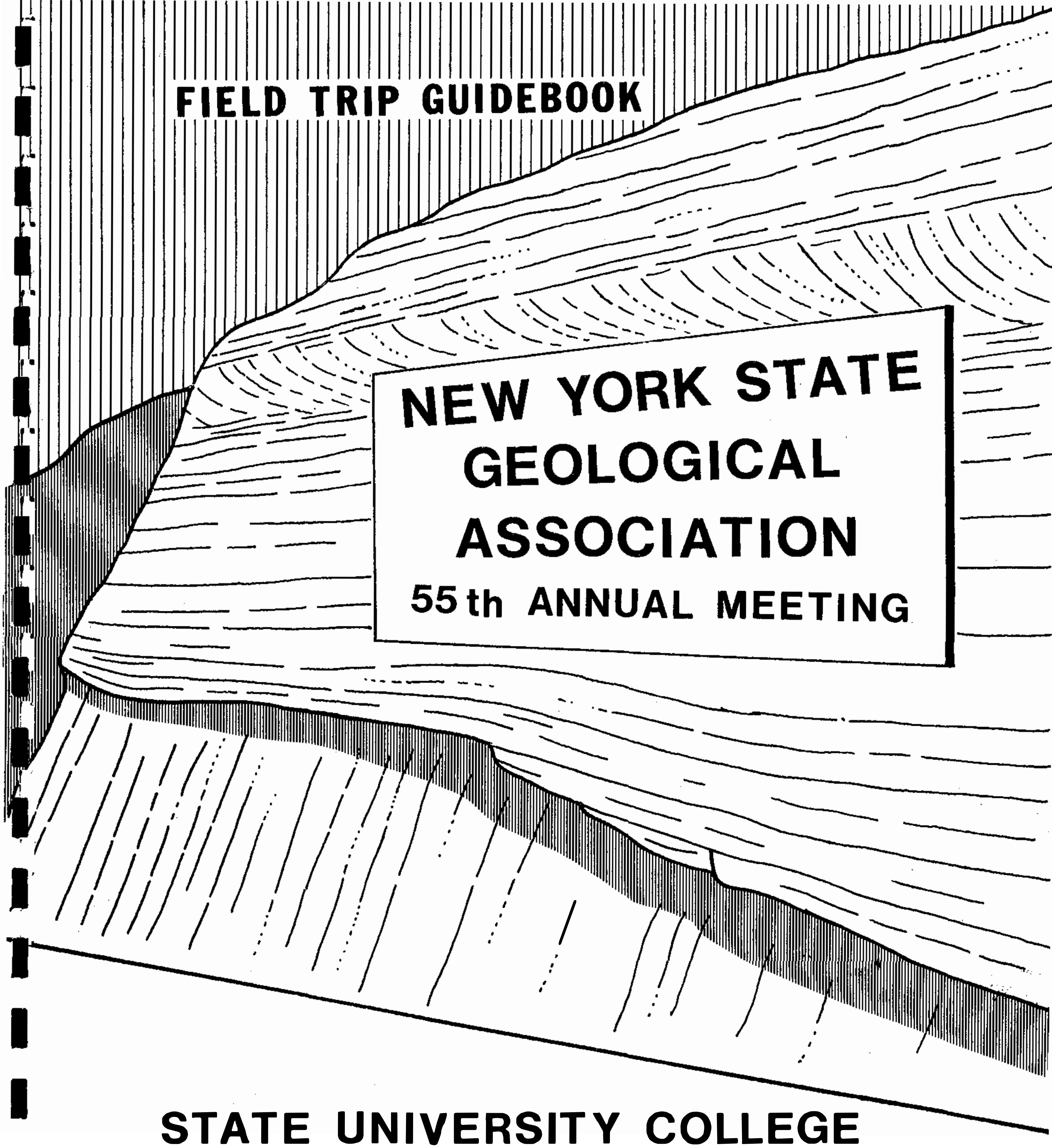

FIELD TRIP GUIDEBOOK

NEW YORK STATE GEOLOGICAL ASSOCIATION

55th ANNUAL MEETING

STATE UNIVERSITY COLLEGE
of ARTS and SCIENCE
POTSDAM, NEW YORK

SEPT. 23-25, 1983

FIELD TRIP NO. 1

SEISMOLOGY, TECTONICS AND ENGINEERING GEOLOGY IN THE ST. LAWRENCE VALLEY AND NORTHWEST ADIRONDACKS

by

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Introduction

The purpose of this field trip is to develop an understanding of the seismicity and tectonics of the St. Lawrence Valley in Northern New York and the engineering geologic aspects of the St. Lawrence Seaway and Power Authority of New York State. Six stops will be made - one in the vicinity of Norfolk, New York and five in the Massena area. The locations of all stops are shown on Figure 1.

Stop 1 will be near Norfolk, New York (Figure 1) to observe a seismic field station which detects earthquakes that are recorded at Potsdam State College. Stop 2 is at the St. Lawrence Seaway Development Corporation office in Massena, New York (Figure 1) where engineers will discuss the St. Lawrence Seaway System. Stop 3 will be at Massena Center, New York, the epicentral region of the Massena-Cornwall earthquake. At this stop residents who experienced this earthquake will share their recollections of the earthquake with you. Stop 4 will be at the Eisenhower Lock where the engineering aspects of the lock will be discussed. Lunch will be eaten here, and hopefully a ship may be observed passing through the lock. At Stop 5 we will view the Long Sault Dam and observe seismic equipment in operation to detect local earthquakes. Stop 6 will be at Moses-Saunders Power Dam where engineers will discuss the operations and construction of the dam. At this stop there are a number of exhibits and a 30-minute film on the construction of the St. Lawrence Power Project.

All participants will meet in Room 120, Timerman Hall at 8:00 A.M., September 24 to hear a slide-talk on the seismology, tectonics and engineering geology of the St. Lawrence Valley. Frank Revetta will speak on the Massena-Cornwall earthquake of September 5, 1944. Ellyn Schlesinger-Miller and Noel Barstow will discuss the seismology and tectonics of the Northern New York area. Bill Harrison will discuss the engineering geology of the St. Lawrence Seaway and Power Authority of the St. Lawrence River Valley. Slides will be shown of the stops made on the field trip. Participants will then proceed into the hallway for a brief discussion of the seismicity of Northern New York and the Lamont-Doherty Seismic Network.

FIELD TRIP SCHEDULE

8:00 - 9:00 A.M.	Room 120 Timerman Hall - Slide-talk on seismology, tectonics and engineering geology of St. Lawrence Valley
9:00 A.M.	Leave for field trip. Meet at parking lot behind Timerman Hall.
9:30 - 10:00 A.M.	Stop 1 Seismic Field Station near Norfolk, New York.
10:30 - 11:00 A.M.	Stop 2 St. Lawrence Seaway Development Building
11:30 - 12:00 A.M.	Stop 3 Massena Center: Epicenter of Massena-Cornwall Earthquake.
12:00 - 1:30 P.M.	Stop 4 Eisenhower Lock (Lunch)
1:30 - 2:30 P.M.	Stop 5 Long Sault Dam
2:30 - 4:00 P.M.	Stop 6 Moses-Saunders Power Dam
4:00 - 5:00 P.M.	Return to Potsdam

STOP 1 SEISMIC FIELD STATION

This stop will enable you to observe the operation of a seismic field station (Figure 2). The seismic equipment is contained in two 55 gallon steel drums. In one drum is a short period (1 second) horizontal geophone, preamplifier-voltage controlled oscillator, and an FM radio transmitter. The geophone is mounted on bedrock which, in this case, is the Ogdensburg dolomite. The geophone detects the ground motion and its voltage output drives the high-gain preamplifier. The amplifier drives a voltage controlled oscillator which is frequency modulated by the geophone signal. This seismic modulated tone is transmitted a distance of 10 miles via an FM transmitter and a high gain directional antenna to Timerman Hall at Potsdam State College. In the second drum are five McGraw Edison 1000 Ampere hour air cells which provide the power for the amplifier, VCO, and radio transmitter for one year.

At the receiver end is another high-gain directional antenna and an FM receiver. The signal, together with the FM carrier wave, is picked up by the receiver and passed into a discriminator where the carrier wave is removed. The signal then passes into the amplifier and into the heliocorder for recording.

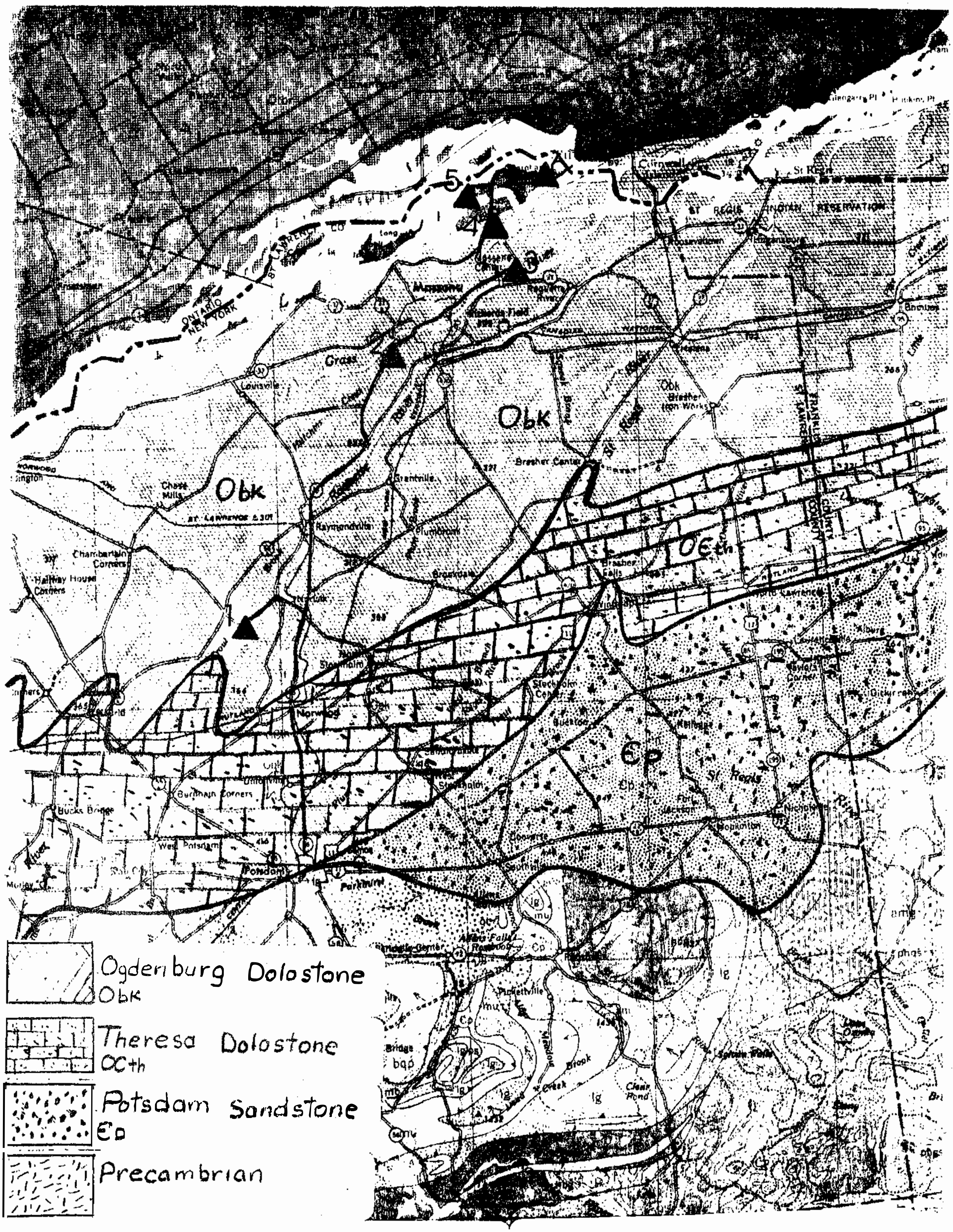

FIGURE 1 Map showing all stops and general geology

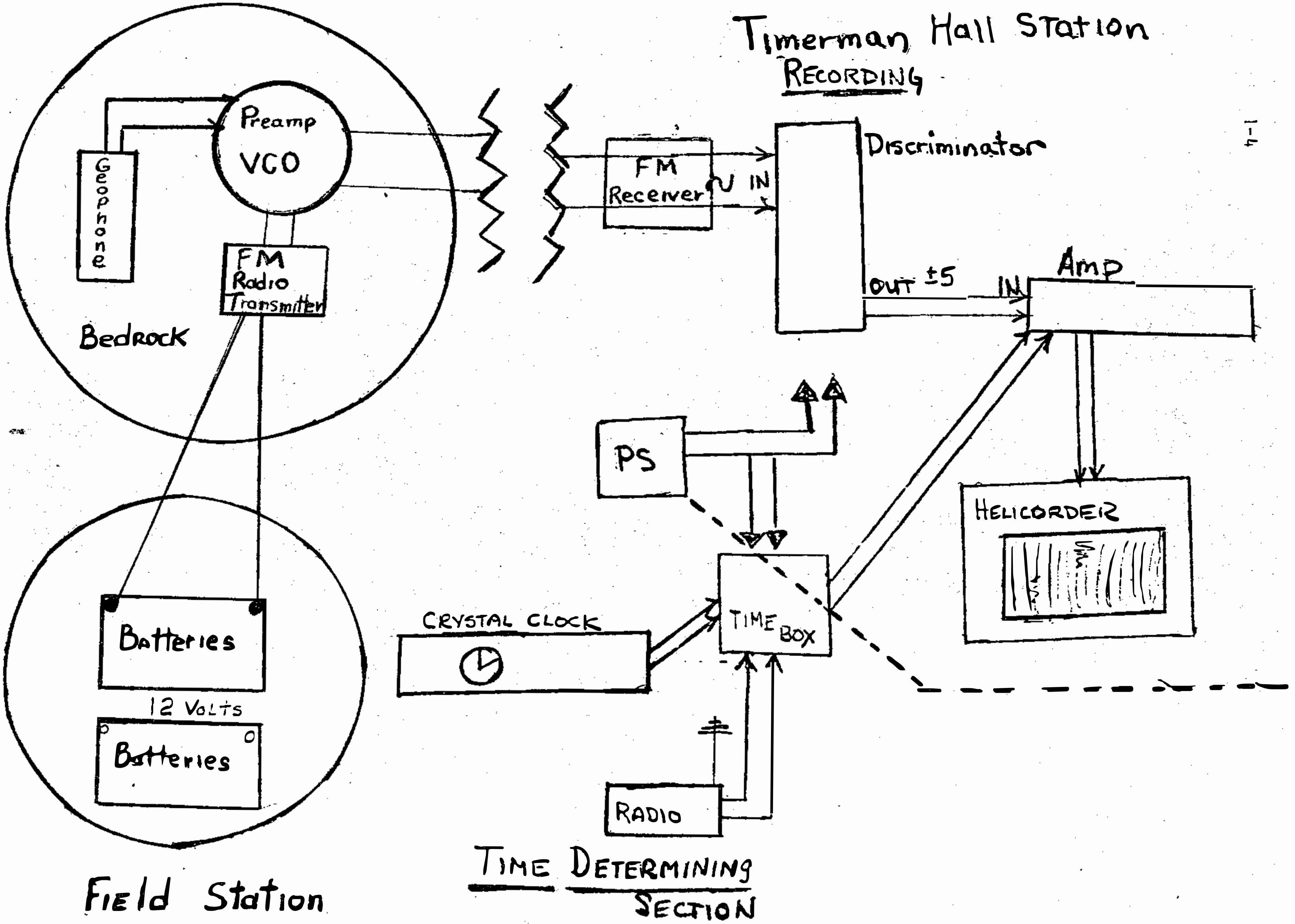

FIGURE 2 Seismic Field station

STOP 2 ST. LAWRENCE SEAWAY DEVELOPMENT CORPORATION OPERATIONAL BUILDING

This stop is at the St. Lawrence Seaway Development Corporation's Administration Building at Massena, New York. At this stop engineers will discuss the construction and operation of the St. Lawrence Seaway. An explanation will be given of a wall display which depicts approximately 2300 miles of waterway from the headwaters of the Great Lakes to the Atlantic Ocean. You will also have the opportunity to view a model of the St. Lawrence Seaway and Power Projects, including the locks, Long Sault Dam, Massena Intake and Village of Massena.

STOP 3 MASSENA CENTER - EPICENTER OF THE MASSENA-CORNWALL EARTHQUAKE OF SEPTEMBER 5, 1944

Massena Center is the epicenter of the Massena-Cornwall earthquake of September 5, 1944 (Figure 3). The epicenter was located from P-phase arrival times and a least square solution and was found to be at 74° 53.9 W longitude and 44° 58.5' N latitude. The depth of focus of the earthquake was estimated to be 20 miles. The magnitude of the earthquake was 5.9 and a maximum intensity of VIII occurred in the vicinity of Massena Center. The total damage was estimated at $2,000,000.

An interesting fact regarding the damage was in the cemeteries. On the Canadian side of the river the tombstones were generally rotated counter-clockwise, and on the United States side they were generally rotated clockwise. It appears that this indicates horizontal displacement along a fault line parallel to the river even though geologists report no surface evidence of any major fault in the immediate area. However, the tombstones and chimney damage indicate an origin somewhere between Cornwall and Massena, which is confirmed from the study of seismograms. The cemeteries are the best evidence of the relative violence of the earthquake in different areas, and they furnish the chief line of division in determining the areas of major damage (Figure 3).

At this stop we will observe tombstones that have been rotated and translated by the Massena-Cornwall earthquake. Also, two Massena Center residents, Messrs. Bob Rickard and James Carton, who experienced the earthquake will discuss their recollections of the event.

STOP 4 EISENHOWER LOCK, ST. LAWRENCE SEAWAY

This structure enables ships traveling the St. Lawrence River to pass around the Moses-Saunders Power Dam and, along with Snell Lock five miles farther east, lowers the ships through a total of 95 feet of elevation. Both locks have dimensions of 850 feet by 80 feet and are of concrete construction. The locks are huge bathtubs, in a sense, with openings along the sides into a passageway (about 13' wide by 15' high) on each side which slopes to the upstream end of the lock. When a ship comes down the St. Lawrence River and through the canal to the lock, the lower lock gates are closed, and the water is at the upper canal elevation. The ship moves slowly into the "bathtub," the upstream gates are closed, and then the water is let out of the locks through the openings in their sides, down the passageway on either side and discharged below the lock. A system of baffles on the downstream end prevents excessive turbulence.

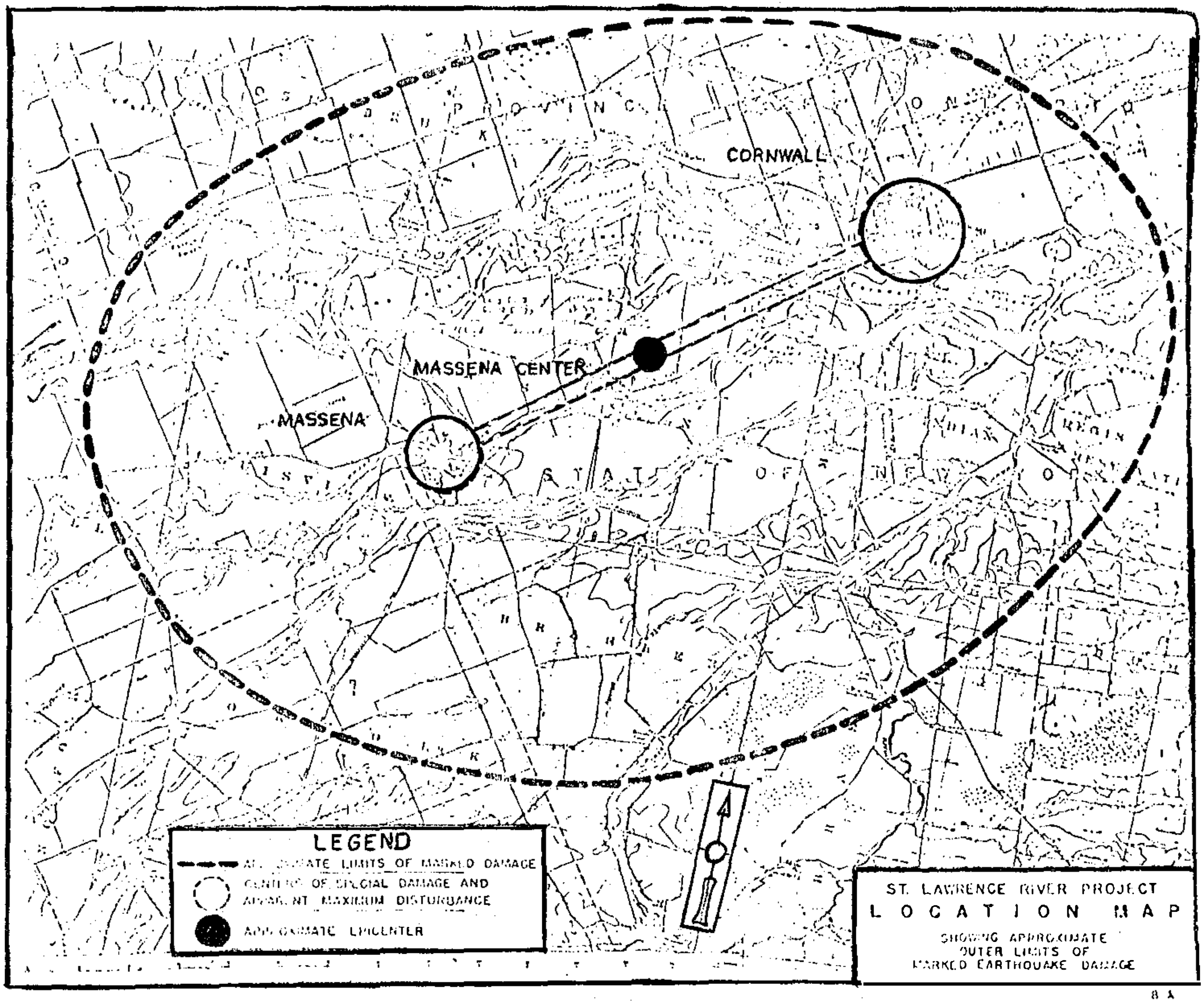

FIGURE 3 *Epicenter of the Massena-Cornwall earthquake*

When a ship comes upstream to the lock, the upper gates are closed and the water level is at the same elevation as the water surface downstream from the lock. The ship moves into the lock, the lower gates are closed, and water is introduced into the side passageways from the upstream end of the locks flowing into the lock through the side openings, thus filling the lock and raising the ship to the elevation of the canal on the upstream side. Then the upper gates are opened and the ship moves out of the lock upstream. Recently, some deterioration of the lock concrete has been observed, and an extensive study has been made by the Corps of Engineers, which is resulting in appropriate remedial measures.

At this stop we will visit the Eisenhower Lock Vessel Traffic Control Center to view its functions. Hopefully, we will see a ship pass through the lock. Lunch will be eaten at this stop and a concession stand is available.

STOP 5 LONG SAULT DAM

The Long Sault Dam is located just below the foot of Long Sault Island, crossing both the main channel of the St. Lawrence River and the smaller channel south of Long Sault Island. It is located four miles north of the Village of Massena, New York and 6.5 miles west of Cornwall, Ontario, Canada (Figure 4). The Long Sault dam serves as a control for the St. Lawrence River, developing approximately 82 feet of drop through the Long Sault Rapids. It is a concrete gravity structure having a maximum height of about 132 feet above foundation. The foundation of the dam is on bedrock (Ogdensburg Dolostone) and the dam is relatively noise free, therefore it is an ideal location for the installation of earthquake detection equipment.

This stop will enable you to observe some seismic equipment installed in the dam by the Lamont-Doherty Geological Observatory and the State University of New York at Binghamton. The dam is an ideal place for the installation of seismic equipment because it is coupled well to the bedrock of the area and is a quiet place. Three instruments may be observed on the lowest level of the dam: a short-period vertical seismometer, strong motion accelerograph (SMA) and a digital cassette accelerograph. The vertical seismometer and the strong motion accelerograph are part of the Lamont-Doherty Seismic Network and the digital event recorder is operated by SUNY at Binghamton.

The short period (1 second) vertical seismometer responds to the ground motion produced by an earthquake. The seismometer drives a high-gain amplifier. The amplifier drives a voltage controlled oscillator (VCO) which is frequency modulated by the seismometer signal. This frequency modulated audio tone is then inserted into a telephone line for transmission to Lamont-Doherty Geological Observatory. At the L.D.G.O. at Palisades, New York the various tones are distributed to the magnetic tape recorder and to appropriate discriminators. The discriminators separate the seismic data from the telephone line carriers. The data is transferred to develocorders and/or helicorders.

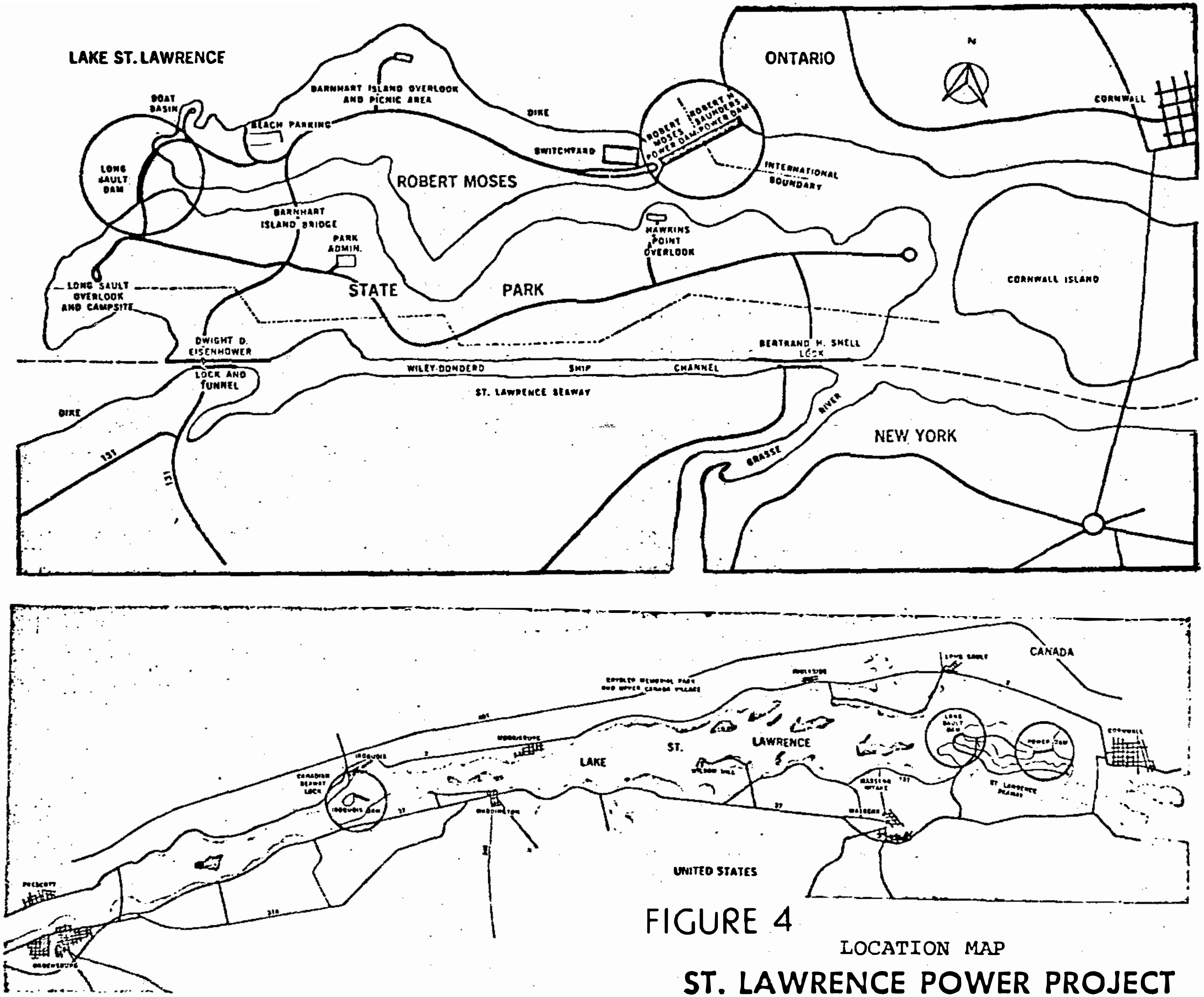

FIGURE 4

LOCATION MAP

ST. LAWRENCE POWER PROJECT

The strong motion accelerograph (SMA) was installed by the Lamont-Doherty Geological Observatory. This instrument contains three accelerometers that record on film the vertical and horitontal accelerations produced by a strong earthquake. The instrument remains in a standby condition until an earthquake triggers it. The "P" wave triggers the instrument which operates till the earthquake is recorded. The SMA can record a single earthquake or a sequence of earthquakes and aftershocks. The event indicator shows when an earthquake has been recorded. Before an event it is black, after the event, it is white.

The reason for recording such motions comes from two widely different scientific needs. Such measurements are necessary within man-made structures for engineers to develop structural design criteria in earthquake engineering. There is very little information about the accelerations produced by earthquakes in the eastern United States. Secondly, seismologists studying the details of the earthquake source for information on dimensions, stress drops and time histories of the rupture process need measurements in the near-field of larger earthquakes.

The third instrument is a digital cassette seismograph which belongs to Francis Wu, SUNY at Binghamton, New York. This instrument is triggered by the "P" wave and records the event on cassette tape. A portable playback-plotter accompanies the instrument to provide playback for set-up, testing, maintenance and analysis. The seismic data can be translated from cassettes to any IBM compatible tape and can provide a wide variety of seismological analysis.

STOP 6 MOSES-SAUNDERS POWER DAM; ST. LAWRENCE SEAWAY, MASSENA, NEW YORK

The location map is shown in Figure 4. This dam provides approximately 912,000 kilowatts of power. The dam has a head of 81 feet, and behind it is Lake St. Lawrence, with its fine marina and Barnhart Island Beach.

A thirty minute film will be shown in the auditorium at the dam, which will illustrate the methods and problems of construction.

A tour of the dam will be made, and from the top of the building Lake St. Lawrence can be clearly seen, with some of the zoned and rip-rapped dikes bounding it composed of compacted glacial till with dry densities on the order of 140 pcf (concrete is 150 pcf).

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Milne, W.G., 1949, The location of the Cornwall-Massena earthquake, September 5, 1944, Publications of the Dominion Observatory, 7, 345-362, 1949.

Berkey, C.P., 1945, A Geological Study of the Massena-Cornwall Earthquake of September 5, 1944 and its Bearing on the Proposed St. Lawrence River Project: U.S. Engineer Office, New York District, p. 110.

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FIELD TRIP NO. 2

GEOLOGIC TRAVERSE FROM POTSDAM TO THE THOUSAND ISLANDS

by

Bradford B. VanDiver, S.U.N.Y. Potsdam

Introduction

The Lowlands Adirondacks, or northwestern part of the Adirondack Mountains Province, contains a record of extremely ancient seas that predate the Grenville Orogeny by hundreds of millions of years, and in which limestones, various detrital sediments, and volcanic materials were deposited. The orogeny, now dated at 1100 m.y. in the Adirondacks, produced severe metamorphism, intense deformation, igneous activity, and a mountain range of Himalayan scale extending for thousands of miles along the eastern side of North America as it existed then. These mountains are referred to as the Ancestral Adirondacks. The Grenville-age rocks we see today, in the Adirondacks, the Thousand Islands, and in the Grenville Province of Canada, are but remnants of the core of that great mountain range, where orogenic processes were most severe (Fig. 1A). There ensued a period of erosion that lasted approximately 600 million years and left a landscape of low relief with karsts developed in the marbles. Flooding by shallow seas that advanced from the east, set the stage for deposition of shelf sediments in late-Cambrian Potsdam time, that continued until the beginning of the Taconic Orogeny in late Ordovician time. This once continuous cover of sedimentary rocks has been largely removed from the Adirondacks and Frontenac Arch in the last few million years by erosion accompanying the still-continuing rapid uplift of those regions (Figs. 1B, 2) (Isachsen, 1975).

The principal purpose of this field trip is to examine the Precambrian and lower Paleozoic rocks exposed in a traverse from Potsdam to Alexandria Bay, with special regard for the nature of the unconformity itself. The trip will be highlighted at midday by a boat trip through the lovely Thousand Islands. The route and stops are shown on Figure 3.

Road Log

The trip begins from the campus of the State University College of Arts and Sciences at Potsdam and proceeds on U.S. 11 to Canton, a distance of approximately 12 miles. In the Village of Potsdam, the route passes over Fall Island in the Raquette River, where the new $5 million hydro-electric and water treatment plant is located. The island is underlain by highly resistant, Grenville-age, metagabbro exposed just below the two dams. The Julia Anderson Park on the island near the second bridge was built upon this tough bedrock in 1981 as a

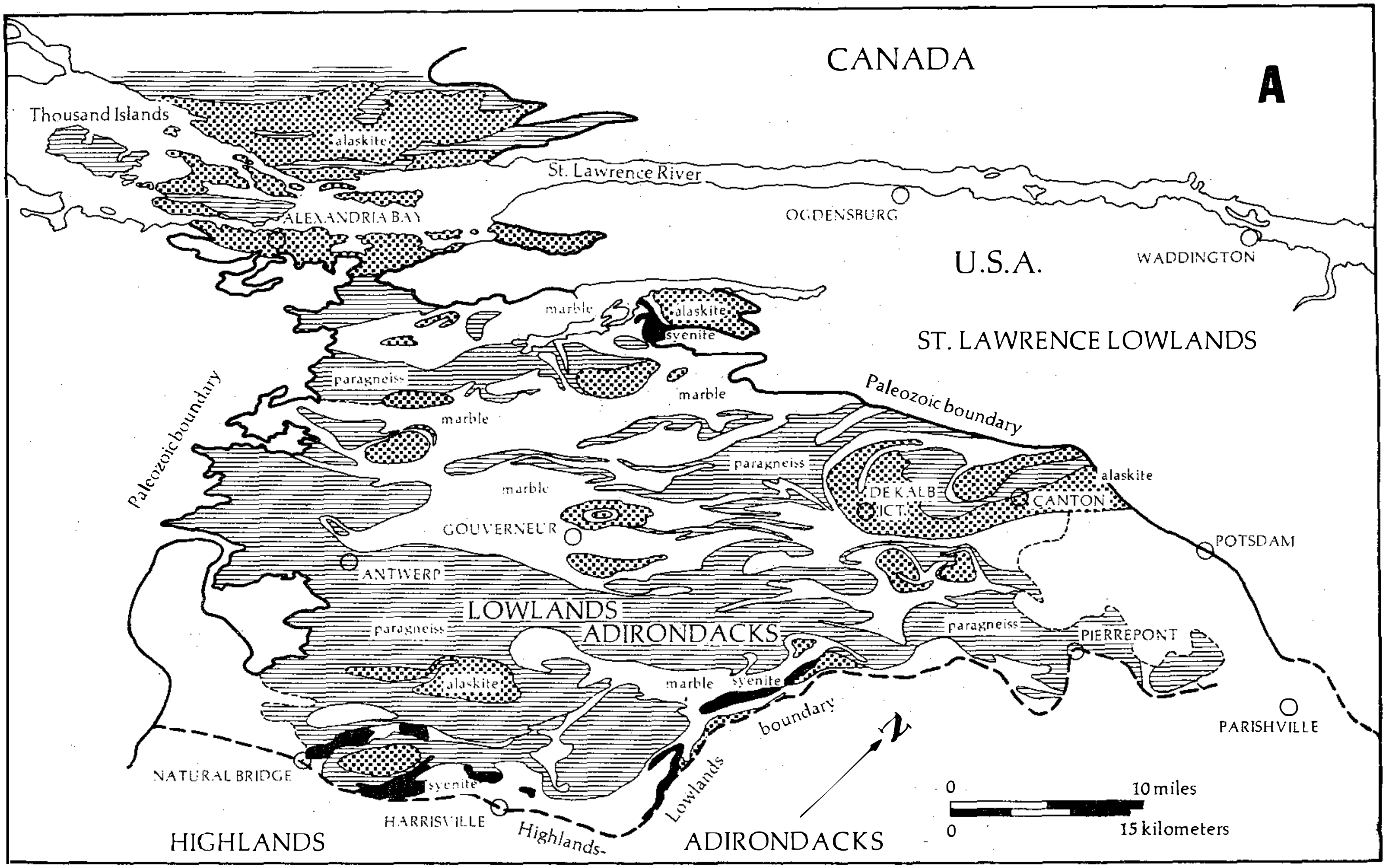


Figure 1A. Generalized Precambrian geology of the Lowlands Adirondacks and Frontenac Arch, ignoring lower Paleozoic outliers. Modified from Isachsen and Fisher (1970), in Van Diver (1980).

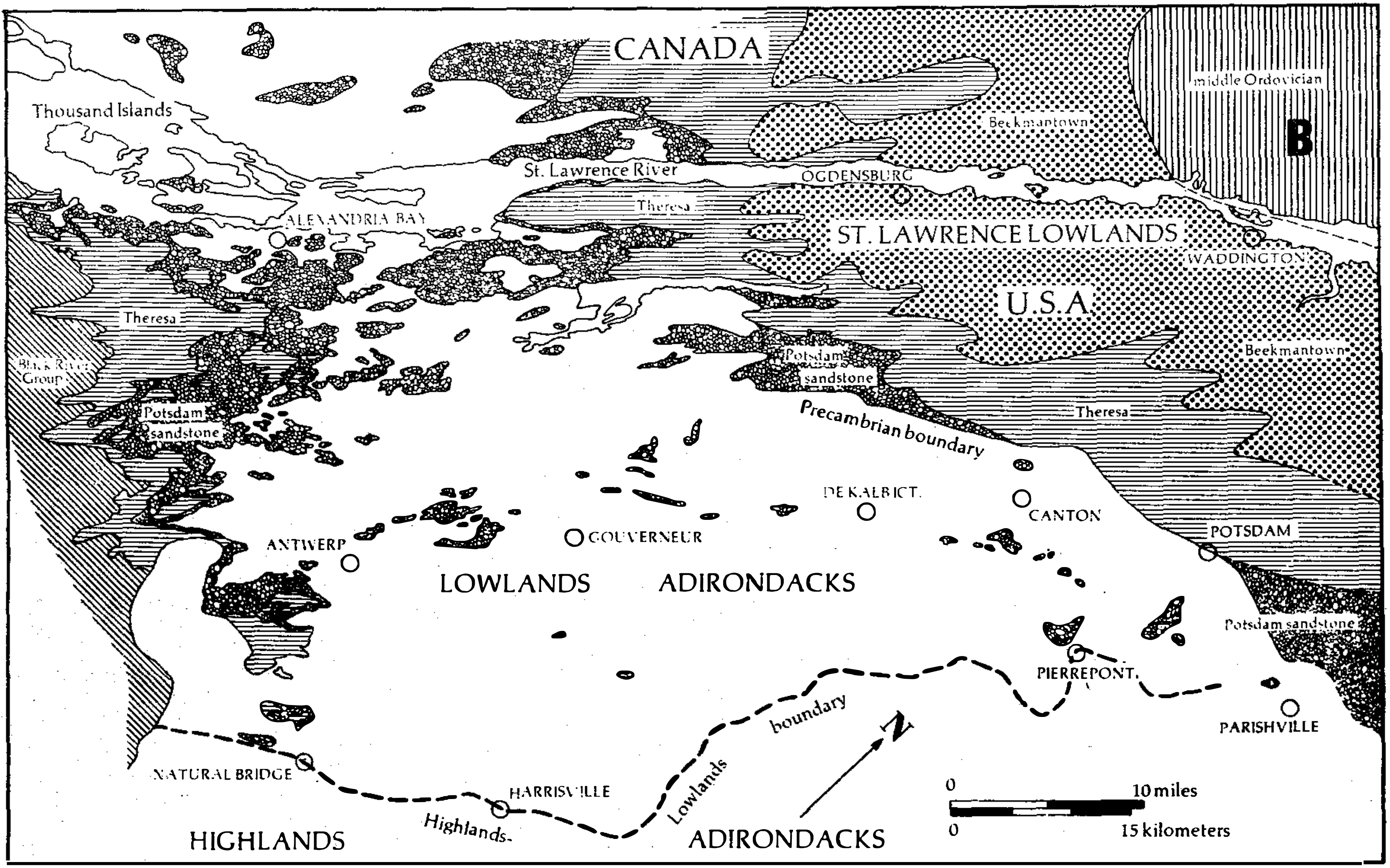


Figure 1B. Generalized Paleozoic geology of the Lowlands Adirondacks, Frontenac Arch, and St. Lawrence Lowlands, ignoring the Precambrian basement geology. Same sources and geographic area as Figure 1A.

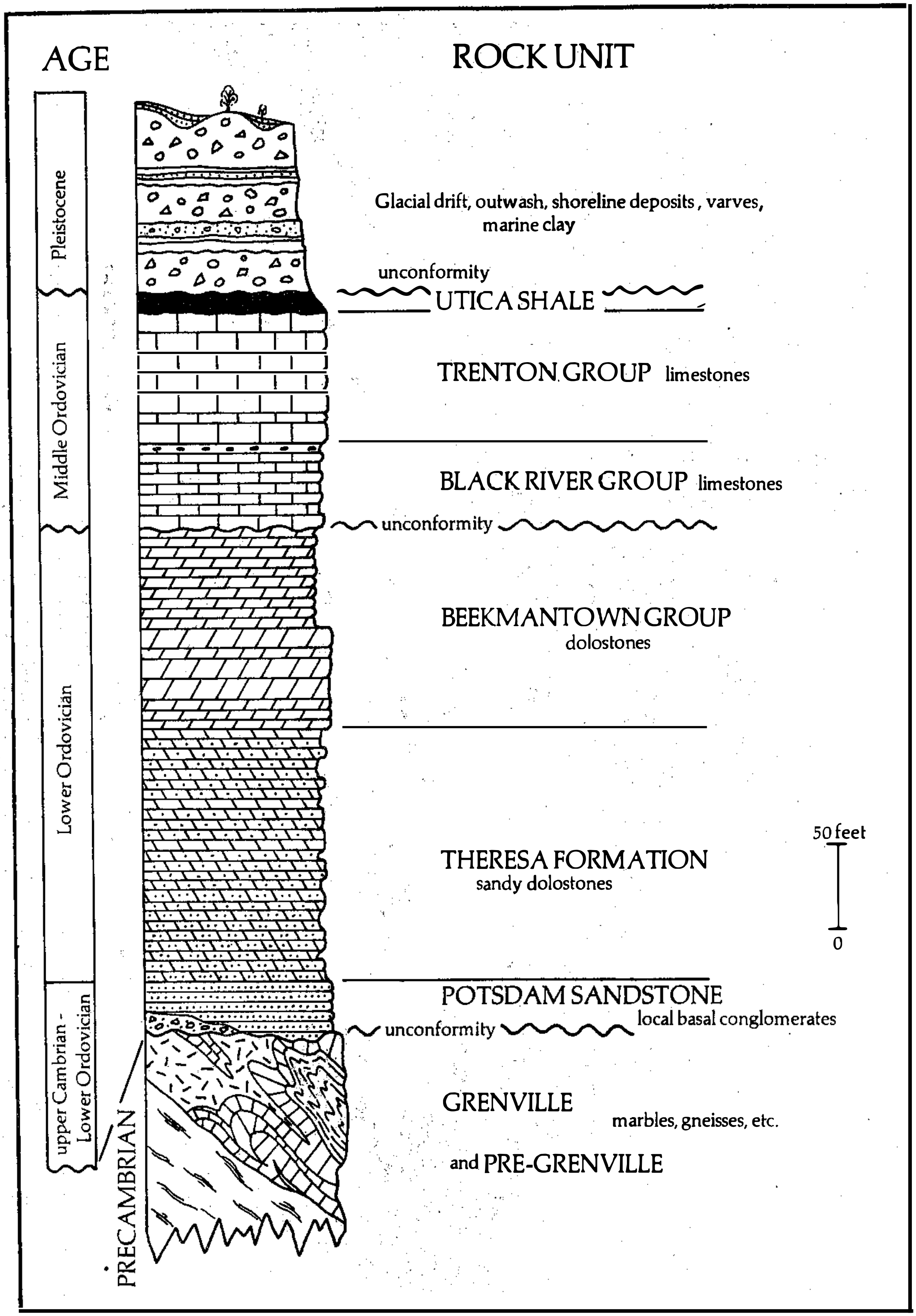


Figure 2. Composite Stratigraphic column for the Adirondacks and bordering lowlands of northwestern New York. From Van Diver (1980).

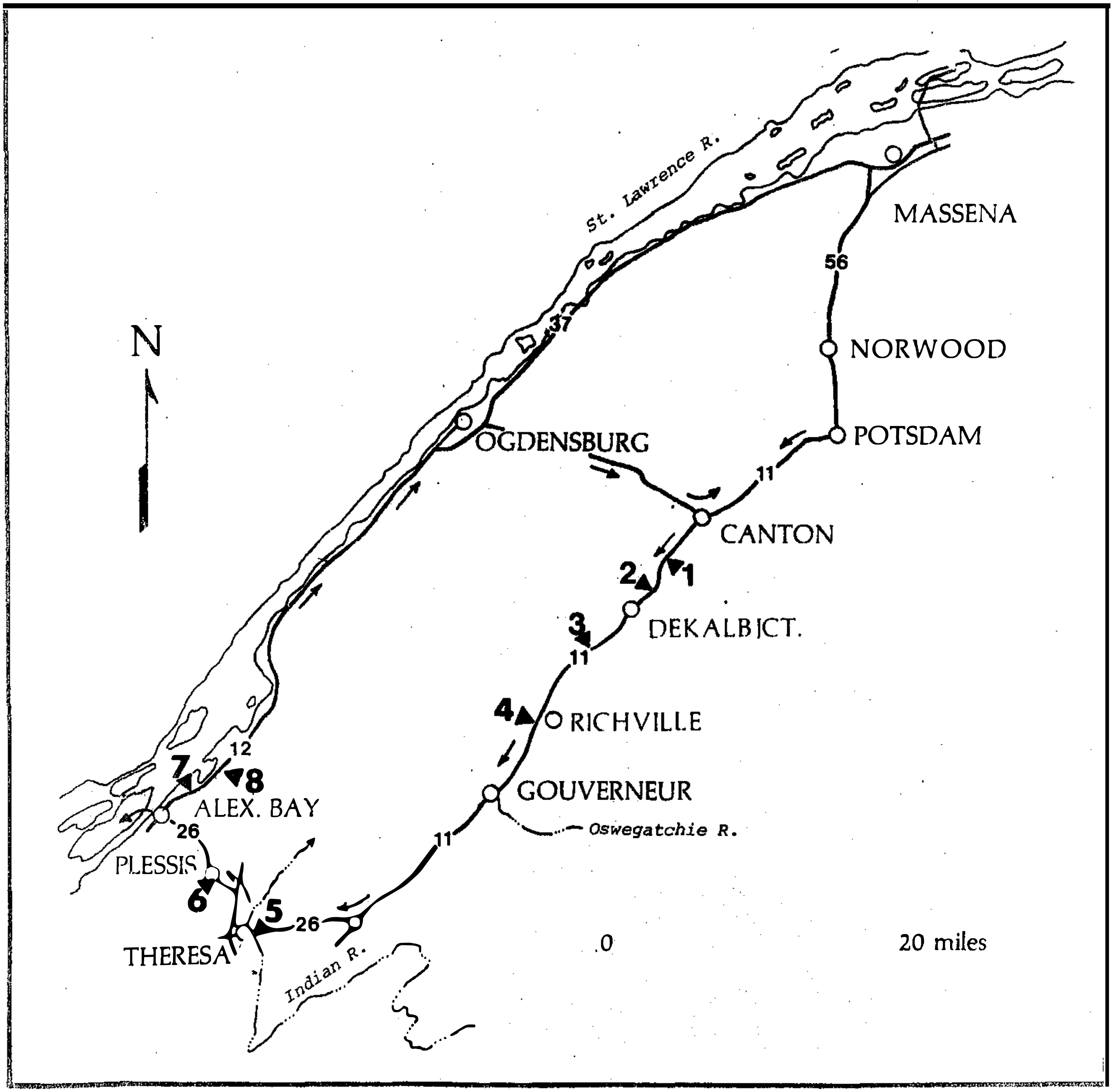


Figure 3. Trip map, with stops.

replacement for the park lost to the construction of the Potsdam Bypass in that same year. To lower the surface 17 inches to the level prescribed by the New York State Department of Transportation plans, workmen had to resort to drilling and blasting of the bedrock.

Potsdam is located only three miles downstream from the type locality for the Potsdam Sandstone near Hannawa Falls, but no exposures of this formation are found in the Village.

En route to Canton, the road traverses rolling pastureland developed by differential erosion of Proterozoic rocks of variable resistance, and modified by glacial scour and deposition. Till deposits take the form of ground moraine, and low drumlinoid hills resulting in an attractive "swell-and-swale" topography. Nearing Canton, a high point of the road affords a panoramic view southward that incorporates the moderately corrugated profile of the Adirondack foothills in the distance and an occasional drumlinoid prominence in the foreground.

The roadlog mileage count begins just beyond the Grass River bridge in Canton, at the traffic light.

Road Log

cumulative miles	miles from last stop	
0.0	0.0	Intersection N.Y. 68 and U.S. 11. Turn left on U.S. 11 toward Gouverneur.
0.6	0.6	Railroad underpass. Exposures of dark, migmatitic gneiss with pink granitic veining.
3.1	2.5	Small marble cut, right, with whitish banded marble below and marble thinly interleaved with rusty calc-silicate rock above. Folding here reflects the ductility contrast between these two rock types that is characteristic of the Adirondack region in general. Flow banding in the marble displays a remarkable fluidity, whereas the calc-silicate, though also intensely folded, has been extensively ruptured and displaced. The result is a chaotic "marble stew," which resembles what might be seen if strips of crisp fried bacon were swirled in smooth peanut butter. More of this will be seen at Stop 1.
3.5	0.4	Low, long roadcut in dark greenish-gray calc-silicate rock with subordinate marble interlayers, right side of road. Tight recumbent folding.

3.9 0.4 STOP 1. This is the now-famous and graffiti-ed Snake Roadcut; the name for which was first published in the guidebook for the 1971 NYSGA meeting at Potsdam (Fig. 4). The cut is a large and outstanding example of the plastic deformation of the Grenville marbles. The "Snake," itself, is a nearly continuous, thin band of microcline-rich rock on the SE cut (left) that has been sinuously infolded with the marble. Despite its thinness and obvious stretching, the Snake has survived nearly unbroken over much of its length. A good example of a refold can be seen at the NE end, where F_1 isoclinal folds have been openly folded around an F_2 hinge surface. The deformation shown by the Snake is deceptively simple. Greater complexity, perhaps with as many as four separate folding events, can be observed above the Snake on top of the cut (DANGEROUS!), where thin, infolded layers of rusty calc-silicate rock have been exposed in three dimensions by solution of the enclosing and interleaved marble. A less dramatic, but safer, example can be observed at the right end of the opposite cut, near road level.

In the marble adjacent to the Snake, note the dark green, concentric banding of diopside, the product of metamorphic reaction between the dolomitic marble and siliceous parent rock of the Snake. Diopside concentration diminishes rapidly away from the band. Also found in this reaction zone are fine-grained brown sphene, copper-colored phlogopite, yellowish metallic pyrite, green actinolite, black tourmaline, and very minor quartz.

Carl and Van Diver (1971) proposed a subaqueous ashfall origin for the parent material of the Snake, interrupting a shelf limestone sequence. This is suggested both by the composition, and the thin, blanket shape of the layer. Other snakes of similar material, and some of phlogopite may be seen on the opposite cut.

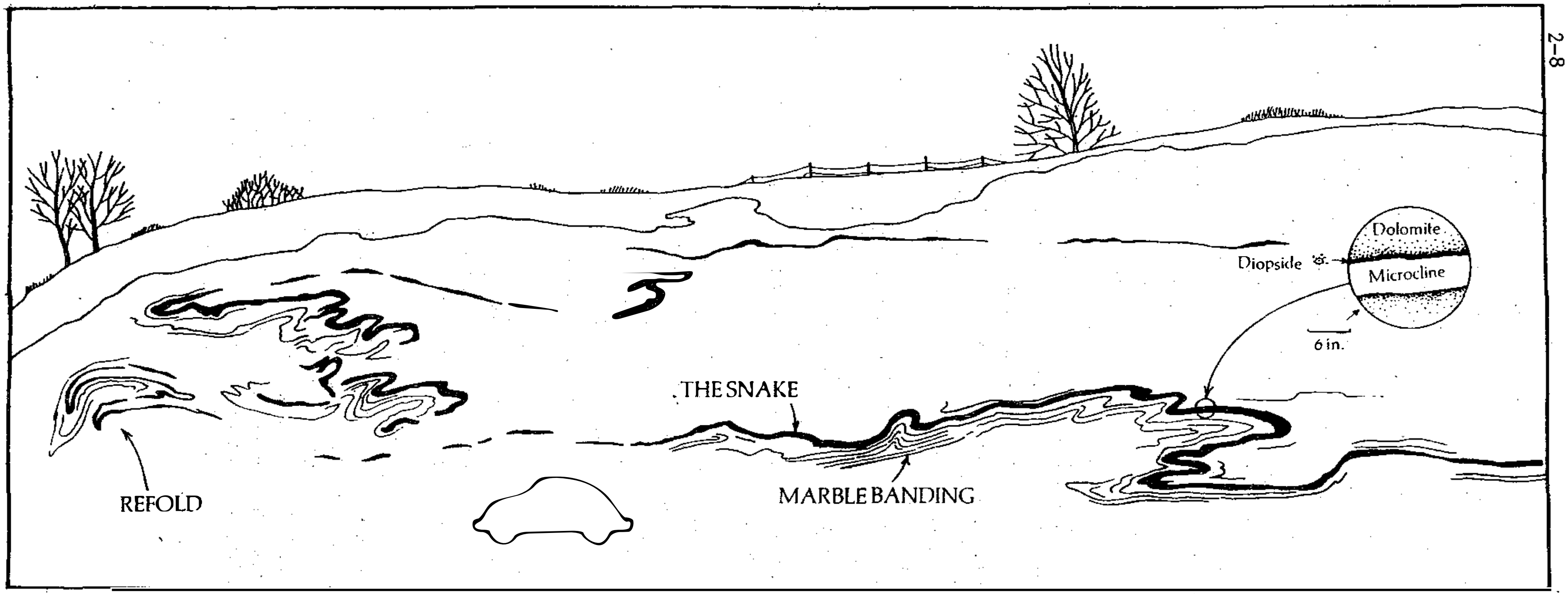


Figure 4. The Snake roadcut.

4.7 0.8 STOP 2. DeKalb Anticline, located 100 feet from the right side of the road (Fig. 5). This is an overturned anticline in dark brown garnet biotite schist, with interlayered light greenish gray, calc-silicate rocks, altogether a rather unusual rock for the Lowlands Adirondacks. The fold is interrupted near its hinge surface by a two-foot pinkish pegmatite dike. As at the "Snake," the deformation here appears deceptively simple. Contoured point diagrams of minor fold axes prepared by several generations of Structural Geology students at Potsdam, indicate refolding (this is nearly identical to similar diagrams prepared for the Snake). Furthermore, there are a few puzzling S-shaped folds at the right side of the dike that suggest renewed deformation after pegmatite emplacement. Study the texture of the dike from side to side, and see if you can find evidence for this interpretation.

A small cut directly across the highway displays a rusty basaltic (diabasic?) dike that intrudes the biotite schist, with contacts that zig and zag alternately along schistosity and jointing. At the left end, there is a small xenolith of granitic rock incorporated in the basalt. Diabasic dikes like this are common in the Lowlands Adirondacks. They intrude the Grenville-age rocks but not the Potsdam Sandstone, and are considered to be of late Proterozoic to early Cambrian age.

7.1 2.4 Junction Co. 17 in DeKalb Junction.

11.7 4.6 STOP 3. Red-and-White Roadcuts. This is one of the most dramatic series of new cuts opened by road construction in 1976-77. The first cut on the right (lowest) exposes highly contorted grayish marble in sharp, irregular, discordant, contact with a chaotic mass of friable pinkish to dark brick red sandstone, sandy intraformational breccia, and conglomerate, with assorted inclusions of marble. A wedge-shaped conglomerate dike is located at the top of the marble just to the right of the sedimentary contact.

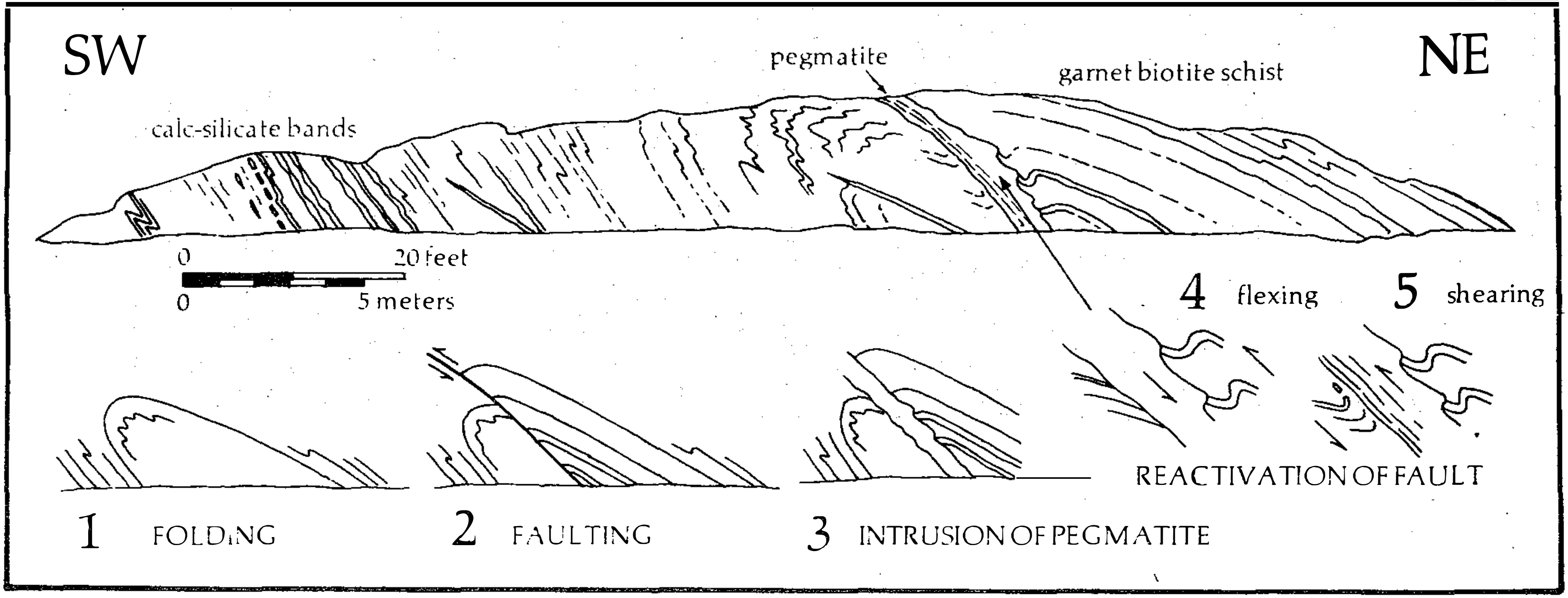


Figure 5. DeKalb Anticline roadcut, with proposed sequence of deformation and emplacement.

All of these features undoubtedly result from the infilling of a sinkhole developed in the marble prior to and possibly continuing during marine transgression in Potsdam time. The contact represents an unconformity spanning about 600 million years. Similar features may be observed at numerous places in the northwestern part of the Lowlands Adirondacks, most notably in the Rock Island Road cut 4 miles north of Gouverneur (Carl and Van Diver, 1971).

On a regional scale, remnants or outliers of sandy and conglomeratic sediments like this become smaller and less frequent southeastward from the continuous Paleozoic boundary near the St. Lawrence River, and they are largely confined to areas of marble. Because of their lack of fossils, often chaotic nature, and discoloration, their assignment to the Potsdam Sandstone is uncertain, but many exposures display upward gradation to clean, pinkish to white or brown, orthoquartzitic, well-bedded arenites typical of the Keeseville member of the unit in this region. Such an upward progression may be seen in the second large roadcut on the right, up the hill. The large, reddish-brown cut opposite this consists of well-stratified, quartz pebble conglomerates, with thin orthoquartzitic sandstones on top. A small knob of marble occurs at road level near the lower end of the cut, where clayey sediment has been found (cave floor?).

Studies by the New York State Geological Survey indicate that the Potsdam Sandstone and the overlying Theresa and younger units dip away from and do not pinch out toward the Adirondack Dome. It is assumed, therefore, that these units once formed a continuous blanket over the region, which has been largely denuded during the geologically recent, and continuing doming of the mountains. It is mainly in thick karst fillings like this near the edge of the Precambrian terrain, that the basal Potsdam, or pre-Potsdam, sedimentary rocks have been preserved.

15.7	4.0	Dark gneiss left.

16.2	0.5	Begin Richville Bypass. Dark gneiss, perhaps meta-turbidite, with apparent preserved small-scale graded bedding.
17.3	1.1	STOP 4. End of Richville Bypass. Dark red cut at right is puzzling, and it is hoped discussion will be generated among field trip participants. The material is similar to, but much more hematitic and voluminous than that of the unquestioned sinkhole fillings. More "normal" Potsdam sandstone may be found at the top of the cut. Conglomeratic sandstone dikes in marble may be found at the upper end of the opposite cut. The left half of that cut, however, consists of a whitish feldspathic (metapegmatite) rock outwardly resembling the marble, and containing several thin, diopsidic marble sills or dikes. What do you suppose is the origin of this rock? See if you can find the contact with the marble.
17.6	0.3	Begin several marble cuts with abundant small reddish conglomeratic sandstone infillings. From here to Gouverneur the road traverses rolling countryside with predominantly NE-trending ridges underlain by gneiss, and marble valleys.
22.6	5.0	Enter Gouverneur. Note the several buildings in town constructed of Gouverneur marble, essentially the same as the marbles we've been looking at.
		Continue on U.S. 11 through the Village.
29.9	7.3	Begin several marble cuts.
32.7	2.8	Potsdam Sandstone cut right, with bowl-shaped structure at top. These structures are commonly found intermingled with cylindrical structures near the base of the Potsdam over marble. They have long been thought to result from the rearrangement of sand by sifting into underlying small solutional pockets in marble. They are copiously developed along the Cream of the Valley Road north of the Rock Island Road cut.
33.0	0.3	Begin several marble cuts, some with dark calc-silicate layers.

33.6	0.6	Marion Construction Materials sand and gravel quarry in kame, right. Well rounded cobbles, abundant cross-bedding.
34.2	0.6	Pinkish alaskite gneiss at x-road, with glacial grooves at top.
34.9	0.7	Optional stop. Begin several cuts of marble with infolded and segmented calc-silicate layers, in direct contact with biotite granite gneiss.
38.1	3.2	Intersection N.Y. 411 in the Village of Antwerp, with cuts in migmatitic gneiss. Pass over Indian River. Turn right to Theresa. The road along the way (about 10 miles) passes by numerous outcrops of gneiss and marble. The gneiss tends to form rounded, elongate, barren knobs, with streamlined, glacially smoothed forms.
48.9	10.8	<u>STOP 5</u>. <u>Theresa Reservoir</u>. The cliff on the left side of the road near the reservoir, again, is a reddish conglomerate and breccia similar to those you have seen in sinkhole deposits. Massive and poorly bedded, it is but one of a wide variety of conglomerates and breccias occupying the interval between Proterozoic rocks and "normal" Potsdam Sandstone in the Lowlands Adirondacks. In this one, pebbles are sparse except near the center base of the cliff. Upwards in the section, the rock becomes sandier, better stratified, and cross-bedded. The underlying rocks are concealed by the cliff, but can be seen just below the Niagara Mohawk dam nearby. The rocks are all steeply-inclined gneiss and metaquartzite. The Indian River drops more than 80 feet here. The dam was built in 1929 on the site of the original, 65-foot "High Falls" - almost certainly a fault scarp. Raising the water to its present level eliminated the 15-foot "Upper Falls" that were located a short distance upstream.
49.3	0.4	Stop sign in Village. Turn right, and continue to junction with N.Y. 37.

50.9	1.6	Junction N.Y. 37. Turn right. Theresa lies close to the Paleozoic boundary, and here the road climbs onto an extensive tableland capped by flat-lying, durable Potsdam Sandstone and occasional outliers of Theresa sandy dolostone perched on top of it.
52.5	1.6	Y-junction. Continue left on N.Y. 26, past several cuts in Theresa Formation.
56.0	3.5	STOP 6 at Plessis. The clean surface of the Potsdam Sandstone here offers a remarkable display of well-preserved glacial scour features, including polish, striae, chatter marks, and large grooves. Also visible on the smooth surface are abundant arcuate cross-bed laminae. The gentle undulation of the Potsdam surface seen here is barely concealed beneath thin soil cover between here and Alexandria Bay. Continue north on N.Y. 26 past cuts of light gray, thin-bedded Theresa Formation.
58.3	2.3	Browns Corners. The flatness of the tableland is most evident here, when viewed across open pastureland with less than 10 feet of relief. Continue left to Alex Bay.
62.3	4.0	Junction N.Y. 12 at Alex Bay. Continue straight ahead through the Village to Uncle Sam's Boatrides, and park for a two-hour boat trip.

BOAT RIDE. The purposes of the boat ride are: 1) to give us a welcome relief from bus travel; 2) to allow time to eat lunch; 3) to view some of the magnificant Thousand Islands, and 4) to view, from the boat, exposures of flat-lying Potsdam Sandstone over granitic gneiss at the southern tip of Wellesley Island.

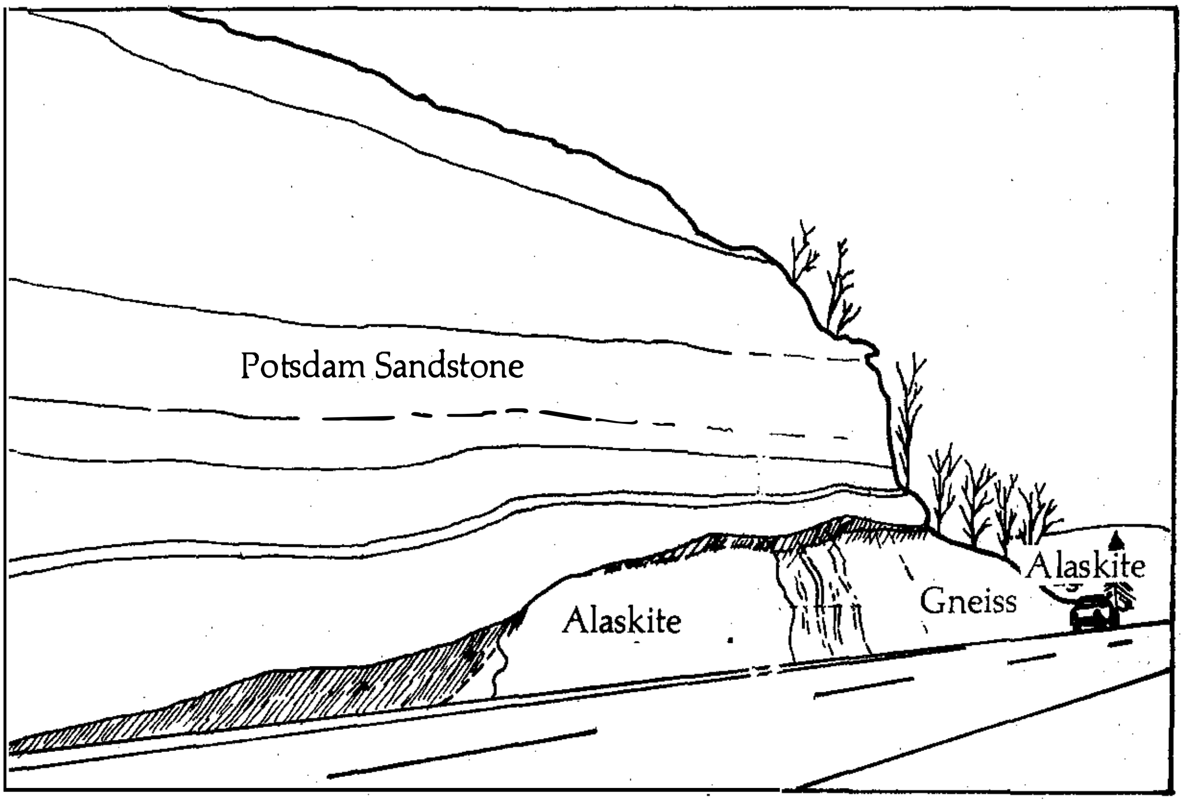
The boat trip will take us first through open water under the beautiful Thousand Islands suspension bridge to the end of Wellesley Island. Then we will wend our leisurely way back through the cluster of scenic islands near the American shore.

It is now believed that the Proterozoic terrain of the Thousand Islands was once blanketed with flat-lying Potsdam Sandstone and younger Paleozoic units, as was that of the Adirondack Mountains. In historical perspective, the Himalayan-sized Ancestral Adirondacks, resulting from the Grenville Orogeny approximately one billion years ago, had by Potsdam time, been worn down to a peneplain, leaving the region vulnerable to marine submergence. Transgression of the so-called "Potsdam Sea" beginning in late Cambrian(?) time (ca. 525 m.y.a.), set the stage for shallow marine deposition of sand, carbonates and clays, the parent materials for the lower Paleozoic units that now rim the Adirondacks and Frontenac Arch. Erosional decimation of these once continuous deposits has been accomplished only in the last 10 million-or-so years as a result of the still-continuing doming of the Adirondacks and concurrent uparching of the Frontenac Arch. Presently, only a few scattered remnants of Potsdam Sandstone remain on the flanks of the Arch in the Thousand Islands region, and on its northwestward and southeastward extensions into Canada and New York, respectively. We will view one of these patches from the boat at the southern tip of Wellesley Island. Farther upstream toward Lake Ontario, a much larger remnant has survived erosion on Howe Island, and still farther, Wolfe Island, the largest of the Thousand Islands, is completely blanketed with limestones belonging in the medial Ordovician Black River and Trenton Groups (the lower Ordovician Theresa and Beekmantown are missing). An exposure of the Proterozoic/Potsdam unconformity that is essentially similar to that of Wellesley Island will be examined at close range at Stops 7 and 8 later.

The Proterozoic rocks of the Frontenac Arch have also been deeply eroded as a result of the ongoing uplift, leaving only the more resistant knobs projecting as islands or shoals. The islands are generally elongated parallel to their strong northeasterly structural grain, a trend that is even more evident in the marble-gneiss outcrop patterns of the Lowlands Adirondacks. For the most part, the islands are lovely, forested, projections of attractive, pink leucogranitic (alaskitic) Alexandria Bay Gneiss (visible mainly along the shores). Most of them take the form of glacier-polished sheepbacks, with gentle stoss sides facing northeastward and steep cliff sides opposite, indicating a southwestward upvalley ice advance. The islands are largely devoid of glacial debris, except for some minor till hills, and thin ground moraine. This scarcity probably reflects, at least in part, the severe erosion resulting from rapid drainage of Lake Iroquois through the St. Lawrence Valley, after that outlet was opened by recession of the Wisconsin ice sheet.

Following the boat ride, we will return to N.Y. 12, and proceed 2 miles from the Church Street intersection toward Ogdensburg to Stop 7, a very large cut on both sides of the road. This is the Alexandria Bay Roadcut, a unique geologic site that has been nominated for inclusion in the DNAG Centennial Field Guide Project.

66.3	4.0	<u>STOP 7</u>. <u>Alexandria Bay Roadcut</u>. (Fig. 6A, B) The northeastern (downhill) end of this cut exposes an angular unconformity of profound dimensions, encompassing a time gap of approximately 600 million years between Proterozoic gneisses and basal Potsdam Sandstone. It enables comparison



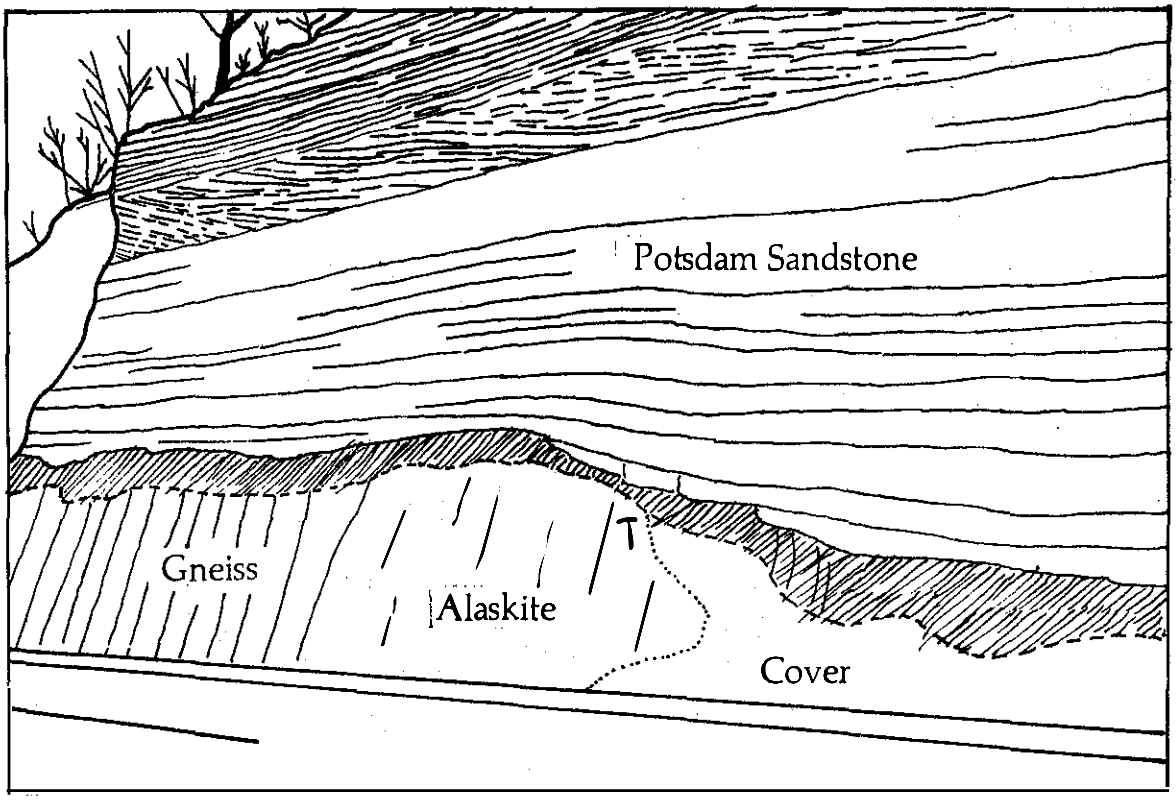


Figure 6. Sketch map of the Alexandria Bay Roadcut, northwest side (A) (above) showing gross features as discussed in the text, and (B) (below) showing the same section on the other side of the road, with considerably more detail.

between the contemporaneous erosional surfaces developed on gneisses and those of the marbles seen earlier.

The Proterozoic rocks beneath the unconformity consist of massive, pink, alaskitic gneisses and darker, banded gneisses with steeply dipping foliation. These are extensively weathered, especially in a narrow zone directly beneath the base of the Potsdam. Note, also, that the upturned edges of the gneiss bands are buckled below the contact. This zone may represent a fossil inorganic soil developed on the pre-Potsdam erosional surface, or preferential, post-depositional, groundwater leaching along the contact (which may also explain the extreme friability of the basal sandstone beds). Can you suggest any other possibility?

Features nearly identical to these have been reported on the other side of the Adirondacks near Putnam Center, N.Y. by Van Diver (1980). The pre-Potsdam erosional surface appears to be structurally intact and rises slightly to the northeast (downhill on the road), forming a boss, or knoll preserving the original relief of the depositional surface. Basal sandstone beds drape over the southwestern slope of the knoll, and pinch out against it, while proximal younger beds thin out over the top of it. Upwards in the section, the bedding becomes increasingly horizontal and uniformly thick. Cross-bedding, in general, is poorly developed, but is more prevalent in the upper part of the section.

The basal Potsdam beds at this roadcut have been described by Kirchgasser and Theokritoff (1971), as mature orthoquartzites with scarce clasts of Precambrian rocks, suggesting an origin by reworking of fluvial sands by an encroaching sea. On a regional scale, marine transgression set the stage for leveling of the irregular Proterozoic surface by filling in all of the karst depressions like those seen earlier, and covering over projections in gneisses such as that of the Alex Bay Cut.

		Continue northeastward toward Ogdensburg.
67.5	1.2	Cross-bedded Potsdam Sandstone cut.
67.9	0.5	Cross-bedded Potsdam Sandstone cut.
68.6	0.7	STOP 8. Proterozoic/Potsdam unconformity. This cut shows features similar to the Alex Bay cut, but here the basal sandstones display better-developed, low-angle, cross-bedding. The purpose of this stop is to allow comparisons between these two exposures of the unconformity, as developed on gneiss. From here, we will proceed directly to Ogdensburg, and then to Potsdam.
69.1	0.5	Begin several excellent exposures of gneiss.
72.8	3.7	Cuts in lower Potsdam Sandstone with distinct lower and upper lithofacies (see Selleck, this volume).
		Continuing northeastward, the cuts along the highway expose progressively higher stratigraphic sections of the Potsdam and Theresa Formations. Contact between the two units is exposed at Chippewa Bay (Selleck, Stop 3, this volume; Kirchgasser and Theokritoff, 1971).
		A good overlook to view the river is located at 78.5 miles, at Cedar Point.
101.3	28.5	Ogdensburg, at traffic light intersection with N.Y. 68. Proceed right to Canton and Potsdam.
130.3	29.0	Arrive Potsdam. End of trip.

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TRIP 3

SELECTED MINERAL OCCURRENCES IN ST. LAWRENCE AND JEFFERSON COUNTIES - NEW YORK

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Introduction

Probably no other region in the State of New York is better known for its wealth of mineral occurrences than St. Lawrence, Jefferson, and Lewis Counties. Indeed, many are among North America's most famous and classic localities (Beck, 1842; Dana, 1877; Kunz, 1892; Jensen, 1978; Robinson and Chamberlain, 1981). The vast majority of these occurrences are found within the Grenville metasediments, which are geologically complex and host a wide variety of mineral assemblages. It is the intent of this trip to acquaint the participant with a selection of localities that provide a variety of geological environments, are of minerological and historical interest, and will hopefully afford good collecting opportunities. For additional information, the reader may wish to consult some of the available collecting guides (Agar, 1921 & 1923; Robinson, 1971; Robinson and Alverson, 1971; Van Diver, 1976).

A brief account of each stop follows, and more detailed information is given under individual stop descriptions.

Stop 1: The Powers Farm at Pierrepont

Many of the most interesting localities in Northwestern New York and Southeastern Ontario are in contact zones between various Precambrian rocks and Grenville marble, and particularly in their associated calcite vein-dikes (Robinson, 1982; Moyd, 1972). Such contacts are often of a local nature, and host a wide variety of complex skarn-like mineral assemblages. The Powers Farm has one such occurrence where a quartz-tourmaline-biotite pegmatite (?) is in contact with coarsely crystallized calcite.

Stop 2: The McLear Mine at Dekalb Junction

The McLear pegmatite is a Precambrian quartz-microcline pegmatite that formed by replacement of crystalline limestone. The presence of large crystals of tremolite and diopside in the quartz core is unique.

Stop 3: The Gem Diopside Mine at Dekalb

This classic North American mineral locality is situated in a folded quartz-tremolite-diopside metasediment of the Grenville series. Diopside rich bands up to several feet in thickness are interlayered with quartz and tremolite schist. Small pockets containing diopside crystals occur locally within the diopside rich bands and along cross-cutting seams of coarsely crystallized tremolite.

Stop 4: The Coal Hill Vein at Rossie

The Rossie Lead Mines are one of the oldest and most famous North American mineral localities. The large crystals of calcite and galena these veins once produced are indeed classics. The Coal Hill Vein is perhaps the best known and is probably a relatively low temperature hydrothermal calcite-galena vein that intruded Precambrian granite in post-Ordovician time.

Stop 5: The Sterling Iron Mine at Antwerp

The Sterling Mine is probably a recrystallized Precambrian gossan. The original hematite body was likely formed in Precambrian time when iron-bearing solutions derived from underlying pyritic schist infiltered the enclosing gneiss and marble, altering these rocks and replacing them with hematite. Subsequent burial and recrystallization is suggested by field relationships and a unique mineralogy and paragenesis.

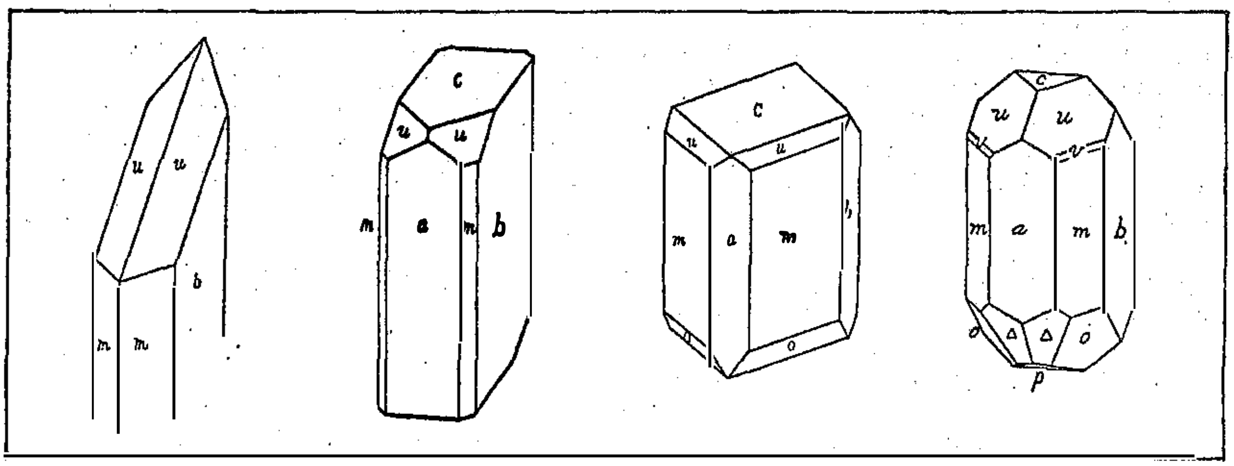

Figure 1. Diopside Crystals - Dekalb, N.Y. (after Ries, 1897)

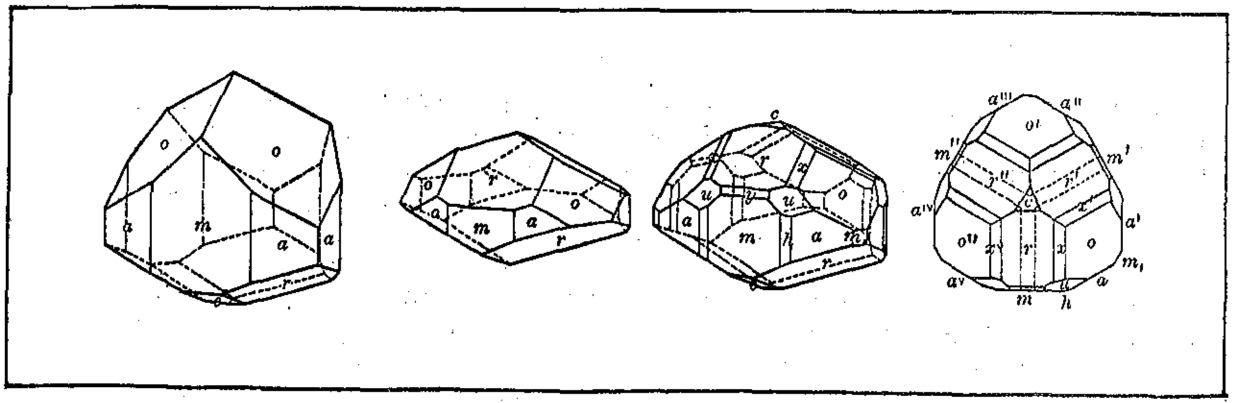

Figure 2. Uvite Crystals - Pierrepont, N.Y. (after Dana, 1877)

Road Log

Total Mileage	Mileage From Last Stop	
0.0	0.0	From Satterlee Hall, SUNY Potsdam, proceed south on N.Y. 56, through Hannawa Falls, to Brown's Bridge Road.
6.3	6.3	Turn right on Brown's Bridge Road and go to the four corners in Pierrepont.
9.7	3.4	Turn right in Pierrepont on N.Y. 68 and continue to Powers Road.
10.5	0.8	Turn right on Powers Road and proceed to the first farm on the left.
10.7	0.2	Stop at the Powers Farm to secure permission to enter the property. A small collecting fee is usually charged. Continue to the end of Powers Road.
11.0	0.3	At the end of Powers Road turn right, following the gravel road across the bridge.
11.1	0.1	Park after crossing the bridge. Take the trail to the left through the wooded meadow to the collecting site, approximately 250 yards from the bridge.

This famous locality has produced literally thousands of lustrous, doubly terminated crystals of black tourmaline (Figure 2). Although no actual mining has ever been done, many hand dug trenches have been made by mineral collectors over the last hundred years, and excellent specimens continue to be found. Although the tourmaline is often called schorl, due to its dark color, Dunn and Appleman (1977) have shown that it is actually a ferroan uvite.

The origin of the deposit appears complex, and the local geology is well obscured by copious glacial overburden. Well formed crystals of uvite, diopside, quartz, biotite, and other species occur in veins and contacts between a quartz-tourmaline-biotite pegmatite (?) and the Grenville marble. The marble is typically recrystallized into coarse, cleavable masses of calcite within these veins and contacts. Occasionally the calcite weathers away, freeing perfectly formed crystals of the silicate minerals that can be found loose in the soil.

Good specimens of the following minerals can be found: amphibole, apatite, biotite-phlogopite, calcite, diopside, pyrite, quartz, scapolite, titanite and a variety of interesting pseudomorphs, including amphibole after pyroxene (uralite), talc (?) after scapolite, pyroxene and quartz, quartz after pyroxene, and goethite after pyrite and mica (?).

11.7	0.6	Take Powers Road back to N.Y. 68 and turn right, following N.Y. 68 to Canton.
18.8	7.1	At the junction of N.Y. 68 and U.S. 11, turn left on U.S. 11 and continue through Canton.
20.2	1.4	After crossing the bridge in Canton, keep left, following U.S. 11 through Dekalb Junction to the Trout Lake Road (County Highway 33).
31.0	10.8	Turn left on the road to Trout Lake.
32.3	1.3	Continue along the Trout Lake Road to the first road to the right and park. The McLear Mine is immediately to the southeast of this intersection.

The McLear pegmatite was discovered in 1907 by J.H. McLear, on the Kilburn Farm, 3.9 miles southwest of Dekalb Junction (Cushing and Newland, 1925; Shaub, 1929). The ore consisted of pure, white microcline perthite, which was hand cobbed and shipped to Rochester and Trenton for use in the pottery industry. By 1929 the Green Hill Mining Company had developed both open cut and underground workings, and shipped over 120,000 tons of pottery grade feldspar (Shaub, 1929). By 1938 mining ceased (Tan, 1966).

The main pegmatite is a lens shaped body 850x115x60 feet with a spacial orientation generally paralleling the regional NE-SW structural trend of the enclosing Grenville metasediments. Radiometric age determination from uraninite indicates the pegmatite was emplaced in the middle Precambrian at 1094 m.y. (Shaub, 1940). The mineralogy of the pegmatite is unique, and suggests a complex origin by successive replacement of the host crystalline limestone by magmatic solutions probably emanating from nearby granites (Shaub, 1929). Based on mineralogic and textural zonation the apparent paragenetic sequence is diopside → tremolite → quartz → feldspar + quartz, giving rise to a gradational contact between the pegmatite and wall rock. Later hydrothermal alteration caused slight sericitization of the feldspars and serpentinization of the diopside and tremolite.

Minerals that may be collected relatively easily include: diopside, microcline, mica, quartz, titanite and tremolite. Allanite, apatite, calcite, chlorite, goethite, hematite, kaolinite, magnetite, molybdenite, pyrite, pyrrhotite, rutile, serpentine, talc, thorite, thucholite, tourmaline, uraninite, and zircon occur more sparingly.

33.3	1.0	From the McLear Mine proceed south (right) on the road to Bigelow for 1 mile and park. The locality for gem diopside is on the ridge across the field, east (left) of the road. This locality is on private land, and is <u>NOT</u> regularly open for collecting! This locality has produced some of the finest crystals of gem diopside known. Early specimen labels may give the locality as the Mitchell Farm, as Calvin Mitchell was probably the first person to find and distribute specimens in the 1880's. By 1889 the famous mineral dealer George L. English acquired the mining rights, and by 1892 George F. Kunz had described crystals over 3 inches long that would yield gems up to 30 carats. For unknown reasons the deposit was not worked again until 1967 (Szenics, 1968), and intermittently thereafter (Robinson, 1973). The mine is situated in a northeasterly trending ridge of diopside-tremolite-quartz schist, approximately 4 miles northeast of the Village of Richville. The relative proportions of diopside, quartz and tremolite vary considerably, and the quartz locally forms tightly folded bands. The gem pockets tend to form within the diopside rich layers and along tremolite veins which follow joints perpendicular to the strike. The pockets are often filled with a compact gray talc and acicular tremolite. The apparent paragenetic sequence is diopside → tremolite → talc + quartz ± calcite. Other species that occur less commonly are pyrite, plagioclase, and datolite (reported but unconfirmed). The diopside invariably occurs as euhedral prismatic crystals with well developed forms {100}, {110}, {001}, {101}, and several {0kl} and {hkl} prisms (Figure 1).
36.0	2.7	Continue south to the four corners in Bigelow, and turn right on the road to Richville.
37.7	1.7	In Richville, turn left on old U.S. 11, following it through the village to its intersection with U.S. 11.
38.4	0.7	Turn left (south) on U.S. 11 and continue to Gouverneur.
44.7	6.3	In Gouverneur, turn right on N.Y. 58 (Clinton St.) just before crossing the bridge.
44.9	0.2	Keep to the left, continuing west on N.Y. 58 to Brasie Corners.
54.7	9.8	At the general store in Brasie Corners, turn left on County Highway 2, to Rossie.

59.0	4.3	Just after crossing the bridge in Rossie, turn left on County Highway 30, toward Oxbow.
60.6	1.6	Turn right on Mine Road.
61.1	0.5	Proceed straight ahead (right), following the old road to the mine.
61.7	0.6	Park in the field to the right at the Coal Hill Vein.

Mining first commenced at the Coal Hill Vein in the winter of 1836, and continued throughout the Civil War. The vein was excavated over a length of 600 feet and to a depth of 200 feet. By 1868 operations ceased, after producing over 1625 tons of lead (Cushing and Newland, 1925). During this period many fine, large crystals of galena and calcite were recovered, and soon became the object of much discussion (Beck, 1842; Emmons, 1842; Dana 1877). Fortunately a number of excellent specimens found their way into prominent collections and may still be seen today at the American Museum of Natural History, Harvard University, Hamilton College, and the New York State Museum. The complexity of forms on some of the calcite, pyrite, and fluorite crystals is nearly unrivalled (Figures 3-5).

The vein consists primarily of calcite with disseminated galena, and occupies a nearly vertical, east-west fault in the enclosing Precambrian granite. Inclusions of partially altered wall rock form a brecciated zone near the contact. By comparison to nearby veins and similar deposits in Ontario, emplacement is thought to be post-Ordovician (Beck, 1842; Smyth 1903; Wilson, 1924). Whether the mineralizing solutions originated from below as relatively cool, chemically inactive fluids, descended from above through meteoric concentration from the overlying Paleozoic rocks, or were perhaps derived from both meteoric and magmatic waters remains an unanswered dilemma (Smyth, 1903; Buddington, 1934; Wilson, 1924; Uglow, 1916). Recent SEM studies have unveiled the presence of an unusual assemblage of anatase, albite, synchysite, and cerian epidote occurring in micro cavities and fissures in both the vein material and altered wall rock. Hopefully, a continuing investigation will help clarify the origin and paragenesis of these veins (Robinson and Chamberlain, in prep.).

Nearly all the following species may still be collected from the dumps, but not in the quality that was produced when the mine was operating: albite, anatase, anglesite (?), calcite, celestine, cerussite, chalcopyrite, fluorite, galena, microcline, quartz, sphalerite, stilbite (?), and synchysite.

62.8	1.1	Return to the Rossie-Oxbow Road (County Highway 30) and turn right toward Oxbow.
66.9	4.1	At the intersection with County Highway 113, bear to the right (straight) and continue through Oxbow.
68.6	1.7	Just after passing through Oxbow, turn right on the road to Antwerp.
71.4	2.8	Proceed straight ahead.
74.5	3.1	Turn left (north) on U.S. 11.
76.1	1.6	Stop at the Villeneuve Farm on the right side of U.S. 11 to obtain permission to enter the Sterling Mine property.
76.7	0.6	Continue north on U.S. 11 to the Sterling Rock Shop and mine road entrance on the right. Park here and walk down the old mine lane approximately 350 yards to the mine.

The Sterling Mine was the first U.S. locality for millerite, and is often regarded as having produced some of the world's best specimens of that species. The mine lies near the middle of a group of hematite deposits known as the Antwerp-Keene belt (Buddington, 1934). Mining first began in 1836 and continued until 1910, creating an open pit 500 feet long, 175 feet wide and 115 feet deep, that produced hundreds of thousands of tons of ore (Smock, 1889).

The geology of this deposit is complex, and a detailed mineralogical study is currently in progress (Robinson and Chamberlain, in press). The mine is situated along a marble-gneiss contact, and the ore is intimately associated with a heavily slickensided quartz-chlorite rock which is thought to have formed by the replacement of the gneiss by corrosive, iron-rich solutions derived from the decomposition of underlying pyritic schist (Smyth, 1894; Buddington, 1934; Prucha, 1957). Both the chloritic rock and marble appear to have been replaced by hematite resulting in a gossan-like structure which was then preserved by a capping of Potsdam sandstone. Open spaces were filled with hematite and quartz, and possibly other species not preserved. Subsequent recrystallization of the quartz and hematite at relatively low pressure and temperature is suggested by the presence of Fe-talc and stilpnomelane, and is supported by fluid inclusion studies (Robinson and Chamberlain, in press). Further changes in the composition, eH and probably pH of the mineralizing solutions are evident from the presence of magnetite pseudomorphs after hematite, both Fe(II) and Fe(III) rich stilpnomelanes, Fe-talc and various sulfide and carbonate phases.

Minerals that can readily be collected are hematite, magnetite pseudomorphs after hematite, quartz, stilpnomelane ("chalcodite"), Fe-talc, siderite, goethite, calcite, ferroan dolomite, and more rarely millerite and jamborite (?), all of which occur as well formed crystals in vugs in the crystalline hematite-quartz ore. Early reports of cacoxenite and ankerite can not be confirmed, and likely resulted from the misidentification of stilpnomelane and siderite (Robinson and Chamberlain, in press).

END OF TRIP

Return to Potsdam is best made by following U.S. 11 north, approximately 44 miles.

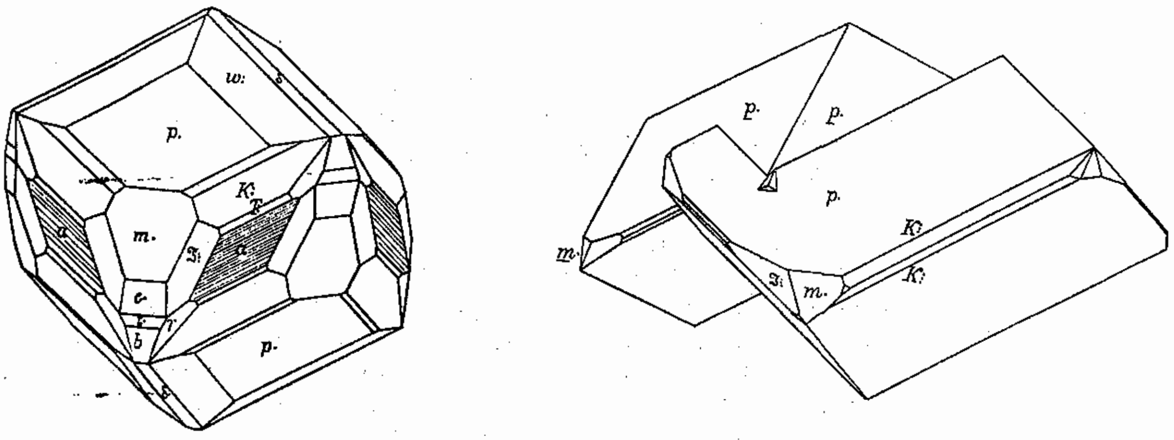

Figure 3. Calcite Crystals - Rossie, N.Y. (after Whitlock, 1910b)

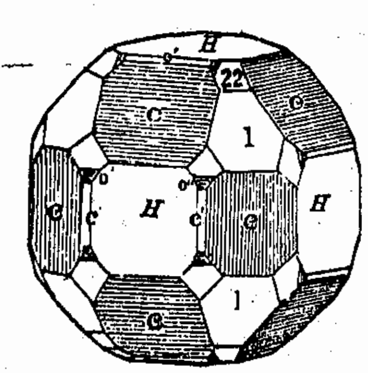

Figure 4. Pyrite - Rossie, N.Y. (after Dana, 1877)

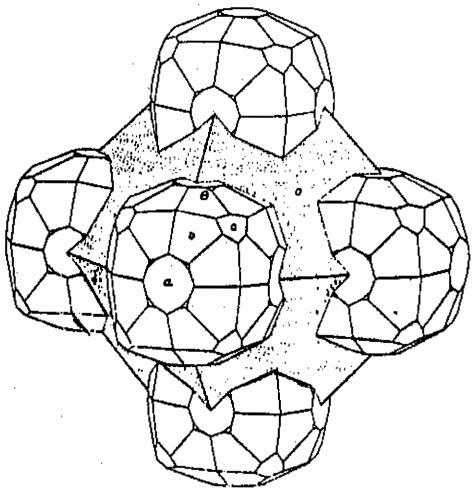

Figure 5. Fluorite - Rossie, N.Y. (after Whitlock, 1910a)

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FIELD TRIP NO. 4

STRATIGRAPHY, STRUCTURE, AND GEOCHEMISTRY OF GRENVILLIAN ROCKS IN NORTHERN NEW YORK

by

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and
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Introduction

The geology of the northwest Adirondack lowlands is characterized by northeast-trending belts of highly deformed rocks, chiefly marbles and gneisses, all metamorphosed to upper amphibolite facies grade during the Grenvillian Orogeny. A clear picture of the structure and stratigraphy of this region has proven elusive due to effects of recrystallization, multiple folding, anatexis and magmatism during metamorphism.

Several different structural and stratigraphic models have been proposed which illustrate the diversity of opinion surrounding these rocks. Engel and Engel (1953) believed the stratigraphy to be part of the overturned, southeastern limb of a regional anticlinorium whose upright limb lay to the northwest in Canada. They recognized five major stratigraphic units which, from NW to SE in order of decreasing age, include the following:

1) Black Lake metasedimentary belt; 2) Gouverneur, or Lower Marble; 3) Major Gneiss belt; 4) Balmat-Edwards, or Upper Marble; and 5) Harrisville-Russell belt (see map, Figure 1 and cross-section, Figure 2).

A model by Lewis (1969) included two major marble units, separated by the Major Gneiss, which were continuous across the northwest Adirondacks but repeated in linear, northeasterly belts by tight, upright folds. More recently Foose (1974) and Wiener (1981) postulate that there is but one carbonate horizon repeated by multiply-refolded nappes.

There seems to be agreement that alaskitic gneisses (leucogneisses) which core domical structures in the northwest Adirondacks constitute a basal horizon over which marble and gneiss precursors were deposited. Geochemical data and recent field mapping reveal a relict stratigraphy consistent with an ash flow tuff origin. Geochemical data from the Major Gneiss are consistent with an origin as slightly reworked, dacitic tuff. Results of mapping by St. Joe Resources Company geologists (including deLorraine) are best interpreted as two distinct carbonate units separated by the Major Gneiss. The basal marble, here termed the Gouverneur marble

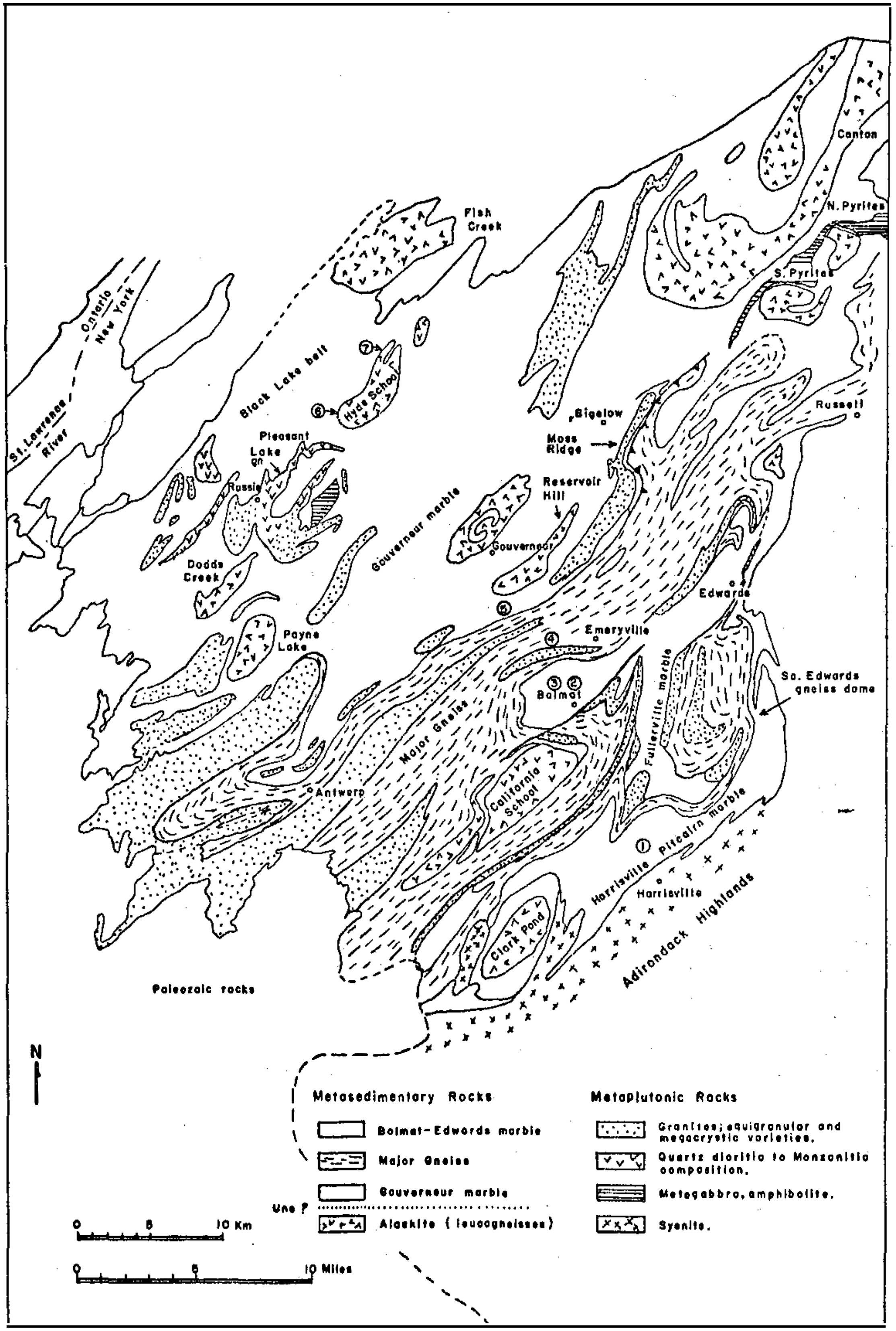


FIGURE I General geology and location of stops.

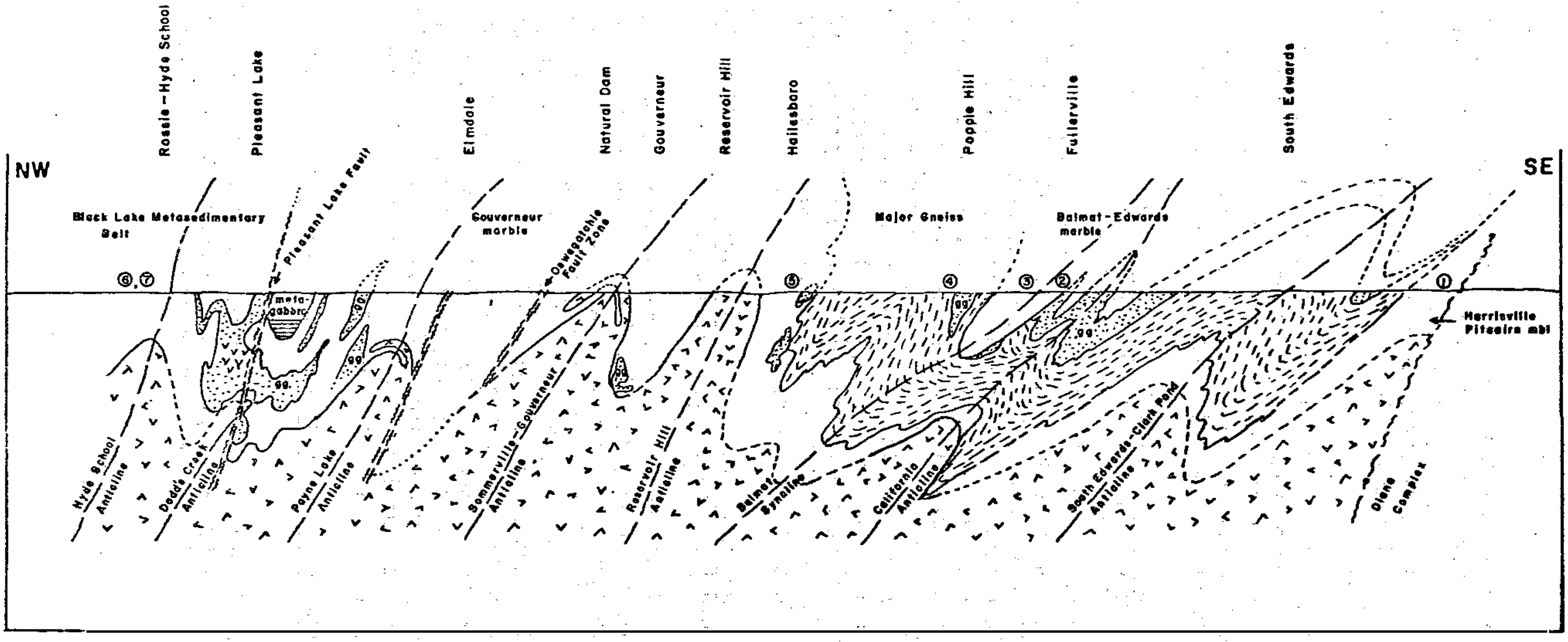


FIGURE 2. Generalized NW-SE geologic cross-section across the NW Adirondacks.

type, directly overlies the leucogneisses and comprises the Engels' Black Lake, Gouverneur (Lower Marble), and Harrisville-Pitcarin marbles (part of the Balmat-Edwards, or Upper Marble of the Engels). Major Gneiss overlies this marble and, in turn, is overlain by an upper marble, hereby called the Balmat-Edwards marble type. This model is similar in some respects to that of Lewis (1969).

The purpose of this field trip is to investigate regional stratigraphy and structure from the perspective given here. We will point out numerous areas where further investigation is needed, particularly with regard to the role of magmatism during (before?) metamorphism. We will also discuss the origin of some of the gneissic rocks in view of recent geochemical data.

Stop No. 1. New roadcut on Route 812 north of Harrisville near bridge over Oswegatchie River, Harrisville quadrangle.

We start our trip in the Harrisville-Pitcarin marble belt adjacent to the Highlands - Lowlands boundary which lies just to the southeast. Marbles here belong to the Lower marble belt (Gouveneur marble type) and overlie the Clark Pond leucogneiss body which lies to the southwest. Formerly, this belt was included in the Upper or Balmat-Edwards marble belt of the Engels. These marbles consist of coarse-grained, light gray and white, banded, graphitic-calcitic marbles with accessory brown tourmaline, local chondrodite and diopside. A thin layer of Major Gneiss between Geer's Corners and Pitcarin separates the Lower (calcitic) marble from the Upper (silicated-dolomitic) marble to the north toward Fullerville and Balmat. Note the lobate form of the intrusive body of quartz-syenite exposed on the right-hand side of the outcrop.

Stop No. 2A. St. Joe Resources Co. #2 Mine area at entrance to Balmat #2 mine, Route 812, Gouverneur quadrangle.

Exposed here in the core of the Balmat syncline is unit 14, one of 15 carbonate units comprising the stratigraphic section at Balmat. Overall plunge of the syncline (overturned) is NNW. Note the profusion of isoclinal folds, rootless fold hinges, transposed layering, and fragmented silicate layers in marble. Look for bladed tremolite clusters, diopside, quartz, serpentine, and dolomitic and calcitic marbles. Contrast the composition of this marble with that at Stop 1. Nearby is the old #2 mine-mill complex, now unused because milling operations have shifted to the new #4 mine area. However, #2 shaft still serves as an access and escape route for the #2 mining area. This is the site of original mining in the Balmat district, having begun in 1930, although sphalerite showings were reported as early as 1838 by Ebenezer Emmons.

Stop No. 2B. Area to right of gate at entrance to #2 mine area; old American Talc shaft.

Exposed here is Unit 13, a talc-tremolite-anthophyllite schist. Suggested by Engel (1962) as a shear zone metasomatically enriched in Mg, it more likely is a siliceous meta-evaporite unit. Its distinctive

Table 1: Chemistry of Popple Hill rock types (Stop No. 4)

	Banded gneiss (6 samples)		Leucosome in banded gneiss (4 samples)		Massive subporphyroblastic rock (7 samples)		Leucosome in subporphyroblastic rock (4 samples)	
	average	δ	average	δ	average	δ	average	δ
SiO_2 (wt. %)	69.68	± 1.92	71.00	± 4.03	63.39	± 2.30	67.45	± 4.45
Al_2O_3	14.61	± 0.57	15.15	± 1.42	16.74	± 0.74	16.37	± 1.84
Fe_T (as Fe_2O_3)	3.66	± 0.82	1.58	± 0.90	6.04	± 0.96	2.17	± 0.82
MgO	1.18	± 0.28	0.35	± 0.16	2.05	± 0.36	0.70	± 0.39
CaO	2.11	± 0.25	1.05	± 0.29	3.92	± 0.36	1.39	± 0.26
Na_2O	3.50	± 0.39	3.42	± 0.88	3.50	± 0.45	2.56	± 0.54
K_2O	3.43	± 0.40	7.14	± 2.38	2.65	± 0.63	8.27	± 1.93
TiO_2	0.47	± 0.11	0.12	± 0.08	0.82	± 0.14	0.25	± 0.14
MnO	0.05	± 0.01	0.03	± 0.01	0.09	± 0.02	0.03	± 0.02
Total %	98.69%		99.84%		99.20%		99.19%	
Rb (ppm)	124.40	± 13.60	161.90	± 55.90	127.60	± 12.60	211.30	± 44.30
Sr	261.10	± 59.70	264.80	± 86.50	702.00	± 85.80	560.00	± 115.70
Y	24.70	± 11.00	27.90	± 19.70	35.00	± 10.40	13.80	± 14.00
Zr	194.50	± 34.00	46.20	± 19.20	223.40	± 36.30	23.50	± 19.70
Nb	11.70	± 2.90	8.00	± 3.00	12.50	± 2.00	7.40	± 5.70
Ba	581.00	± 66.00	786.00	± 254.00	942.00	± 230.00	1582.00	± 464.00
Pb	19.20	± 4.00	39.50	± 7.60	14.40	± 4.30	29.60	± 6.00
Th	4.70	± 3.10	3.40	± 2.80	29.40	± 19.50	2.30	± 2.40
Zn	77.40	± 19.70	19.40	± 15.20	104.00	± 14.40	39.20	± 23.20
Cu	5.00	± 5.90	4.00	± 2.80	0.00		1.90	± 2.50
Ni	21.60	± 3.00	14.60	± 0.50	15.00	± 0.50	13.90	± 0.70

Table 2: Chemistry of Hermon porphyroblastic gneiss between Hermon and Kent Corners (Optional Stop)

	Gneiss (5 samples)		Xenolith-like dark rock within gneiss Sample number:		
	average	δ	16HR3	82-1H	82-2
SiO_2	65.95	± 1.13	56.56	-	-
Al_2O_3	16.23	± 0.27	18.76	-	-
Fe_T	4.43	± 0.31	7.23	-	-
MgO	1.42	± 0.14	2.46	-	-
CaO	2.49	± 0.22	4.49	-	-
Na_2O	3.46	± 0.60	5.36	-	-
K_2O	5.23	± 0.22	3.63	-	-
TiO_2	0.64	± 0.02	1.01	-	-
MnO	0.05	± 0.03	0.08	-	-
TOTAL	99.90%		99.58%		
Rb	136.8	± 5.0	117.4	108.5	105.8
Sr	405.5	± 11.2	425.0	426.6	413.8
Y	39.6	± 4.1	64.7	93.5	48.4
Zr	281.9	± 16.5	459.1	447.1	287.4
Nb	13.7	± 0.9	18.0	18.0	10.4
Ba	1047.0	± 52.0	703.0	561.0	890.0
Pb	28.0	± 1.3	23.4	30.1	29.4
Th	10.8	± 2.4	6.5	11.8	15.0
Zn	57.4	± 12.4	127.1	156.4	85.2
Cu	0.0		0.0	4.6	0.0
Ni	15.1	± 0.9	15.9	16.9	21.3

Amphibolites are generally conformable and in sharp contact with banded gneiss. They contain biotite-selvaged leucosome that resembles its host in plagioclase content and low Ba and Rb.

Leucosome in banded gneiss is of granitic composition with K-feldspar dominant over plagioclase and 25-35% modal quartz. Like the host gneiss, leucosome is enriched in Ba, Rb and Sr. Textures range from xenomorphic granular to strongly flaser and cataclastic. Porphyroclasts are surrounded by wreaths of mortar similar to that surrounding K-feldspar augen in the Hermon gneiss. A possible mode of origin is that of partial melting along shear zones at some early stage of metamorphism and folding.

What was the protolith of the major gneiss? Perhaps dacite volcanics that were slightly weathered and reworked as proposed for paragneiss in NW Ontario by van de Kamp and Beakhouse (1978). There is at least one locality where cross bedding seems preserved. Sillimanite content is variable and may occur as thin lenses or in thin sections, but Al_2O_3 is generally low for a shale. Harker diagrams show igneous trends (except for Na and K) and the rock lacks enough CaO, Cr and Ni to represent the composition of many graywackes. An Na/K ratio of 1.0 is obtained instead of 1.2-1.4 characteristic of graywackes when leucosome is included in an assessment of average outcrop composition (Carl, 1981). The massive rock at the Popple Hill outcrop with its more mafic chemistry may represent a volcanic feeder for material now incorporated in the adjacent banded gneiss.

Stop No. 5A. Bridge over Matoon Creek, Route 58, near Hailesboro, Gouverneur quadrangle. Small outcrop on north side of road.

Gouverneur marble and gray, granitic intrusive rocks exposed here. Note the light gray inclusion of marble (shaped like a steer's head) in the darker gray granitic rocks. Similar gray granitic rocks are well exposed along Route 11 as far south as Antwerp; this string of granitic bodies extends as far northward as Moss Ridge on the Bigelo quadrangle. North of Battle Hill at the south end of Moss Ridge (Gouverneur quadrangle), the gray gneiss undergoes a transition from gray to splotchy gray and red, to pink/red granite. Its red coloration north of Battle Hill causes the unit to resemble the basal leucogneisses. We suggest that Moss Ridge is the northerly extension of the granite intrusive belt and probably constitutes a sill-like body within Gouverneur-type marbles. As such, it is unrelated to the basal leucogneisses as was proposed by Foose (1974). Moss Ridge also lacks a pronounced positive magnetic anomaly that is common to other leucogneiss bodies.

Stop No. 5B. "Train wreck" Outcrop - Fragments of "basaltic" rock in Gouverneur marble.

Clustering of blocks and their rectangular outline suggests disruption of a basaltic dike during folding. Mineralogy of the dike, however, is adjusted to metamorphic conditions. Plagioclase is absent in contact zones in the dike rock which contains meionite scapolite, diopside, microcline, sphene, tremolite, biotite, quartz, tourmaline and apatite. This roadcut also contains a basalt dike that is not disrupted.

Stops No. 6 and 7. The Hyde School "alaskite" body: leucogneiss and amphibolite at the southwest end, and tonalite at the northern edge along the Hyde road, Pope Mills quadrangle.

The Hyde School is the best exposed of several domical leucogneiss occurrences in the Northwest Adirondacks. Many years ago A. F. Buddington proposed that the gneisses represent granitic intrusions into anticlinal crests (phacoliths) during Grenville folding and metamorphism. The Hyde School body, however, is anything but a simple dome. Isoclinally folded and refolded amphibolite layers are shown to mimic the larger structures, and there is evidence that all "domes" are protruberances of a single, multiply-folded, lower stratigraphic unit present throughout the lowlands. The Hyde School body has been recently mapped by Erv Brown.

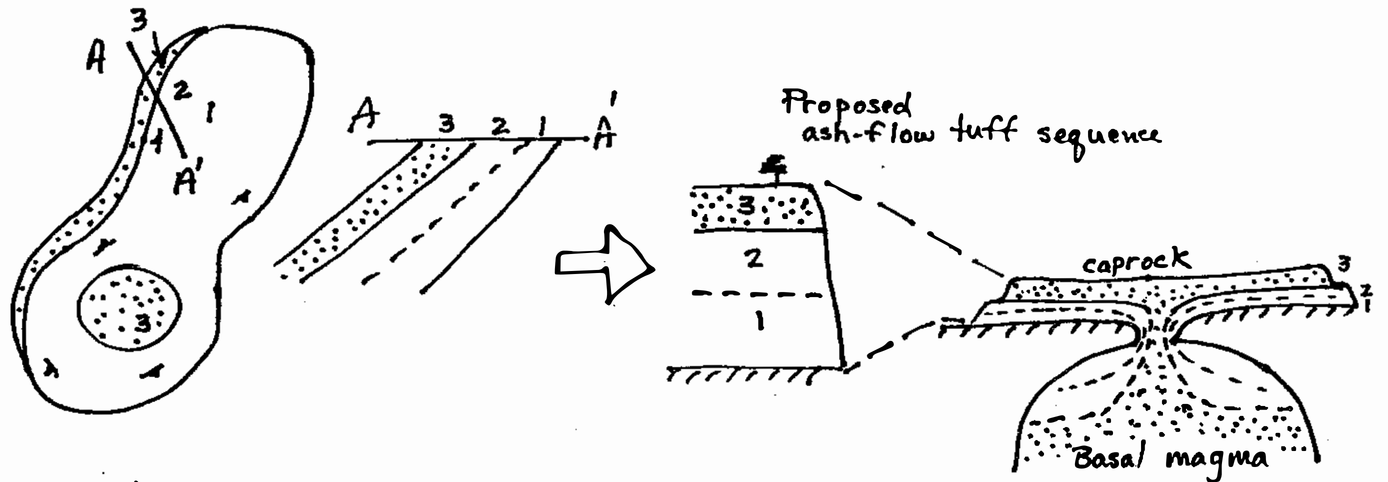
The blunt, southwesterly-plunging end of the Hyde body overlooks a solution valley in the surrounding Lower Marble unit. Amphibolites interlayered with leucogneiss (alaskite) are virtually undisturbed at this locality. Some are broken with coarse-grained quartz and feldspar occupying the break. Extension in the direction of plunge or laterally in the plane of foliation produced tension within these relatively competent layers.

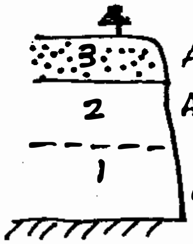
Carl and Van Diver (1975) recognized a stratigraphy of sorts within the leucogneiss and made comparisons of major element chemistry with ash flow tuffs. The presence of dark tonalite-trondhjemite gneiss units within a dominantly granitic gneiss sequence was compared to the capping of ash flow tuff sequences by later, more fluid, plagioclase-rich extrusives. The lower parts of ash flow sequences have rhyolitic tuffs derived from the uppermost, most differentiated portion of the underlying magma chamber. The plagioclase cap rock represents a later outpouring of more fluid magma at greater depth. The stratigraphic sequence on the surface, thus, represents an inversion of the zonation that existed in the underlying magma chamber (Figure 3).

Units of tonalite-troudhjemite occur along the western margin of the Hyde School exposure and in the center of the southern dome. If these are truly the cap rock of ash flow tuffs, then a walk northwardly along the Hyde road is upward in the stratigraphic sequence. It is also a look deeper into the magma chamber that gave rise to that sequence.

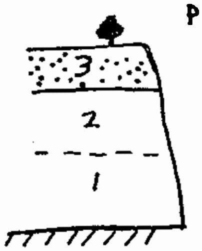
Support for an ash flow tuff origin has recently come from geochronology studies of Bob Lepak (1983) and Tom Maher (1981), students of Norman Grant at Miami University of Ohio. They find a crystallization age for precursors of the leucogneiss at 1263 ± 25 Ma and an initial $^{87}Sr/^{86}Sr$ ratio of 0.7033 ± 0.4. Samples with high Rb/Sr ratios give evidence for open system behavior of Sr that is proposed (by other workers) to have occurred in silicic volcanics. This Sr loss is attributed to factors such as the reordering of K-feldspar structural state during cooling of the tuffs, or by Sr loss in fluids prior to or during metamorphism.

Figure 3 Chemistry and ash-flow tuff model for the Hyde School leucogneisses (Stop no. 7)





wt %–	SiO_2	Al_2O_3	Fe_T	MgO	CaO	Na_2O	K_2O	TiO_2	MnO	Rb ppm–	Sr	Y	Zr
Av. 3 spls:	69.89	14.14	3.33	1.68	3.22	4.51	2.44	0.53	0.05	53.5	436.3	25.0	173.4
Av. 2 spls:	74.81	10.91	5.27	0.50	0.94	3.24	4.10	0.34	0.01	88.0	124.4	96.6	735.2
Av. 2 spls:	74.36	13.27	2.75	0.10	0.55	3.71	4.55	0.19	0.02	111.0	71.7	137.5	499.5



ppm–

Nb	Ba	Pb	Th	Ni	Cu	Zn
9.1	605	8.3	0.6	21.6	32.4	33.4
16.7	373	24.3	7.9	15.5	8.7	48.4
26.8	421	13.8	4.6	17.0	3.2	10.8

ppm–

	La	Ce	Sm	Eu	Tb	Yb	Lu
1 spl:	19.01	31.85	4.80	0.79	0.42	1.97	0.34
1 spl:	88.28	177.03	26.45	1.99	2.84	11.05	1.43

Carl has analyzed rock samples taken along the Hyde road from granitic leucogneiss into the tonalite-trondhjemite unit. Chemistry is given with respect to lithology in Figure 2. Note the change from siliceous to more mafic chemistry toward the plagioclase unit and an "upward" increase in MgO, CaO, Na_2O, TiO_2, Ni, Cu, Sr, and Ba. There is a decrease in SiO_2, K_2O, Rb, Y, Zr, Nb, Pb, and Th. Analyses by Calvin Pride, University of Ottawa, show less total rare earth element content (and no negative Eu anomaly) in the caprock than in the underlying leucogneiss. The caprock is slightly enriched in light REE relative to heavy REE than is the underlying leucogneiss (La/Yb ratios of 9.7 vs. 8.0).

These trends are remarkably similar to those recorded in a vertical sequence of the Bishop Tuff in California by Wes Hildreth (1979). The lower, siliceous part of that sequence is enriched in the small, highly charged cations Y, Nb, Th, and La. It is also enriched in Rb and has a strong negative Eu anomaly. Ba and Sr enrichment occurs in the more mafic caprock. In contrast to the leucogneiss sequence, however, Hildreth reports the caprock enriched in K over Na (odd!) and in Zr content.

Large portions of the leucogneiss sequence must have been rapidly extruded and deposited as is the case for individual flows in a tuff sequence. Deposition of other portions, however, must have occurred intermittantly and in water because of interlayering with numerous thin amphibolites (mafic tuffs?), calc-silicates and garnet-sillimanite gneiss. Extensive compaction, recrystallization and folding evidently obliterated all textural evidence of the precursors.

Stops No. 8 and 9.

Our drive will continue northward from the Pope Mills to the Edwardsville quadrangle, if there is time and desire to do so. New roadcuts in migmatite, K-feldspar porphyroblastic gneiss and the largest roadcut (that we have observed) in an alaskite body at the Fish Creek "phacolith" await your viewing pleasure. Turn around will occur either at Stop 7 or at the Edwardsville grocery on Black Lake after refreshment and an up-date on the fishing.

Optional Stop on return to Potsdam: Hermon porphyroblastic gneiss, 2 miles southwest of Hermon toward Kent Corners, Bigelo quadrangle.

This augen gneiss is part of a mappable unit that overlies the banded paragneiss a few kilometers to the south. Contacts are both gradational and abrupt. Similar porphyroblastic units of different stratigraphic position have been labelled "Hermon granite" elsewhere in the NW Adirondacks, but we show you the locality that, in soft drink terms, is the "real thing."

The underlying major gneiss has its porphyroblastic aspects: sheets a meter thick may be interlayered with banded gneiss, or scattered K-feldspar porphyroblasts may occur in migmatite outcrops. On the other hand, the Hermon gneiss contains dark layers and xenolith-like fragments of fine-grained rock that, megascopically at least, resemble the major gneiss.

How then to regard this rock type with its close proximity to the major gneiss, its K-feldspar augen, cataclastic and recrystallized textures and its contained bits of dark rock? Engel and Buddington believed it to be "reconstituted" paragneiss to which K_2O was added. Other suggestions include a metamorphosed granitic intrusion, recrystallized mylonite, K-feldspar-rich volcanics and arkosic sediment.

Five samples taken along this road (Table 2) show uniform chemistry. The Hermon gneiss contains less silica and more Al_2O_3, K_2O, Sr (but hardly more CaO), Y, Zr, Ba, and Th than banded major gneiss at Popple Hill (Table 1). Those dark, xenolith-like fragments are more mafic than most major gneiss samples with notable enrichment in Zr, Y, and Zn.

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TRIP 5

THE TRENTON GROUP OF THE BLACK RIVER VALLEY

by

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The Trenton Group is made up of six formations (Kay, 1937, 1968). In ascending order these are the Napanee, Kings Falls, Sugar River, Denley, Steuben and Hillier limestones (Fig. 1). To the east it grades into the Dolgeville facies and the Utica Black Shale. The unit is thickest in the Watertown area where it is about 160 m thick. Eastward it thins to about 130 m in the Trenton Falls vicinity, losing strata at both the bottom and top (Fig. 2). East of Trenton Falls the unit thins dramatically and at Canajoharie Creek it is only 5 m thick. Early Trentonian rocks continue to be found east as far as Glens Falls and the Champlain Valley.

The Trenton Group was deposited during the Vermontian phase of the Taconic Orogeny. The dominant events affecting the Trenton Group were two episodes of inversion of topography, one occurring at the beginning of Trentonian deposition and the other occurring at its close.

During the early Trentonian (Rocklandian, Kirkfieldian, Shorehamian and early Denmarkian) the first inversion of topography occurred. Uplift in the source areas of the east was accompanied by very gradual downwarping in the New York State vicinity. The shallow carbonate seas of the Trenton Group invaded New York west and east of the Adirondack Arch (Fig. 2 & 3). To the east carbonates equivalent to the Kings Falls and Sugar River limestones were deposited. These were overlapped by the Utica Black Shale during the middle Shorehamian (Fisher, 1977). By the end of the Shorehamian, the Adirondack Arch had been submerged and breached by the black shales (Fig. 2 & 3). The shale facies migrated almost as far as Middleville.

During the early Denmarkian the advance of the black shale facies slowed and the carbonate - black shale boundary settled in an area just east of Trenton Falls (Fig. 3). The Dolgeville facies represents a bank margin slope transitional between these facies. The early Trentonian version of topography was over and subsidence slowed sufficiently for the carbonate deposition to catch up with and exceed it (Fig. 3), The middle Trentonian was thus a period of shallowing seas and a regressive facies pattern is found. Shallow water facies migrated in from the west and the bank margin steepened (Fig. 3 & 5).

The period of shallowing culminated during deposition of the middle Steuben Limestone (Figs. 3 & 5). Thereafter the second and final inversion of topography occurred. The deeper, more micritic facies of the Hillier Limestone first appears in the vicinity of Westernville (Fig. 2) during the middle Cobourgian. The carbonate of that vicinity were soon overlapped by the Holland Patent Shale. With time, the Hillier Limestone migrated westward followed by the black shale facies. By late Coboürgian the carbonates had retreated to well up in the Black River Valley area (Fig. 3 & 5). They were soon overwhelmed by black shales which swept across them into the interior of North America as the Hudson Valley phase of the Taconic Orogeny quickened.

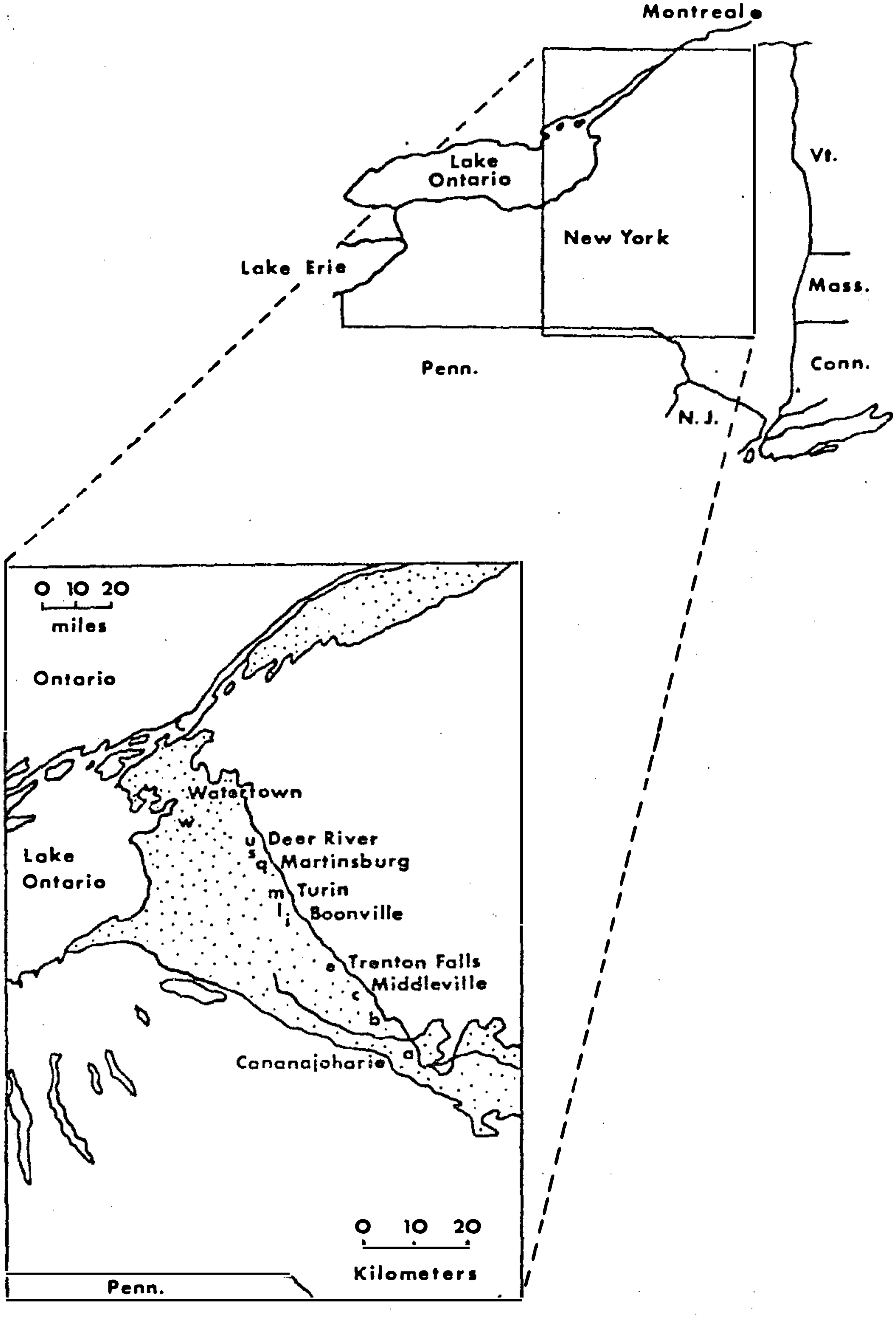


Figure 1. The study area.

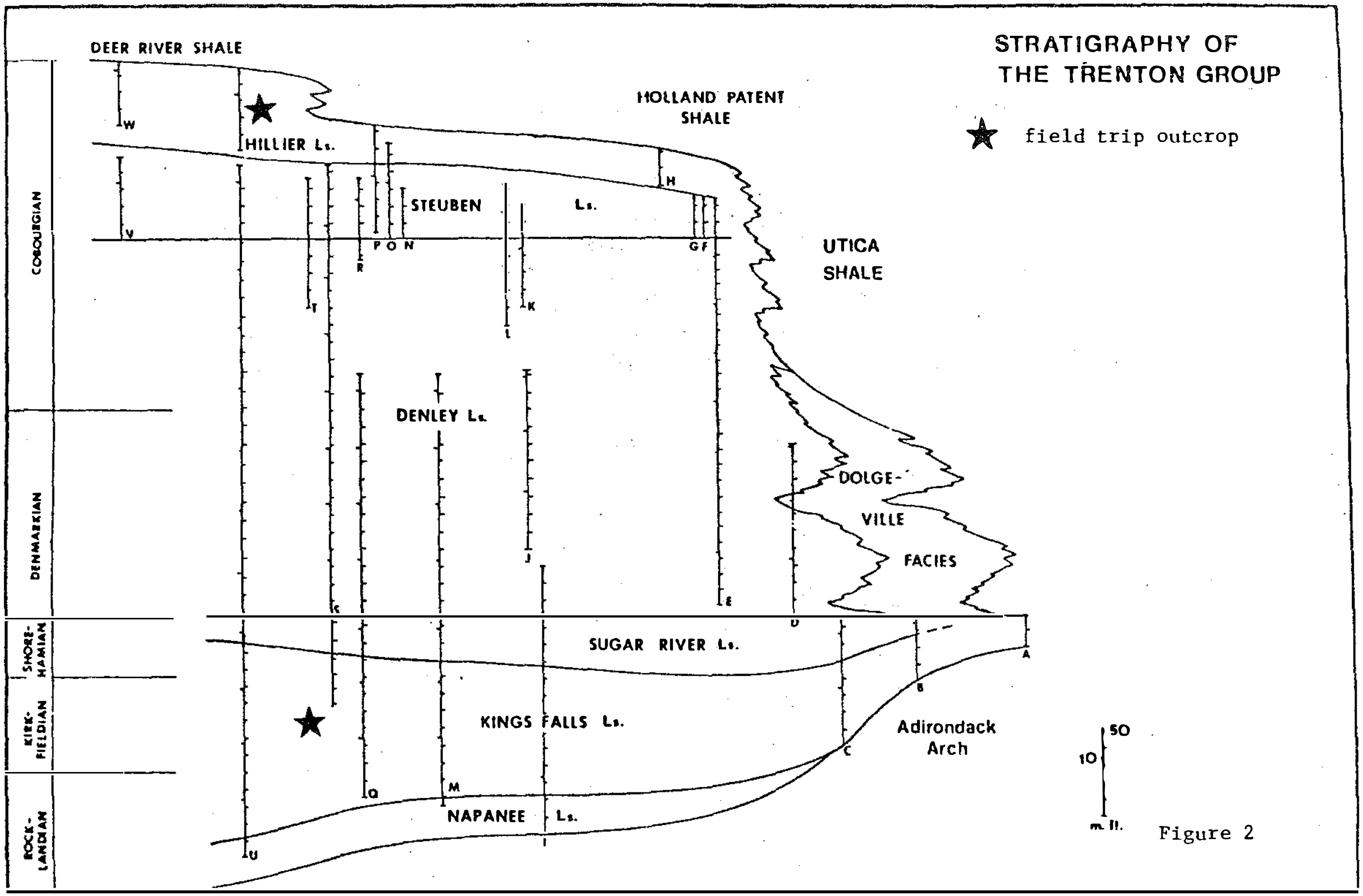
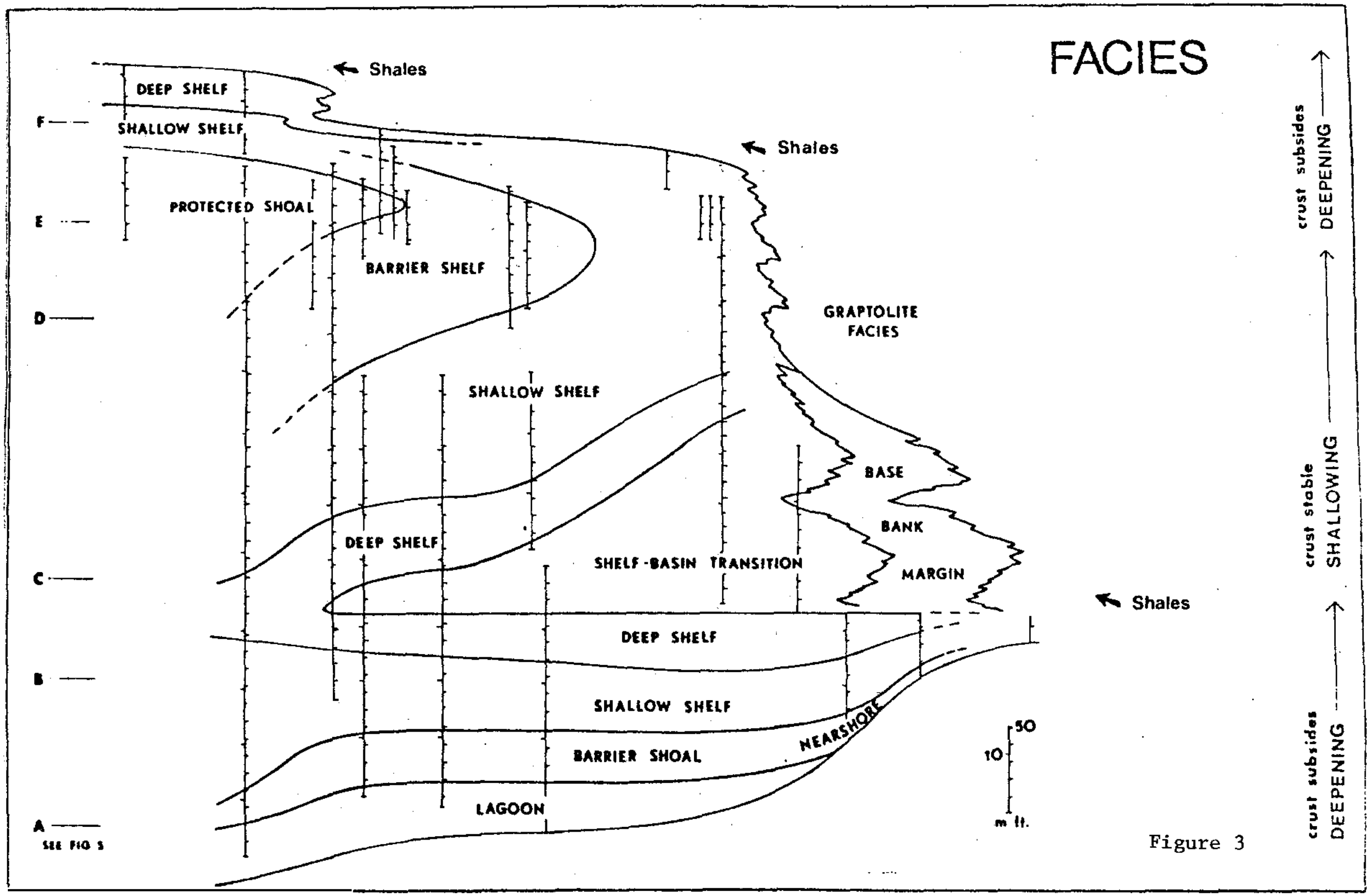


Figure 2. Stratigraphy of the Trenton Group. Vertical lines indicate the important outcrops studied. They are as follows: A. Canajoharie Creek; B. Inghams Mills, below the dam on East Canada Creek; C. Buttermilk Creek, 4 km. north of Middleville; D. Mill Creek, Gravesville; E. Trenton Falls; F. Quarry on West Canada Creek, Prospect; G. Quarry on Rt. 365, south of Barneveld; H. Stream cut along Rt. 274, near Westernville; I. Sugar River along Rt. 12, north of Boonville; J. Moose Creek, upstream from the Sugar River; K. Moose Creek, along Rt. 12D; L. Talcottville, along Rt. 12D; M. Mill Creek, Turin; N. Douglass Creek; O. Whetstone Gulf, below Rt. 26; P. Atwater Creek, southwest of Martinsburg; Q. Roaring Brook, Martinsburg; R. Roaring Brook, Martinsburg; S. Mill Creek, Lowville; T. Black Creek, along Boshart Road, west of Lowville; U. Deer River; V. Gulf Stream, Rodman; W. Rt. 177 west of Rodman. Correlations of the eastern outcrops of the Steuben Limestone are tentative.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DEEP SHELF
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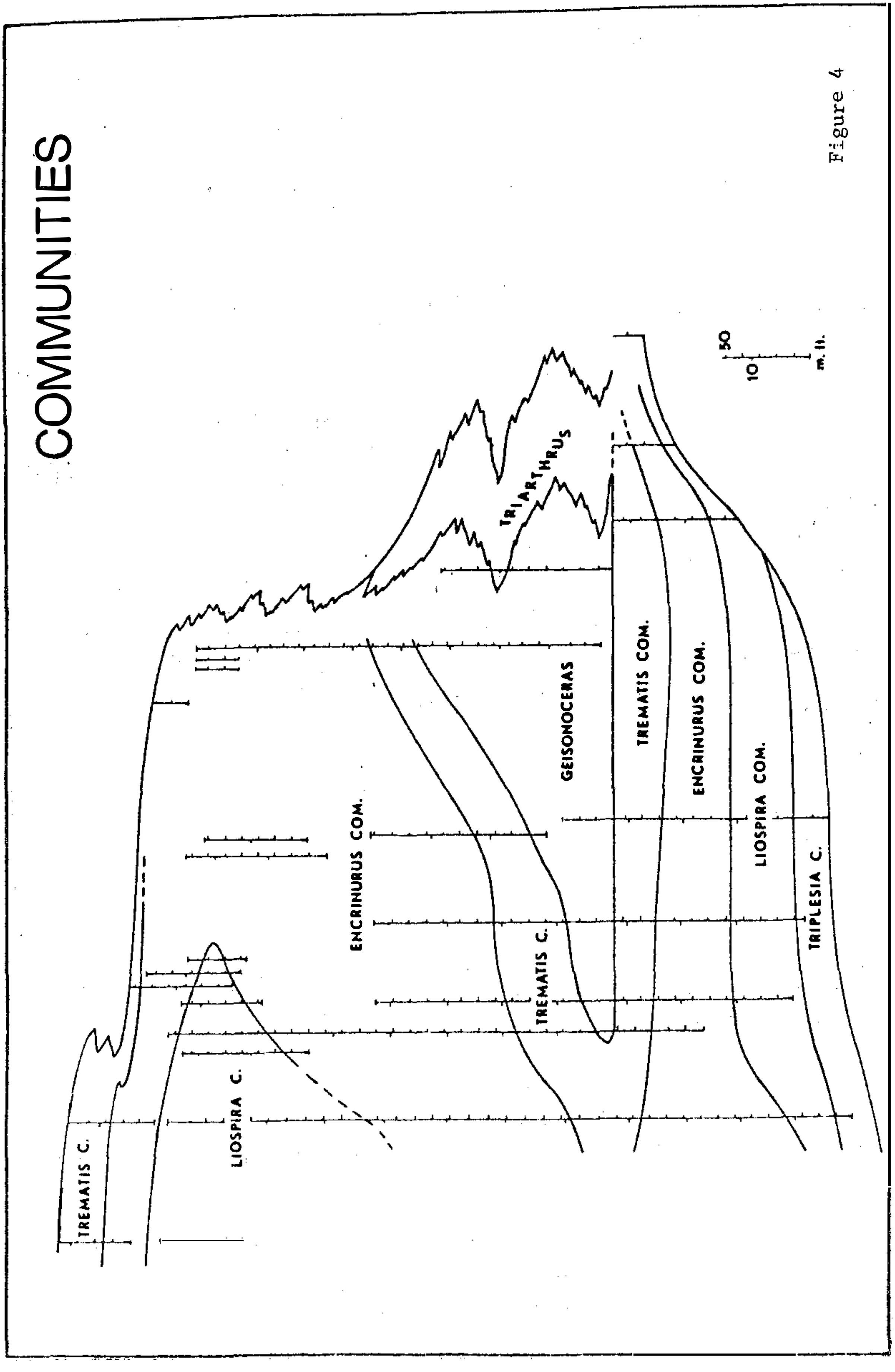
Figure 3



COMMUNITIES

Figure 4

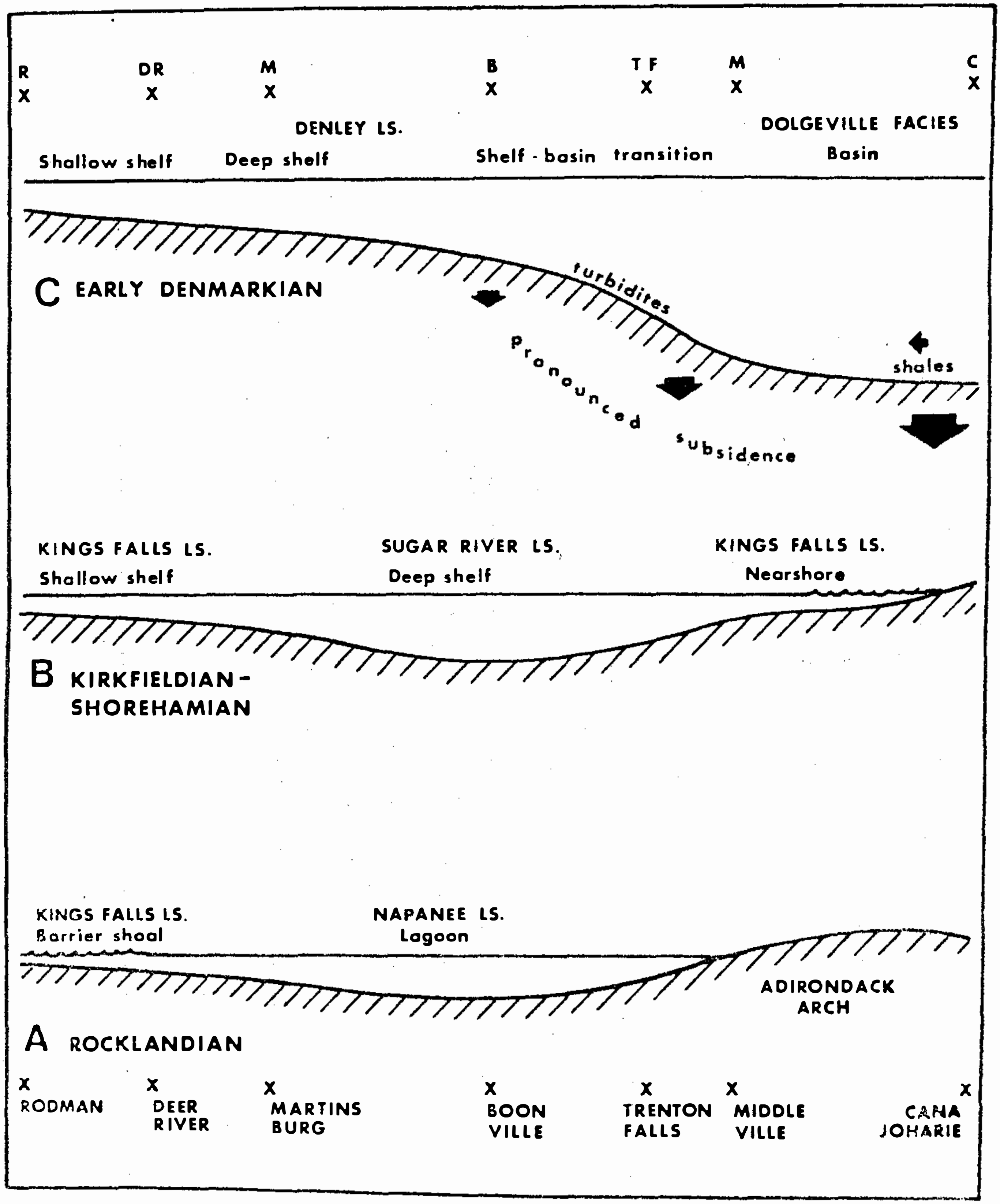
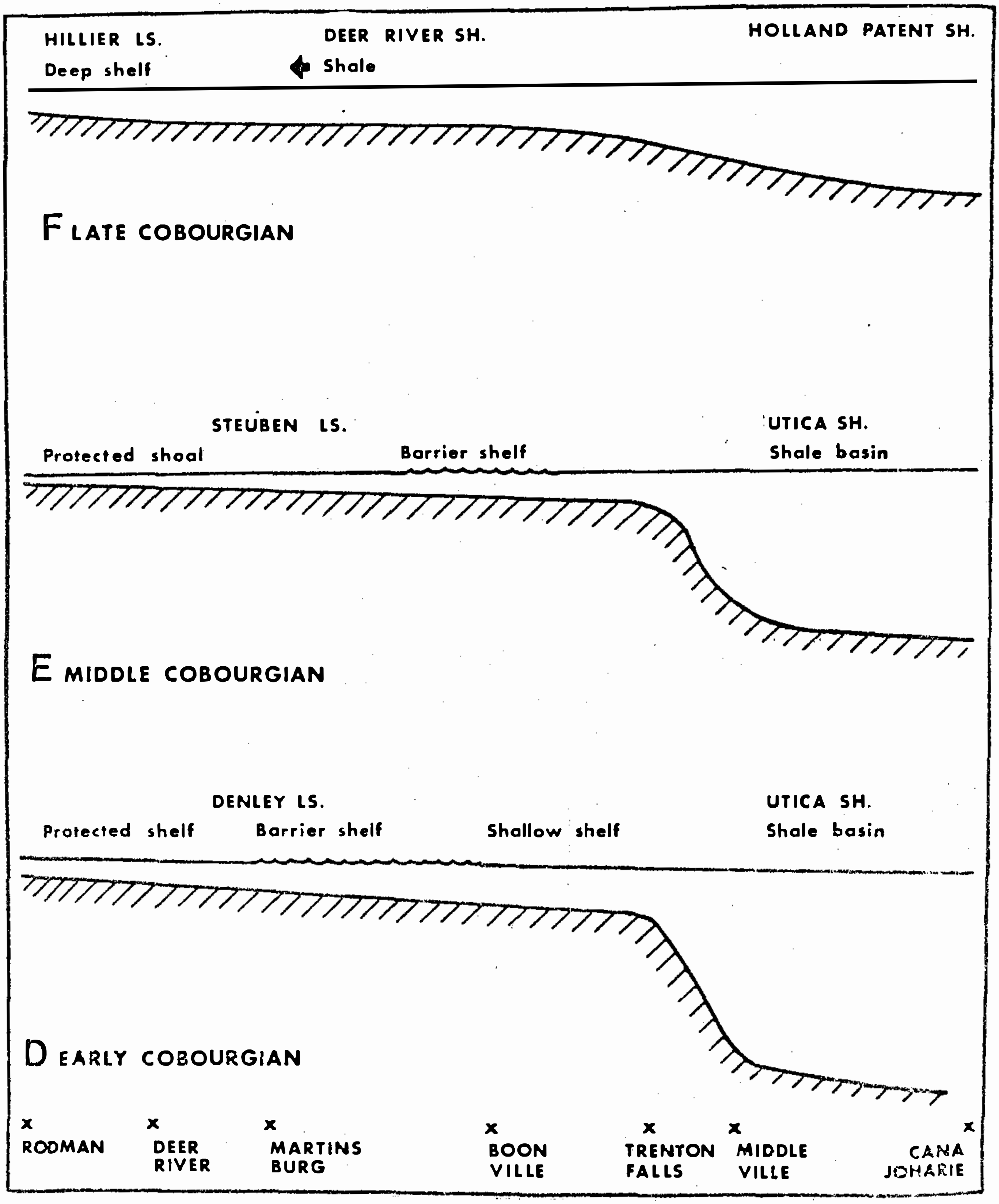


Figure 5. Tectonic evolution of the Trentonian carbonate platform. Letters A through F refer to the time lines on the left of figure 4.


HILLIER LS.
Deep shelf
DEER RIVER SH.
Shale
HOLLAND PATENT SH.
F LATE COBOURGIAN
STEUBEN LS.
Protected shoal
Barrier shelf
UTICA SH.
Shale basin
E MIDDLE COBOURGIAN
DENLEY LS.
Protected shelf
Barrier shelf
Shallow shelf
UTICA SH.
Shale basin
D EARLY COBOURGIAN
RODMAN
DEER RIVER
MARTINS BURG
BOON VILLE
TRENTON FALLS
MIDDLE VILLE
CANA JOHARIE

Road Log

Total Mileage	Mileage From Last Stop	
		This road log begins at the intersection of routes 12 and 26 in the center of Lowville, New York.
0.0	0.0	Proceed north on route 12.
0.8	0.8	Park beyond bridge which crosses Mill Creek. About 90 m of the Trenton Group are exposed at this location. The 16 m of strata below the bridge display the upper Kings Falls Limestone and all of the Sugar River Limestone. Upstream there is a complete exposure of the Denley Limestone. There is only one short break in the section. Finally, the entire Steuben Limestone can be seen along the upper reaches of Mill Creek. The Steuben Limestone begins just below the quarry. Thus, most of the lower Trentonian transgression and all of the middle Trentonian regression are represented at this location.
12.5	11.7	Proceed north on Route 12 to Copenhagen. Park beyond the bridge which crosses the Deer River. About 17 m of the uppermost Trenton Group Hillier Limestone is exposed here. This may be the most complete section of the Hillier Limestone. The rocks become progressively more micritic towards the top reflecting deepening seas. The outcrop thus records the upper Trentonian transgression.

End of trip

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FIELD TRIP NO. 6

A FEW OF THE BEST OUTCROPS IN THE NORTH COUNTRY

BY

James D. Carl, S.U.N.Y. Potsdam

STOP NO. 1 Trinity Episcopal Church, Fall Island, Potsdam, and a walk into the Potsdam business district.

Our tour will begin with Fall Island and Trinity Church and will include a short walk downtown. The community has recently been chosen for a Main Street award for its Market Street renovation project. A number of buildings have been restored or built for compatibility with the architecture of the late 1800s, the period of greatest construction in the village. This two-block section of Market Street and a portion of Raymond Street were placed on the National Register of Historic Places in 1979. Here are sandstone and brick buildings (some marble trim) of Italianate and Greek revival and other styles including the simple slab construction of the earliest commercial sandstone building (1821) that houses Eugene Earle, Jeweler. Note also, the slab and binder construction (1840) of Page One Bookstore.

Background

Little was known about the northern Adirondack region at the close of the Revolutionary War. Carlton Island and Fort Oswegatchie (Ogdensburg) were still occupied by the British, and the north shore of the St. Lawrence River was dotted with settlements of Tory refugees and their families. According to Marguerite Chapman (1969), downstate New Yorkers felt the need to establish a buffer region between English Canada and the Mohawk Valley. Settlements south of the St. Lawrence River would act as a deterrent and give warning of potential invasion from the north.

The state legislature acted to provide for the sale of wilderness land and to appoint land commissioners for its disposal. Townships of 100 square miles were created instead of the 36 square mile block adopted by the Federal government in 1785 as the fundamental surveying unit for western lands. Evidently the state government was reluctant to set up the administrative machinery necessary to sell the land in small parcels. An act of May 25, 1787, established five townships along the south shore of the St. Lawrence River and five to the south of these. Following good advertising procedures the land commissioners named some of the towns after old world cities: Louisville, Stockholm, Potsdam, Madrid, Lisbon, Canton, DeKalb, Oswegatchie, Hague (Morristown), Cambray (Gouverneur).

Public notification of the forthcoming land sale was notoriously and perhaps deliberately hurried. The announcement first appeared in the Albany Gazette on June 7, 1787, for a sale which was to be held on the 10th of July in New York City. Millions of acres were sold for a fraction of their value with a Detroit fur trader-turned-land speculator, Alexander Macomb, buying the lion's share of the pot (3,670,715 acres). Surveying, division and sale of Macomb's purchases began immediately, but evidently did not offset other financial problems because Macomb was imprisoned for debts in the 1790's. Among those solicited for land purchases were the royalty and wealthy of France. The Revolution in America was over. Northern New York promised beaver, wild grapes, maple syrup and even friends of like mind (?) and language in Montreal, a "short" boatride down the St. Lawrence River. Winters were not discussed in detail.

The town of Potsdam was eventually sold to Garrit Van Horne, David M. Clarkson and their associates on November 18, 1802. The saga of the Clarkson family from Bradford County, York, England, begins in the North Country along with the Episcopal heritage represented by this church.

Trinity Church

In early years of the Village, a small frame building on Union Street served as a school during the week and as a community church on Sunday. By the 1820s and early 30s Potsdam was a thriving community with buildings lining both sides of Market Street and stately sandstone houses along Main and Elm. Common worship of the early settlers had given way to organization and construction of churches such as that of Baptists, Methodists, Presbyterians and Universalists. Episcopalians were meeting at the St. Lawrence Academy, a three-story structure, 68 by 36 feet, built in 1825 of Potsdam sandstone and located on the site of the north end of Snell Hall on the downtown campus of Clarkson College.

Although the first Episcopalian priest is said to have visited the county in 1816, the first resident priest was called in 1834 with at least three members of the Clarkson family pledging funds for his support. The Reverend Richard Bury arrived from Ogdensburg, and the parish was formally organized under the name of Trinity Church on March 23, 1835.

The site chosen for construction of a church was Fall Island adjacent to and on the south side of the Parishville Turnpike Road. Thomas Clarkson offered stone from his quarry, free of charge, for the "neat gothic edifice of stone 44 by 64 feet." The original design for the building and name for the parish was taken from Trinity Church constructed in 1788 in New York City. The name also emphasized, for good measure, a theological distinction between Episcopalians and local Universalists. The building was completed and consecrated on a warm July afternoon in 1836. A procession that began at the Academy was concluded with a sermon by Rev. Bury on Fall Island. An engraving of the church as it appeared in 1836 (Figure 1) shows that the church lacked the tall steeple possessed by its namesake in New York. Windows were plain glass, and the high-backed, rented pews were complete with doors. Colorful upholstering was installed by pew renters accustomed to long services, and several pews were reserved for "strangers."

The side walls are about all that remain of the original structure. These walls consist of horizontal layers that alternate rows of flat-faced sandstone blocks (slabs) whose bedding is laid horizontally with rows of blocks (binders) whose bedding is laid vertically. This layer by layer alternation added style and texture to a smooth wall and was said to give added strength. Compare the slab and binder construction with that of strictly flat slabs in the Earle Jewelers building on Market Street.

The simplicity of architectural style of this early church was not acceptable in the second half of the 19th century. Victorian tastes in these parts leaned toward "roughened" (ashlar) stone construction whereby soaring walls of massive stone could be topped or garnished by highly carved stone or wrought iron decoration. The ashlar stone fence in front of the church (1867) was a prelude of changes to come. An ashlar chapel was added in 1885 and the present facade was finished in 1886. The towers capped with ornamental stone are a tribute to the skills of quarrymen and stone cutters as well as to the faithful who paid the bills. A new spirit seems to have prevailed in the church. In 1886 the pews were declared free of rent.

Windows were installed and dedicated as donations became available in the 1890s. Created by Louis Tiffany and Company of New York, the windows depict the designs of notable paintings such as Holman Hunt's "Christ the Light of the World." The beauty of these windows, accentuated by dark ash ceilings, is most striking from the inside on a sunny day. The present rector of the parish, the Rev. Canon James Pennock, is also mayor of the Village of Potsdam.

STOP NO. 2 Former Site of No. 1 Quarry of the Potsdam Red Sandstone Company about 3 miles south of Potsdam on the West Hannawa (Back Hannawa) Road, Colton quadrangle.

Introduction

Much sandstone in buildings throughout the area was taken from quarries that were strung along both sides of the Raquette River south of Potsdam Village. Several sandstone houses (about the size of large log cabins) were built between 1809 and 1820 along the Back Hannawa Road. Much stone was hauled along this road in later years to construct the homes and businesses of Potsdam.

The qualities of Potsdam sandstone were highly praised in the 1850s. The stone was cheap, available and of pleasing red coloration. Elsewhere it may be white or gray. It was also durable and not as susceptable to spalling in case of fire as was granite building stone. Iron furnaces in Ontario and New York State had sandstone lining. Note, say various appraisers, the sharpness of outline in natural exposures that has lasted "several centuries." The stone occurs in even-bedded strata and cleaves into slabs with flat faces and straight edges. There is nothing in the rock to "nourish parasitical mosses." Walls made from this siliceous stone do not become moldy and decaying as is the case with walls of limestone in damp climates. This stone keeps its color, and the claim was made that exposure to air actually hardens it. Perhaps this is over zealous advertising; it may refer to the tight silica cementation that naturally existed once broken and loosened quartz grains were brushed away. This old quarry site is now the property of Niagara-Mohawk Power Co., but sandstone is still taken on occasion for patio or building trim.

Geologic Setting

The Cambrian Potsdam sandstone has been stripped from the Adirondack dome northward to the vicinity of Potsdam Village. Present distribution of that sandstone, however, is uneven. The small park on Fall Island across from the church is underlain by Precambrian amphibolite whereas the Cambrian Potsdam sandstone of No. 1 Quarry is located to the south near the border with the Adirondack highlands.

The Potsdam sandstone is of variable thickness. It was deposited upon an irregular surface of low hills and ridges of resistant Precambrian gneisses or as filling in sinkholes where bedrock consisted of marble. Erosion nearly to the level of that surface has left many sandstone outliers scattered here and there in the Potsdam area and in Precambrian portions of the northwest Adirondacks.

The Raquette River at the quarry site has cut a channel into glacial and deltaic sediment now exposed in the bluffs of Figure 4. The quarry is located within the sandstone outlier that was buried by till deposits during glacial advance and by outwash during glacial retreat. These sediments, in turn, were covered with a layer of magnetite-bearing quartz sand that, in the vicinity of Hannawa Falls, forms a large fan-shaped delta that opens to the north. These sands probably were deposited by the Raquette River when it entered a pro-glacial lake impounded between the highlands to the south and the ice front to the north. Retreat of the glaciers was accompanied by lowering of the lake level, by entrenchment of the Raquette River into the underlying sediments, and by exposure of the sandstone outlier at this quarry. The river at Hannawa Falls, thus, has a relatively steep-walled channel. To the north, however, the braided and meandering channel seems deliberately to avoid disturbing a topography of glacially-deposited hills that consist of ribbed moraine in varying stages of drumlinoid molding (Carl, 1978).

STOP NO. 3 Sand terrace overlooking the St. Lawrence Valley, junction highway 56 with Tucker Road, 1 mile northwest of Colton, Colton quadrangle.

The transition from Adirondack lowlands to highlands occurs between Hannawa Falls and Colton. Our stop marks the southern boundary of the glacially deposited and overridden hills of the lowlands. Presumably (?) it also marks the southern extent of Fort Covington glaciation. We will walk under the power lines toward the edge of the terrace. Ottawa, the Gatineau hills and the other side of the Valley are out there but too far away to be seen. In language understood by corporate executives, the view from the top is superior, even if incomplete.

This area of transition is also the site of at least three sand terraces, the uppermost here at 800 feet elevation which includes the continuous but slightly higher surfaces (up to 900 ft.) along the Colton-Parishville road to the east. Compare terrace elevations here with those of other St. Lawrence Valley terraces as given in MacClintock and Steward (1965, p. 42). A second terrace remnant is preserved 200 feet below this level along highway 56 near Brown's Bridge road. The third or lowermost terrace begins at 580 feet and slopes northward in true deltaic fashion at Hannawa Falls. The delta ends abruptly at Sweeney Road, Potsdam quadrangle, in a northeast-trending, nearly undissected slope. This slope may represent middleset beds draped over the northeasterly end of a till hill. The contact between deltaic sands and underlying till or kame material is observed in gravel pits throughout the area.

Terrace sands consist of moderately well-sorted, angular, magnetite-bearing quartz sands that include heavy minerals derived from mountains to the south. The sands show cross bedding, channeling, climbing ripples and occasional boulders and gravel lenses. Similar sands underlie flat surfaces at lower elevations to the north including that at a recent housing development in Raymondville. Sand grains here are more rounded and contain less magnetite than at Colton. They were evidently recycled in the Champlain Sea. The uppermost terraces at Colton, Parishville and elsewhere along the Adirondack highland-lowland boundary represent the ancient shorelines of pro-glacial lakes that were impounded by retreating ice to the north. Imagine the view from this terrace at Colton roughly 10,000 years ago.

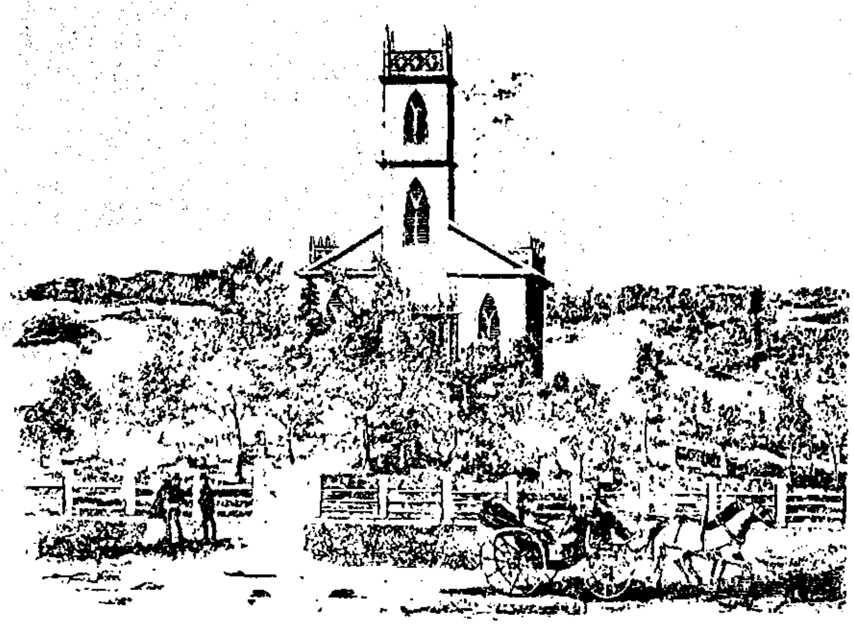


Figure 1 Trinity Church, Potsdam, in 1836. Parishville Turnpike in the foreground. Design for the church was taken after Trinity Church in New York City.

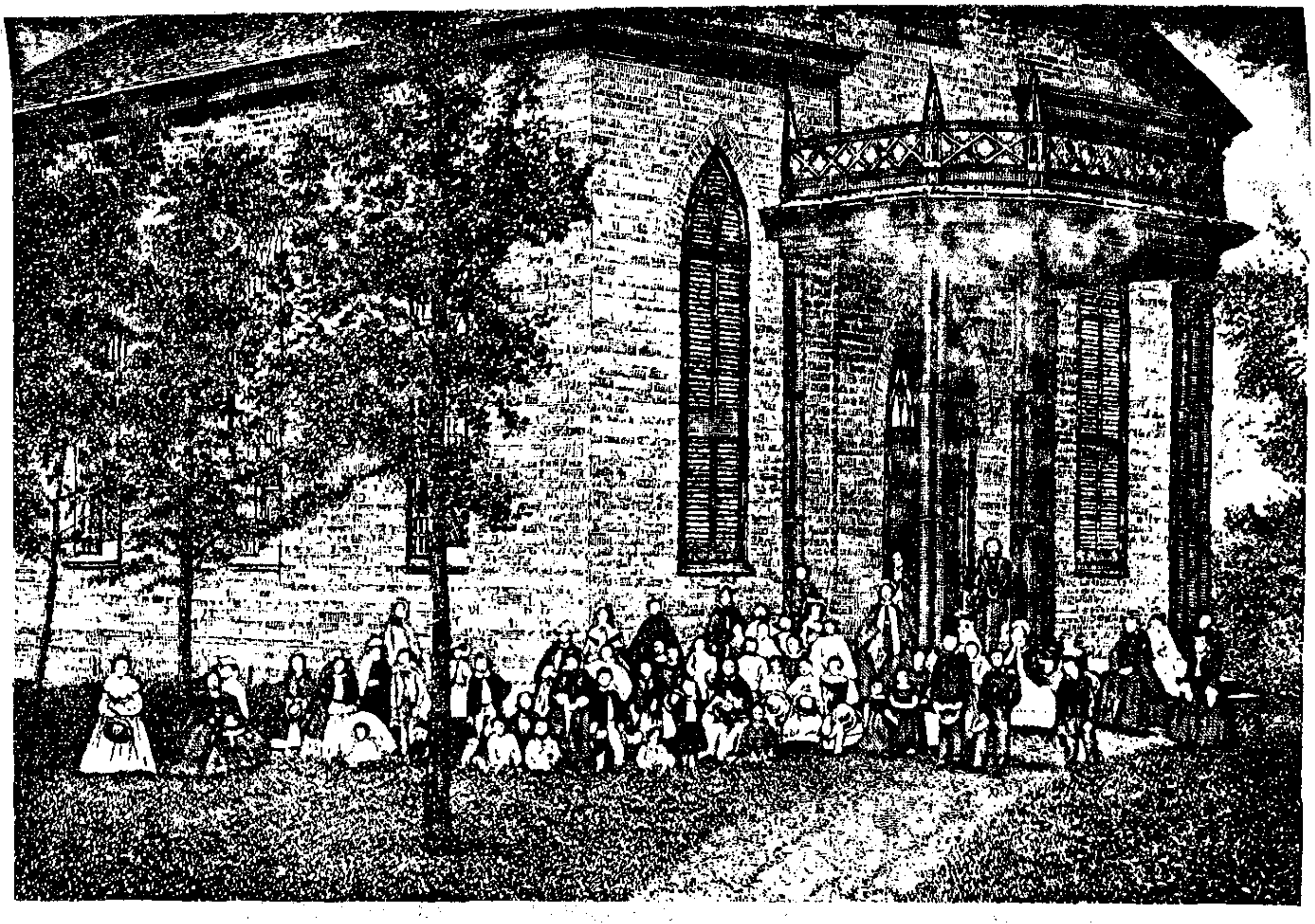
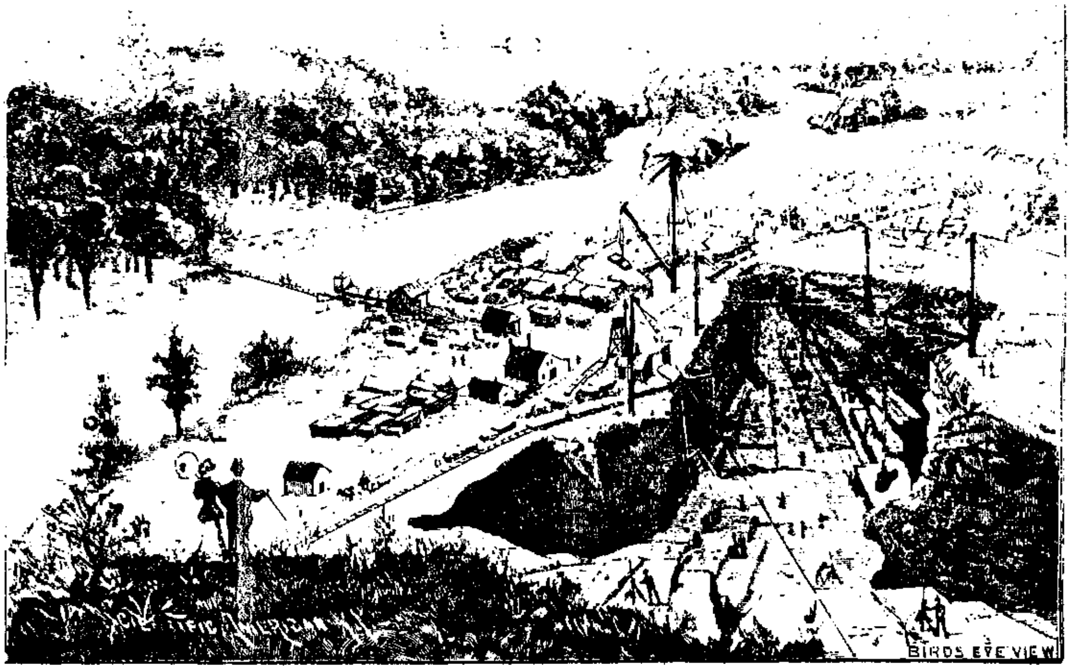


Figure 2 The slab and binder sandstone construction of Trinity Church is illustrated in this 1862 lithograph. The conical figures are teachers and students of the Sunday School. Figures 1 and 2 taken from Annie Clarkson's book "An Historical Sketch of Trinity Church, Potsdam, New York 1835-1896."



SANDSTONE QUARRIES AT POTSDAM N. Y.—[See page 8.]

Figure 3 View southward in 1892-3 over the No. 1 Quarry (now flooded) of the Potsdam Red Sandstone Company which we visit on this trip. The Raquette River flows from upper right to lower left and turns the water wheel located at the walking bridge. Note derricks and booms and numerous outbuildings for stone cutting and machine repair. The gentleman and lady are gazing over a capitalistic enterprise of considerable proportions.

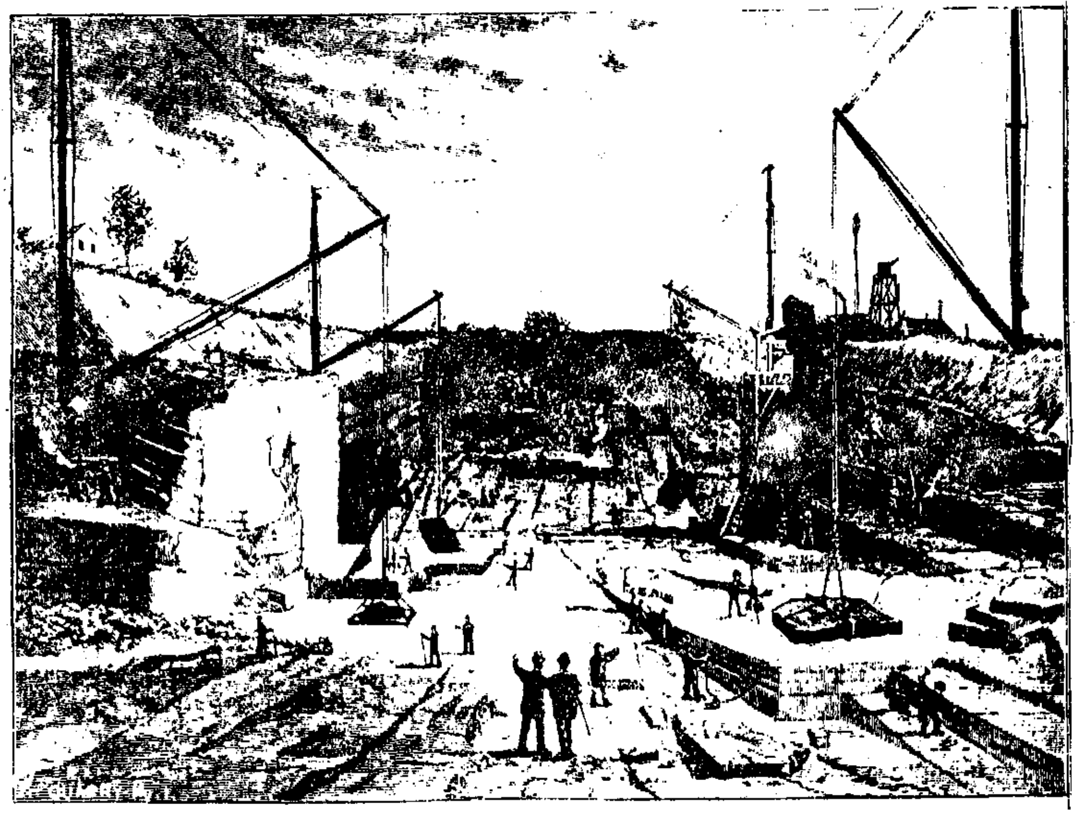


Figure 4 View from inside the quarry northward toward the elevated ground occupied by the couple in Figure 3. Steam power drills are in use, but workers in the lower right corner are using handtools to loosen slabs along bedding planes. Unconsolidated sediments in bluff to left.

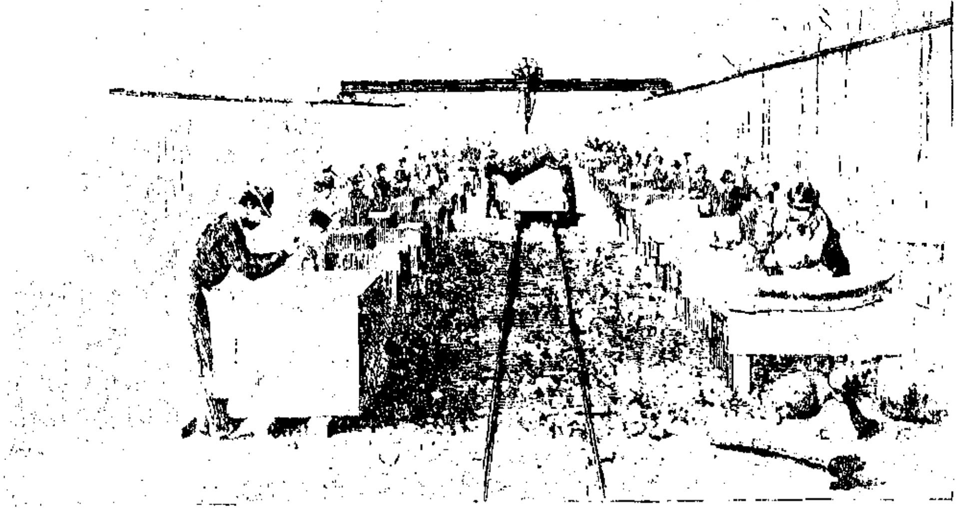
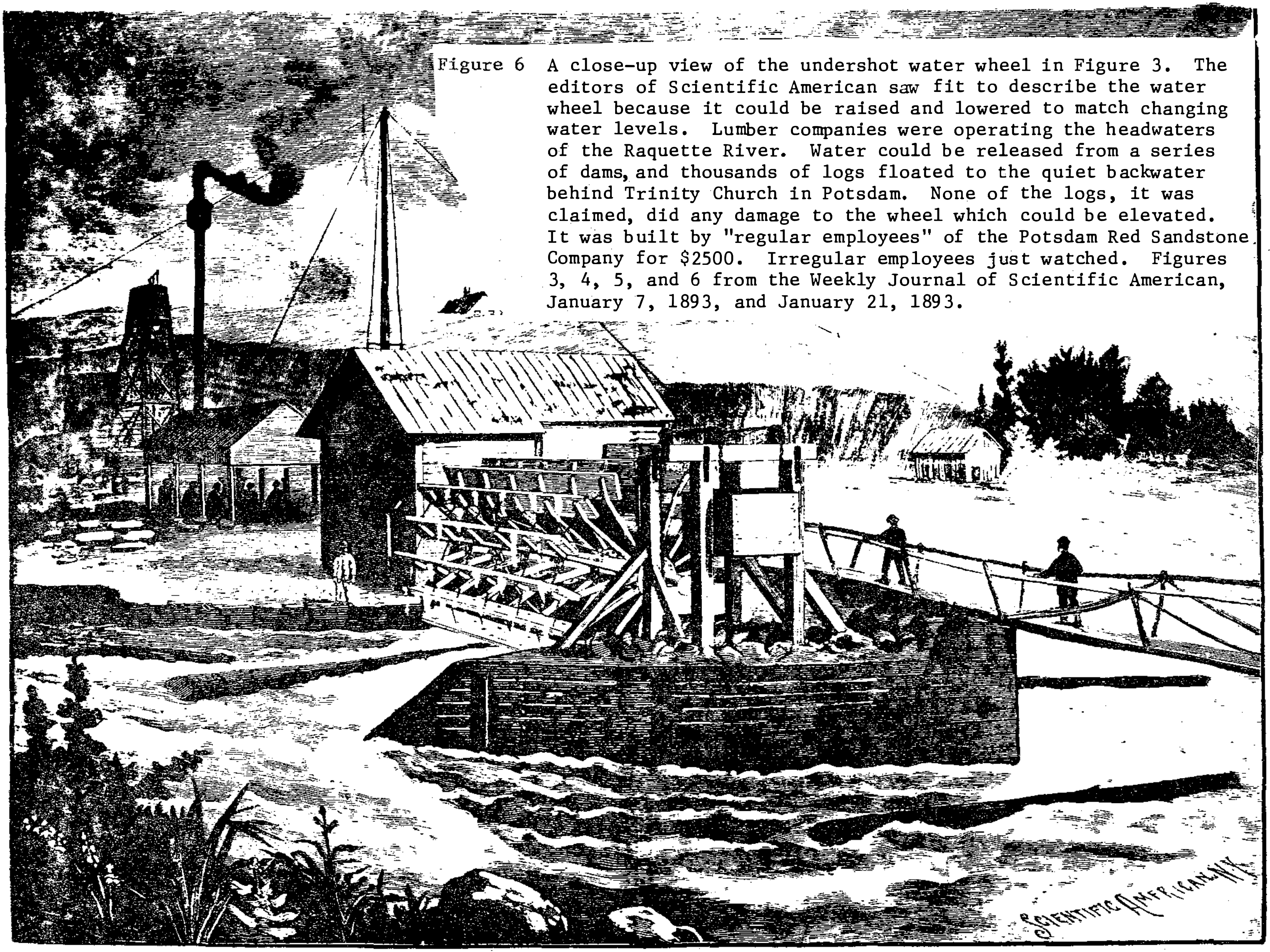


Figure 5 Interior of a stone cutting shop, perhaps the building depicted in Figure 3 to the rear of the quarry. Stone cutting was done by hand according to sketches and measurements made for each type of block. Blocks were labeled, carried to the building site, and the building was quickly assembled like pieces in a 3-D jigsaw puzzle.

Figure 6 A close-up view of the undershot water wheel in Figure 3. The editors of Scientific American saw fit to describe the water wheel because it could be raised and lowered to match changing water levels. Lumber companies were operating the headwaters of the Raquette River. Water could be released from a series of dams, and thousands of logs floated to the quiet backwater behind Trinity Church in Potsdam. None of the logs, it was claimed, did any damage to the wheel which could be elevated. It was built by "regular employees" of the Potsdam Red Sandstone Company for $2500. Irregular employees just watched. Figures 3, 4, 5, and 6 from the Weekly Journal of Scientific American, January 7, 1893, and January 21, 1893.



1. General view of wheel and outer counterpoising. 2. Side end view of wheel. 3. Bracing of wheel shaft. 4. Counterpoising. 5. Adjustment for varying water level.

ADJUSTABLE UNDERSHOT WATER WHEEL FOR VARYING WATER LEVEL, OF THE POTSDAM RED SANDSTONE CO.—[See page 38.]

STOP NO. 4 Gouverneur-type marble about 4 miles west of Canton on highway 11.

Recumbant folding of marble and a thin layer of silicate minerals within that marble. This is the "snake" outcrop described in Brad Van Diver's book, Rocks and Routes of the North Country, and in field trip 2 of this guidebook. If the spray-paint antics of anguished lovers, religious zealots and fraternity pledges permit, we will observe a diopsidic reaction rim between the marble and the layer whose mineralogy includes quartz, microcline, sphene, phlogopite, pyrite, actinolite and tourmaline. The layer may have originated as air-born volcanic ash.

STOP NO. 5 "Train wreck" outcrop. Fragments of "basaltic" rock in Gouverneur-type marble.

An outcrop eminently suited for black and white photography. Clustering of blocks and their rectangular outline suggests disruption of a basaltic dike during folding. Mineralogy of the dike, however, is adjusted to metamorphic conditions. Plagioclase is absent in contact zones in the dike rock which contains meionite scapolite, diopside, microcline, sphene, tremolite, biotite, quartz, tourmaline, and apatite. This lengthy roadcut also contains a basaltic dike that is not disrupted.

STOP NO. 6 Popple (Poplar) Hill migmatite, 1/2 mile north of intersection of highway 58 and Fowler Road, Gouverneur quadrangle.

Best exposure of Major Gneiss in the northwest Adirondacks. A good introduction to problems of origin for migmatite and for the protolith of a widespread rock type in the Canadian Shield. This oligoclase-K-feldspar-quartz-biotite, sometimes sillimanite-garnet gneiss lies between the carbonate units and is traceable for more than 70 km from Philadelphia, New York, to Colton. It is consistently gray and fine-grained except where strewn with convolute quartzo-feldspathic veins, boudins, K-feldspar porphyroblasts, amphibolites and thick sill-like bodies of leucogneiss, all of which are visible at this outcrop. See the discussion for stop number 4 in Field Trip number 4, this guidebook.

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My thanks to Kay Wyant, director of the Potsdam Public Museum, for her comments on the manuscript.

FIELD TRIP NO. 7

GENERAL GEOLOGY OF THE ADIRONDACKS

by

Bradford B. Van Diver, S.U.N.Y. Potsdam

Introduction

The purpose of this half-day trip is to take a broad, general view of the geology of the Adirondacks and bordering St. Lawrence Lowland in a traverse from Potsdam to the top of Whiteface Mountain. It is especially designed so that participants (in private cars) from east or south of the mountains will be that much closer to home at the conclusion of the trip, at about 1:00 p.m.

The route first follows N.Y. 11B from Potsdam to Nicholville, then N.Y. 458 to Meacham Lake junction, then N.Y. 30 to Paul Smiths, then N.Y. 192 and 192A to Saranac Lake, then N.Y. 86 through Lake Placid to Wilmington. From Wilmington, we will follow the Whiteface Memorial Highway to the "Castle," and finally climb the ridge trail on foot to the summit (or take the elevator, if you wish).

From Potsdam to Hopkinton, the route follows rolling farmland with fields locally littered with glacial erratics. The road lies just north of the Precambrian/Paleozoic boundary. At about Southville, it passes over the concealed Highlands-Lowlands Adirondacks boundary, which is principally tectonic and separates predominantly metasedimentary-metavolcanic rocks of the Lowlands from metaplutonic rocks of the Highlands. Nearing Hopkinton, and continuing to Nicholville, an elevated portion of the road permits excellent panoramic views northward to the low flat terrain of the St. Lawrence Lowland. At Nicholville, we pass over the east branch of the St. Regis River where, a short distance upstream, the Nicholville gorge exposes basal conglomerates of the Potsdam Sandstone (the Nicholville conglomerate). At the Fort Jackson gorge a few miles downstream, and north of Hopkinton, more "normal," well-bedded Potsdam is exposed.

Between Nicholville and Santa Clara, the road becomes much more rolling and winding as it passes over metamorphic Precambrian bedrock. There are not many bedrock cuts or open views in this section. At St. Regis Falls, the ledge that sustains the falls consists of dark amphibolitic gneiss with pink granitic veining. Beginning at Santa Clara, and continuing for 10 miles nearly to Meacham Lake junction (N.Y. 30), almost all of the rock cuts consist of dark green, massive, syenitic or mangeritic (pyroxene syenitic) gneiss. In this section also, and continuing to Paul Smiths, the views of Adirondack foothills become much more frequent and open, revealing a knobby, rounded, rather streamlined topography that reflects extensive glacial scour. Very noticeable as we near route 30, is the pronounced assymmetry of the foothills that is characteristic of this region, with gentle stoss sides facing north and cliff sides south that betray a southward, overriding, ice advance. Another notable feature between Santa Clara and Paul Smiths is the abundance of cuts in very sandy, gravelly drift, with local boggy hollows between them. From Meacham Lake junction to McColloms, (about 4 miles) route 30 parallels the Osgood River, which flows alongside a well-defined esker as it empties northward into Meacham Lake. The road crosses a marshy segment of this short stream just south of McColloms.

From Paul Smiths to Saranac Lake, we pass through one of the most scenic, open regions of the Adirondacks. At Gabriels, the scene is decidedly western in character, with a 360° panorama across open potato fields that incorporates the High Peaks in a sweep from east to south, and the foothills in all other directions. The pointed summit and slide-scarred face of Whiteface Mountain stands out like a sentinel almost directly to the east. Gabriels is so blessed because it lies on a sandy lake plain where the soil and climate are well-suited for potato farming.

If anything, the views of the High Peaks are even more spectacular between Gabriels and the junction with N.Y. 86, where the road traverses an east-facing slope above hayfields and marsh bordering Twobridge Creek. The superior height of the High Peaks, which here seem close enough to touch, is largely a function of two factors: 1) the massive, weakly jointed anorthosite bedrock that underlies most of them resists erosion more than the surrounding rock types; and 2) they lie at the crest of the Adirondack Dome which, even now, is experiencing the most rapid uplift.

Saranac Lake lies near the eastern border of the Saranac Intramontane Basin, an anomalous structural depression that stretches for about 35 miles in a northeasterly direction, and varies from 10-15 miles wide. Nearly all of the basin lies between 1540 and 2000 feet. The few bedrock hills, jutting no more than 460 feet above the floor, are probably best described as umlaufbergs - bedrock knobs surrounded by glacial drift, and probably also, in this case, glacio-lacustrine deposits. There are about 50 lakes of a mile or more in diameter in this basin, and well over a hundred smaller ones, making it a canoest's paradise. There are, in fact, so many lakes, that it is commonly referred to as the "Lake Belt."

From Saranac Lake to Lake Placid, the visibility is not nearly so good as that of the Gabriels-Saranac Lake section, as trees and high mountains close in. One of the best open scenes is over the Saranac Lake golf course. The slide-scarred Whiteface summit and surrounding mountains again come into full view in approaching and passing through Lake Placid Village. The Village is situated on Mirror Lake, a much smaller lake south of the ladder-shaped Lake Placid.

Continuing on N.Y. 86 from Lake Placid to Wilmington, we pass through the lovely, narrow, and steep-walled rocky gorge called Wilmington Notch, and then out into the open again past the Whiteface Mountain Ski Center and the Flume. Up to that point, the road follows close alongside the West Branch Ausable River, one of the prettiest of the Adirondack streams, and a favorite among fishermen. The Notch is one of the most conspicuous, narrowest, and deepest of the northeast-trending lineaments so prevalent in the central Adirondacks that have formed by erosion of fault zones. It played important roles in channeling ice movement during Wisconsin glaciation, and in the development of meltwater lakes during glacial retreat.

After leaving Wilmington, and passing through the toll gate on Whiteface, we will go directly to the "Castle" at the end of the road, and park for a climb to the summit. The climb, both by car and foot, represents a scenic climax of the trip. The vistas from the road, of the Saranac Intramontane Basin, Lake Placid (from the first hairpin turn, called the Lake Placid turn), the Wilmington Range, Wilmington Basin and High Peaks (from the second hairpin, or Wilmington Turn) and of the cirque-hollowed rock peak itself, are simply breathtaking. The ridge trail from the Castle to the summit surpasses even that, for here you are perched on a narrow arete between the steep headwalls of two large cirques (the route is well protected with railing). From the summit you will be able to see all of the features already mentioned and, in addition, you will be able to look right down into Wilmington Notch that we passed through earlier and to survey the scalloping of the mountain by the several alpine glaciers that once coursed down its sides. At this point, we will walk around the summit to survey the whole scene, and try to formulate a comprehensive picture of the geomorphic history.

One additional stop will be made on the road down the mountain, to examine a bank of glacial drift that contains suspected fragments of Potsdam Sandstone.

Field Trip Stops

No mileages will be logged for the following Stops. Instead, we will make the stops at the indicated times, holding to a fairly strict schedule, assuming that the trip started promptly at 8:00 a.m.

STOP 1. 8:30 a.m. (10 minutes) Fort Jackson gorge, located 2 miles north of Hopkinton on County 34. Go to the second bridge over the St. Regis River, and park. For about a mile before Hopkinton on 11B, there are open views to the St. Lawrence Lowlands, that give the distinct impression of looking out to the sea over a gently sloping coastal plain. Here, at Fort Jackson, are some clues as to why. The well-bedded and strongly cross-bedded (Keeseville member?) Potsdam Sandstone dips gently northward away from the Adirondack Dome, presumably as a consequence of its geologically recent and ongoing uplift. The gentle slope "to the sea" apparently is the dip slope developed on the resistant Potsdam Sandstone. A few miles upstream in the Nicholville Gorge, the Nicholville

Conglomerate rests directly on Precambrian gneisses, and represents either basal Potsdam or a sub-Potsdam unit.

STOP 2. 9:20 (10 minutes) Parking area 8 miles southeast of Santa Clara. The bedrock cuts here are dark green, massive, syenitic, or mangeritic (pyroxene syenitic) gneiss, like those seen in passing Santa Clara and several more cuts to here. This peculiar rock-type is widely distributed in the Adirondacks, in association with anorthosite, charnockite (hypersthene granite) and various other members of the anorthosite clan. The large erratic boulders placed along the edge of the parking area display some of the other major rock types of the Adirondacks.

This is also a good place to view the low, knobby, glacially-scoured landscape of the foothills country. Extensive glacial polish and striae are visible in exposures about a quarter mile back from the parking area.

STOP 3. 9:55 (10 minutes) Gabriels, scenic camera stop.

STOP 4. 10:45 (30 minutes) High Falls Gorge. This is a commercial tourist attraction located at the north-east end of Wilmington Notch, where the West Branch Ausable River drops over 100 feet. The river follows the Wilmington Notch fault zone and cascades over a resistant mass of granite (Figure 1). Numerous fractures in the gorge are intruded by diabase dikes that weather in recess. Dikes like these (and sills) are extremely common in the Adirondacks. Sixty-one were recorded by W.J. Miller in his geologic study of the Lake Placid quadrangle (1919). Though definitely post-Grenville, their ages probably vary widely. Here, for example, they intrude fractures presumably related to the late Ordovician Taconic Orogeny. Elsewhere, as in the Lowlands Adirondacks, many are pre-Potsdam.

The rushing water has produced numerous potholes in the hard bedrock of the streambed, some of very large size.

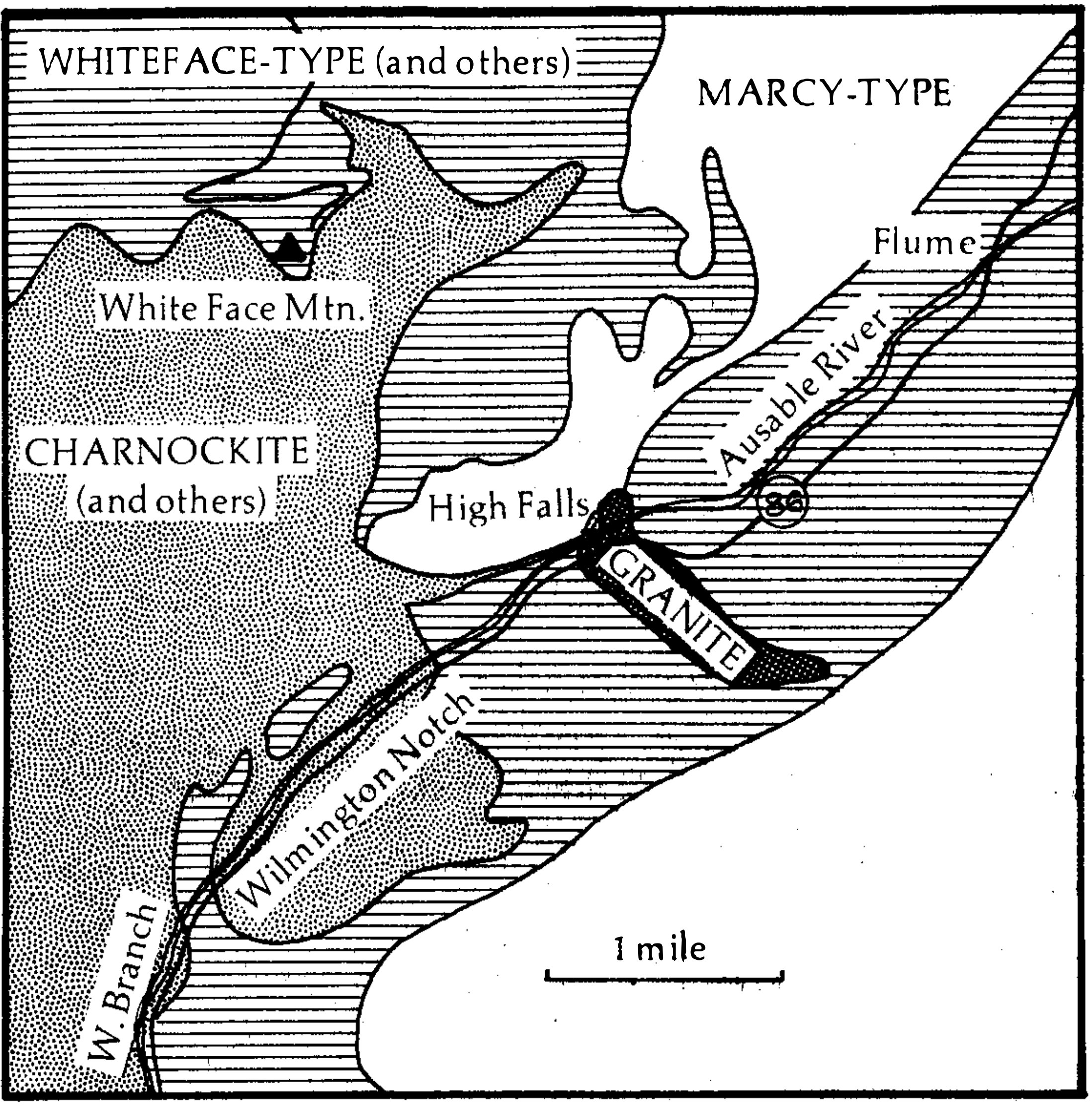

Figure 1. Simplified geologic map of the Wilmington Notch-Whiteface Mountain area, adapted from Crosby (1968).

Similar features may also be seen in the Flume and adjacent roadcut about 2 miles farther east, where N.Y. 86 crosses over the river.

STOP 5. 11:45 (30 minutes)

Whiteface summit. The rock of the summit is Whiteface-type metanorthosite. The Adirondack metanorthosite is a large, massif-type, anorthosite body of thick slab-like form that underlies most of the High Peaks region. Its igneous emplacement predates the Grenville Orogeny, and thus, it has been metamorphosed along with nearly all of the other Adirondack lithologies. Most of this large mass consists of a coarse-grained, porphyroclastic facies, called Marcy-type, in which plagioclase porphyroclasts commonly measure several inches in length, and rarely more than a foot. Whiteface lies near the northern border of the mass where, presumably, the shear and chill effects associated with emplacement are responsible for the finer grain size, more gneissic texture, and more gabbroic composition of the Whiteface-type (Figure 2). The structural and petrologic picture, however, may be considerably more complex, as indicated by Crosby (1968), who considers the rocks here to be part of the Jay-Whiteface Nappe, and who has mapped complex interstratification of Marcy- and Whiteface-types with charnockite, mangerite, other gneisses below the summit. Figure 1 gives a highly generalized picture of the distribution of the major rock types around the mountain.

The effects of alpine glaciation are well represented on Whiteface by several aretes, cirques, and U-shaped valleys downslope from them (Figure 3). In historical perspective, Wisconsin glaciation at climax about 20,000 years ago, covered the Adirondack peaks with a thick blanket of ice. The ice thinned during glacial recession until the higher peaks projected through, but residual ice masses remained in the existing mountain valleys. The resulting alpine glaciers persisted for long enough to carve the distinctive features noted here and present throughout

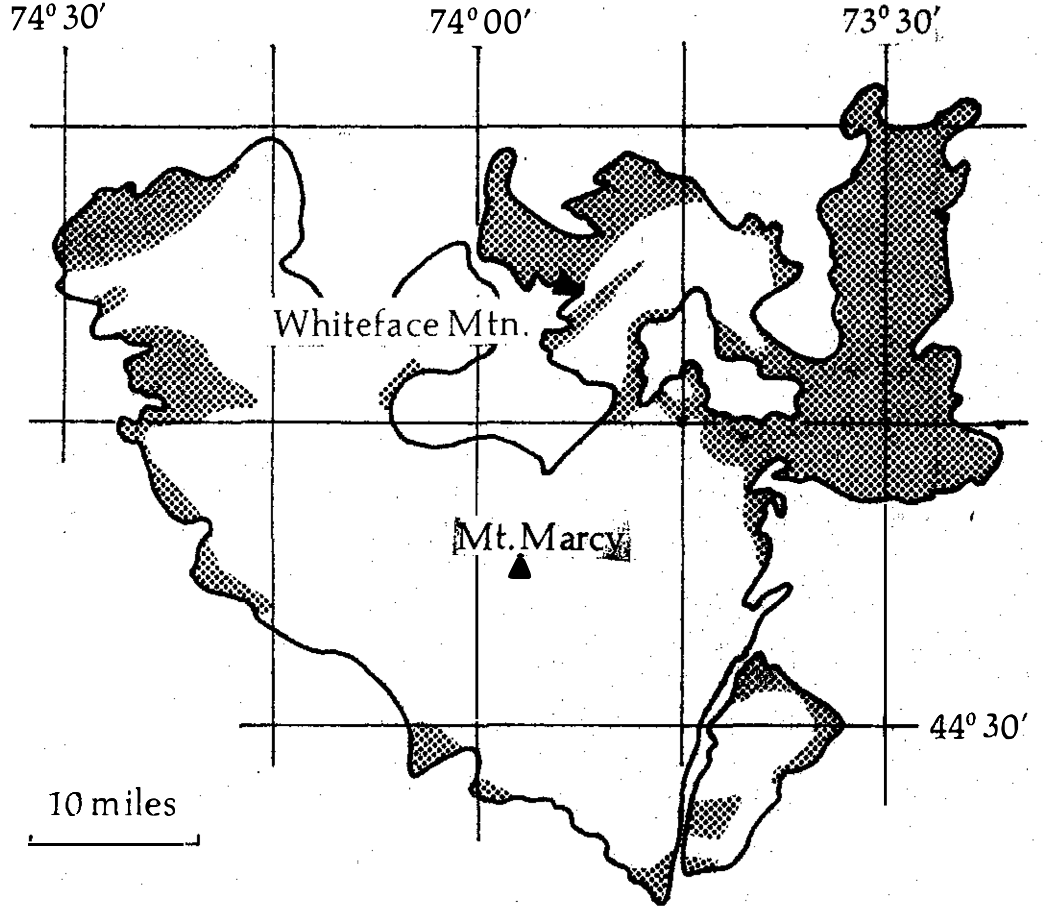

Figure 2. Simplified geologic map of the Adirondack Anorthosite (Marcy Massif), showing the distribution of Marcy-type (unshaded) and Whiteface-type (shaded). From Isachsen and Moxham (1968).

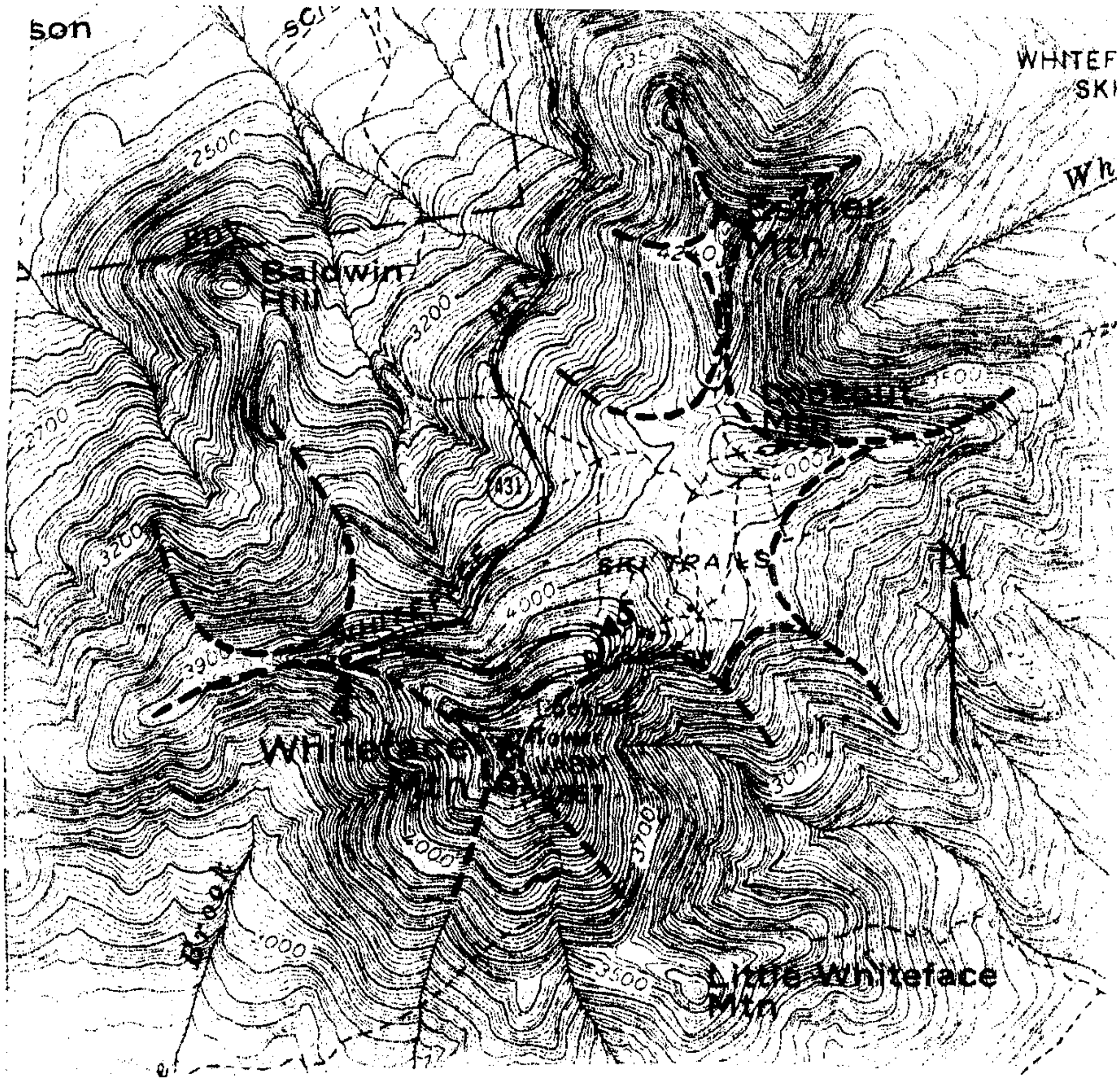

Figure 3. Section of the Lake Placid 15' guadrangle topographic map, showing Whiteface Mountain with the principal glacial cirques outlined.

the High Peaks region. In the Catskill Mountains glacial cirques formed contemporaneously are much better developed, owing to the lesser resistance of the sedimentary rocks there, and to their nearly horizontal stratification.

The peculiar, ladder-shape of Lake Placid, and in fact, its very presence, demand further explanation. The lake occupies a system of crossvalleys developed first by stream erosion of fault zones, and then later deepened and widened by ice advance. It is now dammed at its southwestern end around Lake Placid village by moraine.

The role played by Wilmington Notch in pro-glacial lake development can best be appreciated in the view from the summit. From here, it is seen as a very narrow constriction between two large moderately-level lake plains. Figure 4 shows three stages of deglaciation in this region, with ice first blocking drainage through the Notch, and later melting away to permit convergence of the impounded waters on either side of it.

Other features to note from the summit are:

1) Lake Champlain in the distance opposite to the Lake Placid direction.
2) The profile of the High Peaks region in a sweep from southwest (across Lake Placid) to southeast (ca. 90° to left of Lake Placid).
3) Northeast-trending notches and valleys other than Wilmington Notch.
4) Slide stripes on steep, smooth cirque walls, on Whiteface, and on some of the other peaks.
5) Sheeting of the summit rocks.
6) Representative rock types in the retaining wall near the "Castle."

STOP 6. 12:30

Glacial drift bank on Whiteface highway below the Lake Placid turn. This is a bouldery, sandy, well-washed deposit probably best described as a kame, but

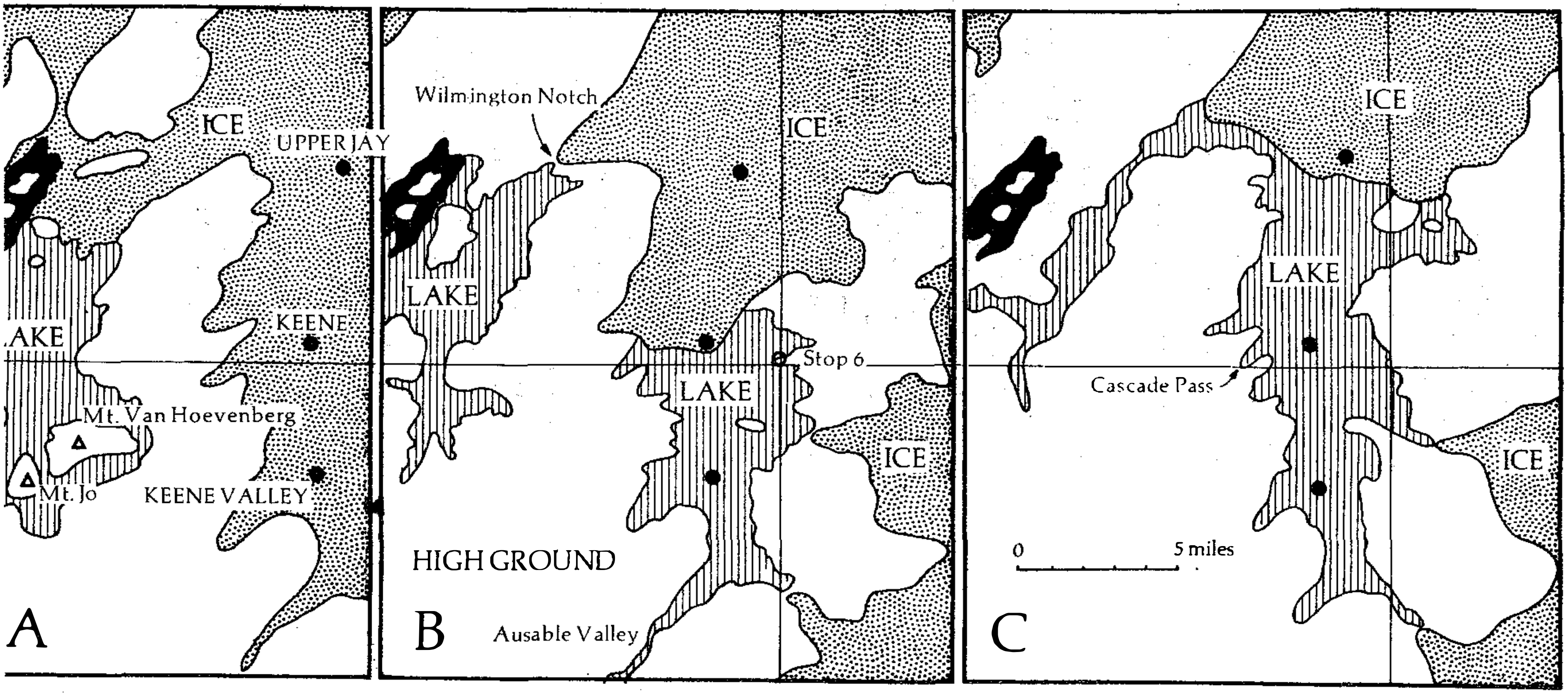

Figure 4. Three successive stages of deglaciation in the Lake Placid-Jay-Keene Valley region, after Alling (1919).

lacking visible stratification (concealed by slopewash?). Pick around among the fragments to see if you can find some Potsdam Sandstone. What would its presence mean in terms of glacial history?

End of trip. Have a safe journey home!

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TRIP 8

GLACIAL GEOLOGY AND SOILS OF THE ST.LAWRENCE-ADIRONDACK LOWLANDS AND THE ADIRONDACK HIGHLANDS

by Michael Kudish

Introduction

A marked difference between the St.Lawrence-Adirondack Lowlands and the Adirondack Highlands does not only occur in the bedrock, but in the glacial deposits, soils, vegetation, growing season, and land use as well. We begin at Potsdam in the St.Lawrence-Adirondack Lowlands at an elevation of 440 feet (134 m) and climb gradually onto the Adirondack Highlands at Paul Smith's College (elevation 1650 feet or 503 m), some 50 miles (80 km) to the southeast. During this tour we will see great changes:

	St.Lawrence-Adirondack Lowlands	Adirondack Highlands
Bedrock	Precambrian, marble-rich, gneisses; Cambrian sandstones; limestones and dolostones of Ordovician age.	Precambrian gneisses, marble-poor. Metanorthosite.
Glacial drift	Crushed rocks listed above plus Canadian Precambrian gneisses.	Crushed rocks listed above plus Canadian gneisses and Cambrian sandstone.
Soils on well-drained sites	Mostly Inceptisols developed in silty and loamy drift. Locally some Alfisols in high-clay drift. Less leached, not strongly banded, dull-colored, neutral to slightly acid, fertile.	Mostly Spodosols, developed in sandy drift. Highly-leached, strongly-banded, brightly-colored, very acid, infertile. Sandy loams very locally in siltier drift.
Growing season	Longer frost-free period due to lower elevation despite more northerly latitude: 140 days at Canton, 150 at Watertown.	Shorter frost-free period due to greater elevation: 103 days at Wanakena, 112 at Tupper Lake, 99 at Lake Placid.
Vegetation	Northern hardwoods plus rich-site hardwoods. Also Red and Bur oaks, Red ash, Shagbark and Bitternut hickories, Cottonwood, Cork elm.	Northern hardwoods on tills (STOP 3A & 3B). Spruce-Yellow birch Mixed Woods on outwash (STOP 4). Rare rich-site hardwoods on siltier sites.
Land use	Agriculture	Forestry

On the Highlands, we will contrast soils and vegetation developed on glacial till and on glacial outwash, both well-drained. We will observe a bog, and, if time permits, an Adirondack Highlands "rich site" on siltier soils.

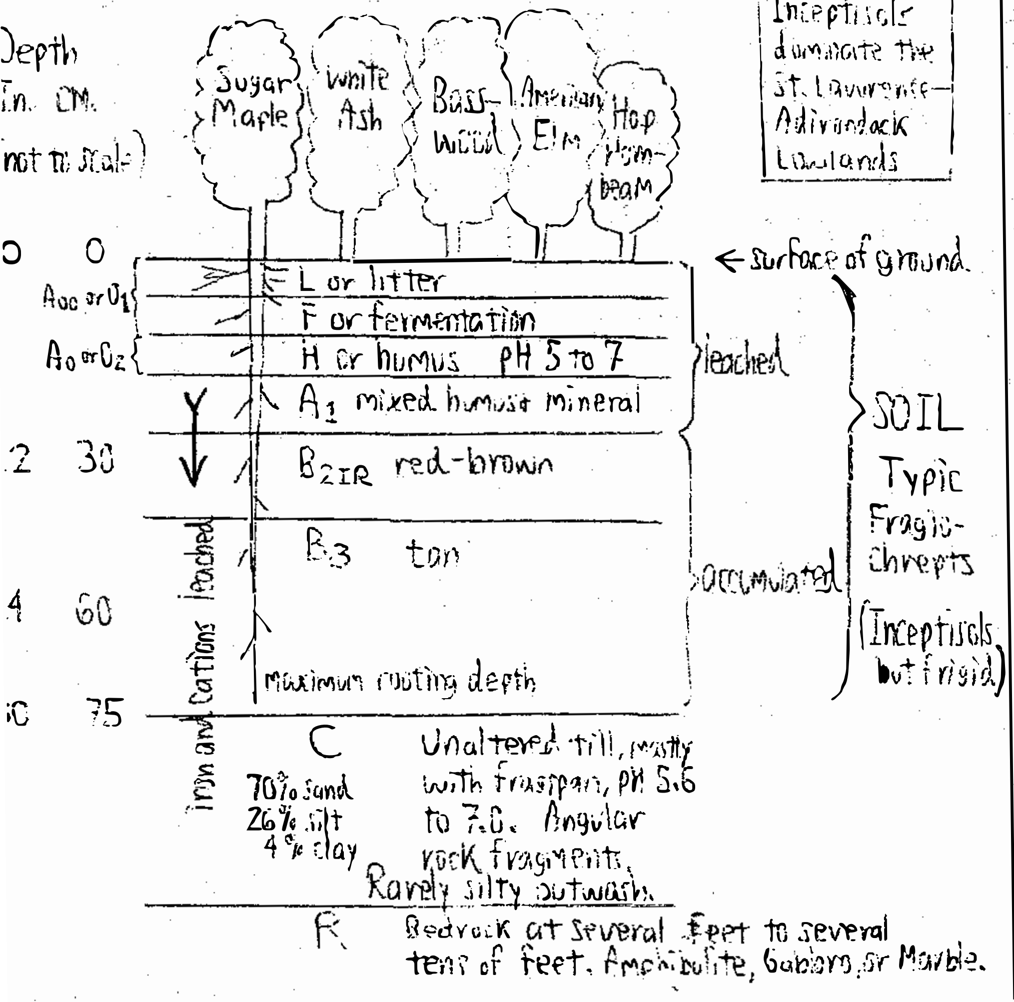
Road Log

Total Mileage	Mileage From Last Stop	
0.0	0.0	Turn left (south) from Barrington Drive on the S.U.N.Y. Potsdam Campus into N.Y. State Route 56 (Pierrepont Avenue).
1.1	1.1	Turn left (southeast) on N.Y. Route 72.
8.7	8.7	Delta of the West Branch St. Regis River into Lake Iroquois at the 900-foot level. View of Parishville Desert (Stop 1) to the north (left) across the River.
9.1	9.1	Cross West Branch St. Regis River and enter Parishville.
9.3	9.3	Turn left (north) from Route 72 onto School Street in Parishville.
10.3	10.3	STOP 1. PARISHVILLE DESERT. According to Van Diver (1976), this is a delta built into Postglacial Lake Iroquois by the West Branch St. Regis River at the 900-foot level. The delta is now deeply dissected, the Desert only a remnant. Much of the material (mostly fine sand) of the delta was probably carried south of Parishville by the ice sheet and then returned north by the River. Sand-blasted ventifact cobbles and boulders are Potsdam Sandstone, Adirondack Highlands gneisses, Canadian gneisses, and Bucks Bridge limestone (a dirty-brown, strongly-weathered part of the Theresa Formation). Van Diver's hypothesis that upper soil layers have been removed by wind erosion is verified by digging a soil pit; the B_{21r} horizon is directly under the surface in places, the upper A horizons being absent. A plantation of Scots (and a few Jack) Pines has provided the seed source for naturalized reproduction of these species. Other pioneers on the droughty, infertile soil are Gray and Paper Birches, Trembling aspen, White pine, Red maple, Fire cherry, Bracken fern, and Pilose Hair-cap moss. Return to Route 72 in Parishville.
11.3	1.0	Turn left and continue east on N.Y. 72.
17.7	7.4	End N.Y. 72. Turn right (east) on Route 11B in Hopkinton.

Total Mileage	Mileage From Last Stop	
19.8	9.5	Turn right (south) on N.Y. 458 from Route 11B in Nicholville. Note the change in land use from existing farms to abandoned farms to forest in only several miles as we climb from the St. Lawrence Valley Lowlands to the Adirondack Highlands. The contact between the Potsdam sandstone and the Highlands gneisses is about two miles south of this intersection but concealed by thick glacial drift. Note also the pioneer vegetation on the abandoned farms: Aspens, Balsam Poplar, Paper and Gray birches, Red cherry, Serviceberry, Meadowsweet, and White pine. Elevation 800 ft.
22.2	11.9	Cut in glacial outwash on left (northeast).
23.0	12.7	First cut in Adirondack Highlands rock. The 1970 Geologic Map of New York identifies it as "amg", interlayered amphibolite and granitic, charnockitic, mangeritic or syenitic gneisses. Elevation 1060 feet.
23.3	13.0	Leave St. Lawrence County and enter Franklin County at the bridge over Lake Ozonia Outlet. Elevation 1000 feet.
24.1	13.8	Gravel pit in glacial till on right (north) and another pit 0.3 mile further.
26.0	15.7	Basswood trees in this area. For this Adirondack rarity, see Figure 1. Basswood indicates rich, fertile soil in the Highlands. Elevation 1300 ft.
27.0	16.7	Cross St. Regis River into community of St. Regis Falls. The falls are over "amg" just out of sight to the left (northwest).
27.1	16.8	Route 458 makes a right-angle bend to the south and recrosses the River. Elev. 1250 ft.
29.7	19.4	amg rockcut on south (right). Elev. 1580 ft.
32.0	21.7	Gravel pit in till on left (north). Another pit at 32.8 miles total.
33.4	23.1	Several rock cuts in "phgs" symbol on 1970 Geologic Map of New York. These are charnockitic, granitic, and quartz syenitic gneisses (see also Buddington, 1937).
33.7	23.4	Recross St. Regis River. Elevation 1337 ft. Community of Santa Clara.

Figure 1: Optional Stop

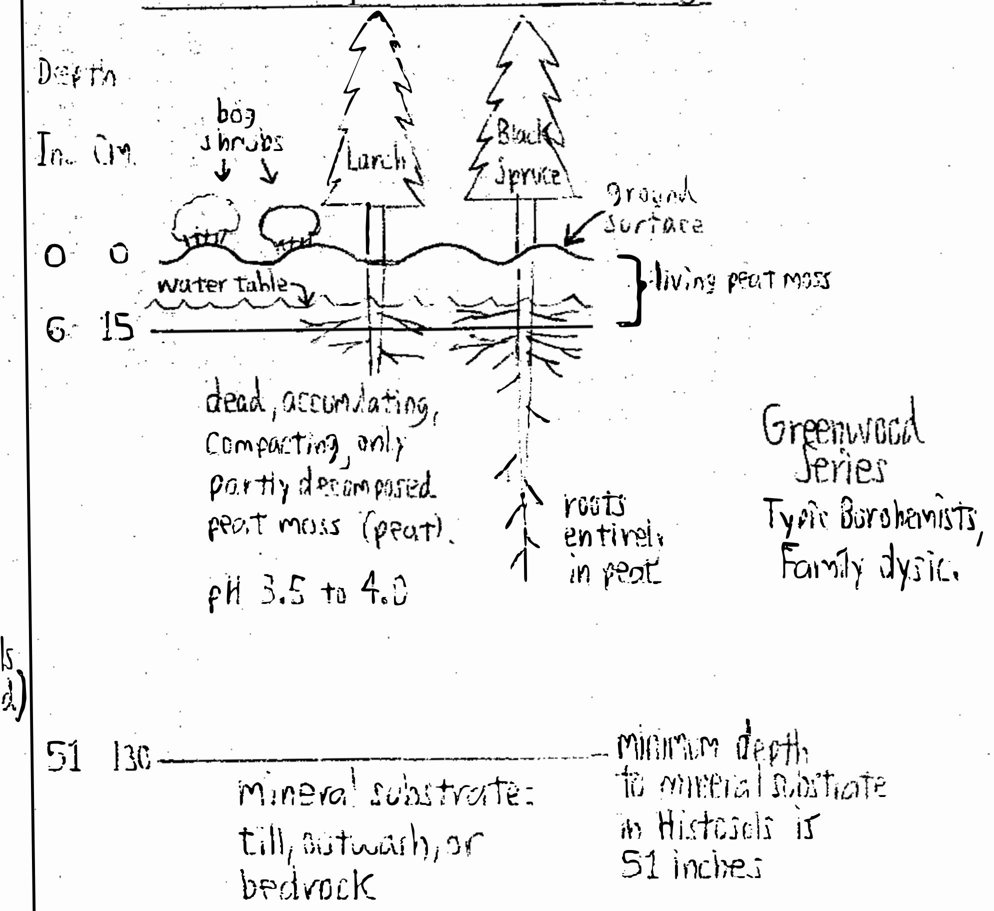
Adirondack Highlands Rich Site



Inceptisols dominate the St. Lawrence–Adirondack Lowlands

Figure 2: Stop 2

Soil Developed in Peat – a Bog



Greenwood Series

Typic Borohemists, Family dysic.

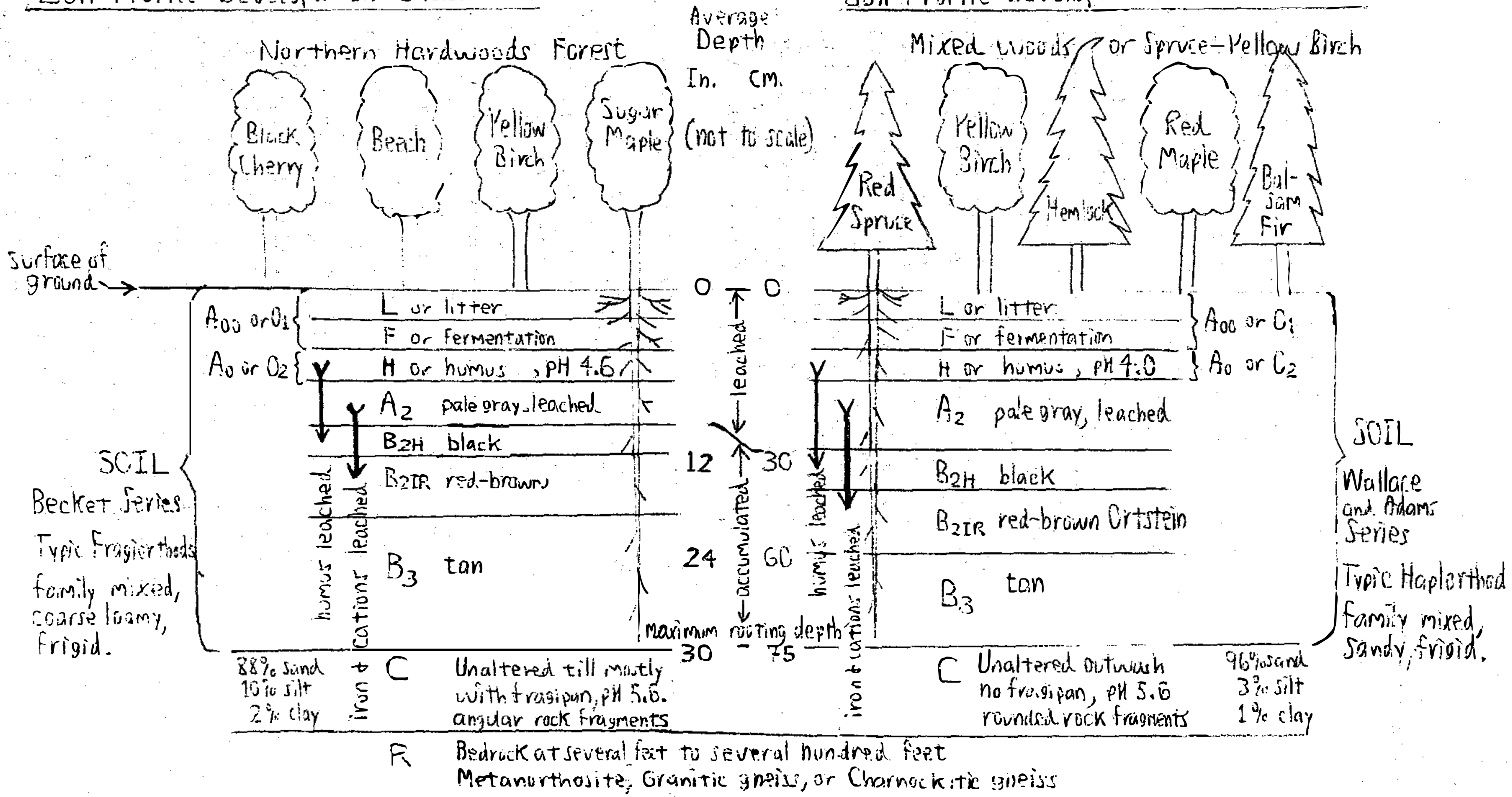
Total Mileage	Mileage From Last Stop	
34.0	23.7	Rock cut in phgs. Shallow soils surround outcrops in the Highlands and often Red spruce and Hemlock predominate. On the deeper, well-drained till soils we have Northern Hardwoods (Beech, Yellow birch, Sugar maple).
34.4	24.1	A Balsam swamp. Poorly-drained areas lacking Peat moss are dominated often by Fir.
35.2	24.9	Rock cut in phgs and a till cut at Mileage 36.0. Elevation 1650 feet.
37.7	27.4	Parking area. Note Northern Hardwoods.
39.4	29.1	Deep cut in glacial outwash. At Total Mileage 39.9, the Town of Santa Clara is using another outwash mass for sanding roads in winter.
40.4	30.1	**STOP 2. BLACK SPRUCE BOG.** Elevation 1450ft. This extensive bog extends to Total Mileage 40.9; stop anywhere along its half-mile length. Note the resemblance to northern Canadian or Alaskan muskeg. Poorly-drained soils are classified by the U.S. Soil Conservation Service as Histosols where at least 51 inches (1.3 m) of organic matter overliesthe glacial drift or bedrock. All living plants and trees are fully rooted in the organic matter; no roots penetrate the mineral substrate. The dominant ground cover plants are the Peat mosses (*Sphagnum* spp.); when these mosses die, they accumulate, decay only partially, become compressed, and create extremely acid (pH 3 to 4) peaty soils. Most mineral nutrients are in limited supply so that the plants which grow here must survive on very low concentrations. A few of the plants have adapted to this environment by capturing insects as a nitrogen supplement (Sundews and Pitcher plants), while most others use mycorrhizal fungi to greatly extend the root absorption surface. Among the spruces in more open areas are Cranberries, Labrador Tea, Bog Laurel, Bog Rosemary, Leatherleaf, and Cottongrass sedge. See Figure 2 .
41.1	0.7	First of a series of rock cuts extending for 0.6 mile. A parking area is at Total Mileage 41.5. The westerly cuts are in phgs but the easterly are in "hbg", biotite and/or hornblende granitic gneiss (Buddington, 1937).

Total Mileage	Mileage From Last Stop	
43.5	3.1	End Route 458. Turn right (south) on N.Y. Route 30. Elevation 1600 feet.
44.7	4.3	Rock cut in phgs. Elevation 1645 feet. From here for the next 4.7 miles, N.Y. 30 crosses a large, rolling outwash plain with numerous cuts and fills across kames, kettles, and crevasse fillings. Much of this area, called McColloms, was burned over in 1903 and earlier, and has been covered with pine plantations.
49.4	9.0	Rock cut in "a", Marcy Metanorthosite (Buddington, 1953; Davis, 1971). Mountain Pond on the left (northeast) is bounded on the west by an esker and on the east by bedrock. Mountain Pond elevation 1634 ft.
50.4	10.0	Barnum Pond on the right (west). View of Jenkins and St. Regis Mountains beyond, the northwesternmost outposts of the Metanorthosite in the Adirondacks.
50.8	10.4	**STOP 3A. GLACIAL TILL.** This cut is in glacial till with a loamy sand texture (average 88% sand, 10% silt, 2% clay), consisting mostly of crushed Metanorthosite, gneisses, and Potsdam Sandstone. It is often quite hard and dense, with silt grains cementing the sand and angular gravel fragments into a fragipan. The vegetation above this cut had been cleared for farmland and then was reforested both naturally and by people. The trees and plants you see here are pioneers; we must go to **STOP 3B** to see natural vegetation on a well-drained till site.
51.1	0.3	Turn left (east) up hill into Beech Hill Road (unmarked), a single-lane paved road.
51.4	0.6	**STOP 3B. NORTHERN HARDWOODS ON TILL.** Park on left (northeast) side of road opposite first house. This road cut shows a typical soil profile developed in the upper 30 or so inches (0.75m)of well-drained glacial till. Soil can be defined as the zone of interaction between parent material (here till) and forest; it is only about 30 in. thick in most places as few roots penetrate deeper. Because of the sandy nature of the till, the soil which develops in it is characterized by rapid leaching (removal of organic matter and minerl material) from the upper or A horizons and deposition in the lower or B horizons. Such soil profiles developed in sands are very colorfully

Total Mileage	Mileage From Last Stop	
		banded although infertile and are called Spodosols (formerly Podzols). The soil series here is Becket, a Typic Fragiorthod, family coarse-loamy,mixed,frigid. The C horizon is unaltered till in its original state, underlies the soil rather than is a part of it, and is not visible here without further excavation. The forest which develops on well-drained tills such as Becket soils is a Northern Hardwoods Forest with Beech, Yellow Birch, and Sugar maple dominant. Walk up the old log road to the left (north) of the cut for a quarter of a mile or so to see this forest. Other trees are Striped maple, Hemlock, Red spruce,and perhaps Black cherry. See Figure 3. The elevation at the road cut is 1680 feet. Marcy Metanorthosite outcrops on the summit of 1863-foot nearby Beech Hill. Common ground cover plants are Spinulose woodfern, Wood sorrel, Clinton's lily, Canada mayflower, Starflower, Wild sarsaparilla, and Purple trillium. Humus pH averages 4.5 to 4.7 under Sugar maple. Return to Route 30.
51.7	0.3	Turn left and continue south on Route 30.
52.7	1.3	**STOP 4.GLACIAL OUTWASH.** Park on the shoulder at the intersection of Route 30 and the Keese Mills Road which diverges to the right (west). Paul Smith's College Campus and Route 30's junction with Route 192 are adjacent. More extensive cuts in glacial outwash are present on Campus and we can observe them if time permits. Elevation of junction of Routes 30 and 192 is 1658 feet. See Figure 4. This cut is in glacial outwash with a sand texture averaging 96% sand, 3% silt and 1% clay. The deposit, made by a meltwater stream flowing to the southwest, consists of the same kinds of crushed rock as are found in the area tills, but with most of the silt and clay carried away in suspension. Due to the inadequate quantity of silt, sand and rounded gravel particles are not cemented together into a fragipan. Our Campus is built upon a series of kames as part of a valley train. Numerous dry kettles and kettle ponds are found locally. The thickness of the outwash valley train, as determined by water well data, ranges from zero at out-

Figure 3 : Stop 3
Soil Profile Developed In Glacial Till

Figure 4 : Stop 4
Soil Profile Developed in Glacial Outwash



crops to over 165 feet (50.3 m); the average thickness on Campus is 60 to 100 feet (18.3 to 30.5 m). The valley train extends for 23½ miles (38 km) southwest from Loon Lake to Fish Creek Ponds, with Paul Smiths about midway. The highest elevation of these sands at the College is between 1680 and 1700 feet so that any higher hills project above this sea of outwash as rock islands mantled with till. Taking isostatic rebound into effect, the original southwest slope of the train seems to have averaged about 5.8 feet per mile (Kudish, 1975,1981).

The soil profile which develops on well-drained outwash sands is also a Spodosol. Because of the still coarser texture, the rate of leaching from the A horizons and the rate of accumulation in the B horizons are greater than in the tills. These outwash soils, with less silt and clay, are even more infertile than their till counterparts. Drainage on the kames and other valley train features can be excessive and plants can wilt during long summer droughts. The sand grains of the B_{21r} horizon are often cemented by iron and aluminum sesquioxides (Fe_2O_3 and Al_2O_3), leached down from the gray A_2 horizon above, creating a dense red-brown hard layer called an Ortstein. Just as fragipans occur locally only in tills, Ortsteins occur only locally on outwash. The critical concentration of silt appears to be about 6%.

The soil series here areWallace (with Ortstein) and Adams (without); they are Typic Haplorthods, family sandy, mixed, frigid.

Climax vegetation on outwash consists of trees which can survive on nutrient-poor, drought-prone sands; the forest type is a mixed woods (mixed broadleaf and evergreen species) dominated by Red spruce, Yellow birch, Balsam fir, Red maple, and Hemlock. White pine follows disturbances and Red pine occurs on sites where wind exposure prevents other trees from surviving. Ground cover is very much like that on till soils, but humus pH is even more acid-- pH 4.0 commonly. Under the more open Red pine stands, commonly on the east shores of lakes, less shade-tolerant species occur: Blueberries, Huckleberry, Wintergreen, Trailing arbutus, Serviceberry, Sheep laurel and Bracken fern.

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TRIP #9

LOWER ORDOVICIAN STRATIGRAPHY AND SEDIMENTOLOGY, SOUTHWESTERN ST. LAWRENCE LOWLANDS

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Introduction

The Potsdam Sandstone and overlying Theresa Formation of the southwestern St. Lawrence Lowlands record the initial transgression of marine waters into the region during latest Cambrian to early Ordovician time (Fisher, 1977). The Potsdam Sandstone is widespread throughout the peripheral Adirondack region of northern and eastern New York, but is highly variable in thickness, composition and environments of deposition. In the area of this field trip (Figure 1), the Potsdam Sandstone (In this region, all of the Potsdam is referable to the Keeseville Member of the Potsdam Sandstone, Fisher, 1968, 1977.) can be subdivided into a lower and upper facies. The lower Potsdam consists dominately of flat-bedded medium- to fine-grained quartz arenites with occasional cross-stratified units of varying scales. The lower facies lacks both body and trace fossils. A variety of red-pink coloration patterns are common in the lower Potsdam, making it a desirable building stone in northern New York. The lower Potsdam in this region is dominately shallow marine in origin, but locally aeolian dune, beach and braided fluvial facies are present.

The upper portion of the Potsdam Sandstone consists of alternating burrowed and flat-bedded slightly calcareous sandstones deposited in a shallow subtidal to low tidal flat setting.

The overlying Theresa Formation consists of three informal subdivisions: lower Theresa thin-bedded calcareous siltstones of intrashelf lagoon origin; middle Theresa interbedded bioturbated dolomitic sandstones and cross-laminated quartz sandstones deposited in a shallow subtidal to low tidal flat environment; and upper Theresa sandy dolostones, dolomitic sandstones and calcareous siltstones of high tidal flat origin.

Biostratigraphically diagnostic macrofossils are absent throughout both formations in this area, although late Tremadocian conodonts have been reported from the Theresa-correlative March Formation in Ontario (Greggs and Bond, 1971). The extremely low faunal abundance and diversity may indicate that high and/or fluctuating salinities were prevalent in these shallow marine peritidal environments.

In the course of the trip, we will cross the so-called "Frontenac Axis", a region where Proterozoic rocks outcrop in a northwest-southeast trending belt, providing a connection in surface exposure between the Adirondack Lowlands and the Grenvillian Canadian Shield to the northwest. We will view the stratigraphic section in descending order as we drive southwest from Morristown to Alexandria Bay, New York, paralleling the St. Lawrence River. The Thousand Islands of this section of the St. Lawrence River are largely held up by Proterozoic gneisses and quartzites, although the larger islands (Wellsley, Grindstone) expose the mantling Potsdam Sandstone.

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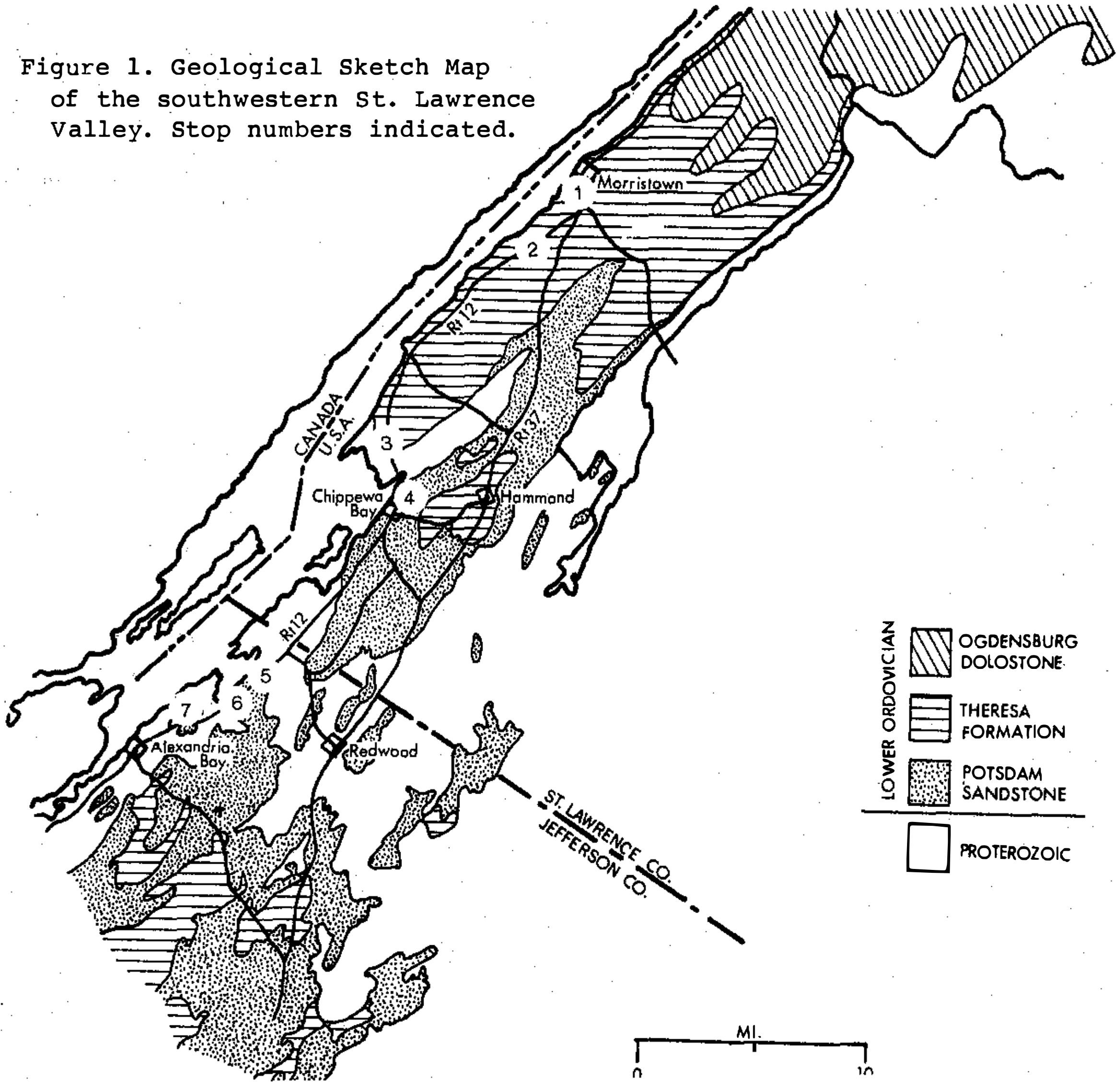
Figure 1. Geological Sketch Map of the southwestern St. Lawrence Valley. Stop numbers indicated.



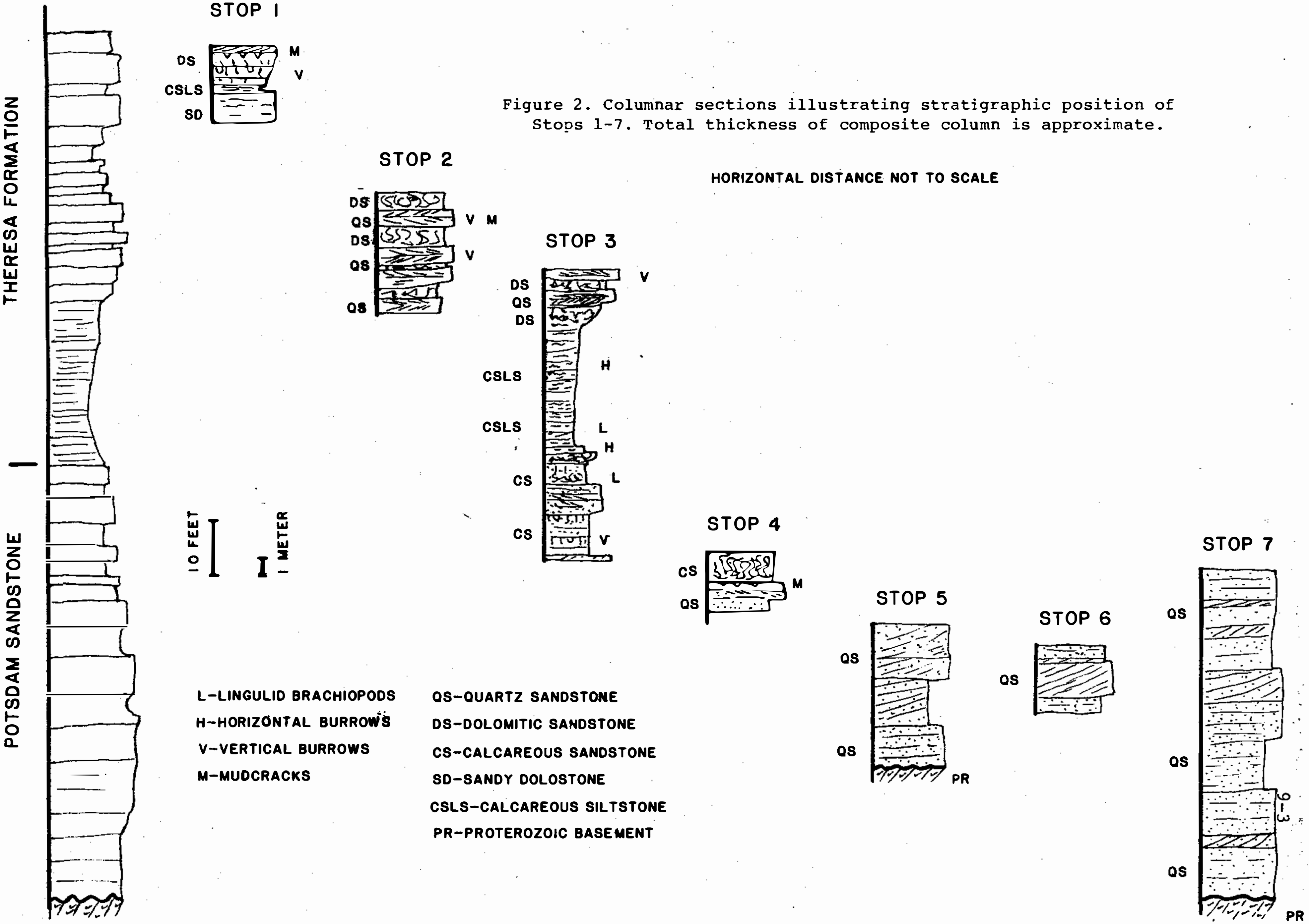


Figure 2. Columnar sections illustrating stratigraphic position of Stops 1-7. Total thickness of composite column is approximate.

Road Log

Note: The detailed road log begins at Stop #1. To reach Stop #1 from Potsdam, N.Y., drive southwest on Rt. 11 to Canton, N.Y., (approx. 11 miles), turn northwest on Rt. 68 to Ogdensburg, N.Y. (approx. 19 miles). In Ogdensburg, turn southwest on Rt. 37 to Morristown, N.Y. (approx. 12 miles). Stop #1 is located on Rt. 37, immediately southwest of the village of Morristown.

Cumulative Miles	Miles from last Stop	
0.0	0.0	**Stop #1.** Roadcuts on both sides of Rt. 37 expose the high tidal flat facies of the upper Theresa Formation. The basal beds at this exposure consist of vuggy, sandy dolostones deposited as upper intertidal mudflats. A thin unit of laminated calcareous siltstone of tidal pond origin overlies the vuggy dolostone. The remainder of the section consists of dolomitic sandstones with abundant vertical and U-shaped burrows alternating with less bioturbated cross-laminated sandstones. These facies represent middle to high tidal flat sands. Quartz- and calcite-infilled voids in the sandy dolostone unit may document the former presence of evaporite (gypsum/anhydrite) nodules.
		Continue southwest on Rt. 37
0.8	0.8	Intersection of Rts. 12 and 37. Bear right and continue southwest on Rt. 12.
2.65	2.65	Entrance to Jacques Cartier State Park on right.
4.05	4.05	**Stop #2.** Middle portion of Theresa Formation. The rhythmic interbedding of yellow-white cross-laminated quartz sandstones and darker, bioturbated dolomitic sandstones is typical of this portion of the Theresa Formation. Rare mudcracks are present within the yellow-white sandstones. The dolomitic sandstones represent shallow subtidal to lower intertidal muddy sand flats that supported an abundant infauna. The yellow-white cross-laminated sandstones were deposited as slightly topographically higher mid-tidal flat sand bodies, upon which benthic fauna could not persist due to active current reworking and/or subaerial exposure to the substrate.

Cumulative Miles	Miles from last Stop	
		The sharp basal contacts of the bioturbated facies with underlying cross-laminated sandstones may indicate that the rhythmic alternation is due to a series of successive slight relative sea level rises of 2-3 meters. Thus, each bioturbated dolomitic sandstone-cross-laminated sandstone pair can be interpreted as a single shallowing upward sequence. A peculiar "wavy-bedded" unit near the northeast end of the outcrops appears to have resulted from intraformational soft-sediment deformation. Note the general low-amplitude folding and small high-angle fault in the exposure. Continue southwest on Rt. 12.
7.55	3.50	Long roadcut exposing lower Theresa Formation and upper Potsdam Sandstone near Oak Point, New York.
11.00	6.95	**Stop #3.** Basal Theresa Formation and Uppermost Potsdam Sandstone. The contact between the Potsdam Sandstone and lower Theresa Formation is prominently displayed at this stop and is marked by a color change (Potsdam= grey-white-yellow; Theresa=grey-brown), an abrupt increase in carbonate content in the basal Theresa, and changes in bedding style. The lower Theresa in this area consists of 2-10 cm beds of plane-laminated or low angle cross-laminated calcareous fine sandstones/ siltstones regularly interbedded with bioturbated calcareous fine sandstones/siltstones. Subvertical escape(?) burrows commonly traverse the plane-laminated beds and record attempts by deposit-feeding fauna to return to the sediment surface following a sudden influx of sediment. The environment of deposition of this basal Theresa facies is interpreted as a subtidal protected intrashelf lagoon characterized by sporadic periods of sediment influx (plane-laminated beds) followed by periods of quiescence of the substrate, allowing colonization by deposit feeders (bioturbated beds). This facies is limited in extent in the region, apparently because of the distribution of basement ridges of Proterozoic quartzite which acted as wave and current barriers. To the south and west of this area, coarser, bioturbated sandstones

Cumulative Miles	Miles from last Stop	
		resembling those seen at Stop #2 occupy the basal Theresa Formation. The upper Potsdam Sandstone at this top consists of a series of units of bioturbated calcareous medium-grained sandstones and plane-laminated to small-scale cross-laminated calcareous medium sandstones interbedded on a scale and style resembling the middle portion of the Theresa Formation seen at Stop #2. Alternating shallow subtidal (bioturbated sandstones) and low intertidal (plane-laminated to small-scale cross-laminated sandstones) environments are similarly inferred. The interesting trace fossil Diplocraterion yoyo is ubiquitous in the Potsdam Sandstone here. The forms are generally indicative of a response to growth and/or erosion of the sediment surface. The generally vertical orientation of these and other burrows is typical of burrows found in modern settings where organisms live within the sediment for purposes of protection from wave and current violence or dessication. This burrow style contrasts strongly with the generally horizontal traces seen in the basal Theresa Formation. Fragments of the inarticulate brachiopod Lingulepis accuminata are common in both the upper Potsdam Sandstone and lower Theresa Formation at this stop. Continue southwest on Rt. 12.
12.65	1.65	**Stop #4.** The contact between the lower Potsdam and upper Potsdam lithofacies is exposed at this roadcut on the southwest side of Rt. 12. The lower portion of the outcrop consists of pink-yellow plane-bedded and cross-bedded medium-fine sandstones typical of the lower Potsdam. The upper, massive calcareous sandstone bed is riddled with burrows, including Diplocraterion yoyo, and resembles some beds of the uppermost Potsdam seen at Stop #3. The bioturbated upper Potsdam is again interpreted as a shallow subtidal to low intertidal sand flat environment. The lower Potsdam here is likely a subtidal shelf sand, but the lack of burrows and other diagnostic primary structures preclude a definitive paleoenvironmental reconstruction.

Cumulative Miles	Miles from last Stop	
		Interestingly, the contact between these two lithofacies at this stop (and throughout this area) appears to represent a period of widespread emergence as documented by shrinkage cracks in the sandstones immediately below the contact and lenses of brecciated sandstones that are interpreted to result from breakup of a silcrete-like cemented soil horizon. Glacially striated and chattermarked surfaces are observable on the northwest side of the road. Continue southwest on Rt. 12.
15.65	3.00	Beginning of series of excellent exposures of Proterozoic gneisses.
19.95	7.30	**Stop #5.** The unconformity between the basal Potsdam Sandstone and underlying Proterozoic basement gneisses is exposed in this roadcut on the southeast side of Route 12. This contact represents a time interval of some 600 million years. The basal sandstones here exhibit large-scale low angle planar-tabular cross bedding, and are devoid of trace and body fossils. The depositional setting for this facies is problematic, although shallow marine tidal inlet, beach or aeolian dune environments are potentially workable facies models. Considerable variation in color pattern is evident in the Potsdam Sandstone, with the basal 0.5-1.0 meters white to light grey in color, whereas the upper portion of the outcrop exhibits the pink, red, orange and salmon colors often seen in the Potsdam Sandstone used as a building stone. In this section, the deeply colored beds contain abundant tiny (2-50 micron) disseminated hematite and leucoxene crystals with these pigments both surrounding detrital quartz grains and imbedded in later authigenic silica cement. Highly corroded grains of detrital magnetite and ilmenite in the colored sandstones appear to have been the source of iron and titanium which subsequently precipitated as hematite (probably with a goethite precursor) and leucoxene under oxidizing diagenetic conditions. The white sandstones immediately

Cumulative Miles	Miles from last Stop	
		above the unconformity contain no hematite or leucoxene, although limonite-goethite halos of relatively recent origin are locally developed around magnetite grains. The pristine condition of the majority of magnetite and ilmenite grains indicates that these basal sands never suffered a persistent oxidizing diagenetic history. The proximity of these unoxidized grains to the underlying pyritic gneisses suggests that the pore waters near the contact were "Eh-buffered" by the alteration of pyrite and Fe-silicates in the gneisses, thus preventing breakdown of the magnetite and ilmenite, and the subsequent precipitation of pigmenting agents. Note that the sole surface of the lowermost sandstone bed mimics the shape of the underlying (now weathered) basement erosional surface.
		Continue southwest on Rt. 12.
21.15	1.20	**Stop #6.** The roadcut on the southwest side of Route 12 exposes typical lower Potsdam Sandstone. Flat-bedded medium- to fine-grained sandstones underlie and overlie a 1 meter thick bed of tangentially cross-stratified medium sandstones. The dominant cross-bed dip direction is nearly due south. Immediately above the thick cross-stratified unit smaller-scale cross-beds dip to the north. As with many exposures of the lower Potsdam Sandstone, assignment of an environment of deposition is difficult here. Although the flat-bedded sandstones lack trace or body fossils, a shallow marine subtidal environment is suggested by the continuity of individual beds, the lack of upward fining or coarsening trends and the lack of obvious channel form geometry. However, definitive diagnostic primary structures are absent. The large cross-stratified unit, produced by a bed form of at least 2-3 meters in amplitude (stoss-side erosion beveled the upper portion of the structure as it migrated, leaving behind a scoured lag deposit of granules at the updip termination of the cross-strata), could have been deposited by a large subtidal sand wave, or an aeolian dune during a period of emergence.

Cumulative Miles	Miles from last Stop	
		Continue southwest on Rt. 12.
22.45	1.30	**Stop #7.** The angular unconformity between the basal Potsdam Sandstone and Proterozoic gneisses is again exposed in these large roadcuts on both sides of N.Y.S. Route 12. The dominant facies present here is typical of the lower portion of the Potsdam throughout the southwestern St. Lawrence Lowlands. Flat-bedded medium- to fine-grained quartz arenites are occasionally interrupted by 0.2 to 1.0 meter sets of cross-strata. The lack of diagnostic trace and body fossils is a nettling problem if we assign a shallow marine environment of deposition to this facies. Note the "weathered zone" at the unconformity. Does this represent a "regolith" or buried soil horizon; or is another explanation more viable? Note also the general absence of clasts of the underlying gneiss in the basal Potsdam Sandstone.

<u>End of Trip</u>

Note: Continue southwest on Rt. 12, passing Alexandria Bay village to access Interstate Rt. 81.