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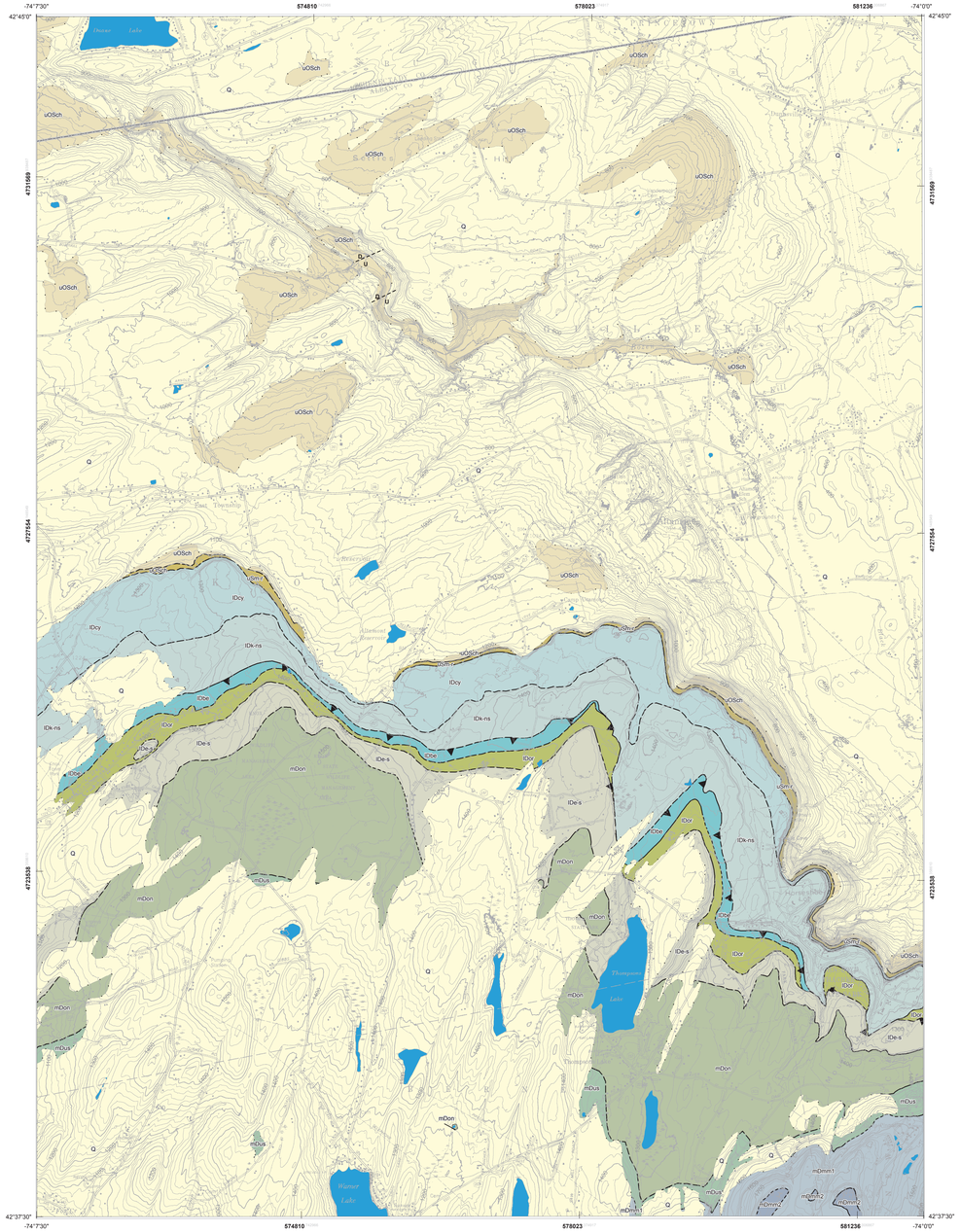


Universal Transverse Mercator, Zone 18 N
North American Datum of 1983

Hygrology, and planimetry layers from the
New York State DOT Raster Quadrangle separates
1993, Elevation contour data from New York State 2 Meter DEM
2008. http://www.orthos.dhses.ny.gov

Topographic map symbols can be found at
http://pubs.usgs.gov/gip/TopographicMapSymbols/
topomapsymbols.pdf
Magnetic declination from the NOAA online Declination
Calculator: http://www.ngdc.noaa.gov/geomag-web/#declination

GN
MN
13°36'
0°32.5'

UTM grid convergence (GN)
and 2013 magnetic declination (MN)
at center of map

Scale 1:24 000
0 1 Miles
0 0.5 0 1 Kilometers
Contour interval 20 feet

Geologic mapping by C.A. Ver Straeten, E.J. Stander, T.D. Engel 2013
Digital data and cartography, B. Bird, 2013

# BEDROCK GEOLOGY OF THE ALTAMONT QUADRANGLE, ALBANY and SCHENECTADY COUNTIES, NEW YORK

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## BEDROCK GEOLOGY OF THE ALTAMONT 7.5 MINUTE QUADRANGLE: AN OVERVIEW

Bedrock on the Altamont 7.5 minute quadrangle is represented by diverse sedimentary rocks, which dip slightly (ca. 1.5o) to the south-southwest. Abundant limestone and shale/mudstone is supplemented by some sandstones, the latter of which increases southward into the Westerlo quadrangle. The rocks are varying cut by inch- to landscape-scale fractures, many with a south-southwest to north-northwest orientation. These fractures occur as joints, thrust and normal faults, and gravity-driven breakage of rocks, especially along escarpments. Karst features are also common across two limestone belts on the quadrangle, including numerous caves.
The rock strata on the Altamont quadrangle formed over a period of approximately 60 million years, between about 450 to 388 million years ago (Ordovician, Silurian and Devonian Periods). They were deposited in a relatively shallow marine seaway that flooded New York and, at times, much of eastern North America. Maximum depths may have reached a few hundred feet depth, while minimum depths were essentially at sea level (supratidal environments). Two times during that time, marine waters withdrew from the region for a few to tens of millions of years, forming major erosion surfaces.

## GEOLOGIC UNITS

Q — Quaternary (Q) material

MIDDLE DEVONIAN PERIOD
(beginning 393 million years ago; on the Altamont quadrangle, 393 to ~388 million years ago)

mDmn2, mDmn1 — Marcellus subgroup
In eastern New York, strata sometimes known as the Marcellus "shale" are divided into two formations; a lower Union Springs and upper Mount Marion Formations. Classic black to dark gray shales, typical of the Marcellus subgroup in eastern New York, only occur in the lower part of the strata in eastern New York (Bakoven Member of the Union Springs Formation). Succeeding higher Marcellus strata are composed largely of dark gray shales, siltstones and sandstones, with an overall increase in sandstone upward.

Mount Marion Formation (mDmn1 and mDmn2: – upper part of Marcellus subgroup)

Dark-gray to gray shales and mudstones, and gray to brown siltstones and sandstones, with a few thin limestones (Hurley and Cherry Valley Members) at the base. Marine fossils often occur in distinct layers separated by roughly 10-26 feet (ca. 3-8 meters) of poorly- to non-fossiliferous strata. Overall, the percentage of sand in the rocks increases upward through the formation; however, only the lower part of the formation is present on the Altamont quadrangle. The Mount Marion Formation represents intermediate depth to shallow marine environments
(from perhaps a few hundred feet at most, to the shoreline at sea level).

Members of the Mount Marion Formation on the Altamont quadrangle, from low to high, include:

1) Hurley Member: Limestone, mudstone and minor silt- to sandstone.
Approximately 4.3 feet thick (1.3 meters), but varies locally. Two to three thin, fossiliferous limestones and a thin sandstone separated by shales of varying thicknesses.

2) Cherry Valley Member: Limestone, with famous Agoniatites vanuxemi cephalopod fauna. Approximately 4.6 feet (1.4 meters) thick. Forms ledges and waterfalls in ravines in the southeast portion of the map. It was not found in the area of much quaternary sediment cover in the southwest portion of the map; it may possibly occur on the order of 100 feet (30 meters) below quarries in the East Berne Member along Simons Road.

3) East Berne Member: Dark-gray shale and mudstone, with minor thin sandstone beds through the member and a thick sandstone at the top. Member marked by distinct basal and top contacts, above Cherry Valley Limestone, and below the overlying Halihan Hill Bed (see below). Approximately 250 feet thick (76 meters) thick in the southeastern portion of the quadrangle.

4) Otsego Member: Shale and sandstone, with an overall increase in the percent sandstone upward through the member. The base of the Otsego is distinct, marked by a generally three foot thick fossiliferous zone with common rugose ("horn") corals, at the top of a thick sandstone (Halihan Hill Bed of Ver Straeten, 1994). Only the lower few tens of feet of the Otsego Member are found on the Altamont quadrangle, capping three hilltops in the southeast corner.

5) undifferentiated upper member: Sandstone-dominated strata; does not occur on the Altamont quadrangle.

NOTE: On the Altamont quadrangle the Hurley, Cherry Valley and East Berne members of the Mount Marion Formation are mapped as mDmn1 (ca. 260 feet – 79 meters thick). The thin, lower portion of the Otsego Member of the Mount Marion Formation found on the quadrangle is mapped as mDmn2.

mDus — Union Springs Formation (mDus: – lower part of Marcellus subgroup)

Dominantly black to dark-gray shales and mudstones, with some thin impure limestone layers. Thin calcareous unit at the top (Stony Hollow Member) in the eastern part of the quadrangle disappears to the west. Strata are generally non-fossiliferous to poorly fossiliferous, with straight and coiled cephalopods, very small conical shells (stylioliinids, dacryoconarids), and some small brachiopods and bivalves. The base of the Union Springs Formation, placed at the top of the underlying Onondaga Limestone, was found in only one locality on the quadrangle. During the Middle Devonian, Union Springs sediments are interpreted to have been deposited in deeper, more basinal environments, perhaps a couple to few hundred feet deep. The Stony Hollow Member was deposited in slightly shallower environments, perhaps analogous to today's mid-continental shelf.

Two members of the Union Springs Formation are found on the Altamont quadrangle, from low to high:

1) Bakoven Member: Organic-rich black to dark-gray shales and mudstones, with thin, minor limestone beds and limestone concretions. Generally non-fossiliferous to poorly fossiliferous; fossils consist largely of shelled animals that lived up in the water column, not on the sea floor (e.g., straight and coiled cephalopods, and stylioliinids/dacryoconarids). The Bakoven Member is approximately 120 feet (37 meters) thick along Pinnacle Road, on the southeast margin of the quadrangle. Strata are not uncommonly deformed by folds and thrust faults.

2) Stony Hollow Member: Thin, buff-colored, calcareous shale to siltstone at the top of the Union Springs Formation. Found in the southeastern portion of the quadrangle; it disappears to the west as the rock laterally changes to dark gray shale. Thin bed at the base with fossils, including brachiopods and the trilobite Dechenella haldemani. Some strata are bioturbated. Pyrite nodules present; the pyrite secondarily replaces barite, which is found in the same strata in other states (e.g., PA, VA, WV). To the west, the Stony Hollow Member disappears as strata change laterally to dark-gray mudstones of the upper part of the Bakoven Member. The Stony Hollow is 10.6 feet thick in a ravine near the east end of Long Road, and 13.5 feet (4.1 metres) thick in the south branch of Onesquethaw Creek, 2.4 miles to the southeast (Westerlo 7.5 minute quadrangle).

mDon — Onondaga Formation (mDon)
Light-colored, fossiliferous, coarse- to fine-grained limestones (grainstones, packstones and wackestones, with scattered chert in some intervals. The relatively hard, resistant limestones of the Onondaga Formation commonly form ledges to cliffs; in Thacher Park, north of Beaverdam Road, the Onondaga forms its own escarpment, as it does in other parts of New York. Oliver (1956) reported a minimum thickness of 110 feet (33.5 meters) for the Onondaga Limestone locally, in contrast with Goldring and Cook's (1935) report of 85 to 100 feet (26 to 30 meters). The base of the formation is indicated by limestone directly overlying fossiliferous sandstone of the Schoharie Formation, visible at springs and in stream beds. The top of the formation is overlain by black shale; the contact was only found at one locality in the quadrangle, near Thompsons Lake.
Chert (sometimes called "flint") is common in some parts of Onondaga Formation, absent in others. It occurs as layers or irregularly-shaped nodules. In lower parts of the formation the chert is light gray, but dark gray in upper strata. Three members of the Onondaga Edge(lif, Nedrow and Moorehouse Members, low to high) are recognized in the Helderbergs, but are not distinguished on the map. Common corals in basal limestones locally developed into a reef mound with abundant corals. Thin clay layers at some levels are the altered remnants of volcanic ash, erupted from Middle Devonian volcanoes in the Appalachians. One of these altered volcanic ash layers in the upper Onondaga Limestone, absent in the Helderbergs, has been dated at 390.0 +/- 0.5 million years old (Roden et al., 1990). Strata are sometimes deformed by folds and thrust faults. Sediments of the Onondaga Formation were deposited in a variety of water depths in a shallow sea (e.g., mid-ramp to shoal type environments), similar to depths found on today's mid-continental shelf to a shallow shoal, where day-to-day

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QUATERNARY

MIDDLE DEVONIAN

EARLY DEVONIAN

LATE SILURIAN

LATE ORDOVICIAN

# EXPLANATION

EARLY DEVONIAN PERIOD (419 to 393 million years ago)

IDes — Esopus and Schoharie Formations (IDe-s)
Sandstone, shale to mudstone, and siltstone, with minor limestone, chert and clay beds. The Esopus Formation is non-calcareous.

The combined Esopus and Schoharie formations are approximately 120 feet thick (37 meters) on the Altamont quadrangle, where not strongly deformed.

1) Esopus Formation: Clayey siltstones and sandstones, and dark gray shale to mudstones compose most of the Esopus Formation. Minor chert and thin clay layers occur low in the formation. Layering (bedding) is generally difficult to distinguish, due to extensive burrowing of the sediment by animals (e.g., worms, clams). Shelly fossils are rare. Strata are not uncommonly deformed by folds and thrust faults. Up to 15 thin clay layers in lowest strata of the Esopus Formation (Sprout Brook K-bentonites) are the altered remnants of volcanic ash, erupted from Lower Devonian volcanoes in the Appalachians. Two of these altered volcanic ash layers have been dated at 408.3 +/- 1.9 million years old (Tucker et al., 1998). Water depths varied some during deposition of the Esopus Formation, in mid- to outer shelf-type environments.

2) Schoharie Formation: Clayey sandstones, siliceous shales and highly fossiliferous sandstones characterize the Schoharie Formation in the Helderbergs. In contrast with the formation in the Hudson Valley, only the upper part of the Schoharie Formation in the Helderbergs is calcareous. Strata in some intervals are deformed by folds and thrust faults. Water depths varied some during deposition of the Schoharie Formation, largely in mid- to inner shelf type settings, but shallowing to shoal type environments at the top of the formation.

IDor — Oriskany Formation (IDor)
Quartz sandstone, often fossiliferous, and cemented by silica (quartz). Forms a thin, very resistant and sometimes wide flat ledge, where softer, less resistant lower Esopus strata have been stripped off the top by erosion. Thickness varies across the quadrangle; Goldring and Cook (1935) reports "a maximum thickness of four feet (1.2 meters), with an average of only one or two feet" (0.3 to 0.6 metres). The Oriskany unconformably overlies the Becraft Limestone. Three formations, found between the Oriskany and Becraft formations in the Hudson Valley and Port Jervis area, are absent in the Helderbergs. They were eroded away during a major sea level drop, prior to deposition of the Oriskany Sandstone. Fossils include numerous brachiopods and other shelly forms of the Oriskany "big brachiopod" fauna. The sandy sediments of the Oriskany Formation were originally deposited in shallow marine, shoal-type environments, where waves contacted the sea floor on a day-to-day basis.

IDbe — Becraft Formation (IDbe)
Light-colored, relatively coarse-grained limestone, composed largely of complete to broken shell material, dominantly fragments of crinoids. Rickard (1962) reported 12 feet (3.7 meters) of Becraft Limestone at Thacher Park, but its thickness varies across the quadrangle (zero to 15.5 feet; ~ 0 to 4.7 meters), probably due to both Devonian-age erosion before deposition of the overlying Oriskany Sandstone, and/or local thinning along rock faults. The lower contact with the New Scotland Formation is gradational. Becraft fossils are much less diverse that the New Scotland, and include abundant crinoid fragments and several different species of brachiopods. The most diagnostic fossil of the Becraft Limestone is a shallow bowl-like fossil on the order of an inch (2 cm) across. The original calcite of the shells is sometimes replaced by silica (quartz), indicated by fossils that weather out in relief from the limestone rock. Chert, rare in the Becraft Formation outside of the Helderbergs, is found locally on the quadrangle. Similar to the Coeymans Limestone below and the Oriskany Sandstone above, sediments of the Becraft Limestone were deposited in shallow, shoal type environments.

IDk-ns — Kalkberg and New Scotland Formations (IDk-ns)
The Kalkberg and New Scotland formations are mapped together on the Altamont quadrangle, in part because their contact is gradational, and often covered under surficial sediments. The two formations total about 115 feet (35 meters) at Thacher State Park (Rickard, 1962). Several thin clay layers in the two formations are altered remnants of volcanic ash deposits (Bald Hill K-bentonites), erupted from Lower Devonian volcanoes in the Appalachians. One of these altered volcanic ash layers was dated at 417.6 +/-1.0 million years old (Tucker et al., 1998).

1) Kalkberg Formation: Fossiliferous, medium-grained limestones, with coarser- and finer-grained beds and minor shale/mudstone. Thin- to medium-bedded layering. On fresh surfaces, the Kalkberg Limestone appears darker gray than the underlying Coeymans Limestone, but often weathers to a buff color. Some dark gray chert also present, generally as nodules. The lower contact with the Coeymans Formation is gradational, indicated by a change to finer-grained strata and more abundant and diverse fossils. These include various brachiopods, bryozoans, and small rugose corals. Rickard (1962) reports 49 feet (15 meters) for the Kalkberg Limestone at Thacher State Park. The Kalkberg Formation was originally deposited in shallow ramp settings similar to the inner continental shelf environments.

2) New Scotland Formation: Fine-grained limestones and calcareous shales and mudstones. Strata are generally thin-bedded; limestones and shales commonly interlayered. Limestones are generally have a high clay content. Strata are often fossiliferous, with relatively high diversity of varied types of fossils. The lower contact of the New Scotland with the underlying Kalkberg is gradational; the New Scotland is distinguished from the latter by more shaly strata, and a more diverse group of fossils. These include diverse brachiopods, along with bryozoans, corals, gastropods, and other fossils including rare trilobites. Rickard (1962) reports a thickness of 66 feet (20 meters) for the New Scotland Formation at Thacher State Park. The unit is locally deformed by folds and thrust faults, some of which rise through the overlying Becraft and Oriskany formations. Sediments of the New Scotland were deposited in deep ramp-type environments, roughly similar to mid- to out continental shelf-type environments.

IDcy — Coeymans Formation (IDcy)
Bluish-gray to light gray, coarse-grained limestones (grainstones to packstones). Thick to massive-bedded, with poorly developed layering. Forms a very resistant ledge, best seen capping the cliffs along the Helderberg Escarpment at John Boyd Thacher State Park and beyond. The lower contact with the Manlius Limestone is marked by a change to coarser-grained limestone, and is erosional. The Coeymans Formation is relatively fossiliferous, including common crinoid fragments, with brachiopods and scattered corals. The brachiopod Gypidula coeymanensis is an index fossil for the Coeymans Limestone; it does, however, also extend up into lower strata of the Kalkberg Formation above. Rickard (1962) reports 37 feet (11.3 meters) to the Coeymans Limestone on the Altamont quadrangle. The rocks were originally deposited in "shoal"-type environments, where day-to-day waves continually crashed against the sea floor.

LATE SILURIAN PERIOD
uSm-r — Manlius and Rondout Formations (uSm-r)
Limestones, dolostones, and minor shales. These units form the lower portion of the Helderberg escarpment cliffs, well seen along the Indian Ladder Trail at Thacher State Park. The Manlius and Rondout Formations were deposited on the margin of the Silurian-Devonian seaway, in tide-influenced environments. Combined thickness of the units were measured at Thacher Park at approximately 57 feet (17.4 meters).

1) Manlius Formation (Thacher Member)
Generally light gray-colored, fine-grained limestones (micrite, wackestone), with buff to yellow weathering dolostone intervals, and reef layers of stromatoporoid sponges. The thinly-laminated dolostones are most notable in the recessed "upper bear path" in the cliffs at Thacher State Park. The Manlius Limestone is 52 feet (15.8 meters) thick at Thacher State Park (Rickard, 1962). The Manlius Formation was deposited in tidal environments on the margin of the Devonian seaway, between just above to a little below low tides. Stromatoporoid reefs, indicated by chaotic-appearing layering in the middle to upper Manlius Formation, formed in shallow depths slightly below low tide.

2) Rondout Formation
Fine-grained, blue to yellowish-brown limestone, dolostone and shale, with greenish-gray sandy, pyritic shale in its lower part. Rickard (1962) reported five to seven feet 1.5 to 2.1 meters) of Rondout on the Altamont quadrangle; this includes the lower sandy, pyritic shale that Goldring and Cook (1935) had interpreted to be the Brayman Shale, which is found west of the Altamont quadrangle. The Rondout Formation is best seen as the deeply recessed interval along the Indian Ladder Trail at Minelot Falls, at Thacher State Park. The Rondout Formation was chiefly deposited in supratidal environments, just above high tides.

LATE ORDOVICIAN PERIOD
uOSch — Schenectady Formation (uOSch)
Sandstones and black to gray sandy to clay-rich shales, thin to massive layered, and commonly interbedded. The proportion of sandstone to shale varies vertically through the formation. Goldring and Cook (1935) estimated 1800 to 2000 feet (548 to 610 meters) for the Schenectady Formation on the Altamont quadrangle, succeeded by 410 feet (125 meters) of strata assigned to the "Indian Ladder Beds". On this map, these strata are mapped together (see below), for a total of up to nearly 2400 feet (731 meters). The Schenectady Formation is interpreted to represent relatively deep water, turbiditic slope-type environments.
The term "Indian Ladder Beds" was applied by Ruedemann (1930), Goldring (1933) and Goldring and Cook (1935) to 410 feet (125 meters) of Ordovician-age shales and thin sandstones below the cliffs at Thacher Park. The previous authors report that they contain a somewhat different fauna from the Schenectady Formation beneath. However, the unit supposedly only occurs along a 2.5 mile lateral distance, which could raise some questions about it's validity as a unit. For this map, strata assigned to the Indian Ladder beds are mapped as part of the Schenectady Formation.

## GEOLOGIC SYMBOLS

Contact, definite — Contact, approximate — Contact, inferred
High angle normal faults — Limit of Quaternary cover

OVERVIEW: STRUCTURAL GEOLOGY OF THE ALTAMONT QUADRANGLE

While the vast majority of units within the Altamont quadrangle dip approximately 1.5 degrees (ca. 160 feet per mile) to the south-southwest, the region is not without its deformational component. The Helderberg hills south of Altamont mark the northernmost exposure of the Hudson Valley fold/thrust belt, and display several major bedding plane detachment structures. Thrust faults and splays have been recognized in the lower Mount Marion through Esopus, Becraft, and New Scotland formations within and outside of the Altamont Quadrangle, with the most obvious examples found along Minelot Creek in Thacher State Park and at the base of the Becraft Limestone, where up to 15 feet (4.6 meters) of thickness is locally absent.

Apart from these decollement structures, a number of high angle normal faults were observed within the Schenectady Formation perpendicular to the trace of the Bozenkill Creek. Displacement along each fault was generally small (on the order of 5-30 cm), but taken together added up to several meters of downward displacement to the Northwest. The fault planes observed along the river's edge tended to anastomose, and may be of relatively recent vintage as the breccciated was entirely unconsolidated.

OVERVIEW: KARST ON THE ALTAMONT QUADRANGLE

Karst is a landform created by the dissolving of the underlying bedrock. Evidence of karst includes the presence of caves, sinkholes, disappearing streams, solutionally-enlarged joints, and springs; and by the general absence of surface streams.
On the Altamont quadrangle karst is found in the Kalkberg, Coeymans, and Manlius Limestones; the Becraft Limestone; and the Onondaga Limestone. The longest caves are found in the Coeymans and Manlius, but considerable karst is found in all listed limestone units.
Good examples may be found in John Boyd Thacher State Park. Caves and springs are seen along the Indian Ladder trail. The best sinkholes are found south of Beaverdam Road at the contact of the Union Springs Formation and the underlying Onondaga, and along parts of the Long Path north of the park office. One thing that is not a sinkhole is Thompsons Lake.

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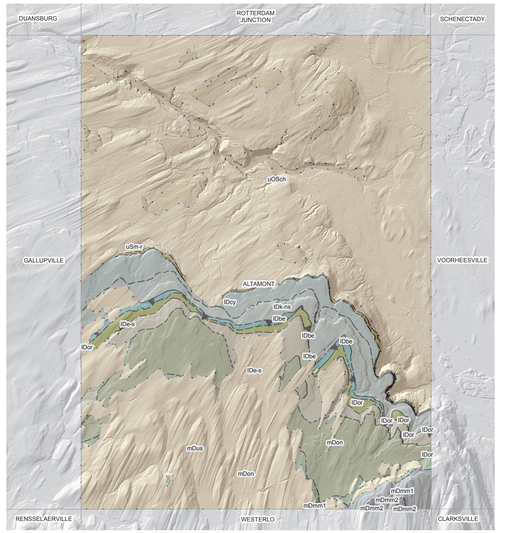
## SHADED TERRAIN MAP AND SURROUNDING QUADRANGLES




1:62 500 scale; 2x vertical exaggeration
*Shaded relief generated from NYS DEP LiDAR data and National Elevation Dataset 1/3 arc-second data from the US Geological Survey.*

## QUADRANGLE LOCATION

***New York State Museum Map & Chart No. 62***
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