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New York State Geological Survey

GEOLOGY OF THE UNION SPRINGS 7.5-MINUTE QUADRANGLE, CAYUGA AND SENECA COUNTIES, NEW YORK

prepared by
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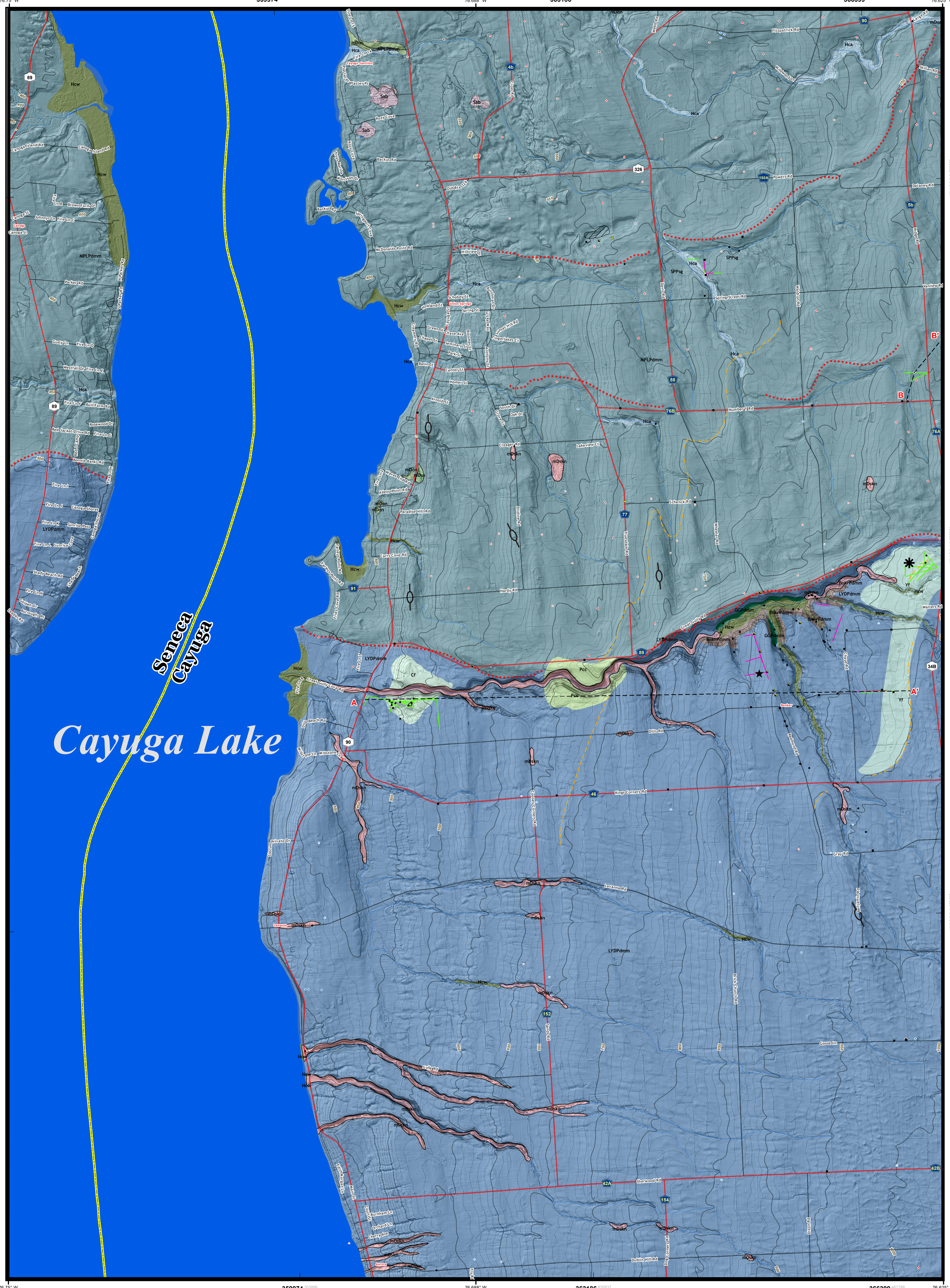
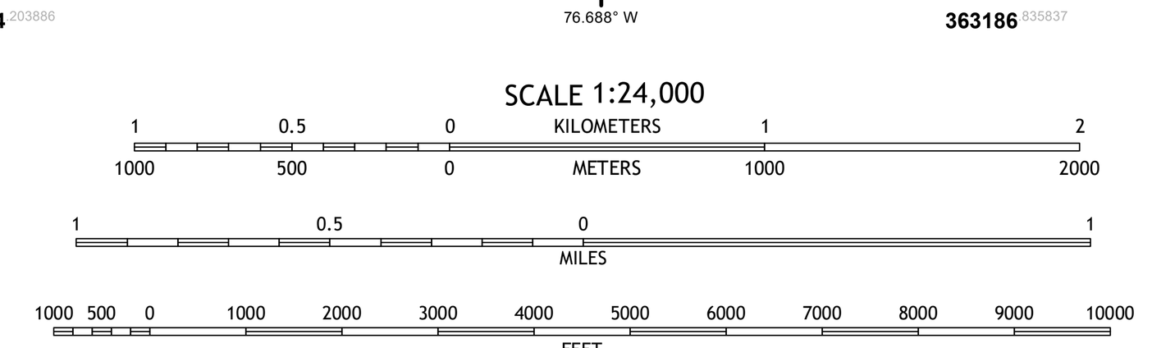


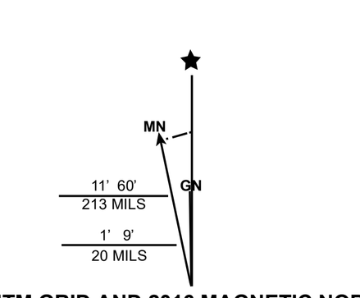
Universal Transverse Mercator, Zone 18 N
North American Datum of 1983

Hygrology, and planimetry layers from the New York State DOT Raster Quadrangle separates for Cayuga and Seneca Counties (https://gis.ny.gov/gisdata/inventories/member.cfm?OrganizationID=108).
Geographic data layers from 2018 TIGER/Line shapes for transportation and hydrograpghy (https://www.census.gov/cgi-bin/geo/shapefiles/index.php)

Shaded relief from Seneca Lake Watershed 2 m, NYS 10m DEM, and Cayuga County 2-meter Lidar data sets (http://gis.ny.gov/elevation/index.cfm)

Magnetic declination from the NOAA online Declination Calculator: http://www.ngdc.noaa.gov/geomag-web/#declination





UTM GRID AND 2016 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET

Geologic mapping by A. Kozlowski and J. Leone, 2016
Digital data and cartography, B. Bird and K. Backhaus, 2016 & 2019.

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2016

Introduction

The surficial geology of the Union Springs 7.5-minute quadrangle was mapped in 2015-16 as part of a National Cooperative Geologic Mapping Program funded StateMap project (award G15AC00340). This map is part of a larger project of the New York State Museum/New York State Geologic Survey to map all of Cayuga County, New York. The purpose of this map was to identify and delineate various geologic formations in the Union Springs quadrangle with the intent that this information can guide municipalities in land use, environmental, and natural resource decisions.

The Union Springs quadrangle is located in central New York 10 miles southwest of Auburn, NY and 30 miles north of Ithaca, NY on the eastern shore of Cayuga Lake. Included within the quadrangle are the villages of Union Springs and Aurora as well as the towns of Springport, Ledyard, portions of Scipio, Fleming and Fayette Township in Seneca County to the west. Outside the village limits this portion of the county is mostly rural with large tracts of forest and agriculture. Cayuga Lake in the western portion of the quadrangle is developed with many vacation residences.

Situated within the Alleghany Plateau physiographic province the landscape is generally subdued, rolling topography with the greatest elevation on a hummocky upland at 1,004 feet above mean sea level (amsl) in the southeastern portion of the quadrangle with the lowest elevation being 380 feet on the shore of Cayuga Lake in the western portion of the map. Several east to west oriented moraines document former ice marginal positions of the glaciers that once covered the entire quadrangle. An accumulation of glacial sediment in excess of 215 feet is reported in the east central portion of the quadrangle. Sediments include diamicton (interpreted as till), sorted clay, silt, sand, and gravel from glacial meltwater and glacial lakes and post glacial alluvium and wetland deposits. The lithologic units that comprise the quadrangle are highly variable in thickness and character although generally are expressed geomorphologically as similar features. For instance the moraines and drumlins are generally diamicton.

Bedrock is sporadically exposed throughout the quadrangle in road cuts, stream cuts, gorges and ditches along roadways. According to various drilling logs, exploration borings and geophysical methods the depth to bedrock ranges from 3 to greater than 200 feet across the quadrangle. An average depth to bedrock for the quadrangle is about 10 feet. The bedrock beneath the glacial sediments in the quadrangle is mapped as Devonian in age (Fisher et. al., 1970). The northern area is underlain by the Onondaga Limestone. The southern portion of the quadrangle is underlain by the Skaneateles, Marcellus, and Union Springs Formations. Drillers' logs indicate the bedrock is layered sedimentary rock of limestone, shale or gypsum and gray, black, green or red in color.

Surficial Map Units.

The Union Springs quadrangle is covered by a variety of sediment types deposited by the glacier directly, meltwater from the glacier or post-glacial streams and lakes. Due to extensive fieldwork and rigorous chronologic control based **on** abundant age dating, we have the ability to define the chronostratigraphic framework of glacial deposits in addition to lithostratigraphic character. Further, the incorporation of high resolution (0.7m cells) lidar terrain models provides a context to identify distinct landform associations. Thus, despite lithologic similarities of materials for the first time we are able to provide a composite geologic map using an allostratigraphic approach implemented by morphostratigraphy. The key concept in this mapping approach is that units are defined by bounding surfaces and is inclusive of all sediments contained within. The geologic formations below are described here for the first time and we have made every attempt to define them following guidance from the North American Stratigraphic Code. In many of the description there is reference to deglacial chronologies for the northeast as reported by Muller & Calkin (1993) and Ridge (2003). The chronostratigraphic descriptions also refer to Phases and Episodes of Late Quaternary time-stratigraphic intervals within the Great Lakes Area as outlined by Karrow et al., (2000). Attempts to define a chronostratigraphic framework within the map area is largely due to earlier reports of Shumaker (1957) who reported the presence of preserved subtill organics in stratified sand units in the vicinity of Great Gully. Ages reported in Formation descriptions below with an asterisk correspond to calibrated ages.

Cayuga Group

Hca — **Cayuga Member Alluvium (Hca)**
This member represents stratified, silt, sand gravels and cobbles deposited in rivers, streams and lakes. Principally inferred as post-glacial alluvium, it includes modern channel, over-bank and fan/deltaic deposits. Although these deposits principally are Holocene in age, at the latitude of the Union Springs 7.5-minute Quadrangle isostatic rebound had recovered to a linear stage during the Late Wisconsin (Bird and Kozlowski, 2016). As a result, in the area constrained by the quadrangle modern lake levels closely coincide with lake levels present during the main phase of glacial Lake Iroquois that inundated and occupied the southern Ontario Basin including Cayuga Lake, thus some deltaic deposits in his member may be of Late Pleistocene age.

Hcw — **Cayuga Member Wetland (Hcw)**
This member comprises of peat, muck, marl, silt clay or sand deposited in association with wetlands environments. Various sediments can be present as transitional from one facies to another.

Great Gully Group

Pbnkr — **Bunker Formation (Pbnkr)**
Exposed by erosion associated with incision of Great Gully, the Bunker Formation consists principally of a gray colored, matrix supported, clast rich, over consolidated and highly jointed diamicton (glacial till). This indurated unit is abundant in red and green clasts of the upper Ordovician Queenston Shale and black Ordovician Limestones. The till unit is occasionally interbedded with sporadic sand and silt lenses and generally appears thicker than two meters but has been observed in wireline cores and outcrops as thick as 14 meters. Underlying the principle till member unit are stratified, sometimes cross-laminated sand and silt beds that range in thickness from 1-4 meters. Associated with the sand and silt units is indurated peat member 0.25-0.5 m in thickness. This paleosol serves as important marker bed and has been encountered in several exploration boreholes. The sand, silt and peat are interpreted as lacustrine and near shore sediments deposited during an interval of high lake level during a phase we term as glacial Lake Nanette within the Cayuga Basin. The sand units often contain organic detritus and wood and the upper contact between the till unit often displays shearing and deformation. The age of the Bunker Formation is Middle Wisconsin (MIS 3) and the till member is bracketed in age by the overlying sand member of the Ledyard Formation (~40,000 years before present*) and multiple age dates from AMS radiocarbon, optical stimulated luminescence (OSL) and pollen spectra from the underlying sand and peat member that consistently yield and age between 50,000 and 55,000 years before present*. The till unit is consistent with a regionally recognized glacial episode known as the Brimley Phase observed in Southern Ontario and the organic sand dominant facies are consistent with Interstadial Port Talbot Phase recognized in buried deposits along the north shore of Lake Erie.

Paa — **Aurora Formation (Paa)**
Exposed along the walls in the eastern end of Great Gully, the Aurora Formation consists of a cross-bedded and cross-rippled sand member 2-3 meters in thickness that contains an abundance of organic detritus within the sedimentary structures. These sand units often display alternating oxidized (orange) and reduced (gray) coloration. The organic detritus includes branches and wood fragments that are beyond the range of radiocarbon dating. Multiple optical stimulated luminescence dates on these sand beds yield an approximate age of 60,000-76,000 years before present* The diamicton (till) member of the formation consists of a gray, matrix supported, clast rich, highly jointed unit sometimes in excess of 10 meters thick, but more often less than 3 meters in thickness. An underlying 1-2-meter-thick gray colored, massive, fine-grained sand member brackets the diamicton. Optical stimulated ages on this fine-grained sand indicate burial occurred between 90,000 and 100,000 years before present*. Thus, our interpretation is that the diamicton represents an Early Wisconsin (MIS 4) glacial advance into the Finger Lakes Region and is possibly equivalent to the Guildwood or Greenwood Phases observed in the Ontario Provinces (Karrow et. al., 2000).

Pgg — **Great Gully Formation (Pgg)**
The Great Gully Formation consists of a thin, discontinuous bedded, medium-coarse grained oxidized sand and gravel member often no more than one meter thick that overlies a dark gray, matrix supported, clast rich, jointed, dense and highly indurated diamicton (glacial till) member. This diamicton contains an abundance of black Ordovician Limestone boulders and clasts often faceted and striated in greater abundance than other tills observed within Great Gully. This member is only visible in the eastern end of Great Gully along the floor of the ravine and appears as the lowermost observed till that occupies a north-south buried valley that transects Great Gully. The thickness of the deposit is poorly constrained; however, exploration wireline cores indicate thicknesses of 12 meters are present. Optical stimulated luminescence ages between 90,000 and 100,000 years before present* from the lower member of the Aurora Formation indicate this till unit is likely of Illinoian Age (MIS 6). By association we surmise the discontinuous sand and gravels above the till may represent the Sangamon Interglacial period (MIS 5). The till member is quite likely equivalent to the York Till in Southern Ontario.

Pkc — **Kings Corners Formation (Pkc)**
The Kings Corners Formation consists bedded silt, sand and gravel, with sand and silt facies that are overconsolidated, indurated and or semi-lithified. It also contains multiple diamicton units (till member). These deposits have only been observed in deep exploration boreholes directly beneath the Great Gully Formation. The age of the formation is unknown but as it underlies the Illinoian age till it is presumed to represent Pre-Illinoian alluvial, lacustrine and glacial environments.

Mapleton Group

Pmpl — **Mapleton Formation (Pmpl)**
The Mapleton Formation comprises the uppermost stratigraphic unit north of Great Gully. Principally, it consists of a matrix supported, clast rich diamicton (till) approximately 2-15 meters thick deposited during the Port Huron Phase readvance approximately 15,000 years before present (Kozlowski et. al., 2018). Till is a generic term used to describe poorly sorted admixture ranging from silt sized particles to boulders deposited directly by glacial ice, diamicton is the non-genetic scientific terminology to describe poorly sorted deposits. In some locations the Mapleton Formation has a silt rich semi-stratified appearance that resulted from subaqueous deposition within high-elevation proglacial lakes within the Cayuga Basin. The formation is in direct association with the east to west trending Mapleton Moraine on the north rim of Great Gully that demarks the furthest southern extent of the Port Huron Ice Advance. This glacial till is correlative with the Summerset Till described by Calkin and Muller (1992) along Lake Ontario Shoreline and the Sterling, New York area. We believe this till unit to correlative with the Halton Till in southern Ontario.

Psp — **Springport Member (Psp)**
The Springport Member consists of isolated and discontinuous pockets of well-sorted and stratified sand and gravel, 2-15 meters thick deposited as glacial outwash or in association with meltwater streams that were adjacent to former glaciers prior to the Port Huron Phase advance and hence this member is overlain by the Mapleton Formation. In some localities the cemented gravels and sands convey groundwater and form localized springs and may serve as a framework for water resources. Spring Road south of the Village Union Springs probably derived its name from seeps originating from the Springport member.

Pf — **Farleys Member (Pf)**
The Farley Member consists of bedded sand and gravel with a maximum observed thickness of approximately nine meters deposited as deltas entering a proglacial lake at an approximate elevation of 558 feet amsl within the Cayuga Basin. This delta deposit represents glacial Lake Dana, the second youngest Late Wisconsinan proglacial lake level after glacial Lake Iroquois.

Pcc — **Cooney Corners Member (Pcc)**
The Cooney Corners Member consists of bedded sand and gravel of unknown thickness deposited as deltaic facies into glacial Lake Warren (of the Cayuga Basin, See Fairchild, 1934), a proglacial lake at an elevation of 692 feet amsl (212 meters amsl) that was building into the Cayuga Basin. The exact age of this stabilized lake level is uknown, but it coincides with a well-developed shoreline and represents the second highest lake level after the Port Huron readvance to the Mapleton Moraine.

Pno1 — **Number One Member (Pno1)**
The Number One Member consists of a bedded and stratified sand and gravel deposited as a deltaic landform into glacial Lake Hall, a high elevation proglacial lake stage occupying the Cayuga Basin at an elevation of 905 feet amsl (275 meters amsl). This member represents the first and highest in elevation of the deltaic deposits observed along the course of Great Gully. Meltwater channels flowing westward along the margin of the Ontario Lobe delivered sediment into the elevated lake stage associated with the Port Huron readvance to the Mapleton Moraine. Similar to the Cooney Corners Member, coincident shorelines are traceable on the lidar terrain models to this member that initiates on the western edge of Scipio Township near the head of Great Gully.

Ledyard Group

Plyd — **Ledyard Formation (Plyd)**
First identified on the Swayze Farm located near the intersection of Kings Corners Road and Redmond Road where it was first observed, the Ledyard Formation is the name applied to the matrix supported, clast-rich, calcareous diamicton (till) brown to gray in color that blankets the upland surface south of Great Gully. Often observed as 1-2-meter-thick deposit directly overlying Devonian bedrock; however, exploratory wireline coring indicates thicknesses of at least 12 meters are present and extend across the map area. Good examples of shallow till/rock relationships may be observed in roadside ditches along Cooney Corners Road, Dills Road and Kings Corners Road in the central Union Springs map area. Within Great Gully and adjacent tributaries, an underlying bedded fine to medium grained sand and silt unit is traceable and comprises the sand member of the Ledyard Formation. Age assignment of the Ledyard Formation is ambiguous. Theoretically the till sheet should be associated with the Port Bruce Phase readvance hypothesized to have reached a terminal position of the Valley Heads Moraine south of the Finger Lakes Basins slightly prior to 17,000 years before present (Muller and Calkin, 1993; Ridge, 2003). Yet, our field mapping and stratigraphic investigations indicate only a single diamicton (till unit) at the surface of the map area. Multiple age dates from both AMS radiocarbon and optically stimulated luminescence (OSL) on the underlying sand member and organic materials contained within yield an age range of 30,000-40,000 years before present* equivalent with the Farmdale Phase interglacial of (Karrow et. al., 2000). Thus, the direct age relationship with the surface till of the Ledyard Formation may also represent the Nissouri Phase equivalent to Marine Isotope Stage (MIS) 2, associated with the late glacial maximum approximately 25,000 years before present*.

Bedrock Geologic Units of the Union Springs 7.5 Minute Quadrangle

Despite the predominance of surficial deposits left by glaciers various bedrock units were quarried on the Union Springs Quadrangle in the past, and some continue to provide useful materials today. Many small, abandoned quarries occur north of the Village of Union Springs. Uses included stone blocks for building homes and chimneys and for foundations for homes and barns. Further several gypsum operations are near the shore of Cayuga Lake. The Skaneateles Formation continues to be mined locally for crushed rock gravel on roads and driveways. Previous geological studies of the Union Spring 7.5-minute quadrangle include Goldring (1935), Johnsen (1958), and Rickard (1962).

mDon — **Onondaga Formation (mDon)**
Light-colored, fossiliferous, coarse- to fine-grained limestones (grainstones, packstones and wackestones), with chert in some intervals. The relatively hard, resistant limestones of the Onondaga Formation commonly form ledges and sometimes cliffs and escarpments (as on the Union Springs quadrangle to the north). The formation forms the bedrock across a broad area the northern portion of the Union Springs quadrangle and is exposed along NY State Route 326 north and east of the Village of Union Springs. 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 (Edgecliff, Nedrow and Moorehouse Members, low to high) occur in the region, but are not distinguished on the map. Common corals in basal limestones locally developed into a reef mound with abundant corals. 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 waves crash against the sea floor.

mDus — **Union Springs Formation (mDus: = lower part of the Marcellus subgroup)**
Dominantly black to dark-gray shales and mudstones, with some thin impure limestone layers. Strata are generally non-fossiliferous to poorly fossiliferous, with straight and coiled cephalopods, very small conical shells (styliolinids, dacryoconarids), and some small brachiopods and bivalves. The base of the Union Springs Formation, at the contact with the underlying Onondaga Limestone, was not found 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.

mDskn — **Skaneateles Formation (mDskn)**
Dominantly black to dark-gray shales and mudstones and sandstones. The Skaneateles Formation as present in the Union Springs quadrangle is typical of the marine siliclastic sequence observed throughout the Hamilton Group in the region. These inner shelf facies are characterized by interbedded sandstones and siltstones and contain well preserved sedimentary structures. Shales are bioturbated and have an abundance of fossils in some beds. Dark gray "Leiorhynchus" bearing clayshales of the Levanna Member are most commonly observed in the southern half of the quadrangle from Great Gully southward. Shales are highly fissile and well jointed where observed.

Sab — **Bertie Formation (Sab)**
Dominantly light-gray dolomitic and gypsiferous shales, and gypsum. Bertie Formation is observed in the northern portion of the Union Springs quadrangle near Cayuga Lake. The locations are former mine sites where the gypsum is mined for agricultural purposes.

Methods

For this map multiple methods were used to gather surface and subsurface data. For field mapping a two meter long hand auger was used to collect samples below the soil to refusal in 65 locations and another 43 samples were collected from excavated areas such as drainage ditches, road and stream cuts, and construction sites. Each of these locations was recorded with a global positioning system (Garmin 72H in NAD 81 UTM 18N coordinates) and the sediment encountered was noted. A field map of this information was created and is retained in the NYSGS Open File collection.

Subsurface geology was investigated utilizing (8) Geoprobe direct push continuous cores in deltaic facies that were conducive to this investigative method. In addition (4) continuous HQ diameter wireline exploration cores were collected to characterize the deeper geologic deposits within the map area. Water wells (11 total wells) from the Department of Environmental Conservation (NYSDEC), New York Department of Transportation (NYSDOT) borings(4), and NYSDEC oil and gas well records (40) were also used to decipher the subsurface of the Union Springs quadrangle.

Working with the lithologies recovered from exploration cores and integrating NYDEC water well records, the sediment lithologies were simplified from drillers' descriptions to more concise, uniform descriptions. The thickness of each lithology and bedrock depth was recorded and the location plotted. The uppermost layer under the topsoil was used to delineate the surficial geology while the stratigraphy was used to create a geologic cross section which extends west-east along the central portion of the map from A to A'. The same process was followed for the NYDOT and engineering borings.

Field data were digitized in ArcMap 10.2. Polygons were created based upon the lithology of the surface material and the sample and boring locations were plotted. The cross section was created using Adobe Illustrator CS6 with a topographic profile from ArcMap and wells and boring. Chronologic information on the age of geologic formations was derived by optically stimulated luminescence (OSL) dating on sand sized quartz using single aliquot regenerative (SAR) methods completed by Shannon Mahan of the Geology and Environmental Change Science Center (USGS, Denver). Accelerated mass spectrometry (AMS) radiocarbon dating on wood and plant macrofossils were also utilized on strata where organic materials were preserved. Age calibrations were completed using the Calib 7.1 (Reimer et al, 2013) , Pollen analyses was also completed on recovered peat horizons.

An array of geophysical methods was employed in the study and production of this map. Suspect terrains believed to contain granular facies such as deltas, fans and meltwater channels were explored using a Geophysical Survey Systems Incorporated (GSSI) SIR 3000 ground penetrating radar with a 100 MHz bistatic antenna configuration and a 200 MHz monostatic antenna. Numerous large electrical resistivity transects were completed using a Dipole-Dipole configuration. Three seismic refraction transects to map the depth to bedrock in thick sediment cover were completed by Pricilla Duskin of the New York State Department of Transportation. Surveys were completed in the map area. In addition 45 passive seismic readings were completed in the map area to map depth to bedrock.

Conclusions

The pattern and character of surficial geology present in the Union Springs quadrangle display some of the most complex, variable and fascinating geology mapped within New York State. This level of complexity is the direct result of repeated cycles of glaciation and the interaction with a dissected and mature pre-glacial bedrock landscape. Sediments in the Union Springs quadrangle are a result of a both advancing and retreating glacier across the area. Deeply buried deposits within Great Gully record an unprecedented level of stratigraphy for the region that records cycles of glacial and interglacial events over the last 130,000 years. Copious interbedded and stratified subtill deposits retain an abundance of preserved fossil plants, wood, insects, pollen and sedimentary structures that provide a context of climate change in central New York from Marine Isotope stages 1-6.
The surface diamictons of the Mapleton Formation and the Swayze Formation were deposited directly by the ice during advance and subsequent retreat of the glacier, in the process forming Moraines, and low relief hummocky topography. Cycles of advance and subsequent retreat within the Cayuga Lake Basin trapped melting waters creating extensive high elevation proglacial Lakes, such as Lake Hall, Lake Warren, and Lake Dana. Sand, silt and gravel washed into these descending lake stages via meltwater streams and developed deltaic landforms such as the Farely, Cooneys Corners and number One Formations along the Great Gully drainage. Three distinct ice marginal positions on the map represent stages of glacier dynamics within the Cayuga Basin during the late Wisconsin Epoch. The Mapleton Moraine located along the northern rim of Great Gully demarcates the maximum extent of the Port Huron Phase re advance into central New York. Two kilometers to the north the Chestnut Hill Moraine extends from the Chestnut Hill Cemetery in Union Springs to Ridge Road on the Fleming Town Line. One kilometer north the more pronounced Union Springs Moraine represents a second recessional ice margin constructed after the Port Huron advance. After the ice margin retreated north of Cayuga Lake the lower stage glacial Lake Iroquois was established, followed by Holocene Lake levels, organic deposits began to build in the low, wet areas which still persist today.

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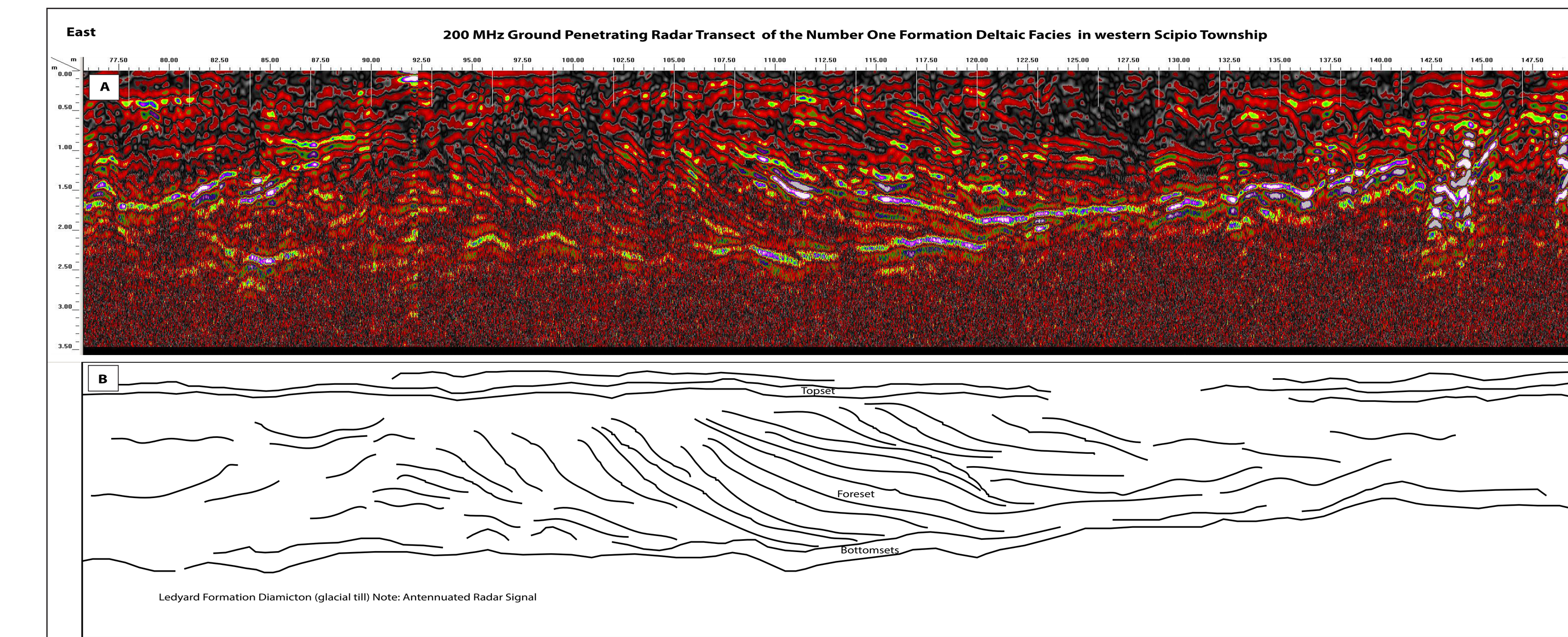
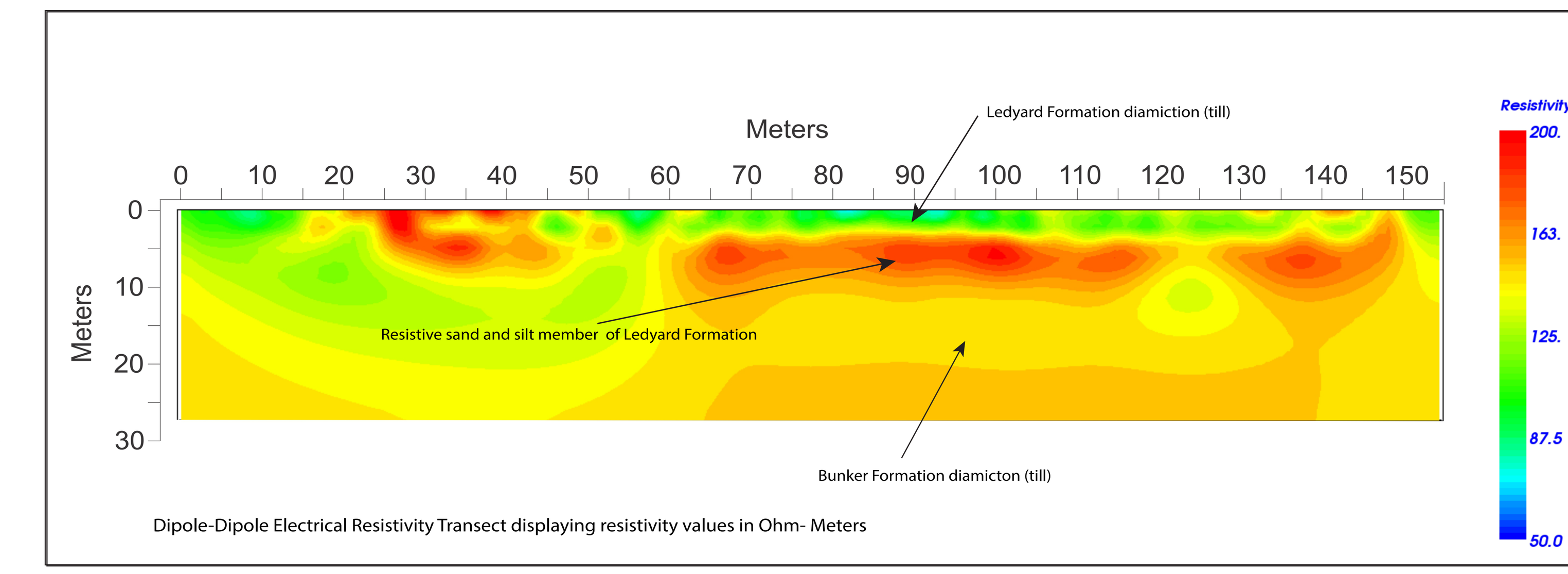
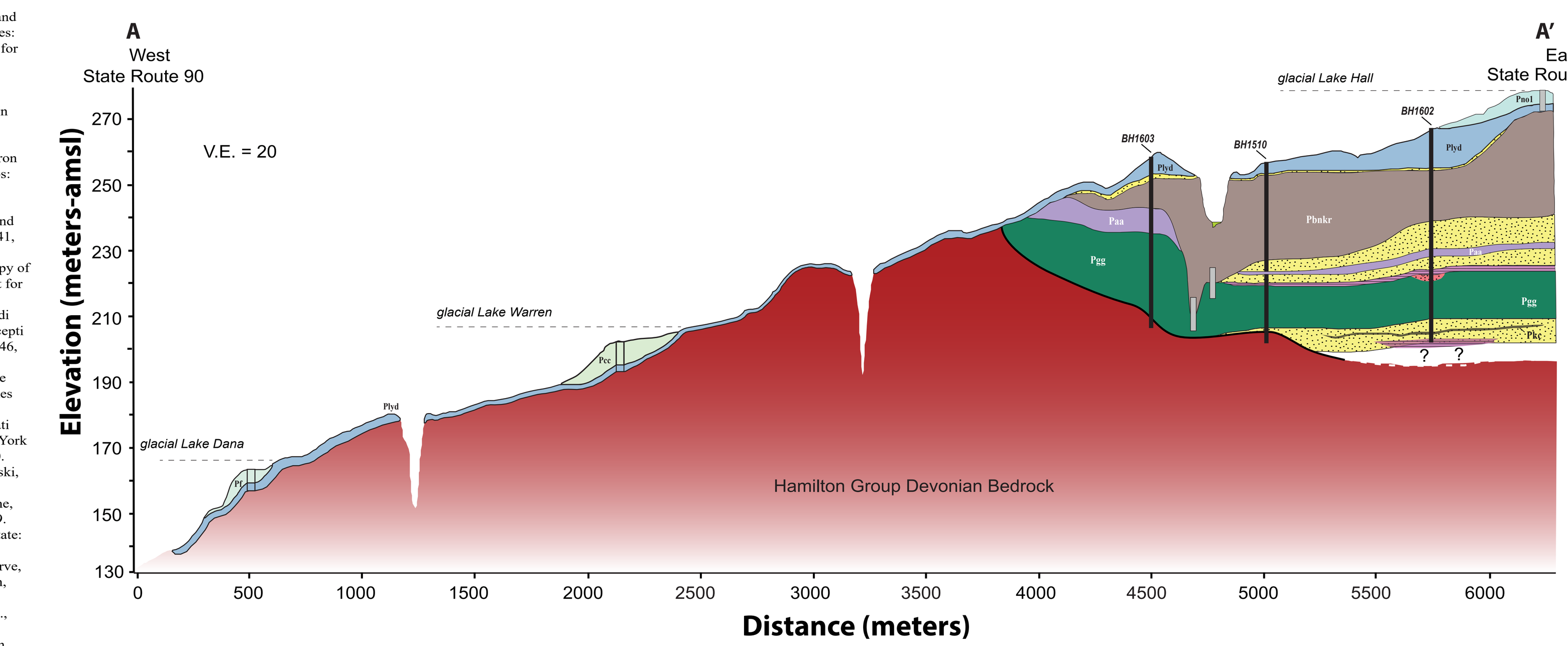


Image A is processed radar record; Image B is interpreted line drawing



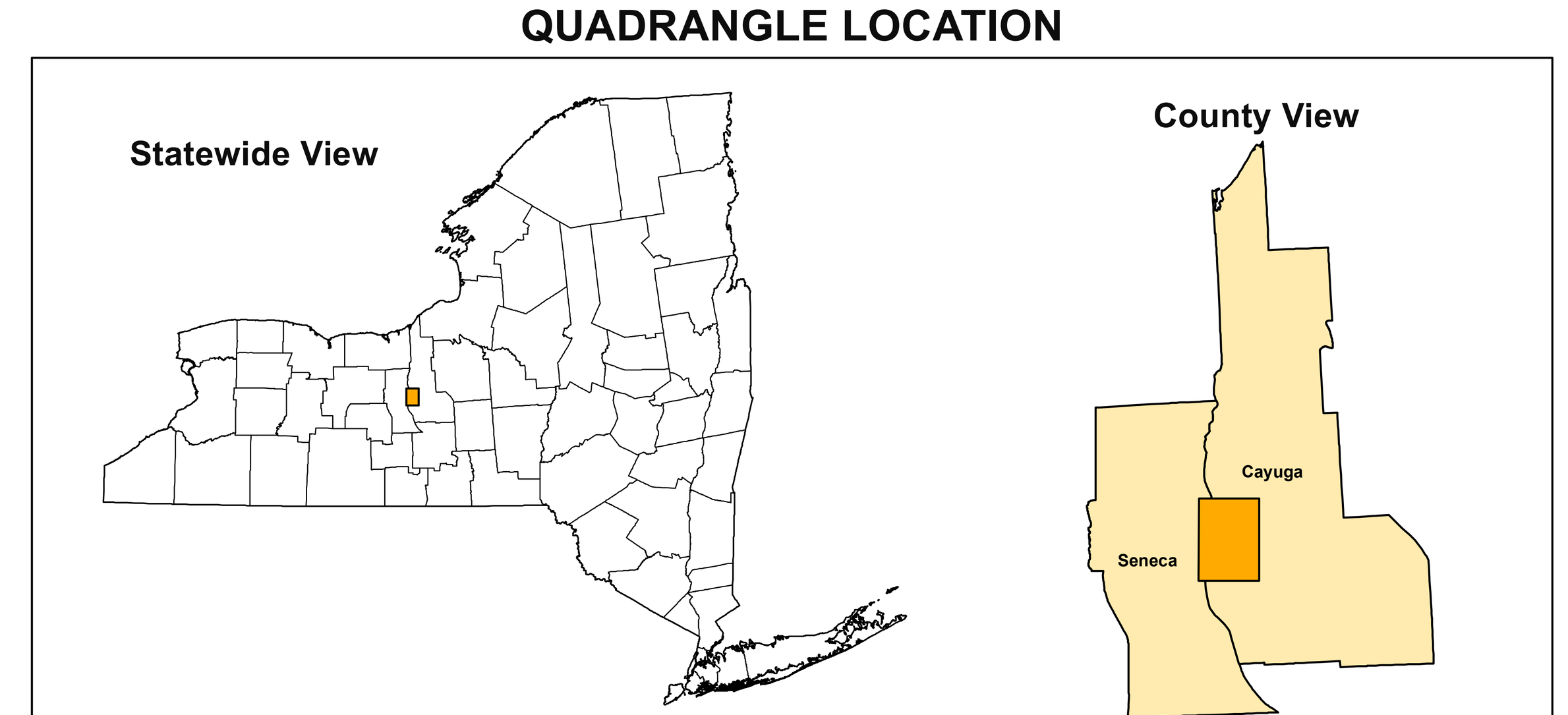
Dipole-Dipole Electrical Resistivity Transect displaying resistivity values in Ohm- Meters



SYMBOLS

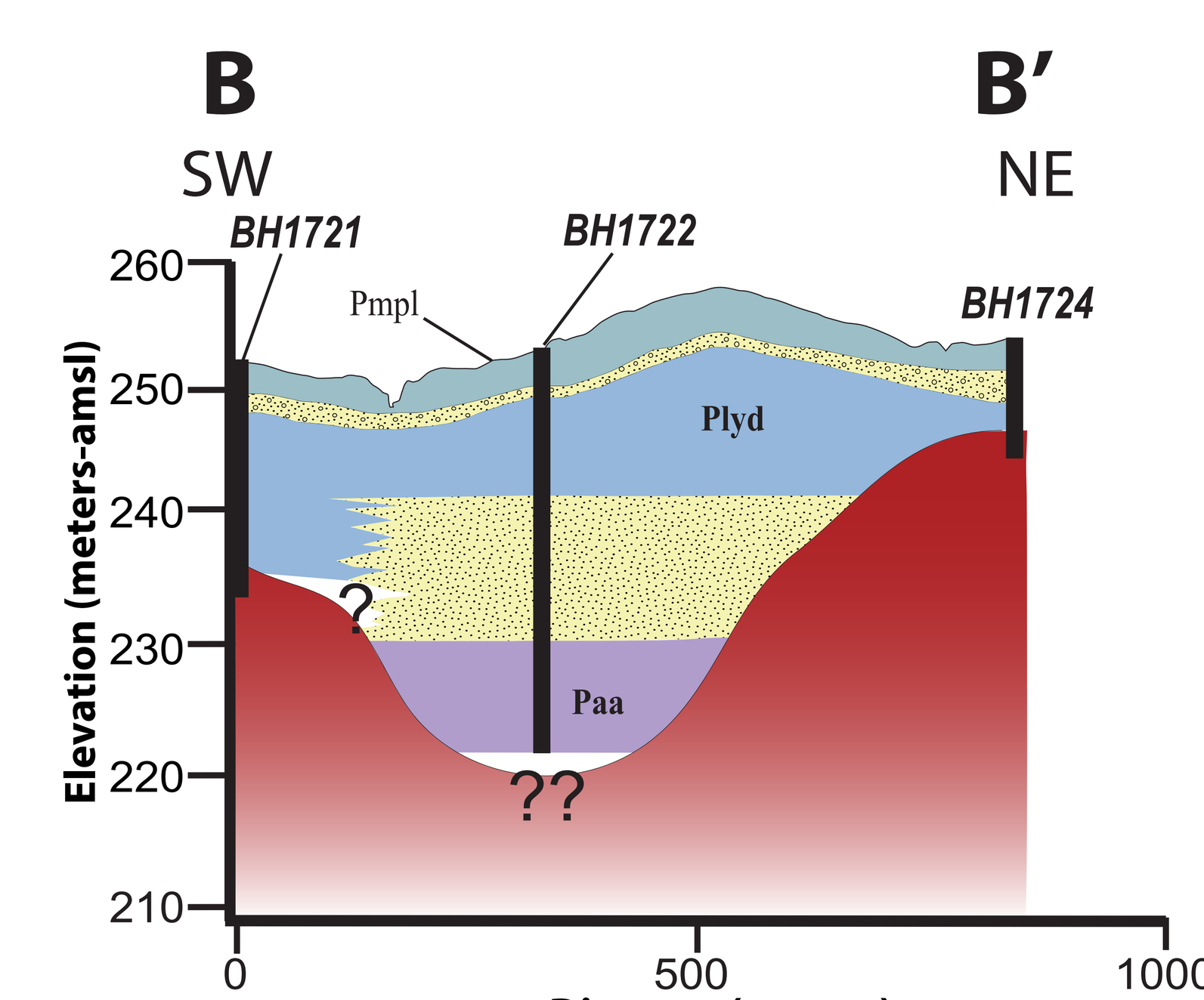
Streets	Water Bodies	NYSGS Borehole Location	Active Seismic Station	Drumlins
Highways	Streams	NYSDEC Water Well Location	Passive Seismic Station	Glacial Lake Shoreline
County Line	Cross-Section Lines	NYSDOT Boring Location	Resistivity Transect	Ice Margin
Contours	NYSGS Soil Sample Location	NYSDEC Oil & Gas Well Location	GPR Transect	Karst

QUADRANGLE LOCATION

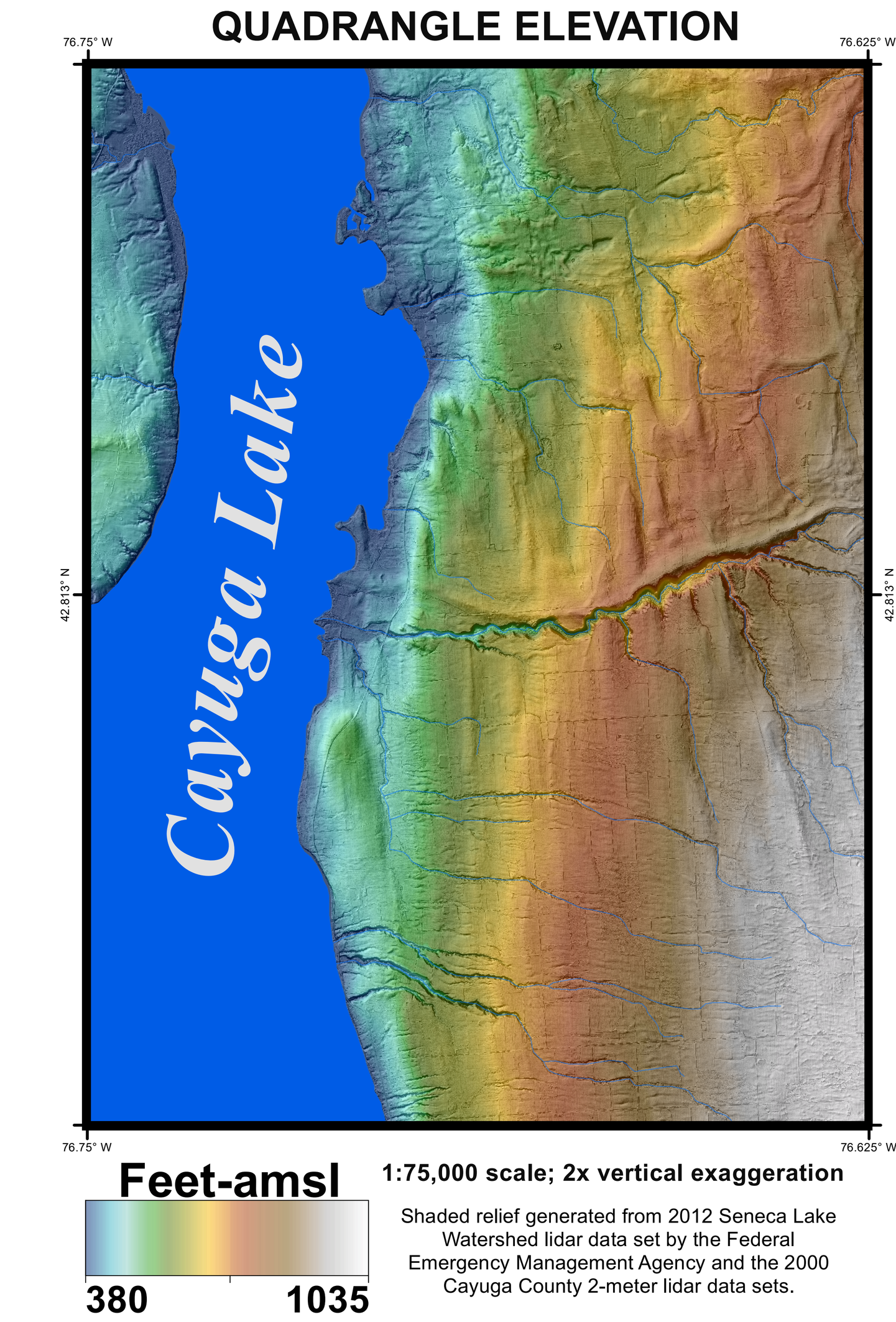


ADJOINING QUADRANGLES

Seneca Falls	Cayuga	Auburn
Romulus	Union Springs	Scipio Center
Ovid	Sheldrake	Genoa



QUADRANGLE ELEVATION



1:75,000 scale; 2x vertical exaggeration

Shaded relief generated from 2012 Seneca Lake Watershed lidar data set by the Federal Emergency Management Agency and the 2000 Cayuga County 2-meter lidar data sets.

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