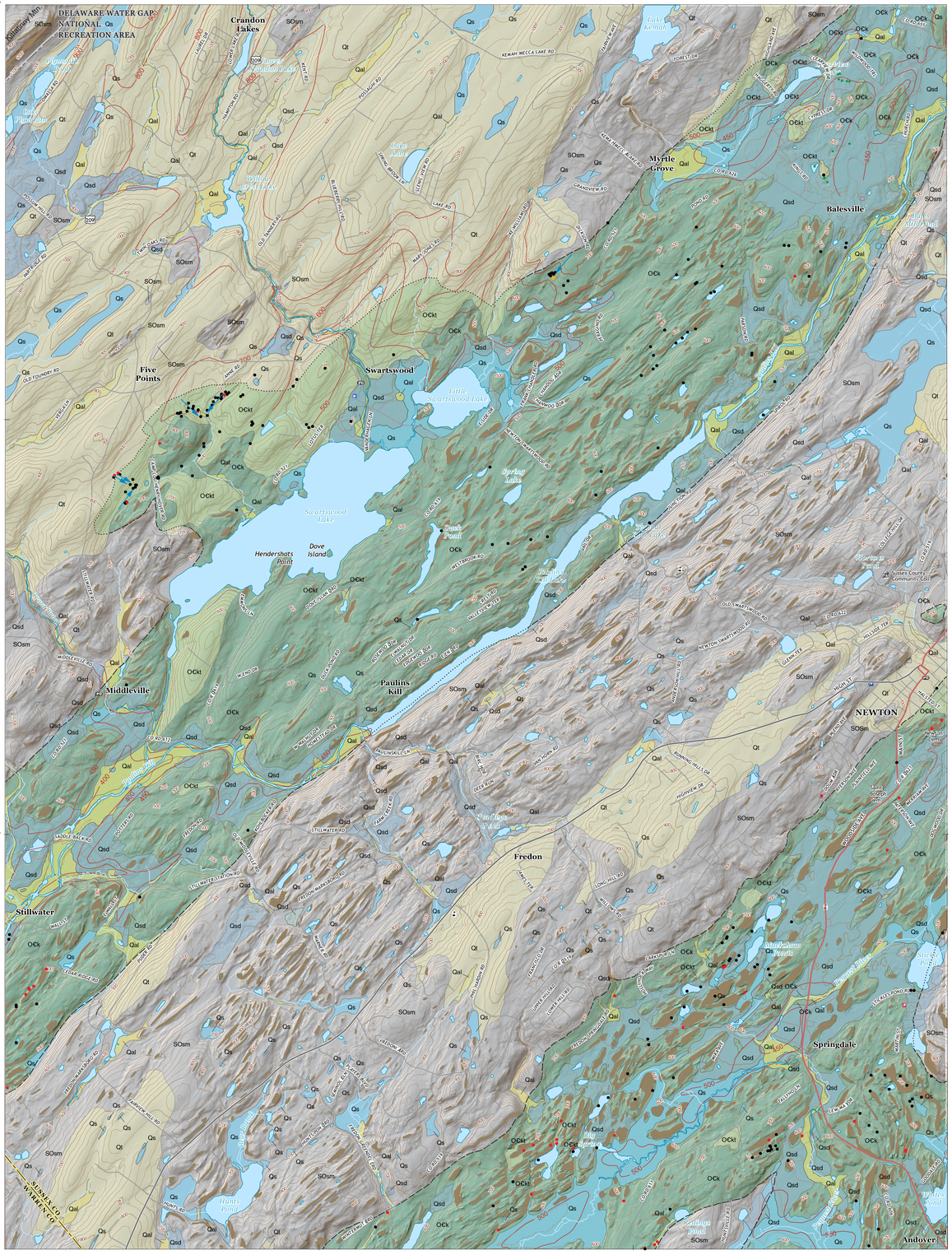
DEPARTMENT OF ENVIRONMENTAL PROTECTION
WATER RESOURCES MANAGEMENT
NEW JERSEY GEOLOGICAL AND WATER SURVEY

Prepared in cooperation with the
U.S. GEOLOGICAL SURVEY
NATIONAL COOPERATIVE GEOLOGIC MAPPING PROGRAM

KARST FEATURES OF THE NEWTON WEST QUADRANGLE SUSSEX AND WARREN COUNTIES, NEW JERSEY OPEN-FILE MAP 160



INTRODUCTION

The Newton West quadrangle lies along the southwestern boundary between Sussex and Warren Counties within the Valley and Ridge Province. Northeast-trending ridges controlled by both bedrock and glacial sediments border the southwest-draining rivers. The largest river, the Paulins Kill, and Paulins Kill Lake divide the quadrangle into northwestern and southeastern areas. Pleistocene glacial deposits locally blanket the bedrock and include meltwater sediment, thick till and local northeast-trending drumlins (Witte, 2012). Continued weathering, erosion and fluvial processes led to a changing landscape that includes karst features.

Federal and state parks, along with county and municipal open space lands, preserve public access for hiking, camping, boating, fishing and hunting. The Delaware Water Gap National Recreation Area covers the quadrangle's northwestern corner along Kittatinny Mountain. Swartswood State Park, which includes Swartswood and Little Swartswood Lakes and several smaller water bodies, lies in the north central part of the quadrangle. To the south lies Whittingham State Wildlife Management Area and Kittatinny Valley State Park, including Whites Pond, Swartswood, Kittatinny Valley and Whittingham all cover predominantly carbonate bedrock and present varying degrees of karst development.

STRATIGRAPHY

The geology of the Newton West quadrangle consists of sediments of Quaternary age that overlie rock of lower Paleozoic age. Quaternary sediments record the advance and retreat of the late Wisconsinan glaciation and subsequent erosion and deposition that led to the modern landscape. Paleozoic-aged rocks are dominantly Cambrian and Ordovician with the northwestern corner of the quadrangle containing Silurian clastic rocks. All the Paleozoic rocks have been subdivided into different formations (Drake, 1992; Drake and others, 1996; Monteverde and Herman, 2021) but for this map they have been combined into two units, the Shawangunk and Martinsburg Formations and the Jacksonburg Limestone and Kittatinny Supergroup carbonates, the latter having karst characteristics.

Witte (2012) mapped the Quaternary geology of the Newton West quadrangle. He subdivided the sediments into two broad categories of glacial and postglacial deposits, both of which were further subdivided into numerous classifications. For this map only, the glacial deposits were condensed into two units: 1) meltwater deposits consisting of glacial-lake delta deposits and lake-bottom deposits (Qsd) and 2) till comprised of two till units and the Odgensburg-Culvers Gap moraine (Qt). Postglacial deposits include stream deposits (Qal) and swamp and bog deposits (Qs). Swamp and bog deposits and the meltwater deposits primarily lie in the lowland areas which are underlain with carbonate bedrock. Stream deposits lie along waterways while the till occurs as a locally thick sediment blanket within the quadrangle. Witte (2012) further identified the extent of bedrock outcrop. Due to glacial erosion, much more bedrock exposure exists north of the late Wisconsinan terminal moraine than to the south (figure 1). In this quadrangle this is particularly evident in the carbonate section in the southeastern part of the map. This is thought to impose a strong influence on the degree of karstification in the carbonate rocks between north and south of the late Wisconsinan terminal moraine.

Bedrock map units have been simplified into non-carbonate and carbonate units. The non-carbonate unit (SOsm) consists of the Martinsburg Formation and the Shawangunk Formation. The carbonate unit (OCk) consists of the undivided Jacksonburg Limestone and the Kittatinny Supergroup (Drake and Lyttle, 1980) that represents the shallow passive margin that developed on Laurentia after the breakup of Rodinia. The Kittatinny Supergroup includes a basal quartz sand of the Hardyston Quartzite from the initial ocean transgression followed by a thick carbonate sediment bank containing the Leithsville Formation, Allentown Dolomite and the Beekmantown Group. In New Jersey these shallow platform carbonates have almost all been completely dolomitized though a relatively few limestone beds that have not been completely dolomitized exist. The Jacksonburg Limestone lies above the Kittatinny Supergroup. The Jacksonburg was deposited during the onset of the Taconic orogeny. An erosional unconformity created by the migration of a peripheral bulge due to the approach of an island arc during the initial stages of the Taconic (Jacobi, 1981; Quinlan and Beaumont, 1984) separates the dolomite units from the Jacksonburg. The Jacksonburg Limestone represents a resubmergence and subsequent deeping that eventually developed into a forelend basin that has been filled by the turbidite sediments of the Martinsburg Formation. All these units have been folded and faulted during the Taconic. Shawangunk Formation sediments mark the end of the Taconic. The Allegherian orogeny further folded and faulted the Paleozoic rocks of the Newton West quadrangle.

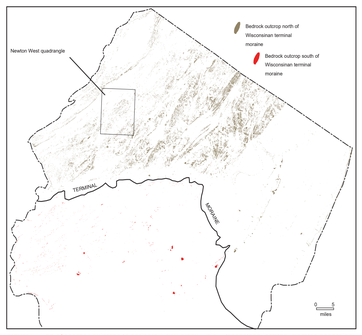


Figure 1. Map of bedrock outcrops in northern New Jersey. Late Wisconsinan terminal moraine separates regions of older weathering profiles to the south in red from those more recently scoured during the last glacial event in tan. Map from Stanford (2016).

STRUCTURE

Carbonate rocks in the Newton West quadrangle occur as two major belts cutting across the map area. The Crooked Swamp block covers the southeastern corner of the quadrangle while the Paulins Kill Valley block cuts across the middle of the quadrangle in a northeast-southwest direction (figure 2). The general structure of the area is two broad fold pairs with the carbonates cropping out along the anticlinal cores and the Martinsburg occupying the synclinal basins. Both anticlines have northwest directed thrust faults cutting their southeastern limbs. This deformation formed during the Taconic and Allegherian orogenies. Some deformation could originate from the Acadian orogeny. Parting surfaces are important in karst development. Three parting surfaces that could control sinkhole development include bedding, joints and cleavage. Carbonate bedding orientations are similar in both areas with moderate northeast strike and either gentle southeast or northwest dip (figure 3). Using the Cylindrical Best Fit application on stereonet software of Allmendinger and others (2013) and Cardozo and Allmendinger (2013) a calculated fold axis of the carbonate rocks in the Crooked Swamp block has a trend and plunge of 040/8, while the Paulin Kill Valley block fold axis has a trend and plunge of 045/1. Most outcrops do not display evidence of joints and cleavage. Where evident, joint trends vary between the two areas with a cross strike trend more common in the Crooked Swamp block and a more dispersed trend in the Paulins Kill Valley block. Cleavage appears more commonly as a spaced fabric with a more consistent trend in the Paulins Kill Valley block. There the cleavage nearly parallels the bedding strike with a dominant southeast dip. A more scattered cleavage trend exists in the Crooked Swamp block. A trend that parallels bedding with a southeastern dip is evident but other trends exist.

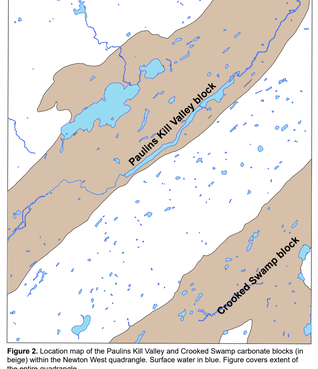


Figure 2. Location map of the Paulins Kill Valley and Crooked Swamp carbonate blocks (in beige) within the Newton West quadrangle. Surface water in blue. Figure covers extent of the entire quadrangle.

KARST FEATURES

Karst features occur throughout northwestern New Jersey wherever carbonate rocks crop out. Thickness and age of the overlying regolith play a part in the relative degree of karstification across this region. Dalton (1976) suggests the development of a high frequency of karst features south of the late Wisconsinan terminal moraine. A higher occurrence of surface carbonate outcrops exists north of the terminal moraine. An older, thicker mantle of weathered material covers the carbonates to the south, whereas north of the terminal moraine the glacier scoured the bedrock, removing the weathered mantle and locally leaving exposed bedrock. Directly to the west in the Flatbrookville quadrangle Canace and others (1996a, 1996b) describe blind valleys where the glaciers beveled off the overlying rocks exposing old cave passages. As shown in figure 4, solution of carbonate outcrops follows bedding and joint trends (Monteverde and Dalton, 2002; Monteverde and Witte, 2016). Cleavage is poorly developed regionally in the carbonates and plays a limited to no role in solution development.

Figure 4. Series of bedding-strike controlled sinkholes marking discontinous streams running through the Beekmantown Group, upper part. Photo by Z. Schagrin.

Several large depressions (green dots on the map) found in the northeastern section of the quadrangle near Balesville formed during the retreat of the late Wisconsinan glacier. They occur within the meltwater deposits. These depressions tend to have rounded rims, show no evidence of recent movement and occur where glacial sediment is relatively thick. Mature trees estimated to be 30-40 years old are in the bottom of these glacial depressions. The depressions can reach more than 30 meters (100 ft) across and 5m (16 ft) deep. One small pond proximal to several glacial depressions near Balesville is thought to be glacial in origin due to a similar morphology of the pond's walls. Springs (red dots on the map) are restricted to the two carbonate belts. They are often found in close proximity to depressions and/or bodies of water.

Individual and groups of depressions and sinkholes (black dots on the map) occur throughout the Crooked Swamp and Paulins Kill Valley blocks. In the Paulins Kill Valley block, they are more common to the north. Most appear close to bedrock outcrops as relatively small depressions that lack evidence of recent subsidence. Groups of depressions generally align parallel to bedding. Most recently active sinkholes lie along or close to the Martinsburg contact with the carbonates west of Swartswood Lake, often in regions of till cover. Martinsburg black sandstone and slates and Shawangunk quartzite pebbles and cobbles dominate the erratics in the till, possibly leading to a more acidic ground water.

Several locations in this region have slight differences between the alignment of surface water discharge and development of sinkholes. Several springs arise from till covering Martinsburg rocks and feed streams that flow about 100 meters in an east-southeasterly direction toward carbonate outcrop where they return to the subsurface in a sinkhole (figure 5 and blue arrows on map near Five Points). These springs had a relatively low flow. Several aligned sinkholes control the distance of the surface water flow. In low flow conditions water flow is captured entirely by the closest sinkhole. During increased precipitation the greater water discharge overfills the closest sinkhole and overflows as surface flow to the next sinkhole. This process continues through several small sinkholes during highest surface flow conditions. Two small valleys in this area have either solely surface water or spring water drainage, both traversing over or through the till. In both cases the water flow parallels the approximately 045° bedrock strike trends. At the spring occurrence, small millimeter-scale quartz crystals often can be found at the mouth of the spring. These crystals are common within tension gashes in deformed Martinsburg suggesting the spring drains an area of deformed Martinsburg. In both cases multiple sinkholes align in the direction of downstream flow. One other southeastern flowing unnamed stream with the most consistent drainage flows across a bed of Martinsburg and Shawangunk cobbles before descending into an 18 m (60 ft) diameter 7.5 m (25 ft) deep sinkhole. In times of high runoff, the water can form a circular flow within the sinkhole before descending into the subsurface. One large sinkhole captures all the surface flow here. To the northeast of Little Swartswood Lake a similar condition occurs with surface flow and sinkhole alignment approximately parallel to strike except there are two parallel sinkhole paths. One path might be an older stream path before a channel avulsion to the current path where a deeper depression exists.

Several caves and rock shelters have been discovered in the quadrangle (Dalton, 1976) and explored by New Jersey members of the National Speleological Society (table 1). Descriptions of cave passages including height and trends both regionally in the carbonates (Dalton, 1976; Monteverde and Dalton, 2002) and on this quadrangle have been compared to local bedding, joint and cleavage orientations to suggest that cross- and bed-parallel joints control cave development. Joints play the dominant role as the initial groundwater pathway into the subsurface bedrock. The role of layering concerns the differences in carbonate chemistry where dissolution is more common in one layer than another.

DESCRIPTION OF MAP UNITS

Postglacial Deposits

Qal **Stream deposits (Holocene and late Wisconsinan)** – Stratified, moderately- to poorly-sorted yellowish-brown, brown, and brownish-gray sand, gravel, silt, and minor dark gray clay and dark brown organic material deposited by streams. Locally bouldery. Includes alluvium which forms narrow, sheet like deposits on the floors of modern valleys and higher stream terraces that flank the course of modern streams. Includes stratified, moderately to poorly sorted sand, gravel, and silt in fan deposits that lie at the mouth of tributaries. As much as 40 feet thick.

Qs **Swamp and bog deposits (Holocene and late Wisconsinan)** – Dark brown to black, partially decomposed remains of mosses, sedges, trees and other plants, and muck underlain by laminated organic-rich silt and clay. Accumulated in kettles, shallow postglacial lakes, glacially scoured bedrock basins, poorly-drained areas in uplands, in abandoned stream channels on alluvial plains, and hollows in ground moraine. Locally interbedded with alluvium and thin colluvium. In areas underlain by limestone and dolomite may contain calcareous marl. As much as 25 feet thick.

Glacial Deposits

Qt **Till (late Wisconsinan)** – yellowish-, reddish-, olive-brown, and grayish brown sandy, sandy-silty, and clayey-silty diamicton consisting of a very poorly sorted matrix of sand, silt, and clay and containing 5 to 35 percent pebbles, cobbles, and boulders. Deposited directly by or from glacial ice. Till is widespread, generally less than 20 feet thick and lies on bedrock. In areas of thin till, bedrock outcrops are abundant and most of these exhibit signs of glacial erosion. Thicker till forms aprons on the north facing hillslopes, drumlins, and ground and recessional moraine and may be as much as 100 feet thick. Typically, it is a compact silt to silty sand containing as much as 15 percent pebbles, cobbles, and boulders. In places overlain by thin, noncompact, poorly sorted silty sand to sand containing as much as 35 percent pebbles, cobbles, boulders, and interlayered with lenses of sorted sand, gravel, and silt. This material appears to be ablation till and flow till.

Qsd **Meltwater deposits (late Wisconsinan)** – Stratified, well- to moderately-sorted sand, yellowish-brown, brown, and brownish-gray boulder-cobble to pebble gravel, pebbly sand and minor silt deposited by meltwater streams in valleys as outwash plains and fans and meltwater terraces and small glacial lakes as deltaic and lacustrine-fan deposits. In places includes light to dark gray, parallel-laminated, irregularly to rhythmically-bedded silt, clay, and very-fine sand; and minor cross-laminated silt, fine sand, and minor clay deposited on the floor of glacial lakes. As much as 150 feet thick.

Bedrock

SOsm **Shawangunk and Martinsburg Formations, undivided (Middle Silurian and Upper to Middle Ordovician)** – Shawangunk is very light to medium dark gray, and greenish gray to medium greenish gray, very fine to coarse grained, thin to thick bedded, planar bedded, cross bedded, and ripple bedded, light gray to light olive gray and moderate yellowish brown to moderate reddish orange and moderate brown weathering, conglomeratic quartzite with rounded to subangular quartz and lesser chert pebbles as much as 2.25 in. long, but averaging about 0.25 in. long, and dark gray to grayish black silty shale pebbles averaging about 2 in. long, but as much as 10 in. long. Medium dark to dark gray, thin to thick bedded siltstone and shale is interbedded with the sandstone and conglomerate approximately in the middle of the unit which thins from west to east. Martinsburg upper member, Ramseyburg, is medium to dark gray slate and medium gray, fine- to medium-grained, thin to thick bedded, cross bedded to planar bedded, moderate-brown-weathering, graywacke sandstone and siltstone in fining upward sequences. Lower member, Bushkill, is medium to dark gray, laminated to thin bedded slate with thin beds of quartzose and graywacke siltstone and carbonaceous slate in fining-upward sequences. Variations in grain size and sedimentary structures within neighboring beds gives unit a characteristic ribbon slate appearance. About 6,900 ft thick.

OCk **Jacksonburg Limestone and Kittatinny Supergroup, undivided (Ordovician to Cambrian)** – assemblage of five formations and groups dominated by dolomite. Locally unit is shown (OCkt) below the glacial units. Upper unit, Jacksonburg Limestone, is medium to dark-gray, laminated to thin bedded, argillaceous limestone grading downward into medium to dark gray, fine to medium-grained, thin to medium bedded, light gray to light bluish gray weathering, fossiliferous limestone. Continuing downward, Beekmantown Group is medium- to dark gray, aphanitic to medium-grained, laminated to medium bedded, locally mottled, light to medium gray- to yellowish gray weathering dolomite. Local quartz sand lenses and floating grains, chert nodules and lenses; unit may be slightly fetid. Grades down to medium-gray to black, fine to medium grained, locally coarse grained, medium to thick bedded, mottled medium- to medium dark gray weathering dolomite. Light-olive-gray to dark gray, fine to medium grained, laminated to medium bedded, dark yellowish orange- to medium-gray-weathering dolomite. Grades down to medium to dark gray, fine-grained, mostly laminated and medium-bedded, olive gray-, light brown- and dark yellowish orange-weathering dolomite containing occasional medium to dark gray, fine-grained, lenticular, thin to medium bedded, light bluish to light-gray-weathering limestone. Below the Beekmantown Group the Allentown Dolomite is medium light to dark gray, fine to medium-grained, locally coarse grained, locally cross bedded, thin- to thick-bedded dolomite, commonly weathering to alternating light and dark gray. Orthoquartzite and nodular to bedded chert occur throughout but more common in upper part. Shaly dolomite occurs in increasing amounts lower in section. Characteristic sedimentary features include planar and trough cross bedding, oolites, algal stromatolites, ripple marks, edgewise conglomerate and mud cracks. Basal unit is the Leithsville Formation. Regionally, this unit is medium to medium dark gray, fine to medium-grained, medium bedded, medium-gray-weathering, commonly bioturbated dolomite. Middle of unit is interbedded medium- to dark gray, pale reddish brown to dark yellowish orange to greenish gray, thin to medium bedded quartz sandstone, siltstone, shale and shaly dolomite. Total thickness is approximately 3,400 ft.

OCkt

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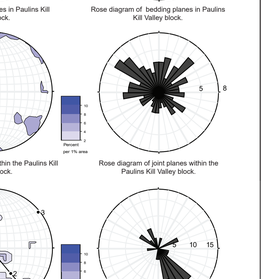
CORRELATION OF MAP UNITS



EXPLANATION OF MAP SYMBOLS

Bedrock contact - Dashed line represents approximate location of boundary between Kittatinny Supergroup and Jacksonburg Limestone with the Shawangunk and Martinsburg formations; short dashed line where approximate location is concealed.

Surficial contact

800 Contours showing altitude of the top of bedrock where thick surficial cover exists (Witte, 2012).

Direction of spring and/or stream flow into sinkholes

PLANAR FEATURES

Locations of generally broad depressions interpreted to be of glacial origin. All locations were field checked.

Locations of springs. All locations were field checked.

Locations of sinkholes and depression suggested to be formed by karstification. Identified using LiDAR, air photos and field investigations.

Locations of photos used as figures.

OTHER FEATURES

Locations of bedrock outcrop identified by air photo interpretation and field investigations by Witte (2012).

Delaware Water Gap NRA boundary

Figure 3. Orientation of bedding, joints, and cleavage planes in carbonate rocks in the Crooked Swamp and Paulins Kill Valley structural blocks. Data density contour uses 1% area with a 2% contour interval. N represents the number of readings analyzed in the plot. Black dots labeled 1, 2 and 3 represent calculated eigenvalues with 1 being the largest eigenvalue and 3 the smallest. Great circle represents cylindrical fold axis of data defined by the vector to circle 3, the smallest eigenvalue. Eigenvalues and fold axis are defined using the Cylindrical Best Fit option in Stereonet software described in Allmendinger and others (2013) and Cardozo and Allmendinger (2013). Rose diagrams depict dip direction of planes shown in corresponding stereonets.

Table 1. Caves and rock shelters within the Newton West quadrangle. Data from Dalton (1976) and recent updates from New Jersey members of the National Speleological Society.

Name	Length (ft)	Type	Notes
Big Spring, NW			Large spring with a reported cave entrance nearby.
Big Springs (Springdale) Shelter			
Campbell Cave			Cave entered from a 30 foot deep well.
Cave, Swartswood Lake			Cave of unknown size in bottom of large sinkhole into which surface stream flows .
Crystal Spring Sink			Sound of water below the rocks.
Dead Cat Cave			Small.
Devil's Den, "Devil's Hole"?	>400, >85 deep	rectangular	A large cave, now gated.
Inslee Cave	20	rectangular	A low tunnel into the hill about 10 feet above pond.
Moody's Rock			A large rock shelter on edge of pond.
Newton Cave Grave			Location of grave marker in face of cliff reported to be a cave.
Newton Internet Cave			A small shelter cave with some popcorn-like marks on walls.
Newton Sheep Rock			Small rock shelter in the Newton Cemetery.
Possums Cave			A very small crawl cave.
Stillwater Cave ?			Small cave.
Stillwater Cave 1 (Dead Man's cave)	30	linear	Short crawlway 70 yards from cave 2.
Stillwater Cave 2 (Devil's cave)	30	linear	Slit entrance into room 300 yards from road.
Stillwater Cave 3 (Talus cave)	small		Series of openings in next gully along road from cave 2.
Stillwater Cave 4 (Twist cave)	12	linear?	Small cave 210 feet up gully from cave 1.
Sussex County Caverns 1	30	rectangular	Steeply sloping passage to water table.
Sussex County Caverns 2	50	rectangular	7 foot pit leads to a steeply sloping passage to the water table.
Swartswood Sinks			Several sinkholes in pit.
Tanya's Cave	10	room	Very small cave in outcropping on north side of road.
Terry's Pit	20	40' pit	40 foot deep pit opened in 1973.

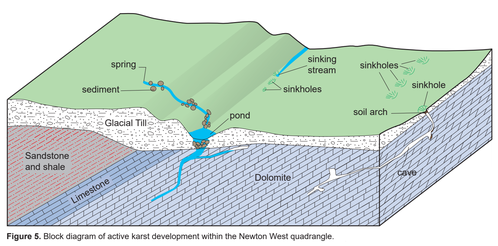


Figure 5. Block diagram of active karst development within the Newton West quadrangle.

Produced by the United States Geological Survey
North American Datum of 1983 (NAD83)
World Geodetic System of 1984 (WGS84). Projection and
1 000-meter grid: Universal Transverse Mercator, Zone 18T
10 000-foot ticks: New Jersey Coordinate System of 1983,
Pennsylvania Coordinate System of 1983 (north zone)

This map is not a legal document. Boundaries may be generalized for this map scale. Private lands within government reservations may not be shown. Obtain permission before entering private lands.

Imagery.....NAIP, September 2015
Roads..... U.S. Census Bureau, 2015 - 2016
Names.....GNIS, 2016
Hydrography.....National Hydrography Dataset, 2015
Contours.....National Elevation Dataset, 2013
Boundaries.....Multiple sources; see metadata file 1972 - 2016
Wetlands.....FWS National Wetlands Inventory 1977 - 2014

UTM GRID AND 2017-19 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET

SCALE 1:24 000

CONTOUR INTERVAL 20 FEET
NORTH AMERICAN VERTICAL DATUM OF 1988

This map was produced to conform with the National Geospatial Program US Topo Product Standard, 2011. A metadata file associated with this product is draft version 0.6.19

Karst geology mapped by R.W. Witte[1] in 2017-18
D.H. Monteverde[1] in 2018-19
Digital cartography by D.H. Monteverde[1] and R.S. Pristas[1]
[1]retired, NJGWS
LiDAR base from New Jersey Office of GIS (State of New Jersey, 2018)
Submitted in fulfillment of U. S. Geological Survey Award Number G18AC00178. Following submission, map will be reviewed, edited, and published in digital format as a free download available on the N. J. Geological and Water Survey website. The views and conclusions contained in this document are those of the author and should not be interpreted as necessarily representing the official policies, either expressed or implied, of the U. S. Government.

1 Lake Maskenozha
2 Culvers Gap
3 Branchville
4 Flatbrookville
5 Newton East
6 Blairstown
7 Tranquility
8 Stanhope
ADJOINING QUADRANGLES

ROAD CLASSIFICATION
Expressway
Secondary Hwy
Ramp
Local Connector
Local Road
4WD
Interstate Route
US Route
State Route

KARST FEATURES OF THE NEWTON WEST QUADRANGLE SUSSEX AND WARREN COUNTIES, NEW JERSEY

By

Donald H. Monteverde[1] and Ron W. Witte[1]

2023