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## INTRODUCTION

Surficial materials in the Pittstown 7½ minute quadrangle are highly variable and cover most of the unweathered bedrock surface. They include 1) weathered bedrock, weathered during the Quaternary and possibly Neogene from Triassic fanglomerate, sandstone, and mudstone and Cambrian and Ordovician dolomite, limestone, and shale, 2) glacial till of pre-Illinoian (older than ~788 ka, ka = thousand years) age, 3) glacial outwash in the South Branch Raritan River (SBRR) valley of pre-Illinoian age, 4) stony colluvium of Quaternary age chiefly derived from weathered bedrock, and 5) alluvium of pre-Wisconsinan, Wisconsinan and Holocene age. The areal extents of surficial deposits shown on the map are based on their physical characteristics, readily distinguishable boundaries, location on the landscape, and by genetic and morphologic criteria.

The physiography of the quadrangle reflects a composite landscape shaped largely by fluvial and periglacial processes. Over the last two million years, the study area was shaped by multiple periods of glacial and periglacial weathering related to the growth and decay of the Laurentide ice sheets in North America. Although the effects of glaciation in modifying the land may have been pronounced, these modifications have been largely masked during periods of periglacial modification. Based on the sawtooth record of the marine isotope record, Braun (1989) estimated that there might have been as many as ten glaciations of a magnitude sufficient to introduce a periglacial climate to eastern Pennsylvania and New Jersey. During these periods, much cooler temperatures and increased precipitation enhanced the break-up and fragmentation of rock largely by frost shattering. Additionally, the transport of materials downslope by mass wasting became greater due to a change from a deep-rooted to a shallow-rooted vegetative cover. Colluvium, the main product of periglacial mass wasting, was shed from uplands onto the lower parts of hillslopes, the floors of narrow valleys, and the heads of first-order drainage basins. In contrast, during the warm interglacials the relative rate of chemical weathering increased and an extensive cover of deeper-rooted vegetation helped reduce the rate of mass wasting. During these periods, thick soils were formed and bedrock was deeply weathered forming saprolite and decomposition residuum. Colluvial valley-fills were also largely eroded by fluvial action.

The topographic position, degree of preservation, and difference in weathering characteristics of glacial drift in New Jersey show that continental ice sheets reached New Jersey at least three times (Salisbury, 1902; Stone and others, 2002). The main effects of these glaciations were 1) the widening and deepening of valleys, 2) smoothing, streamlining, and wearing down of ridges, 3) erosion of preglacial soil and regolith, 4) change in stream drainage by derangement, 5) formation of many wetlands, and 6) the filling of valleys with stratified materials (sand, gravel, silt and clay). Only the oldest glaciation, the pre-Illinoian, reached the quadrangle. The maximum glacial limit, defined by the most southerly occurrence of gneiss and chert erratics, trends east to west, passing near Pittstown (fig. 1). Most evidence of pre-Illinoian glaciation has been removed by weathering and erosion. A few scant patches of pre-Illinoian till (Qpt) and outwash (Qps) and scattered erratics are all that remain of New Jersey's most extensive glaciation.

## PHYSIOGRAPHY AND BEDROCK GEOLOGY

The Pittstown quadrangle (fig. 1) lies in the Piedmont Province. 1,600 square miles of the Piedmont lies within New Jersey, about one-fifth of the state. A drainage divide between the Delaware and Raritan Rivers runs through the quadrangle separating drainage between Delaware and Raritan Bays. Streams in the southwestern part of the quadrangle (Lockatong and Wickecheoke Creeks and Plum Brook) flow southwest to the Delaware River. Elsewhere, Cakepoulin and Assiscong Creeks, and Walnut Brook flow east, and Cramers and Allerton Creeks flow west, to the SBRR. The area is a mix of suburban and rural lands. Patchwork wood lots and cultivated fields cover large areas. Larger forested areas cover terrain of higher elevation to the northwest. The highest point is approximately 807 feet (246 m) above sea level on a small hill just northwest of Mechlings Corner. The lowest point, at approximately 135 feet (41 m) above sea level, is on the SBRR where it flows eastward out of the quadrangle.

The Hunterdon Plateau, which is a somewhat undulate dissected plain underlain by slightly folded and faulted sedimentary rocks of Triassic age, covers most of the quadrangle. The bedrock consists of Triassic quartzite fanglomerate, sandstone, argillite, and mudstone of the Stockton, Lockatong, and Passaic Formations (Herman and others, 1992). The coarsest-grained rocks, consisting of fanglomerate, lie to the north. Grain size decreases along a general southward trend, with rocks transitioning to sandstones and then argillites or mudstones. Correlatively, topography changes with underlying lithotype (fig. 2). An idea presented by Hack (1960) and summarized here is that topography is largely the result of differential erosion of rocks that have varying degrees of resistance to erosion. Areas underlain by fanglomerate typically hold up the highest areas. Topography is typically rugged here, the result of deep dissection. Rock outcrops are few because in most places the rock surface is covered by thick saprolite, fragmentation rubble, and colluvium. Areas underlain by sandstone are similar but have a slightly lower degree of dissection. Elsewhere in the map area, the Piedmont is underlain by argillite and mudstone. Topography over these less resistant rocks is a slightly rolling plain that ranges in elevation from 500 to 600 feet (152-183 m). Overall, elevation decreases from 800 to 500 feet (244-152 m) going north to south.

A hillshade image of the quadrangle (fig. 3) created from LiDAR data clearly shows two large-scale structural features. The first is a large westward-plunging syncline marked by concentric sets of strike ridges. In many places, streams flow along arcuate courses that parallel the ridges. This geometry is especially prevalent in the southern half of the quadrangle where local bedrock is largely interlayered argillite and mudstone. The second feature is an escarpment along the east side of the quadrangle that parallels the strike ridges. Elevation change across the scarp is about 200 feet (61 m) forming a pronounced rise in the land. In part, the scarp is formed along the contact between the easily eroded mudstones of the Passaic Formation and the tough argillites of the Lockatong Formation. The scarp is also in proximity to the Flemington Fault and its many splays (Herman and others, 1992). The down thrown side of the fault block to the east underlies areas of less resistant rock eroded to a lower elevation.

## PREVIOUS INVESTIGATIONS

Cook (1880) discussed the geology of New Jersey's glacial deposits in an Annual Report of the State Geologist. He included detailed observations on the terminal moraine, recessional moraines, distribution and kinds of drift, and evidence of glacial lakes. Deposits of "older" weathered drift were discussed by Cook (1880) who noted the distribution of quartzose boulders and scattered patches of thin gravely drift in western New Jersey. Most of this material was thought to be "modified glacial drift", possibly deposited by meltwater and reworked later by weathering and fluvial erosion. On closer inspection (Salisbury, 1894) this "modified glacial drift" was determined to be of glacial origin and called extra-morainic drift because of its distribution south of the terminal moraine.

A voluminous report by Salisbury (1902) detailed the glacial geology of New Jersey region by region. The terminal moraine and all surficial deposits to the north were interpreted to be products of a single glaciation of Wisconsinan age. South of the terminal moraine Salisbury (1902, Plate XXVIII) shows two deposits of extra-morainic glacial drift. The first, forming a narrow belt just outside the terminal moraine, was interpreted to be glacial drift of Wisconsinan age mixed with material that was older than Wisconsinan. Salisbury indicated that the drift was deposited during a temporary advance of ice beyond the terminal moraine, or was carried out by running water. The second body of extra-morainic drift was interpreted to be largely glacial and much older than the terminal moraine based on its deep weathering and patchy distribution. It extends as much as 20 miles (32 km) beyond the terminal moraine. Salisbury (1902) assigned a Kansan age to the older drift because its deeply weathered appearance suggested it was the product of a much older glaciation than the Wisconsin. Chamberlin and Salisbury (1906) correlated this oldest drift with the sub-Aftonian glacial stage of Iowa, using the term "Jerseyan" as an equivalent stage for the older glacial deposits in Pennsylvania and New Jersey. Bayley and others (1914) divided the extra-moranic drift into "early glacial drift" that was largely till deposited during the Jerseyan stage and "extra-morainic drift" that consisted of a mix of Wisconsinan and early drift.

Salisbury (1902) also discussed the character and development of terraces in the SBRR valley. The most notable are remnants of an extensive terrace that lies about 35 feet (11 m) above the modern river. The "clayey gravel" of that terrace is moderately weathered, largely consisting of gneiss clasts with secondary quartzite, sandstone, and shale.

## PREGLACIAL DRAINAGE and GEOMORPHOLOGY

The Delaware and Raritan Rivers were probably well established close to their current courses before the Pleistocene. Transverse gaps in the Highlands north of the map area are possibly relicts of a pre-Pleistocene Raritan River drainage system that flowed in a southeasterly direction from Kittatinny Valley across the Highlands to the present Raritan basin (Witte, 1997). Later the Delaware River, through headward erosion and stream capture, has enlarged its drainage area chiefly by extending its tributaries up northeast-southwest trending belts of rock less resistant to weathering, and rock weakened by faulting and extensive fracturing.

In response to the overall lowering of sea level during the Pleistocene, the drainage has further evolved by incision, which along the larger tributaries of the Delaware River has resulted in the formation of a much lower, narrower, river valley. Extensive headward erosion by first and second-order streams has also resulted in the dissection of the older valley floors, and the bordering uplands. The location and elevations of Illinoian glaciofluvial deposits in the Delaware River valley (Ridge, 1983; Stone and others, 2002) and Illinoian fluvial deposits in the SBRR valley show that the river valleys in the study area had been lowered or nearly lowered to their present levels by the time of the Illinoian glaciation.

## QUATERNARY GEOLOGY

New Jersey's terrestrial glacial record shows that the Laurentide ice sheet reached New Jersey at least three times (Stone and others, 2002) over the last two million years. These glaciations (fig. 1), following the terminology of Richmond and Fullerton (1986), are from youngest to oldest the late Wisconsinan (Marine Isotope Stage (MIS) 2), late Illinoian (MIS 6), and one or more pre-Illinoian G (MIS 22) or older glaciations. Braun (2004) cited evidence of four glaciations in Pennsylvania: Late Wisconsinan, Late Illinoian or pre-Illinoian B (MIS 12), pre-Illinoian D (MIS 16), and pre-Illinoian G (MIS 22). There is some disagreement concerning the age of the older glaciations and number of pre-Illinoian glaciations, but there is a remarkable congruency between the glacial limits mapped in Pennsylvania and New Jersey on either side of the Delaware River. The youngest glacial deposits, laid down during the late Wisconsinan substage, provide the clearest record of glaciation. The Illinoian and especially the pre-Illinoian glacial history is much less clear due to extensive and complex weathering and periglacial modification. In the Pittstown quadrangle, only the pre-Illinoian glaciation is represented. Pre-Illinoian ice reached its terminal position in the northern part of the quadrangle along a line that runs roughly east to west passing through Pittstown. The pre-Illinoian glacial limit in New Jersey (pIGL) is based on the most southerly occurrence of thin, deeply weathered patchy till, and till-stone lags, collectively known as the Port Murray Formation, till facies (Stone and others, 2002), and erratics. In western New Jersey, the limit lies just south of Musconectong Mountain crossing the Delaware River near Holland, New Jersey (fig. 1). Clasts weathered from Triassic fanglomerate make the identification of pre-Illinoian glacial drift in this area difficult.

Tracing the pIGL into Pennsylvania, there is a close accordance with pre-Illinoian boulder and cobble lags mapped by Braun (1994) near Monroe, Pennsylvania. As in New Jersey, the identification of glacial drift in areas of fanglomerate is problematic. Alternatively, some of these lags may be weathered pre-Illinoian outwash given their position along and above the Delaware River. Farther west the limit is traced to pseudo-moraine areas in the Saucon and Lehigh Valleys (Braun, 2004).

### Pre-Illinoian Glaciation

New Jersey's oldest glaciation is represented by the Port Murray Formation (Stone and others, 2002) (fig. 1), which replaces the term "Jerseyan". The formation consists of till, till-stone lag, and meltwater deposits. It is deeply weathered, thin and patchy, and lies on weathered bedrock. Deposits are generally only preserved in lowlands in areas of low relief isolated from erosion, and more rarely in uplands where deposits remain on low topographic saddles and broad low-relief surfaces. In places, these older deposits have been found beneath colluvium. They are typically less than 15 feet (5 m) thick. Constructional topography is not preserved. The drift is not found in the modern valleys, more often lying as much as 100 feet (31 m) above modern valley floors in areas that are protected from mass wasting and fluvial erosion. In most places, these older deposits appear to be till. However, after a long and complex weathering history most of these polymictic materials have become clayey, slightly stony diamictons. Original characteristics are often difficult to discern. The strong consensus is that these materials are of glacial origin.

The southern limit of the pre-Illinoian glaciation (pIGL) is based on the most southerly occurrence of thin, deeply weathered patchy till of the Port Murray Formation, till-stone lag, a few stratified deposits, and erratics. In most places the limit is approximate. The pIGL lies as much as 15 miles (24 km) south of the Illinoian glacial limit, following a westward trending course from Mountainside, Union County, to Holland, Hunterdon County, New Jersey (fig. 1). Pre-Illinoian glacial deposits have not been recognized east of Mountainside.

As previously discussed, the age of this oldest and most extensive glaciation is uncertain. The Port Murray Formation is correlative with the oldest glacial deposits in eastern Pennsylvania, which are older than 788 ka based on the reversed magnetic polarity of lake-bottom deposits cited in Braun (2004). Braun (2004) assumed a pre-Illinoian G (850 ka) age for these deposits whereas Stanford (1997) favors a pre-Illinoian K (2.1 Ma, Ma = million years) age. Samples collected from a silty-clay bed in a deeply weathered, probably glaciofluvial deposit in the Pohatcong Creek valley near Kennedys (fig. 1), and from varved glaciolacustrine clay near Bernardsville, show that these sediments were laid down during a period of reversed magnetic polarity (written commun., J. C. Ridge, Tufts University, 1998 and C. Lepre, Rutgers University, 2010). This places the age of the deposits older than 788 ka. Based on the correlation of continental glaciations in the northern hemisphere with the offshore oxygen isotope record, these deposits may have been laid down during a glaciation sometime between 2-2.5 Ma or between 1.3 Ma and 800 ka. It is possible that the Kennedys deposit is not outwash, but alluvium laid down by Pohatcong Creek or the Delaware River. If this is the case, because the Kennedys deposit lies within the belt of older glacial drift, the older drift is of the same age or older than the 788 ka minimum age of the Kennedys deposit.

A few high standing deposits of deeply weathered gravel (Qps) and gravel lags have been mapped in SBRR valley lying 80 to 120 feet (24-37 m) above the modern river. Based on their topographic position and advanced degree of weathering they are interpreted as pre-Illinoian glacial outwash. Subsequently, the SBRR has down cut into the Port Murray surface. Based on the locations and elevations of the Illinoian deposits, this downcutting occurred between the pre-Illinoian and the Illinoian glaciations.

### Illinoian glaciation

When ice was at the Illinoian maximum position about 20 miles (32 km) north of Hamden near Flanders, New Jersey, meltwater deposited a small outwash plain in the headwaters of the SBRR valley upstream from the map area (Drakes Brook outwash of Stone and others, 2002). Some of this outwash may have been carried into the map area and laid down either in the upper terrace (Qtu) or the older upper terrace (Qtuo) deposits. However, the size and continuity of the upper terrace in the Raritan Valley downstream from Clinton, and its poor development or absence upstream from Clinton, suggest that the upper terrace was not continuous with the Drakes Brook outwash and is mostly nonglacial. Weathering of gneiss clasts in the upper terrrace is similar to that in Illinoian glacial deposits. This similarity suggests that the upper terrace is of similar age. Since the terrace has not been dated it may also be younger than Illinoian, possibly representing valley cutting and filling throughout the early and middle Wisconsinan and into the early late Wisconsinan. It is older than the late Wisconsinan glacial maximum (25 ka) because, downstream in the Raritan Valley, it is inset and overlain by the late Wisconsinan Millstone terrace deposit in Manville and the Plainfield outwash plain in the Bound Brook area (Stanford, 1992). Today, the upper terrace deposit lies about 20 feet (6 m) above the modern river. Two erosional remnants of the older upper terrace (Qtuo) lie about 10 to 15 feet (3-6 m) higher than the main upper terrace.

### Late Wisconsinan glaciation

The only meltwater discharge into the SBRR valley during the late Wisconsinan maximum was lake outflow from glacial Budd Lake, about 20 miles (32 km) north of Hamden. This discharge did not contain sediment and so a valley train was not deposited. A low terrace (Qtl), with unweathered to lightly weathered gneiss clasts, may represent aggradation during this time, largely built up by non-meltwater sources. Similar low terraces downstream in the Raritan Valley are clearly not related to meltwater and grade to the Millstone terrace deposit and the Plainfield outwash plain of late Wisconsinan age in the Bound Brook area (Stanford, 1992).

## SURFICIAL DEPOSITS

Surficial materials in the study area include alluvium, colluvium, wind-blown sand, glacial drift, and weathered bedrock. They are defined by their lithic characteristics (composition, texture, color, and structure) and bounding discontinuities.

### Non-Glacial Deposits

Stream deposits (alluvium, stream-terrace deposits, and alluvial-fan deposits)

Alluvium (Qal) is chiefly of Holocene age and includes both channel (sand and gravel) and overbank (sand and silt) sediment laid down by streams in sheet-like deposits on the floors of modern valleys. Stream-terrace deposits (Qst) forming a terrace that lies 5 to 10 feet (1.5-3 m) above the modern flood plain of Walnut Brook in the southeast corner of the quadrangle include both channel and overbank sediment. Alluvial-fan deposits (Qaf) are scattered throughout the map area. They lie at the base of hill slopes where streams emerge from uplands. Their surfaces are entrenched by the modern drainage. These entrenched erosional channels show that the fan is not presently forming and that their formation is cyclic; influenced chiefly by climate and its effects on weathering, sediment supply, and amount and type of vegetative cover. Incision to the modern flood plain was completed by about 14 ka based on radiocarbon dates of 13.8 to 13.9 calibrated ka on wood and charcoal from a bed of organic silt beneath channel gravel along Walnut Brook in the southeast corner of the map area (Herman and Stanford, 2014). Incision occurred due to the decrease in sediment supply in response to forestation of the drainage basin as climate warmed.

Hillslope sediment

Hillslope deposits include colluvium (Qcf, Qcs) and a mix of alluvium and colluvium (Qac). The colluvium is widespread and is derived from underlying and upslope materials transported downslope by soil creep, solifluction, earth and debris flows, and rock fall. The source materials are chiefly derived from the fragmental disintegration of bedrock by frost shattering, bioturbation, and chemical weathering. It typically forms a monolithic diamict that mantles most slopes and forms thick aprons of material on their lower parts. It also collects in small first-order drainage basins in upland areas. In places, colluvium includes thin beds and lenses of sorted, stratified sheet- and rill-wash sand and gravel. Alluvium and colluvium (Qac) consists of a mixture of diamict and sorted sand, gravel, and silt that has accumulated in thin sheets in narrow valleys and the heads of first-order drainage basins. The toe slopes of small colluvial aprons are in som eplaces included in the Qac map unit.

### Glacial Materials

Till

Till is a poorly sorted, deeply weathered, nonstratified to very poorly stratified mixture of clay- to boulder-sized material deposited directly by or from a glacier. Till in the study area is represented by the Port Murray Formation, till facies (>788 ka). Port Murray till (Qpt) is highly weathered, has a clayey matrix, is oxidized and leached of carbonate material, lies on weathered bedrock, and is only found in topographic positions where it has been protected from erosion. Elsewhere, where erosion has occurred, glacial erratics may be found in modern drainages. These are remnants of a formerly much more extensive till sheet. In the quadrangle, remnant deposits of Qpt and erratics are found north of the Pittstown area. The erratics consist of gneiss, chert, and quartz-pebble conglomerate and Paleozoic quartzite. Qpt has undergone extensive modification by weathering and erosion. Downslope transport of the drift largely by colluviation is thought to have stripped most of this material off areas of moderate to steep relief.

Deposits of glacial meltwater streams

Meltwater deposits of pre-Illinoian age, known as the Port Murray Formation, stratified facies (Qps), are found in the SBRR valley where they form patchy, high-standing, deeply weathered gravels on rock-cut benches 80 to 120 feet (24-37 m) above the modern river. The SBRR has cut down as much as 120 feet (37 m) into bedrock since these gravels were laid down.

### Weathered bedrock

Weathered bedrock consists of saprolite, decomposition and solution residuum (Richmond and others, 1991), and rock rubble that formed on bedrock of Triassic, Ordovician, and Cambrian age. It was mostly formed during the Quaternary under temperate climatic conditions during interglacial periods. Some weathered bedrock may also be of Neogene age. Weathered bedrock materials are divided into map units based on lithologic criteria. Bedrock does not generally crop out except along streams, and on some steep slopes.

Weathered fanglomerate (Qfw) is chiefly decomposition residuum consisting of rounded to well-rounded quartz-pebble conglomerate and quartzose sandstone cobbles and pebbles in a silty-sandy matrix (fig. 4). The material is typically not layered. However, in places remnant bedding may be faintly preserved. Well records (on file at the New Jersey Geological and Water Survey) show that this material may be as much as 50 feet (15 m) thick.

Weathered shale, mudstone, siltstone, and minor sandstone (Qsw) consists chiefly of decomposition residuum and shale-chip or flagstone rubble. In places underlain by Triassic rocks, a dark reddish-brown clayey-silty nonstructured to structured saprolite may be found (fig. 5). Well records show that this material may be as much as 10 feet (3 m) thick.

Weathered carbonate rock (Qcbw) consists chiefly of yellowish- to reddish-brown silty clay solution residuum and karst-fill materials. It is largely unstructured and contains sparse clasts of chert and vein quartz. Weathering extends deeply in the subsurface along fractures, joints and bedding planes. In many places, the weathered bedrock alternates in the subsurface with nonweathered bedrock. Bedrock outcrops are widely scattered; most are marked by subcrop consisting of irregularly-shaped boulders on ridgecrests or steep hillslopes. The bedrock surface is very irregular and deeply etched along joints and fractures. Sinkholes are common.

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## DESCRIPTION OF MAP UNITS

Map units denote unconsolidated materials more than 5 feet (1.5 m) thick. Colors based on Munsell Color Company (1975), and were determined from naturally moist samples.

### HOLOCENE AND LATE WISCONSINAN

**af** — **ARTIFICIAL FILL** - Rock waste, gravel, sand, silt, and manufactured materials emplaced by humans. As much as 25 feet (8 m) thick. Many small areas of fill are not shown.

**Qal** — **ALLUVIUM** - Stratified, moderately- to poorly-sorted sand, gravel, silt, and minor clay. Color of the sand and finer sediment varies from gray to dark gray, reddish-brown to brown, and yellowish brown. Locally bouldery and in places may contain wood and fine organic material and may be overlain by and interlayered with thin colluvium. As much as 20 feet (6 m) thick. Includes planar- to cross-bedded gravel and sand in channel deposits, and cross-bedded and rippled sand, massive and parallel-laminated fine sand, very fine sand, and silt in overlying floodplain deposits.

**Qac** — **ALLUVIUM AND COLLUVIUM, UNDIFFERENTIATED** - Stratified, poorly to moderately sorted, reddish-brown to brown, yellowish-brown, and gray, sand, silt and minor gravel; as much as 20 feet (6 m) thick. Interlayered with, or overlying, massive to weakly layered, poorly sorted sand, silt, and minor gravel.

### LATE WISCONSINAN

**Qaf** — **ALLUVIAL-FAN DEPOSITS** - Stratified, moderately- to poorly-sorted, brown to yellowish-brown, reddish-brown, sand, gravel, and silt in fan-shaped deposits; as much as 20 feet (6 m) thick. Includes massive to planar-bedded sand and gravel and minor cross-bedded channel-fill sand. Bedding dips as much as 30 degrees toward the trunk valley. Locally interlayered with unstratified, poorly sorted, sandy-silty to sandy-gravelly diamicton interpreted to be of colluvial or mass flow origin. Fans form at the mouths of gullies and ravines. Clasts are local in origin, typical lithologies similar to weathered bedrock and colluvial source materials.

**Qst** — **STREAM-TERRACE DEPOSITS** - Weakly stratified, well- to moderately-sorted, reddish-brown, brown, yellowish-brown, massive to thinly planar-bedded, and minor cross-bedded very fine sand, fine sand and silt, and minor pebble-to-cobble gravel, in terrace flanking Walnut Brook. Gravel consists of red and gray shale, mudstone, and sandstone and minor gray basalt. As much as 15 feet (5 m) thick. Forms terrace with a surface 5 to 10 feet (1.5-3 m) above the modern flood plain.

**Qtl** — **LOWER TERRACE DEPOSITS** - Stratified, well- to moderately-sorted, yellowish-brown, grayish-brown, to light reddish-brown sand, cobble to pebble gravel, minor boulder gravel, and minor silt in the South Branch Raritan River valley. Gravel consists of gray to brown quartzite and quartzite conglomerate, white to gray quartz, red to gray siltstone and sandstone, gray to white gneiss, and minor black chert. Clasts are unweathered. Consist of massive to horizontally-bedded and imbricated coarse gravel and sand, and planar to tabular and trough cross-bedded, fine gravel and sand in bars, and channel-lag deposits with minor cross-bedded sand in channel-fill deposits. In places covered by thin overbank deposits of yellowish-brown to reddish-brown massive to faintly laminated clayey silt and very fine sand. Form terrace remnants that lie 5 to 10 feet (1.5-3 m) above the modern flood plain. As much as 30 feet (9 m) thick. Equivalent to the Raritan lower terrace deposit of Stone and others (2002)

### MIDDLE PLEISTOCENE TO HOLOCENE

**Qcs** — **SHALE, SANDSTONE, AND MUDSTONE COLLUVIUM** - Silt, sandy silt, clayey silt, reddish-brown to yellowish-brown, with some to many subangular flagstones, chips, and pebbles of red and gray shale, mudstone, and minor sandstone. Poorly sorted, nonstratified to weakly stratified. Flagstones and chips have strong slope-parallel alignment of flat surfaces. As much as 30 feet (9 m) thick.

**Qcf** — **FANGLOMERATE COLLUVIUM** - Poorly sorted, nonstratified to weakly stratified, reddish-brown to yellowish-brown silty sand with angular and subangular fragments, pebbles and cobbles of fanglomerate with some to many subrounded to rounded quartzite and quartzite conglomerate pebbles and cobbles. As much as 20 feet (6 m) thick.

### ILLINOIAN (?) TO LATE WISCONSINAN (?)

**Qtu** — **UPPER TERRACE DEPOSITS** - Stratified, well- to moderately-sorted, reddish-brown, brown, and gray, sand, cobble-pebble and pebble gravel, and minor silt. Gravel clasts are subrounded to well-rounded. Gravel consists of gray to brown quartzite and quartzite conglomerate, white to gray quartz, red to gray siltstone and sandstone, gray to white gneiss, and minor black chert. Gneiss and some siltstone and sandstone clasts have weathering rinds up to 0.5 inch (1.3 cm) thick, or are partially decomposed. Form terrace remnants that lie 15 to 20 feet (4-6 m) above the modern flood plain in the South Branch Raritan River valley. Equivalent to the Raritan upper terrace deposit of Stone and others (2002).

### ILLINOIAN (?)

**Qtuo** — **OLDER UPPER TERRACE DEPOSITS** - Sediment as in unit Qtu forming two terrace remnants that lie 10 to 15 feet (3-5 m) above the upper terrace.

### PRE-ILLINOIAN

**Qpt** — **PORT MURRAY FORMATION, TILL FACIES** (Stone and others, 2002) - Deeply weathered, compact, massive to crudely layered reddish-yellow to strong brown to yellowish-brown, or reddish-brown to weak-red sandy silt and clayey silt that typically contains 2 to 5 percent gravel. As much as 20 feet (6 m) thick. Gravel consists of pebbles and cobbles of quartzite, gneiss, quartzose sandstone, siltstone, and chert, and a few boulders of quartzite, quartzite conglomerate and gneiss. Gneiss clasts have thick weathering rinds or are completely decomposed; carbonate clasts are fully decomposed. Quartzite, sandstone, and chert pebbles and cobbles have pitted surfaces and thin weathering rinds. Matrix contains clay, quartz weathered rock fragments, minor weathered mica, and few heavy mineral grains. Subvertical joints are poorly to moderately developed to depths exceeding 10 feet (3 m). Clasts and joints are commonly coated with red ferrous or black ferromanganese oxide. In many places, quartzite and quartzite conglomerate clasts and sparse chert clasts form a very thin stony lag on weathered rock. As much as 10 feet (3 m) thick.

**Qps** — **PORT MURRAY FORMATION, STRATIFIED FACIES** (Stone and others, 2002) - Reddish yellow (7.5 YR 6/6-8) to strong brown (7.5 YR 5/6-8) sand and gravel, and sand. Clasts are subrounded to well-rounded quartzite, quartzose sandstone, siltstone, chert, and gneiss. Gneiss clasts are decomposed to depths exceeding 15 feet (5 m). Quartzite and chert clasts have thin weathering rinds (< 0.1 in., 2.5 mm) and are coated with a brown iron-manganese stain. Sandstone and quartzite clasts have pitted surfaces. Planar bedded with minor cross-stratification. Soils developed on these deposits form diamict sediments that may resemble pre-Illinoian till (Qpt). As much as 15 feet (5 m) thick.

### NEOGENE (?) TO QUATERNARY

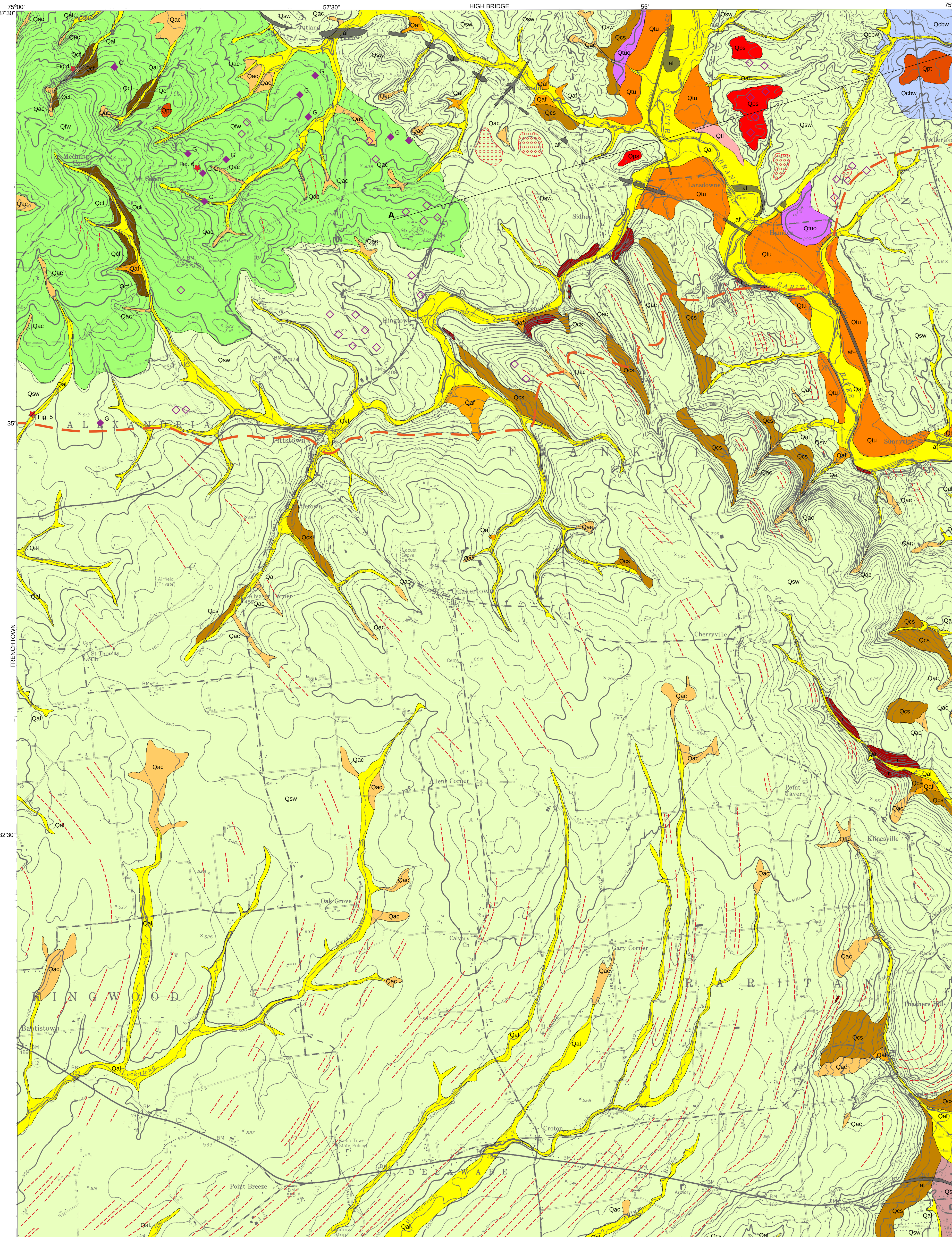
**Qcbw** — **WEATHERED BEDROCK DERIVED FROM DOLOMITE AND LIMESTONE** - Massive, compact light red to red, reddish-yellow to strong brown to yellowish-brown, or yellow, color is locally highly variegated, clay and silty-clay solution residuum of clay, quartz, and iron oxide; generally containing less than 5 percent chert, vein quartz and minor quartzite; thickness is highly variable, typically less than 15 feet (5 m), but locally as much as 100 feet (30 m). Locally includes thin colluvium as much as 5 feet (1.5 m) thick on gentle hillslopes. Also may include sand, gravel, silt, and clay washed into sinkholes and solution cavities from overlying colluvial, alluvial, and glacial sediment. Weathered zone typically ends at an abrupt, very irregular contact with unweathered bedrock and also extends deeply along joints and fractures.

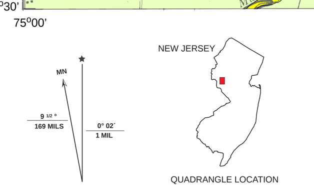
**Qfw** — **WEATHERED BEDROCK DERIVED FROM QUARTZITE FANGLOMERATE** - Yellowish-brown to reddish-brown sandy silt decomposition residuum containing 10 to 50 percent pebbles and cobbles of quartzite and sandstone, and fanglomerate; as much as 70 feet (21 m) thick. Locally includes thin colluvium less than 5 feet (2 m) thick. Weathered zone typically grades downward through a zone of fractured rock into underlying unweathered bedrock.

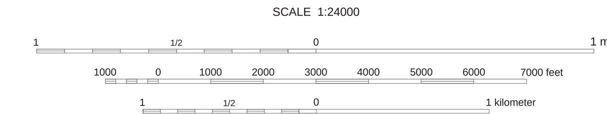
**Qsw** — **WEATHERED BEDROCK DERIVED FROM SLATE, SILTSTONE AND SANDSTONE** - Massive to layered, noncompact to slightly compact reddish-brown silty clay or sandy silt decomposition residuum of clay, quartz, and rock fragments; and slate-chip gravel containing flat pebbles and flagstones of slate, tabular pebbles and flagstones of siltstone, and tabular to blocky pebbles and cobbles of sandstone; as much as 30 feet (9 m) thick. Locally includes thin shaly colluvium on hillslopes; as much as 10 feet (3 m) thick. Weathered zone typically grades downward through a zone of fractured rock into underlying unweathered bedrock.

### PRE-CENOZOIC

**r** — **Bedrock** – Outcrop, subcrop, and minor regolith. In places includes extensive rock waste on steep slopes.







Geology mapped by Scott D. Stanford (1988) and Ron W. Witte (2013-2014). Research supported by the U. S. Geological Survey, National Cooperative Geologic Mapping Program, under USGS award number G13AC00182. The views and conclusions contained in this document are those of the authors and should not be interpreted as necessarily representing the official policies, either expressed or implied, of the U. S. Government. GIS application by Mike Girard, New Jersey Geological and Water Survey. Digital cartography by R.W. Witte, New Jersey Geological and Water Survey. Base from U.S. Geological Survey, 1955. Photorevised 1970.

[1]Retired, New Jersey Geological and Water Survey

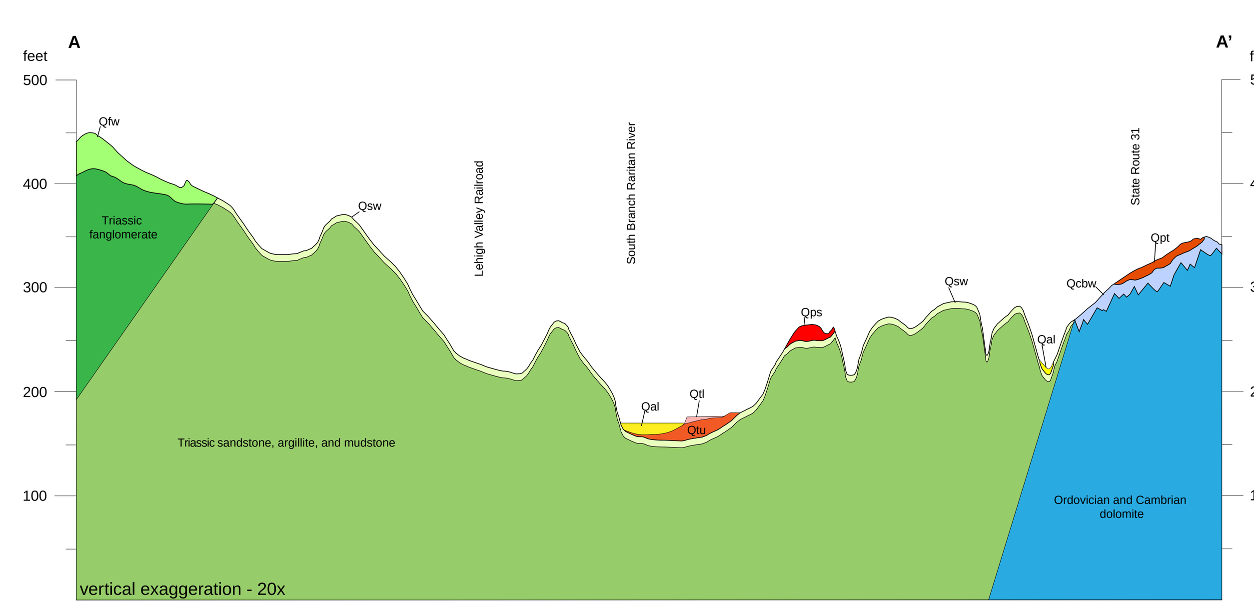
SCALE 1:24000

CONTOUR INTERVAL 20 FEET
DATUM IS MEAN SEA LEVEL

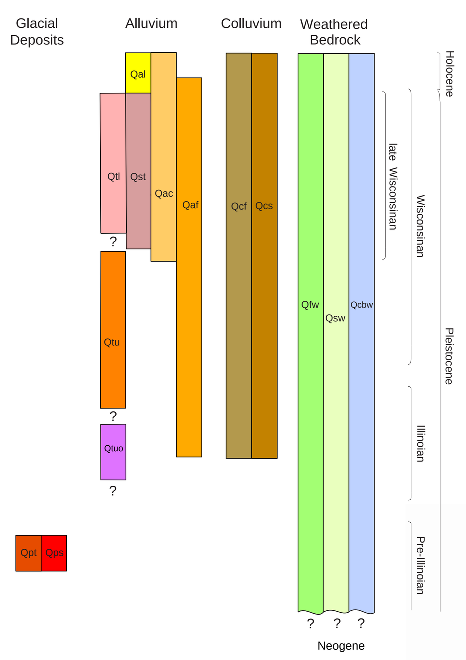
# SURFICIAL GEOLOGIC MAP OF THE PITTSTOWN QUADRANGLE
## HUNTERDON COUNTY, NEW JERSEY


BY
RON W. WITTE[1] AND SCOTT D. STANFORD


2018



## CORRELATION OF MAP UNITS



## EXPLANATION OF MAP SYMBOLS

Contact - Contacts of Qal, Qtl, Qtu, Qtuo, Qaf, and Qac are well-defined by landforms and are mapped from 1:12,000 stereo airphotos, LiDAR imagery, and field observations. Contacts of other units are gradational, feather-edged, or approximately located.

Bedrock ridge - Low ridge or scarp parallel to strike of bedrock (fig. 3). Mapped from 1:12,000 stereo airphotos and LiDAR imagery.

Erratic - Letter denotes lithology, G = gneiss and C = chert.

Boulders of early glacial drift from Bayley and others (1914).

Location of photographs in figures 4, 5, and 6.

Maximum glacial limit based on the most southerly occurrence of erratics. Erratics are from the Port Murray Formation.

Gravel lag - Pebbles and cobbles from pre-Illinoian outwash (Qps) on and mixed in with weathered siltstone.

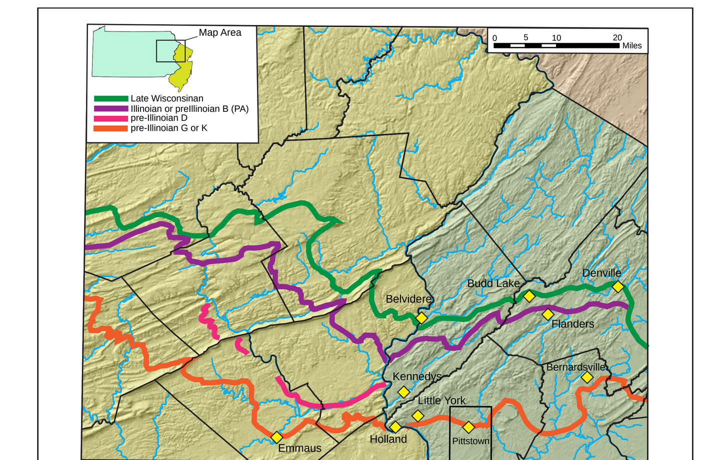


Figure 1. Map showing the extent of glaciation in eastern Pennsylvania and western New Jersey and location of the Pittstown - N.J. 7 1/2 minute quadrangle. Glacial limits from Braun (1994), Sevon and Braun (1997), Stanford (1997), and Stone and others (2002).

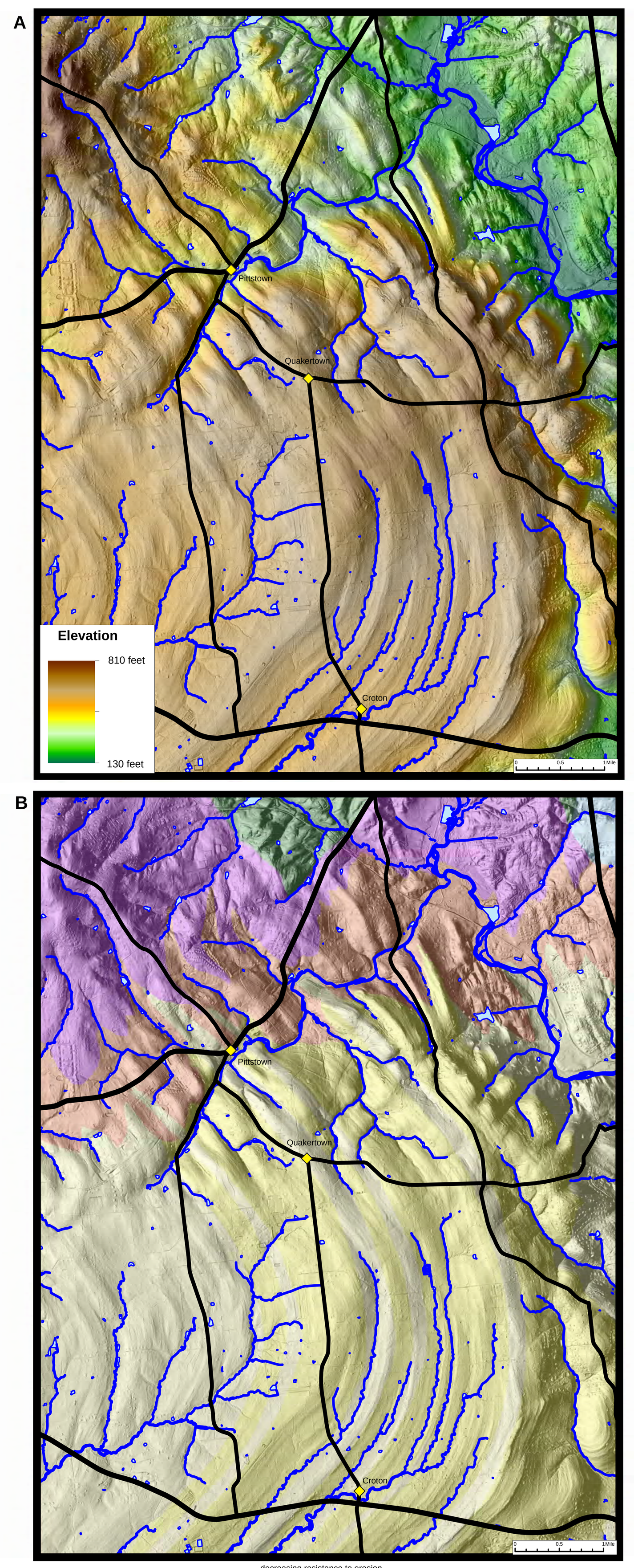


Figure 2. Color-shaded relief map (2a) and simplified bedrock map (2b) of the Pittstown 7 1/2 minute topographic quadrangle. The highest land lies in the northwest corner of the quadrangle, an area underlain by Mesozoic fanglomerate that is rich in quartzite and quartz-pebble conglomerate clasts. Elsewhere, Mesozoic sandstone and argillite typically underlie areas of high to intermediate elevation with Mesozoic mudstone and Paleozoic carbonate underlying the lowest land.

Figure 4. 10-foot (3 m) deep gully north of Mechlings Corner showing weathered Mesozoic fanglomerate (Qfw, inset A) overlying fanglomerate. Qfw is a gravelly diamicton consisting of subrounded to well-rounded quartzite and quartz-pebble conglomerate clasts in a silty sandy matrix. In places faint layering may be observed, indicating the slow transport of material downslope by mass wastage processes. On the geologic map this material is grouped with in situ weathered fanglomerate. It is only shown as colluvium (Qcf) where it forms a thick apron on the lower part of slopes. Inset B shows rounded clasts weathering out of fanglomerate that is exposed on the gully's floor. Photo by R. Witte.

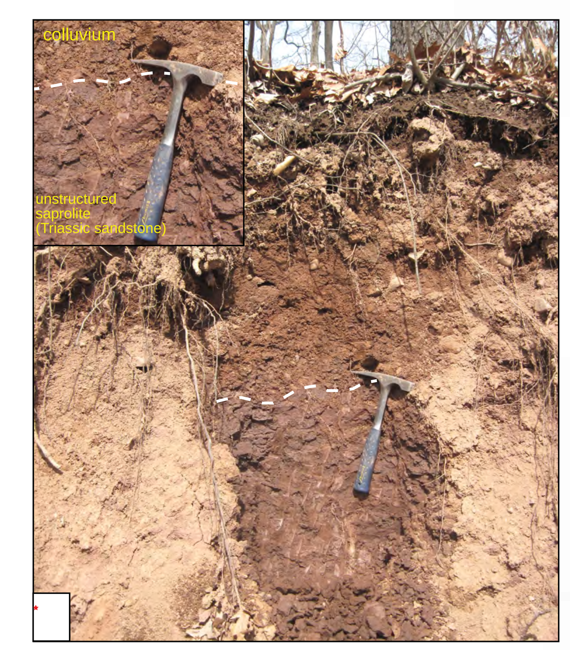


Figure 5. Thin slightly stony colluvium (Qac) overlying weathered Triassic sandstone (Qws) exposed along the cutbank of a small stream west of Pittstown. Qws here is an unstructured slightly clayey, silty saprolite. In most places it is less than 10 feet (3 m) thick. Photo by R. Witte.

Figure 6. Chert (below hammer, C) and gneiss cobbles (G) in stone row near Mechlings Corner. These clasts are remnants of pre-Illinoian till (Qpt) that once covered the northern part of the study area. During a long weathering and erosion history (longer than 788 ky) most deposits of Qpt have been eroded, especially in areas of moderate to high relief. Erratics like these are all that's left of what was once a widespread till sheet. They are used to map the maximum glacial limit, which runs eastward through Pittstown toward Little York. The lighter clasts are quartzite and quartz-pebble conglomerate. These stones have probably weathered out of the Triassic fanglomerate that underlies the northern part of the quadrangle. A few may be erratics. However, because they could not be positively identified as such they were not used to map the pre-Illinoian glacial limit.

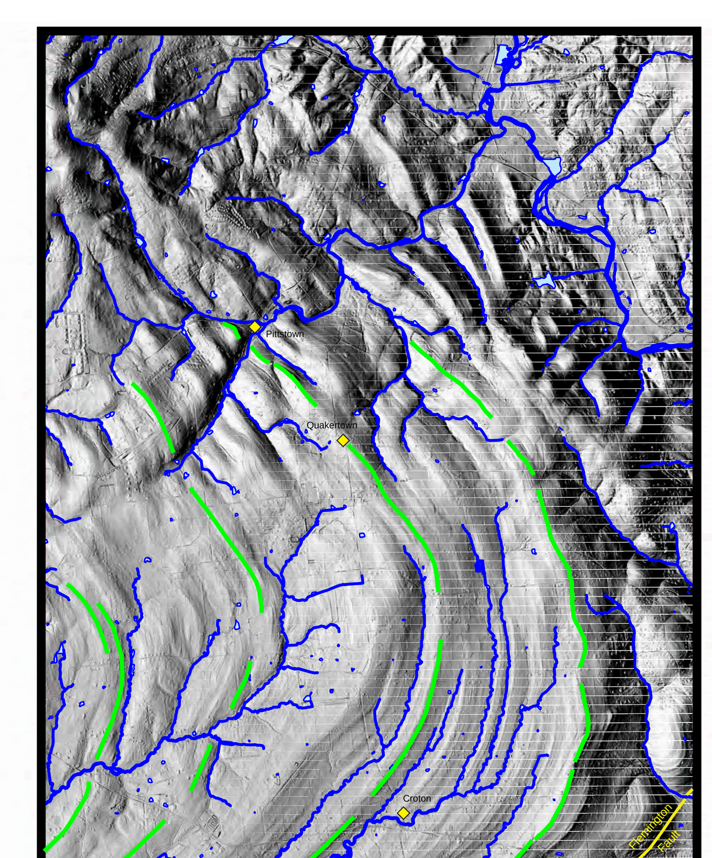


Figure 3. Hillshade of the Pittstown 7 1/2 minute topographic quadrangle showing strongly developed lineaments on gently westerly dipping and folded sedimentary strata. Most of the lineaments are strike ridges less than 20 feet high developed in argillite and mudstone. They are extremely well pronounced in areas underlain by Triassic argillite and mudstone (select ridges are shown by green lines) where they highlight lithologic variations where beds are slightly more resistant to erosion than adjacent beds. Overall, they define a broad, west-plunging syncline. Correspondingly, in many places drainage patterns are in close accordance with this geometry. Elsewhere, joints and small faults control cross-strike drainage.