New Jersey Geological Survey

Information Circular

Glacial Sediment and the Ice Age in New Jersey

Over the last one and a half million years of the **Pleistocene Epoch**, great ice sheets centered in the subarctic regions of North America grew during periods when the climate was colder than it is now. These continental-sized **glaciers** formed from the gradual buildup of compacted and recrystallized snow. Eventually, the ice became thick enough to flow under its own weight, and spread outward. During their maximum extent, the ice sheets may have been 10,000 feet thick, and 2,000 feet thick above High Point, New Jersey. The exact causes of climatic cooling are not known, but current scientific theory suggests that small changes in the earth's orbit, tilt of its axis, direction of ocean currents and storms, and volcanic dust in the atmosphere all may have contributed to global cooling. The geologic record shows that the growth and decay of these ice sheets was cyclic. In New Jersey this meant the climate varied from arctic or subarctic in glacial periods to temperate or subtropical during **interglacial** periods. Currently, we are considered to be in an interglacial stage.

The distribution of glacial deposits in northern New Jersey, and wide differences in the extent of their weathering and preservation, show that continental ice sheets expanded to and retreated from the New Jersey area at least three times during the Pleistocene Epoch (fig. 1). The age of the oldest of these, the **pre-Illinoian** glacial deposits, is uncertain. Their intense degree of weathering and poor preservation suggest they were laid down more than 800,000 years ago. About 150,000 years ago during the **Illinoian** stage, an ice sheet again covered northern New Jersey, and the most recent glaciation was during the **late Wisconsinan** substage, about 21,000 years ago.

The action of each ice sheet modified the landscape by deeply scouring valleys, wearing down and streamlining bedrock ridges, hills, and slopes, and by eroding most preglacial soil and loose rock. Scratches and grooves cut in bedrock, called **striations**, record the direction of glacier flow. The boulders, gravel, sand,

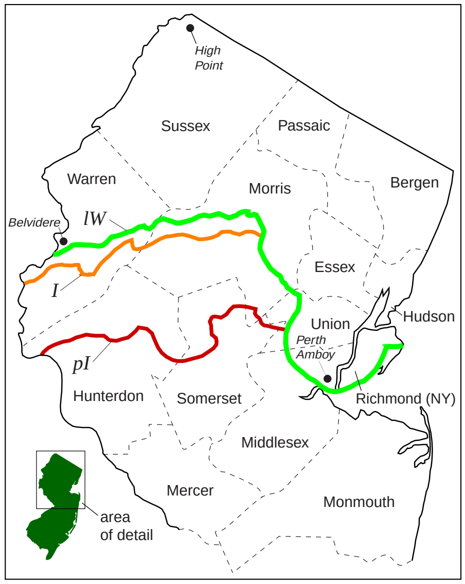

Figure 1. Limits of glaciations in New Jersey and nearby New York. The trace of the lW limit generally marks the position of the Terminal Moraine. Key: *lW* - late Wisconsinan, *I* - Illinoian, and *pI* - pre-Illinoian.

silt, and clay captured by the ice sheets were either deposited as **till**, which is an unsorted mix of clay- to boulder-sized material deposited directly from glacial ice, or **stratified sediment**, which is sorted and layered material deposited by glacial meltwater streams at and beyond the glacier's margin (fig. 2). Till was deposited on the bedrock surface in sheets, in streamlined hills called drumlins, and in ridges called moraines laid down along the former margin of the ice sheet. Stratified sediment was laid down in valleys by rivers that drained away from the glacier, and in glacial lakes. The harsh climate immediately south of the ice sheets also enhanced erosion of surficial sediment on hillslopes, and increased the fracturing of exposed rock largely by frost shattering. In contrast, temperate and subtropical climates during interglacial periods lessened rates of physical weathering, but increased rates of chemical weathering and the formation of thick weathered bedrock, called saprolite. During periods of **deglaciation**, the edge of the ice sheets thinned and wasted away by the gradual northerly recession of their margins. Glacial retreat was probably triggered by (1) climatic warming such that ice at the glacier margin melted faster than it was replaced by flowing ice and/or (2) a decrease in the formation of new glacier ice due to reduced precipitation across the ice sheet.

Most of the glacial sediment in New Jersey was deposited during the last ice age. During this period an ice sheet advanced southward in small lobes following the Hudson, Passaic, Hackensack, Kittatinny, and Delaware Valleys. Over time, the glacier ice became thick enough to flow over Kittatinny Mountain, New Jersey Highlands, and Watchung Mountains. Its furthest advance in most places is marked by the **Terminal Moraine**, which forms a nearly continuous low ridge from Belvidere through Perth Amboy to New York (fig. 1). Accompanying the forward movement of the ice sheet was the deposition of basal till (fig. 2). This material is a compact, poorly sorted, nonlayered mixture of clay- to boulder-sized material laid down at the glacier base (fig. 3). Stones largely made

Figure 2. Composite diagram showing the depositional setting of glacial sediments. Key: 1) basal till, 2) flowtill, 3) planar beds of gravel and sand, 4) inclined beds of sand and some gravel, and 5) laminated beds of silt, clay, and very fine sand.

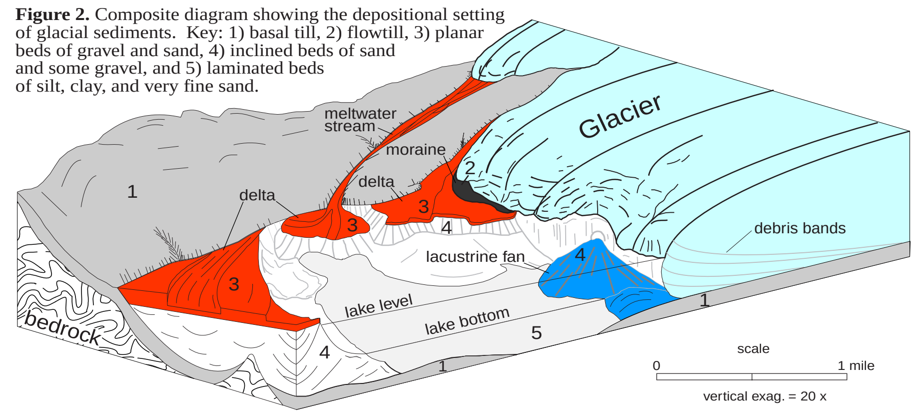

Figure 3. Basal till. This unsorted and unlayered mixture of clay- to cobble-sized material was laid down at the glacier's base.

from nearby bedrock may make up as much as 20 percent of the deposit by volume. They typically have a subangular to subrounded shape, and many are striated and polished. These features were formed during glacial transport. Overlying this lower compact till is a thin, discontinuous, noncompact, poorly sorted silty sand or sand containing as much as 35 percent pebbles, cobbles, and boulders, and interlayered with thin beds of sorted sand, gravel, and silt. Typically these stones are more angular than those in the underlying till. This material melted out of the glacier, and was gradually let down on the land surface as the glacier ice melted. It is called **ablation till**. If the material has flowed onto adjacent glacier ice or land (fig. 2), then it is called **flowtill**.

Till covers the bedrock surface north of the Terminal Moraine in most places except the rocky crest of some ridges and a few steep slopes. Where it is thin, the undulatory, uneven bedrock surface shows through. Thicker till subdues these irregularities, and in many places completely hides them. Very thick till forms aprons on north-facing slopes, extensive sheets called ground moraine, and elliptically-shaped hills called **drumlins**. Drumlins are elongated in a direction parallel to glacier flow. They formed beneath the ice sheet where the glacier streamlined older surficial material or where the glacier molded till. In places where the margin of the ice sheet remained in a constant position, **end moraines** were deposited. These features, such as the Terminal Moraine (fig. 1), are bouldery, chiefly cross-valley ridges that mark the former lobate edge of the ice sheet. They are made of till and minor layers of silt, sand, and gravel, and their topographic form consists of irregularly-spaced knolls, smaller ridges, and depressions. End moraines form at the glacier's edge where sediment, released from melting ice, accumulates (fig. 2). Morainal material is also pushed into place by the motion of the ice sheet.

Glacial **erratics** (fig. 4) are rocks transported by glaciers and laid down a distance, often many miles, from their original location. Many are unlike the bedrock on which they rest because glacial ice in many places flowed across different types of bedrock. Most show evidence of glacial erosion by their subrounded to rounded shape, faceted sides, and striated and polished surface. They are found throughout northern New Jersey and they record the direction the glacier flowed.

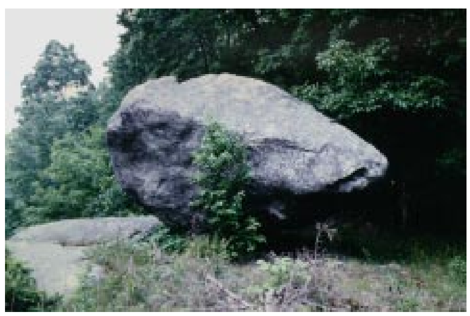

Figure 4. Large erratic lying on bedrock. The boulder is about 10 feet in length.

Meltwater deposits consist of layered gravel, sand, and silt laid down by meltwater streams at and beyond the glacier margin (fig. 2). Based on their texture, nature of layering, and their depositional environment, they are placed into three groups. The first consists of stream deposits (fig. 2). These are largely made up of horizontal to gently dipping layers of coarse to fine gravel and sand (fig. 5) laid down in valleys that drained away from the glacier. The second group is made of **deltas** and **lacustrine-fan** deposits. These chiefly consist of steeply to gently dipping layers of fine gravel, sand, and silt (fig. 6) called foreset beds that were laid down in glacial lakes. The third group consists of **lake-bottom** deposits. These are largely made up of horizontal, very thin layers of silt, clay, and very fine sand that were laid down on the floor of glacial lakes either by the settling out of suspended sediment from the murky lake water, or by deep-water currents.

Figure 5. Horizontally-layered gravel and sand. These coarse-grained sediments were laid down by a glacial meltwater stream.

Figure 6. Inclined layers of sand; also called foreset beds. These well sorted and layered sediments were laid down in a glacial lake.

The economic value of glacial sediment in New Jersey has enormous potential. Some of the state's most prolific sources of drinking water are the many coarse-textured stratified glacial deposits laid down during the last ice age. This material has also been mined for use as aggregate, select fill, surface coverings, decorative stone, and building stone. Deposits of clay and silt are used as liner and cap material for landfills, and till is locally used as fill.

Prepared by Ron W. Witte

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STATE OF NEW JERSEY

Christine Todd Whitman, Governor

Department of Environmental Protection

Robert C. Shinn, Jr., Commissioner

Environmental Planning and Science

Robert Tudor, Assistant Commissioner

Division of Science and Research

Leslie J. McGeorge, Director

New Jersey Geological Survey

Haig F. Kasabach, State Geologist

Comments or requests for information are welcome.
Write: NJGS, P.O. Box 427, Trenton, NJ 08625-0427
Phone: 609-292-1185 Fax: 609-633-1004
Visit the NJGS web site @ www.state.nj.us/dep/njgs

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