficial geologic maps available at the New Jersey Geological and Water Survey website (www.njgeology.org). They were used to generate thickness maps at a scale of 1:100,000 in Stanford and others (1990, 2007). Data in the south coastal area in Atlantic, Cape May, and Cumberland counties are, in part, from Gill (1962) and Newell and others (1995). The thickness and outcrop data discussed in this circular are available as geographic information system (GIS) files at (www.njgeology.org/geodata/dgs07-2.htm).

Surficial deposits greater than 50 feet thick occur in two geologic settings in New Jersey: 1) glacial deposits in the northern part of the state and 2) fluvial-estuarine valley fills in the central and southern part of the state. Bedrock, weathered bedrock, and Coastal Plain formations crop out or have only a thin veneer of surficial deposits over much of the state. These areas are shown in gray on figure 1.

Glacial Deposits

Thick glacial deposits remain from two glaciations: one about 150,000 years ago (150 ka), or earlier, known as the Illinoian glaciation, and one at 25 ka, known as the late Wisconsinan glaciation. An earlier glacier, the pre-Illinoian, entered New Jersey sometime between 2.5 million years ago (2.5 Ma) and 800 ka, but its deposits are highly eroded and rarely exceed 50 feet thick. Glacial deposits more than 50 feet thick occur in three settings: 1) valley fills, 2) thick till in drumlins and till ramps, and 3) stacked till and glacial-lake sediment along the terminal moraine (fig. 2).

Valley fills consist mostly of sediments laid down in glacial lakes that either formed in valleys that drained toward the gla-

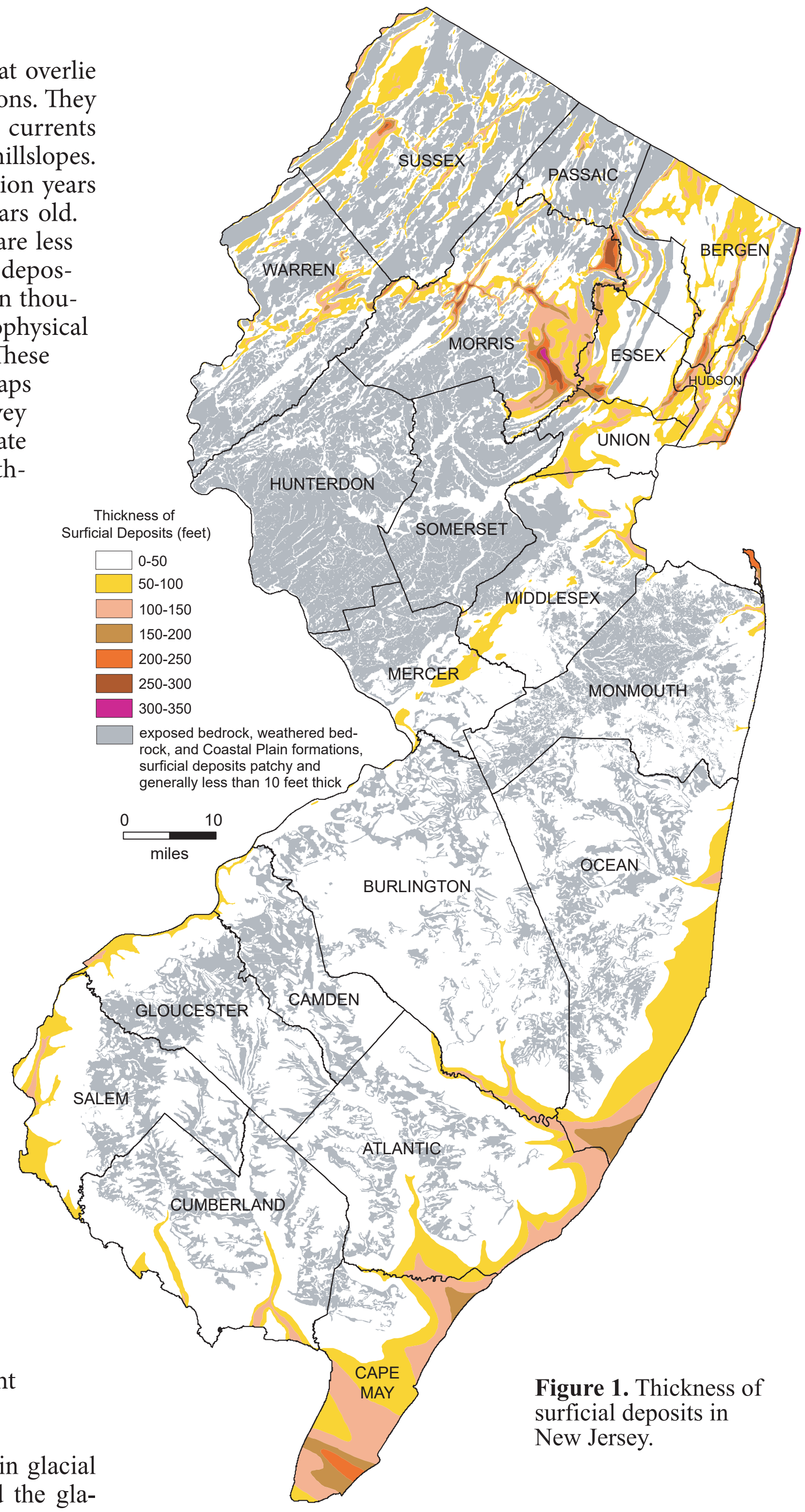

Figure 1. Thickness of surficial deposits in New Jersey.

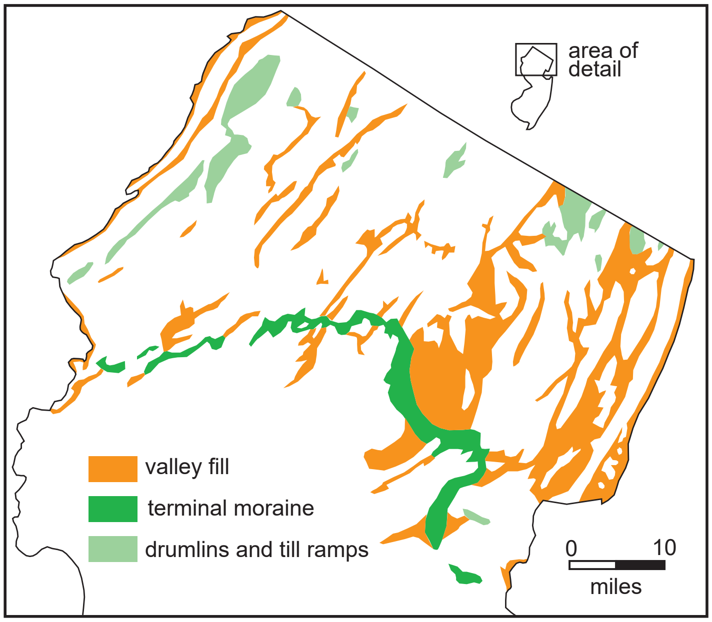

Figure 2. Settings where glacial sediment is more than 50 feet thick.

cier and so were dammed by the ice front, or that drained away from the glacier and were dammed by glacial deposits. In valleys floored with soft rock like shale (in the Ramapo, Passaic, and Hackensack valleys), weathered carbonate rock (in the Musconetcong, Pequest, and Wallkill valleys), or arkosic sandstone (in the Hudson valley), the glacier scoured the valley floor providing additional depth to the lakes (fig. 3). The lakes were partly or fully filled with sand and gravel in deltas and fans, and fine sand, silt, and clay that built up on the lake floor. In some valleys, sand and gravel were laid down in glacial-river plains atop the glacial-lake deposits. These plains formed after the lakes drained when their ice dams melted or when their sediment dams eroded, or after the lakes became filled with sediment.

Thick till was deposited by the late Wisconsinan glacier in drumlins, which are streamlined ridges parallel to ice flow, and till ramps, which are wedge-shaped deposits plastered by the moving glacier against the north and northwest-facing slopes of ridges. Clusters of drumlins form sizable areas of thick till in northern Bergen County, on a broad area west of the summit ridge of Kittatinny Mountain in Sussex County, and along the east base of Kittatinny Mountain in Sussex and Warren counties. The drumlins are cored, in places, with older Illinoian till.

Along the terminal moraine, which marks the limit of the late Wisconsinan advance in most places, the glacier margin was stable for perhaps as long as 1000 years. This stability allowed the glacier to deposit as much as 150 feet of till, forming a belt of ridges and knolls one to two miles wide. In the Passaic, Rockaway, Musconetcong, and Pequest valleys, the glacier overrode earlier deposits. In these valleys, till of the moraine overlies late Wisconsinan glacial-lake deposits laid down in front of the advancing glacier, and Illinoian till and glacial-lake deposits beneath the late Wisconsinan deposits. The total thickness of glacial deposits along the terminal moraine is as much as 400 feet.

Thick glacial sediments along the terminal moraine and in glacial lakes and drumlins completely filled some preglacial river valleys, causing the postglacial rivers to adopt new routes. River diversions of particular note (fig. 3) are: 1) The preglacial Raritan River, which flowed eastward from Bound Brook around the north end of Staten Island until its valley was blocked by the terminal moraine at Plainfield. This diverted the river to its present course southeastward from Bound Brook. 2) The preglacial valley network in the upper Passaic valley, which drained southeastward to the Raritan through a gap in Second Watchung Mountain at Short Hills before the gap was filled by the terminal moraine. This diverted the postglacial river northward to join the Pompton River and exit the Watchung Mountains at Paterson. 3) The preglacial upper Musconetcong valley, which drained south and east into the Rockaway valley before its valley was blocked by the terminal moraine at Ledgewood. This diverted the river southwestward to the Delaware. 4) The preglacial upper Lamington (also known as the Black River) valley, which drained northward to the Rockaway at Kenvil before it was blocked by the terminal moraine and filled with glacial-lake deposits. This reversed the river to its present southerly route across a former drainage divide and into the Hacklebarney Gorge. Other drainage dislocations further to the north affected smaller areas and are more difficult to reconstruct in some places because deeper glacial erosion has erased the details of preglacial drainage.

Fluvial-Estuarine Valley Fills

The surficial deposits of central and southern New Jersey include fluvial, estuarine, coastal, and colluvial sediments. Fluvial sand and gravel range in age from late Miocene (10 Ma) to recent. They form widespread veneers as erosional remnants on upland plains and as terraces and floodplains in valleys. They cap older, unconsolidated Coastal Plain formations and are generally less than 25 feet thick. Fluvial deposits more than 50 feet thick occur only in an abandoned valley in Mercer and Middlesex counties, where a large river system that included the Hudson and, possibly, rivers draining from southern New England, flowed to the southwest through central New Jersey between 5 and 2 Ma. This river cut a valley to a depth slightly below that of modern

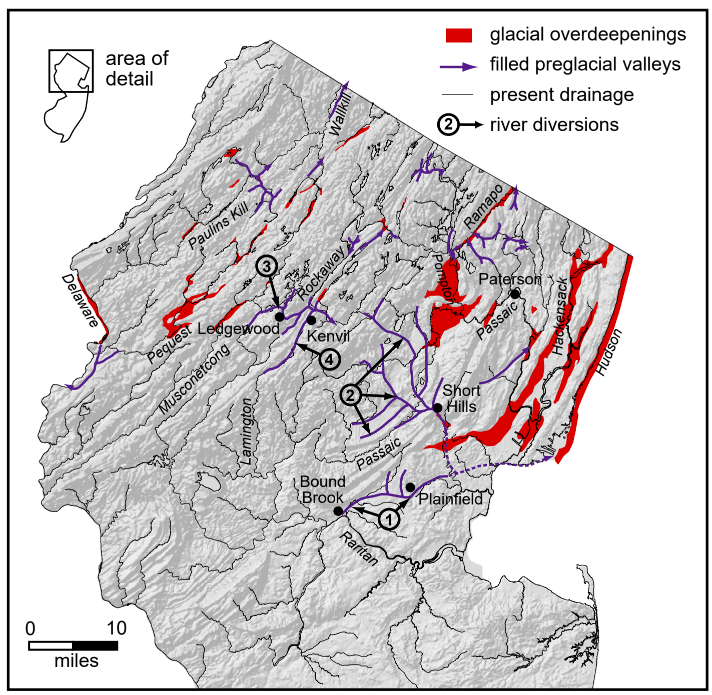

Figure 3. Glacially overdeepened valleys and drainage shifts following glaciation. Numbers correspond to river diversions discussed in text.

sea level. Later, during a period of high sea level in the Pliocene between 3 and 4 Ma, the river deposited a valley fill of sand and gravel known as the Pensauken Formation. Where the Pensauken filled the deepest part of the valley, it is as much as 120 feet thick. Pleistocene erosion by the Delaware River south of Trenton and by the Raritan River and its tributaries north of the Jamesburg area removed much of the former Pensauken valley fill so today only a narrow belt between Trenton and Jamesburg still contains thick deposits.

All other areas of thick deposits in southern New Jersey are estuarine valley fills of Pleistocene (2.5 Ma-11 ka) and Holocene (11 ka to present) age. The Pleistocene was a period of repeated continental glaciation. Sea level dropped as glaciers grew and rose as they melted. During lowstands of sea level, coastal rivers deepened their valleys and extended them onto the exposed continental shelf. During highstands these valleys were submerged to become estuaries and bays. As the valleys flooded, they filled with a sequence of 1) fluvial sand and gravel at the base, deposited during the lowstand, 2) estuarine sand and silt and, 3) near the coast, beach and nearshore sand.

There were at least three periods when sea level was higher than at present: at around 80 ka, 125 ka, and 400 ka or earlier. During these highstands, estuarine sediment was deposited within the valleys, and barrier beaches and coastal terraces built up at their mouths. These deposits filled the downstream parts of valleys during the subsequent lowstand, causing rivers to shift to circumvent the blockages as sea level dropped. This shifting was especially pronounced in the Delaware Bay area (fig. 4), where a lowstand channel of the Delaware River, cut during the Illinoian glacial period at around 150 ka, was filled with estuarine sediment in Salem County and blocked in Cape May County by the southward growth of a beach spit that now forms the Cape May peninsula. The Salem County portion of this former Delaware River channel is known as the Pennsville paleovalley. The Cape May portion is the Rio Grande paleovalley. To circumvent these blockages, the Delaware River cut a new channel to the west of the Pennsville paleovalley and to the south of the Cape May peninsula during the subsequent Wisconsinan lowstand. This channel is beneath the present river and bay, and has itself been filled with estuarine sediment as sea level rose during the Holocene. Growth of the Cape May spit earlier in the Pleistocene also blocked an older paleochannel of the Maurice River north of the Rio Grande paleovalley.

Similar shifts on smaller scale occurred in the lower reaches of the Cohansey and Great Egg Harbor rivers (fig. 4). The Mullica and coastal rivers north of the Mullica did not shift much because they drain areas of higher relief. Their valleys were narrower and afforded less opportunity for lateral erosion.

The thickest Holocene sediments in New Jersey, more than 300 feet thick, are estuarine silt and sand beneath Raritan Bay and the Hudson River. The Hudson valley had been overdeepened by glacial scour north of the terminal moraine. South of the moraine, on what is now the continental shelf, it was deepened by outflows from glacial lakes during retreat of the late Wisconsinan glacier. The Raritan River, diverted from its preglacial course during the glaciation, was a tributary to this deepened Hudson valley and so was able to cut a lowstand channel to the depth of the Hudson in what is now Raritan Bay (fig. 4). During the subsequent rise of sea level these valleys flooded, became estuaries, and filled with estuarine sediment. Over the last several thousand years, Sandy Hook has grown northward as a beach

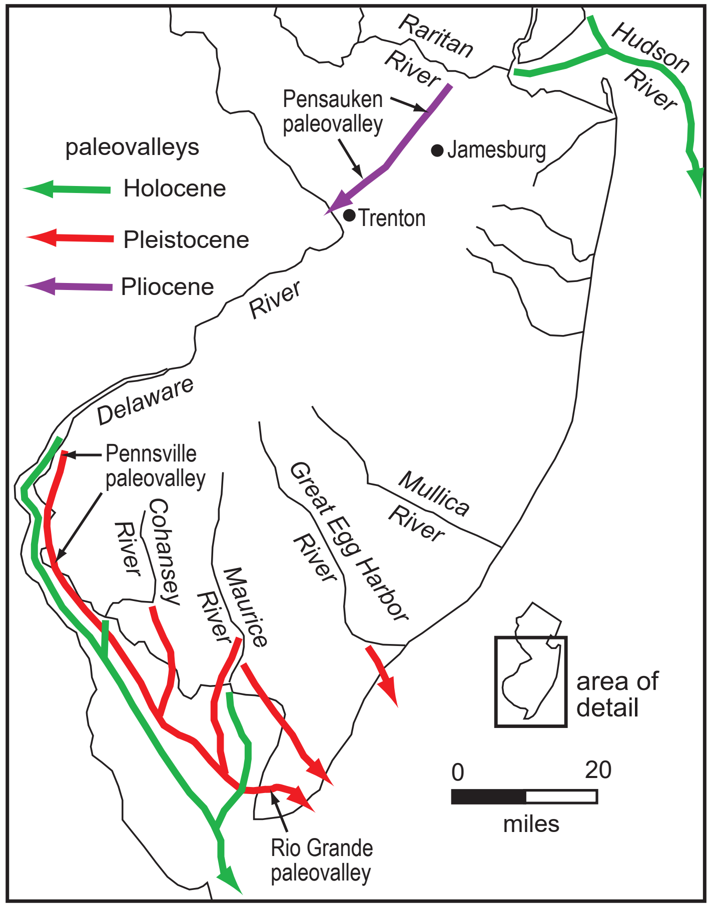

Figure 4. Paleovalleys in the Coastal Plain, with age of valley fill.

spit atop the filled Raritan valley at the mouth of Raritan Bay, capping the estuarine sediments there with sand.

Areas of Thin Surficial Deposits

Surficial deposits are thin over much of the state (gray areas on fig. 1). North of the terminal moraine, the late Wisconsinan glacier eroded pre-existing surficial deposits and weathered rock from much of the land surface, especially on uplands formed on hard rocks like gneiss, quartzite, diabase, and basalt. As much as 40% of the surface in these areas is exposed bedrock, shaped by glacial erosion into ledges and cliffs (fig. 5). In a few places north of the terminal moraine, weathered rock that was not eroded by the glacier is preserved beneath glacial sediments. Weathered rock beneath the glacial sediments is not widespread.

South of the terminal moraine, but north of the Coastal Plain, surficial deposits are largely restricted to floodplains, terraces, and a few windblown deposits in valleys, and aprons of colluvium at the foot of hillslopes. Most of the surface is underlain by weathered rock rather than by surficial deposits. Bedrock crops out on the steepest slopes, narrow ridgetops, and stream-cut channels where weathered material is eroded as fast as it is generated. On some rock types, such as carbonate rock, which is slowly dissolved by rainwater and groundwater, and some gneiss, conglomerate, and sandstones that are rich in feldspar and mica minerals that alter to clay, the weathered material may be as much as 300 feet thick. The thickness of this weathered material varies greatly over short distances due to variation in the composition, bedding, or degree of fracturing in the rock. Less easily weathered rocks, such as shale,

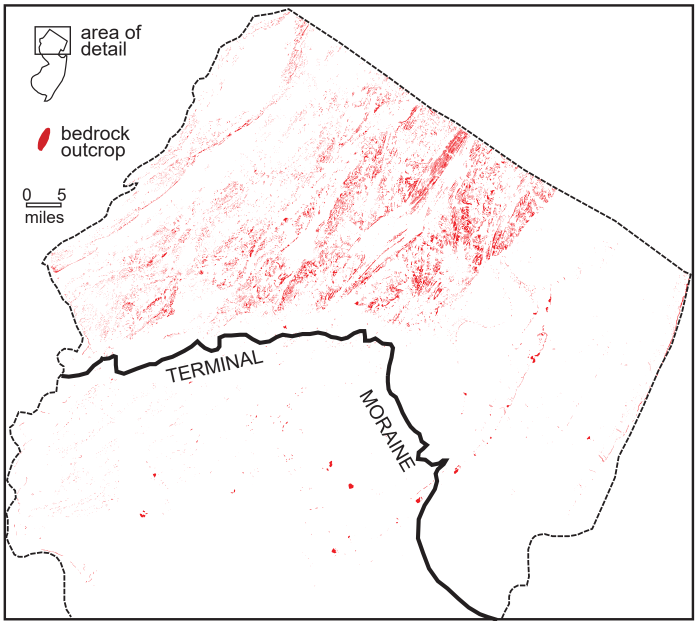

Figure 5. Bedrock outcrop areas in northern New Jersey.

basalt, diabase, and gneiss with less feldspar and mica, generally do not develop thick weathered mantles. Because the thickness of weathered rock varies widely even in small areas, it is not shown on figure 1.

In the Coastal Plain, surficial deposits are thin or absent on steeper slopes, where they have been eroded away, and in some headwater and upland areas, where they were not deposited. In these settings, sand and clay of the underlying Coastal Plain formations are exposed. The sand and clay are composed mostly of minerals that do not weather easily, and so do not develop weathered mantles. Iron-bearing minerals like glauconite, which is a significant component of some Coastal Plain formations, weather to orange, yellow, and brown colored oxide and hydroxide compounds. These weathering products alter the original color of the formations, and cement sediments in places to form ironstones. The weathering does not change the overall grain size or composition of the formations.

Groundwater Resources from Surficial Deposits

Surficial sand and gravel are aquifers where they are sufficiently thick, permeable, and saturated. These locations include: 1) glacial valley fills, 2) the Pensauken Formation in parts of Mercer and Middlesex counties, and 3) sand beds within the Cape May Formation on the Cape May peninsula. Glacial aquifers are important resources in northern New Jersey, where they provide about 40% of the groundwater supply. The aquifers consist primarily of glacial-lake sand and gravel in valley fills more than 100 feet thick. These are confined where they are overlain by lake-bottom clay and silt, and unconfined where the clay is absent. In valley fills along the terminal moraine, the sand and gravel is buried beneath till of the moraine. There it may be partly confined. A few wells in glacial sediment draw water from sandy till, or sand and gravel beds within till, and from glacial-river sand and gravel, although these deposits are generally too thin or discontinuous to be major aquifers.

Sand and gravel of the Pensauken Formation is a minor aquifer in parts of Mercer and Middlesex counties, primarily where it forms a thick valley fill overlying less productive bedrock formations like gneiss and schist. The Cape May Formation, a Pleistocene estuarine and beach deposit that rings the coast of New Jersey, includes two aquifers on the Cape May peninsula: the Holly Beach aquifer, an unconfined beach and nearshore sand that is the topmost aquifer on the peninsula, and the Estuarine Sand aquifer, a partly confined older sand that generally occurs between a depth of 100 and 200 feet (Gill, 1962). Throughout the state, even where surficial deposits are too thin to be aquifers, they are important components of the groundwater resource. They store water which sustains base flow in streams. They also transmit water to underlying bedrock and Coastal Plain aquifers.

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2016

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Banner Photograph: Glacial sediment overlying gneiss, Ringwood, Passaic County.
(Photo by S. Stanford)