TRIP A-3

SEDIMENTARY ENVIRONMENTS IN GLACIAL LAKE ALBANY IN THE ALBANY SECTION OF THE HUDSON - CHAMPLAIN LOWLANDS

by

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Introduction

The history of Lake Albany has intrigued glacial geologists since the turn of the century. The simple, single-stage lake of Peet (1904) soon was modified by Woodworth (1905) to a two-stage model where varved Lake Albany clay is overlain by sand of Lake Quaker Springs. Later workers, up to the present time, have defined more lake stages using the elevations of beaches, deltas, and terraces and by the character of the deposits of each lake stage. Stratigraphic sections revealed in new exposures and test borings have permitted the definition of sedimentary packages associated with each stage of Lake Albany. This field guide is a preliminary description of this new stratigraphy and provides the student with selected field stops that allow examination of the sediments.

The study area is in the mid-Hudson section of the Hudson-Champlain Lowlands (Fenneman, 1938). It lies between the Adirondack Mountains on the northwest, the Taconic Mountains on the east, and the Helderberg Plateau on the southwest (Fig. 1). The lowlands were deeply dissected by a southward drainage system prior to the Wisconsinan glaciation (Davis and Dineen, 1969). This drainage system consisted of the Colonie Channel and its tributaries - the Mohawk, Ballston, and Hudson-Battenkill Channels (Fig. 1). Only the Hudson-Battenkill channel is occupied by major drainage at present.

The Hudson Lobe of the Laurentide ice sheet occupied the lowlands during the Wisconsinan Glacial Stage. As the Hudson Lobe retreated, proglacial Lake Albany developed on the south. Lake Albany occupied the area from 15,000 to 12,600 y.b.p. (Connally and Sirkin, 1973). Drainage from the Great Lakes Basins entered this lake via the Mohawk River Valley (Stoller, 1911). The lake expanded from south to north as the Hudson Lobe retreated, with the ice margin as the north shore of the lake (LaFleur, 1965b). The initial lake deposits were ice-contact sand and gravel that grade up into varved silt and clay (LaFleur, 1969, Dineen, 1979). Kame deltas developed when the ice margin hesitated during its retreat. Lake Albany extended 225 km from Newburgh to Glens Falls (Peet, 1904). Several large ice blocks were left behind by the retreating glacial lobe. The locations of the five ice blocks in the Albany area were the Hudson-Battenkill Channel near Selkirk (Dineen, in prep.), the Colonie Channel between Schenectady and Troy, at Round Lake, at Saratoga Lake (Hanson, 1977), and the Mohawk Channel at Schenectady (LaFleur, this volume). These ice blocks impeded sediment transport and controlled glacial and post-glacial drainage.

Glacial Lake Albany

Lake Albany developed in the preglacial channels between the ice margin and some obstruction to the south. Major tributaries entered the lake north

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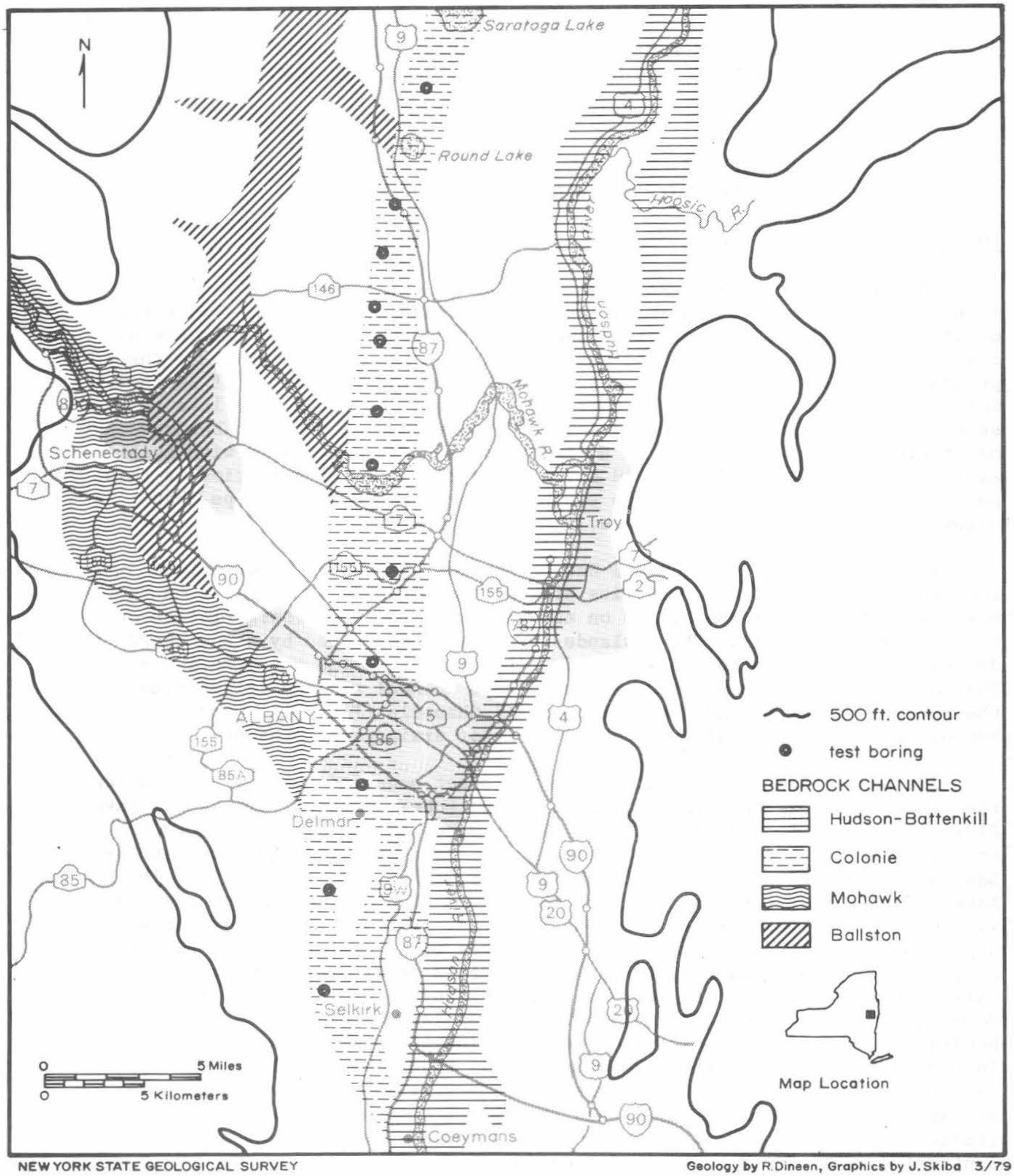

Figure 1. PREGLACIAL DRAINAGE CHANNELS

of the latitude of Troy (Figs. 1 and 2). The lake tended to widen and to become shallower from south to north (Fig. 2 and Table 1). The preglacial river channels divided the main lake basin into several north-south subbasins (compare Figs. 1 and 2). Lake sediments in these basins provide the evidence for the detailed history of the lake by their origin, altitude, and geographic position. The primary contributors of sediment to Lake Albany were:

1. Meltwater from the retreating ice margin;
2. Major tributaries that built large deltas into the lake (Fig. 2);
3. Minor tributaries that drained the adjacent highlands.

The Mohawk delta at Schenectady (stop 2) was dumped into the Mohawk subbasin, the Hoosic delta was deposited into the Hudson-Battenkill subbasin, and the Kayderosseras delta was deposited in the Ballston and Colonie subbasins near Saratoga Lake (Fig. 1). The ice margin provided sediment to all the subbasins during the early Lake Albany stage and was the major sediment contributor to the Colonie subbasin. Lake deposits draped over the bedrock topography with the thickest section of sediment developed along the axis of the channels (Fig. 3Ba). Time-equivalent deposits were higher in elevation along the margins of the channels than in the center, because of the initial dip caused by lake bottom topography and the compaction of the sediment column (Fig. 3Ba and Dineen, Waller, Hanson, in prep.). The cluster of large tributaries debouching into the lake north of Troy (Fig. 2) caused the sedimentary deposits of Lake Albany to become thicker and more coarse northward, (Dineen, Waller, Hanson, in prep.). Individual units wedge out and overlap northward, i.e., the basal layers are older to the south because of the progressive northward retreat of the ice margin (Fig. 3Bb). Thus, the base of Lake Albany's sediment column is time-transgressive northward.

The column of sediment that was deposited in Lake Albany is characteristically coarse at the base, fine in the middle, and coarse at the top (Fig. 3Aa), although this general trend was interrupted by specific depositional episodes. The sequences on Fig. 3A and the maps on Figures 1 and 2 are based on test borings, water wells, field exposures, and map patterns (Dineen, Waller, Hanson, in prep., DeSimone, 1977, Hanson, 1977, Dineen, 1977, LaFleur, 1969, 1965a, 1961a, Schock, 1963). The basal part of the sequence includes gravel, flowtill, and sand that pass upward to varved silt and clay (Fig. 3Aa). The coarse-grained basal sediments were deposited in deep lake water at the ice margin by meltwater streams and sheet flow from under the glacier. They were predominantly bedload and lag deposits. The deepwater varved clay and silt sequence contains turbidites that fine upward from sand and/or gravel to rippled silt to planar laminated silt and clay. The turbidites were probably deposited during catastrophic floods of meltwater from the ice front and the major tributaries. LaFleur (1975) and Hanson (1977) cite geomorphic evidence for catastrophic floods from the Mohawk Valley. The varved silty clay grades upward into laminated sandy silt, which coarsen upward into sand and gravel. The upper, coarser-grained sediments were deposited in shallow water, and prograded across the lake bottom as the central part of the basin filled in with mud. This progradation of coarse sediment over fine sediment is well shown on the cross section for Stop 4 (Fig. 6). The Delmar Readvance occurred as the Hudson Lobe readvanced into Lake Albany. This event is reconstructed from several lines

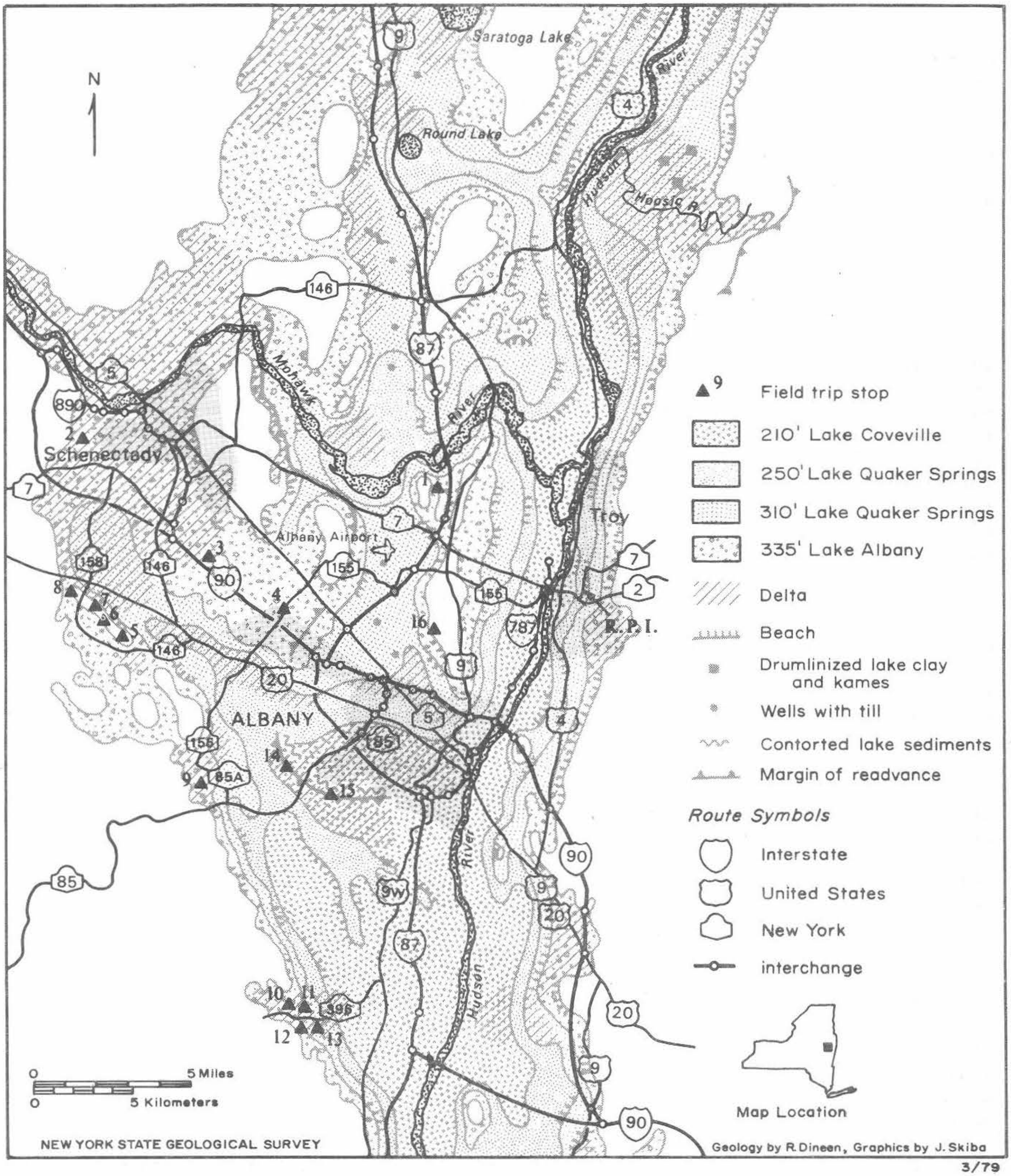

Figure 2. FIELD STOPS & GENERALIZED GLACIAL GEOLOGY

of evidence that include:

1. Folded beds of fine-grained lake deposits with associated outwash sand and gravel which occur near Delmar, south of Albany (Fig. 2 and Dineen, in prep., and Fig. 9, Stops 14 and 15). These folds are push-ridges.
2. Patchy till and outwash deposits enclosed in the upper lake sediments which occur in wells and test borings between Round Lake and Albany (Dineen, Waller, and Hanson, in prep., Fig. 2).
3. Contorted clay and silt beds in the area south of Round Lake (Fig. 2 and Hanson, 1977).
4. Till overlying kame deltas (Stop 1, Fig. 5a, and Hanson, 1977).
5. Drumlinized clay and kames in the Hoosic River area (Fig. 2).
6. Anomalously high seismic velocities that are probably over-compacted lake deposits near the mouth of the Hoosic River.

Broad sandy flats, exposed at the lake shore as the lake level dropped from +330 ft. to +310 ft., supplied large quantities of fine sand and silt to the upper part of the sequence of Lake Albany sediments. Wind, eroding these newly exposed areas, delivered these size grades to the nearshore lake environment where wedges of blown sediment spread into the lake. At the same time, aeolian dunes developed on these exposed flats. Stops 3 and 4 (Fig. 6) are in these dunes. The lake and dune sand is 75 to 100 ft. thick in the area of Stops 3 and 4 (Fig. 6). The axis of maximum sand thickness trends northwest to southeast, and lies between NY5 and I-90 (Fig. 2 and Dineen, 1975). The lake sand becomes siltier and eventually grades into lake clay towards the east and with depth (cross section, Fig. 6).

Wind action was intense, being unimpeded by vegetation. The resulting dune complex was particularly well developed in the sand-abundant newly exposed and abandoned Schenectady Delta (Dineen, Rogers, and Buyce, 1978).

The presence of well-developed beaches on the east shores of Lakes Albany and Quaker Springs, and on the west shores of islands in the lakes (Fig. 2 and Dineen, in prep., DeSimone, 1977, LaFleur, 1961a and 1965a), and of poorly-developed beaches on the west shores of the lakes (Dineen, in prep.), and of the southeast dune and cross bed orientation (Dineen, Rogers, Buyce, 1978) indicate that the dominant wind was from the northwest. The progradation from northwest to southeast of the wedges of windblown-lake deposited sand (Dineen, 1979) corroborates this conclusion. The Mohawk River was deflected northward into the Ballston Channel by the emergent Schenectady delta. Overflow of catastrophic floods from the Mohawk Valley built deltas at the mouths of the channels cut into the rock ridge separating the Ballston and Colonie Channels in the area of Round Lake (Figs. 1 and 2).

Lake Quaker Springs

A relatively abrupt drop in Lake level from +310 ft. to +270 ft. marked the transition from Lake Albany to Lake Quaker Springs. This lake was shallower than Lake Albany, and like the latter, became shallower and narrower north of the latitude of Albany than it was south of there to the latitude of South Bethlehem (Fig. 2 and Table 1).

The deposits of Lake Quaker Springs coarsen upward rapidly (Fig. 3Ab). Sand and gravel deposited in shallow water and the wedges of windblown lake deposited sand and silt rapidly prograded across the lake bottom. Much of this sediment was recycled from the older lake deposits. Few coarse-grained turbidites were deposited in Lake Quaker Springs in the Albany area, perhaps because the mouth of the Mohawk River had migrated north to Saratoga and Round Lakes (Stoller, 1922, LaFleur, 1965b) and the ice margin was no longer nearby.

The sediment column of Lake Quaker Springs is significantly thinner than the column of Lake Albany (compare Figs. 3Aa and 3Ab) because:

1. The sediment influx from the ice margin dwindled as the ice margin moved north out of the Hudson Valley;
2. The sediment influx from the Mohawk River was displaced to the north; and
3. Lake Quaker Springs lasted a much shorter period of time than Lake Albany (Fig. 4).

Glacial Lake Coveville

Lake Coveville began when the water level in the Hudson-Champlain Lowlands dropped from +270 ft. to +230 ft. Once again, large areas of sandy lake plain were exposed in places around the newly stabilized lake. Again, winds began to erode the lake plains, building subaerial dunes and lacustrine silty sand wedges. Beaches, dune orientation, and a complex of nearshore sand bars in the Delmar area suggest that the dominant wind was still from the northwest (Dineen, Rogers, and Buyce, 1978; Dineen, in prep.). The beaches are well-developed on the east shore of the lake. The beaches, terraces, and deltas show a lower lake level at +200 ft. Thus, Lake Coveville, like Lake Albany, consisted of at least two closely-spaced and closely-timed lake levels.

The depth the Lake Coveville was greatest in the South Bethlehem area, where it was less than 21 m. (Table 1). The depth and width of Lake Coveville decreased from South Bethlehem north to Troy, and actually, the lake resembled a wide river (Fig. 2).

The sedimentary column of Lake Coveville, which is no more than 5 m. thick near Albany, coarsens upward very rapidly, reflecting the rapid filling of the basin by wind-blown sand and silt and by the fluvial reworking of lake plain sand, silt, and gravel.

Lake Fort Ann

Lake Fort Ann is well recorded in the Champlain Valley (Chapman, 1937, LaFleur, 1965b). The Hudson River Valley was the spillway for the lake. Fort Ann was basically a wide river in the Albany area. It is recorded by cut terraces with thin (3 to 5 m. thick) veneers of sand.

Relationship of Later Lake Sediments to Lake Albany

As discussed above, much of the sediment that was deposited in Lake

Quaker Springs and Coveville was recycled from the newly-exposed lake plains of Lake Albany. Stream and wind action tended to transport the sandy sediments towards the south and east. A preliminary analysis of beach and bar orientation and morphology suggests that the long-shore lake current trend was also towards the south (Dineen, in prep.). Thus, sedimentary facies migrated towards the south-southeast.

Sediments of succeeding lakes have an off-lapping relationship (Fig. 3Bb). The off-lapping facies sequence is similar to that of a regressive sea (Matthews, R.K. 1974 p. 41), with conformable sedimentary sequences in the center of the basin and disconformable sequences around the edges within the areas affected by shallow water environments (Fig. 3Ba and 3Bb). The younger lake shores are topographically lower than the older lake shore because the water levels dropped through time. The dropping water level, plus filling-in of the basin, resulted in thinner sedimentary columns for younger lakes (Fig. 3), a rapid progradation of shallow-water, coarse-grained clastics across the lake basin (Figs. 3Aa, 3Ab, 3Ac), and narrower, shallower lakes through time (Fig. 2). The dropping water level also caused the off-lapping relationships of the lake sediments (Fig. 3Ba, 3Bb).

Environments of the Lakes

The environments of the Glacial Lake Albany sequence (Fig. 4) can be described using the sediments observed in the field and test boring data:

1. Ice-Contact Environment: is recorded by imbricated lag and bedload gravel and trough and planar cross-bedded sand, gravel, and silt, with minor flow tills. This facies was deposited in the lake in close proximity to the ice margin by sheet flow from under the glacier and melt water channels in the glacier. The facies geometry is generally that of a blanket draped over pre-existing basin topography, although eskers, kames and kame deltas are also present. This facies forms the basal units of the Lake Albany sequence (Fig. 3Aa), which are exposed at Stops 1, 5, 6, 7, 8, 14, 15, and 16.
2. Deep Water Environment: is recorded by varved clay and laminated silts with some turbidite gravel. This facies was deposited in deepwater below wave base, and consist of distal delta and basinal sediment. This facies is exposed at Stops 1, 2, and 5.
3. Nearshore Environment: produced ripple-trough laminated, ripple-laminated, to planar-laminated sand and slightly gravelly, silty sand. Planar to trough cross-bedded gravel occurs in the toe of deltas. This facies includes proximal delta sediments and sediments that were deposited above wave base. It is recorded at Stops 1, 2, 8, 9, 10, 11, 12, and 13.
4. Windblown - Lake Deposited Environments: produced ripple-laminated to planar cross-laminated, silty sand to sandy silt. This is a subdivision of the nearshore facies. Wedges of sediment formed off-shore from dune fields, because the sediments were blown into the lake from exposed lake plains. Such sediments are poorly exposed at Stop 3.
5. Shore Environment: is recorded by trough cross-bedded to planar cross-bedded sand and gravelly sand deposited in beaches, in delta

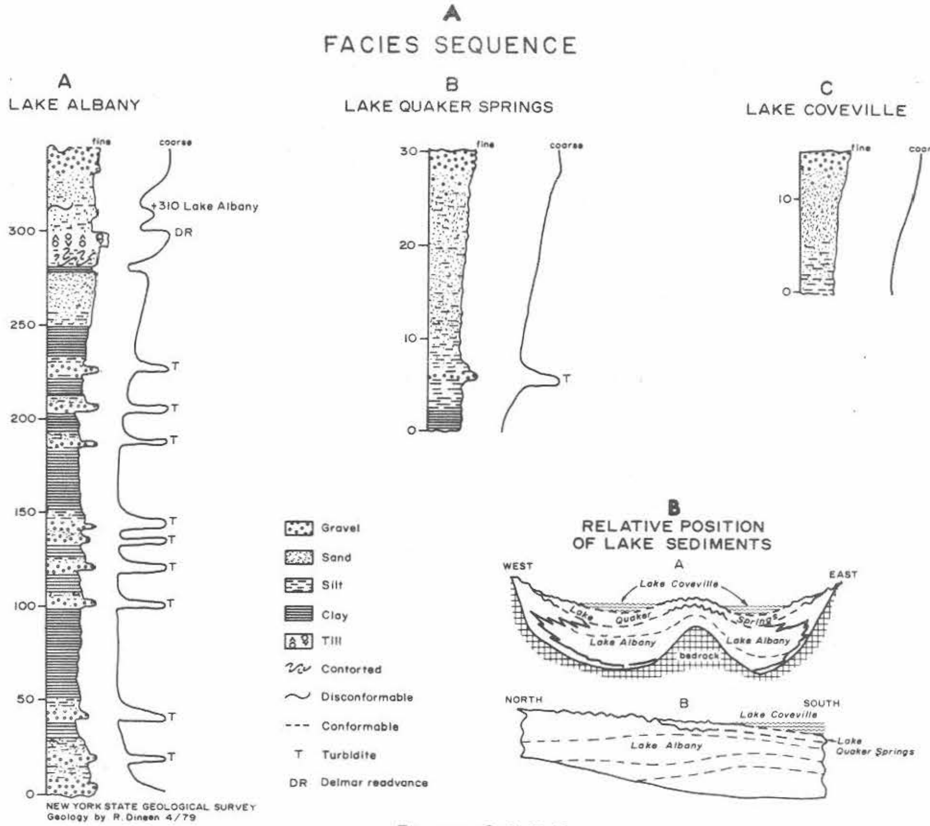

Figure 3 A & B

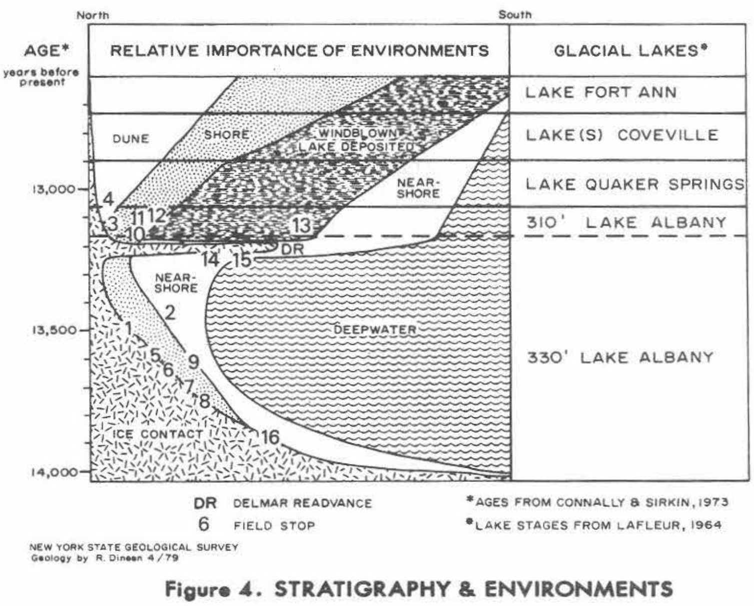

Figure 4. STRATIGRAPHY & ENVIRONMENTS OF THE GLACIAL LAKES

topset beds, and tributary streams. Such deposits are exposed at Stops 1, 2, 3, 10, 11, and 12.

6. Aeolian Environment: produced planar cross laminated, fine sand that was deposited in dunes, and ripple-laminated, silty sand and peat that were deposited in interdune bogs. These facies prograded across the exposed lake plains from west to east. They are exposed at Stops 3 and 4.

The relative importance of these environments was different in each of the lake stages. Figure 4 illustrates these changes. The earliest stage of Lake Albany was dominated by the ice-contact environment, which decreased in importance as the ice margin retreated from the area. The Delmar Readvance resulted in a brief increase in the importance of the ice-contact environment in the time of late Lake Albany.

The deepwater environment was important during most of Lake Albany time (Fig. 4), but its importance decreased dramatically in the later lakes as the basin filled with sediment and the lake level dropped.

The nearshore environment increased in importance in the lakes of lower water level. The windblown - lake deposited facies of this environment became dominant as the water level continued to drop.

The shore environment increased in importance as streams and deltas prograded across shallow Lakes Coveville and Fort Ann. The aeolian environment became important after the inception of the +310 ft. Lake Albany (Fig. 4), and continued through the later lake stages until approximately 5,000 y.b.p. (this date is based on a radiocarbon date from the base of an interdune bog in the Pine Bush, R. Pardi, Queens College Radiocarbon Laboratory, pers. comm. 1979).

Lake Stage	Elevation in Feet				Depth in Feet			
	1	2	3	4*	1	2	3	4
LAKE FORT ANN	140	140	140	140	20	30	20	30
LAKE COVEVILLE	210	200	190	190	20	20	20	20
LAKE COVEVILLE	240	230	220	210	20	30	70	30
LAKE QUAKER SPRINGS	280	270	260	250	20	20	100	80
LAKE ALBANY	320	310	300	290	30	60	150	130
LAKE ALBANY	340	330	325	325	270	530	300	300

1 = Saratoga Lake (from Round Lake, Mechanicville, and Schaghticoke 7½ minute quadrangles).
2 = Albany (from Voorheesville, Albany, and Troy South 7½ minute quadrangles).
3 = South Bethlehem (from Clarksville, Delmar, and East Greenbush 7½ minute quadrangles).
4 = Coeymans (from Ravena, Kinderhook, and Alcove 7½ minute quadrangles).

* General locations from north to south.

TABLE 1 -- GLACIAL LAKE STAGES IN THE ALBANY-SCHENECTADY AREA

Lake Stage	Width in Miles				Notes
	1	2	3	4	
LAKE FORT ANN	1.6	1.6	1.6	1.6	Predominantly fluvial deposits in the Albany area. Recorded by erosional terraces with thin veneers of coarse sediment along the valley wall of the Hudson.
LAKE COVEVILLE	2.4	2.4	5.9	2.4	Thickest sediments in the South Bethlehem area, sediments are related to the S.B. deltas. Erosional terraces common north of Albany.
LAKE COVEVILLE	2.1	2.4	6.3	2.8	Off-shore bars common SE of Delmar. Recorded by Hoosic and South Bethlehem deltas, and by erosional terraces north of Albany. Good beach development.
LAKE QUAKER SPRINGS	3.5	12.6	6.7	5.5	Recorded by North Albany, Normanskill, Hoosic, and South Bethlehem deltas.
LAKE ALBANY	11.0	16.5	7.9	5.9	Recorded by Wynantskill and Normanskill deltas, and at South Bethlehem. Dunes are graded to this lake. Deltas at Shenendehowa related to this stage. Good beach development.
LAKE ALBANY	15.8	17.8	9.9	4.0	Good beach development. Poor delta preservation at South Bethlehem. Prominent Hoosic, Schenectady, Wynantskill, and Kinderhook deltas.

TABLE 1 -- GLACIAL LAKE STAGES IN THE ALBANY-SCHENECTADY AREA (cont'd)

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Road Log

Total Mileage	Mileage From Last Stop	
		This trip will be on the Troy South, Niskayuna, Schenectady, Voorheesville, Albany and Delmar 7½ minute quadrangles. This field log describes 16 stops, more than one can visit in a single day. It is intended as a guide to glacial exposures that show relationships of local stratigraphic interest or that illustrate general principles of sedimentation in the glacial-lacustrine environment. We will visit those exposures that are accessable and in good shape on the day of the field trip.
0.0	0.0	We start at the Houston Field House - Rensselaer Polytechnic Institute. The bluff to the east of the field house is a beach of +330 ft. Lake Albany (LaFleur, 1965a).
		Proceed west on Burdett Avenue to the intersection of 40th Street (NY 7).
0.3	0.3	Turn left (south) on 40th. Proceed along 40th St./NY 7 to Congress St.
1.0	0.7	Turn right (west) on Congress St. and follow NY 7.
1.8	1.1	Cross the Hudson River on the NY 7 bridge.
		We have driven down the east wall of the preglacial Hudson-Battenkill Channel. Test borings for the bridge and its approaches indicate that a -20 ft. terrace underlies the floodplain in this area. A +40 ft. bedrock terrace underlies Watervliet to the west. The test borings indicated that only a thin layer of till underlies the floodplain silty sands (J. Rumsey, N.Y.S. Dept. of Transportation, personal communication). The -20 ft. bedrock terrace can be traced 12 miles south as far as Castleton and 3 miles north as far as Waterford.
3.0	1.2	Proceed up the west wall of the Hudson-Battenkill channel.
4.0	1.5	Proceed along NY 7 (west) to the Latham circle. Follow ramp to US 9 (north).
5.7	1.7	Proceed north along US 9 to Dunsbach Ferry Road.

6.1	0.4	Turn left (northwest) on Dunsbach Ferry Road. Proceed to intersection of Pollock Road. Turn left (west) on Pollock Road. We have been driving along the interfluve between the Colonie Channel (west) and the Hudson-Battenkill Channel (east). Proceed down the hill into the Dephuskill Valley. The access road to the Wunderlich pit is on the right.
6.5	0.4	Stop 1 Wunderlich Pit (Fig. 5a) This pit is in the Pollock Road kame delta. The ice margin was to the north. Meltwater built a kame delta into Glacial Lake Albany at the end of an esker complex, which lies north of the kame delta. Some clay lies draped over the eskers to the north, implying that the ice had melted away by the time of Lake Quaker Springs. The Section exposed in the pit is: Top to 4m — Grayish brown sandy, silty, boulder till. 4 to 24m — Gravity and thrust-faulted, yellow-brown, planar cross-bedded, gravelly sand, with ripple laminae at the base and contorted laminae at the top. 24 to 30m — Trough cross-bedded, gravity faulted, sandy gravel The basal gravel was deposited by southward-flowing water in an esker channel, the gravelly sand, in a kame delta. These beds grade southward into trough cross-bedded, silty sand. They are partially overlain by varved clay to the south. The till at the top was deposited during the Delmar Readvance. Leave the Wunderlich pit, turn left (west) and proceed along Pollock Road.
7.2	0.7	Follow the left-hand fork to the intersection with Sparrowbush Road.
7.6	0.4	Turn right (west) on Sparrowbush Road.
7.7	0.1	Turn left (northwest) on Forts Ferry Road.
7.8	0.1	Turn left (southwest) on Mill Road.
8.7	0.9	Proceed to intersection of NY 7. Turn right (west) on NY 7. We have crossed the east wall of the Colonie Channel. A test boring in the channel along strike with the Loudonville

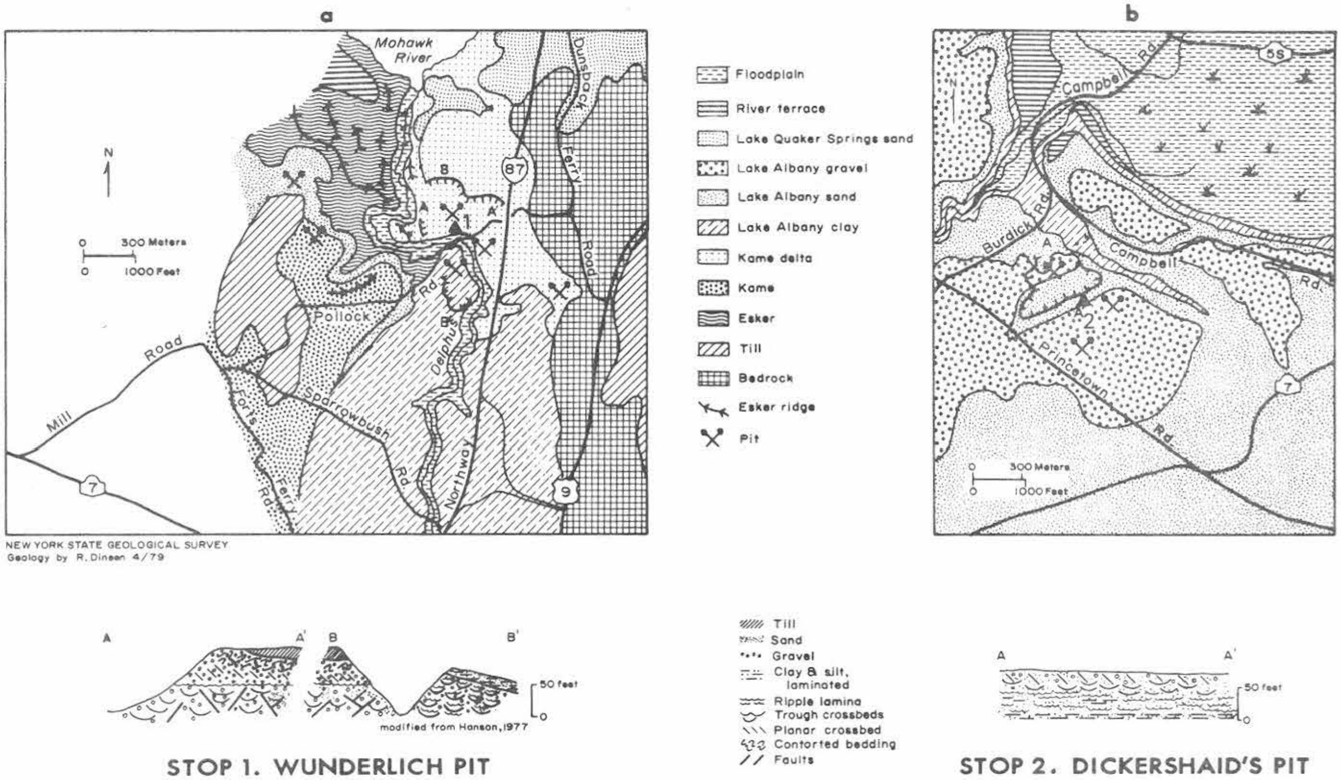


Figure 5.

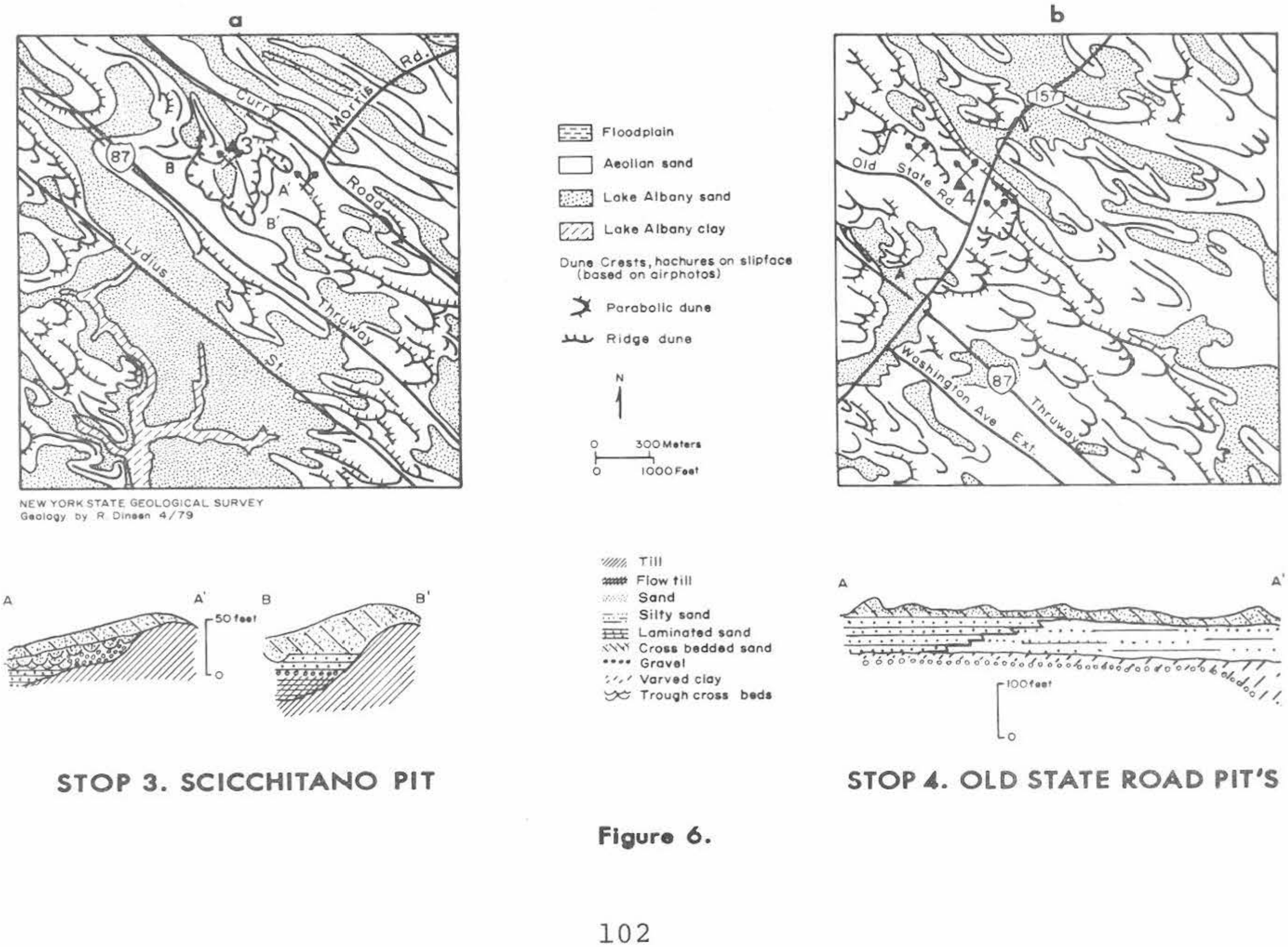


Figure 6.

		esker contains large quantities of ground water under artesian pressure. Roger Waller measured a 12m artesian head in that well (Dineen, Waller, and Hanson, in prep.).
10.4	1.7	We are now crossing dune sand that mantles Lake Albany clay (Hanson, 1977). We are also crossing the west wall of the Colonie Channel.
13.9	3.5	Intersection of Union St. and NY 7. Bear left, stay on NY 7.
16.1	2.2	Entrance to Interstate 890 west, proceed on I-890 west. Crossing Ballston Channel, we are on (and in) the Schenectady delta that the Mohawk River built into Lake Albany (Stoller, 1911). A test boring for I-890 penetrated 174 ft. of silty sand and 20 ft. of till without hitting bedrock.
		Dunes are well developed in this area. Gastropods occur locally in sand just below the dune sand - lake sand contact.
18.3	2.2	We are now on the Mohawk River floodplain. Test borings for the General Electric Plant and US 5 Schenectady - Scotia bridge penetrated 40 ft. of fining-upward sand, gravel to organic silt. These floodplain deposits overlie 50 ft. of alternating beds of sand and silty clay that overlie till (Winslow and others, 1965 and J. Rumsey, N.Y.S. Dept. of Transportation, personal communication). The floodplain deposits tend to coarsen to the west (Winslow and others, 1965). They are the main source of water for the City of Schenectady (Stoller, 1929) and yield over 16 million gallons of water per day (Winslow and others, 1965).
20.4	2.0	Exit at Campbell Road -- The Schenectady well field is to the west.
21.4	1.0	Intersection of Princetown and Campbell Roads, bear left following Campbell Rd.
21.8	0.4	Intersection of Campbell and Burdeck Road, bear right on Burdeck Rd.
22.0	0.2	Intersection of Burdeck and Thompson Roads, bear left on Thompson Road. The next stop on the left is less than 0.1 mile from this point.
		Stop 2 Dickershaids Pit (Fig. 5b)

This pit is cut into the Schenectady delta. Its section consists of:

Top to 7.6m	light brown, trough cross-bedded, medium to fine sand with some gravel
7.6 to 20m	light brown, ripple-laminated, fine sand. Concretions are common in this zone
20 to 23m	yellow brown, varved silt and clay

Test borings to the east indicate that the clay extends to a depth of 230 ft. (Winslow and others, 1965).
The gravelly sands at the top of the pit are topset/fluvial beds that prograded eastward across the delta front sand, which in turn had prograded eastward across bottomset clay and silt. The sand is the source beds for the dunes that lie to the east (Dineen, Rogers, and Buyce, 1978).
Leave Stop 2, turn left (south) onto Thompson Road.

22.3	0.3	Intersection of Thompson and Princetown Roads
23.2	0.9	Turn left onto Princetown Road. Intersection of Princetown, Curry, Fort Hunter, and Duanesburg Roads. Proceed on to Curry Road (NY 7). We are travelling across the topset beds of the Schenectady delta.
24.6	1.4	Intersection of Altamont Ave. and Curry Road. Bear right on Curry (proceeding east). Dunes are just starting to appear in this area.
26.5	1.9	Crossing over I-890. Notice the small dunes to the left (northeast). We are proceeding along a series of dune ridges.
28.1	1.6	Access road to Stop 3 on right. Turn right, proceed south to end of road.
28.4	0.3	Stop 3 Scicchitano Pit (Fig. 6a) This pit shows dune, beach, and lake sediments (Dineen, 1977). The hill to the east is a dune-sand mantled drumlin. A compound dune cluster built up around the drumlin. Bedrock lies approximately 60 ft. below the surface, the Ballston Channel lies to the west.

The drumlin stood as an island in Lake Albany, as the Schenectady delta built out into this area. A +330 ft. beach is exposed on the east side of the pit. It consists of a wave-cut platform, cut into till, overlain by a lag concentration of boulders and trough cross-bedded, gravelly sand. Horizontal to ripple-laminated sand and silt were deposited off-shore. Planar cross-laminated dune sand over-lies the lacustrine deposits.

Parallel ridges with a NW-SE trend are the dominant form of dune crests in the Pine Bush sand plain, the name of the pine and oak brush-covered sandy area between Albany and Schenectady. A secondary mode of dune form comprises crescentric ridges that are convex to the southeast. Ridges of this concentric type commonly join adjacent parallel ridges or form hooks curving to the southwest from the south-east end of a ridge. In the past, these crescentric dunes have been interpreted either as barchans (which suggests a southeast wind direction) or as parabolic dunes (which suggests a northwest wind). These interpretations were based on shape, directions of steeper slopes and linear trends. Recently, we have been able to settle this controversy with cross-bedding data, gathered from deep cuts made in the dunes during a recent flurry of construction projects throughout the Pine Bush area (Dineen, Rogers, and Buyce, 1978). Weathering and bioturbation have destroyed the primary sedimentary structures in the top three meters of the dune sand, so that a substantial excavation is required to expose undisturbed deposits that contain directional features. Measurements of over 200 cross-beds at 35 localities in the Pine Bush dunes give down-dip modes to the northeast, southeast, and south. These data combined with the NW-SE trend of the linear ridges and the southeast convexity of the arcuate ridges indicate that the dominant dune-forming winds were north-westerly, hence the crescentic dunes are parabolic.

That southwest winds were also important is indicated by a prominent northeast mode in the dip directions. Fig. 6 of the dune crests shows the characteristic dune ridge pattern. Careful analysis of dune morphology, especially on aerial photos, shows the northeast side of linear ridges to have steeper slopes than the southwest side, and the southwest limbs of parabolic dunes to be atrophied. These observations corroborate the evidence for wind directions given by cross beds.

Only one measurement was recorded of a cross-bed dipping toward the northwest quadrant, which indicates a nearly complete absence of dune-forming winds from the southeast during the post-glacial period.

The parabolic dunes have a relatively gentle convex upwind slope of $<10^{\circ}$ and a steeper concave downwind slope of $>15^{\circ}$. They are transverse forms as opposed to the longitudinal ridge-forms.

The dune ridges in the Pine Bush are sinuous, generally parallel, and as much as two kilometers long. They are generally lower than the parabolic dunes.

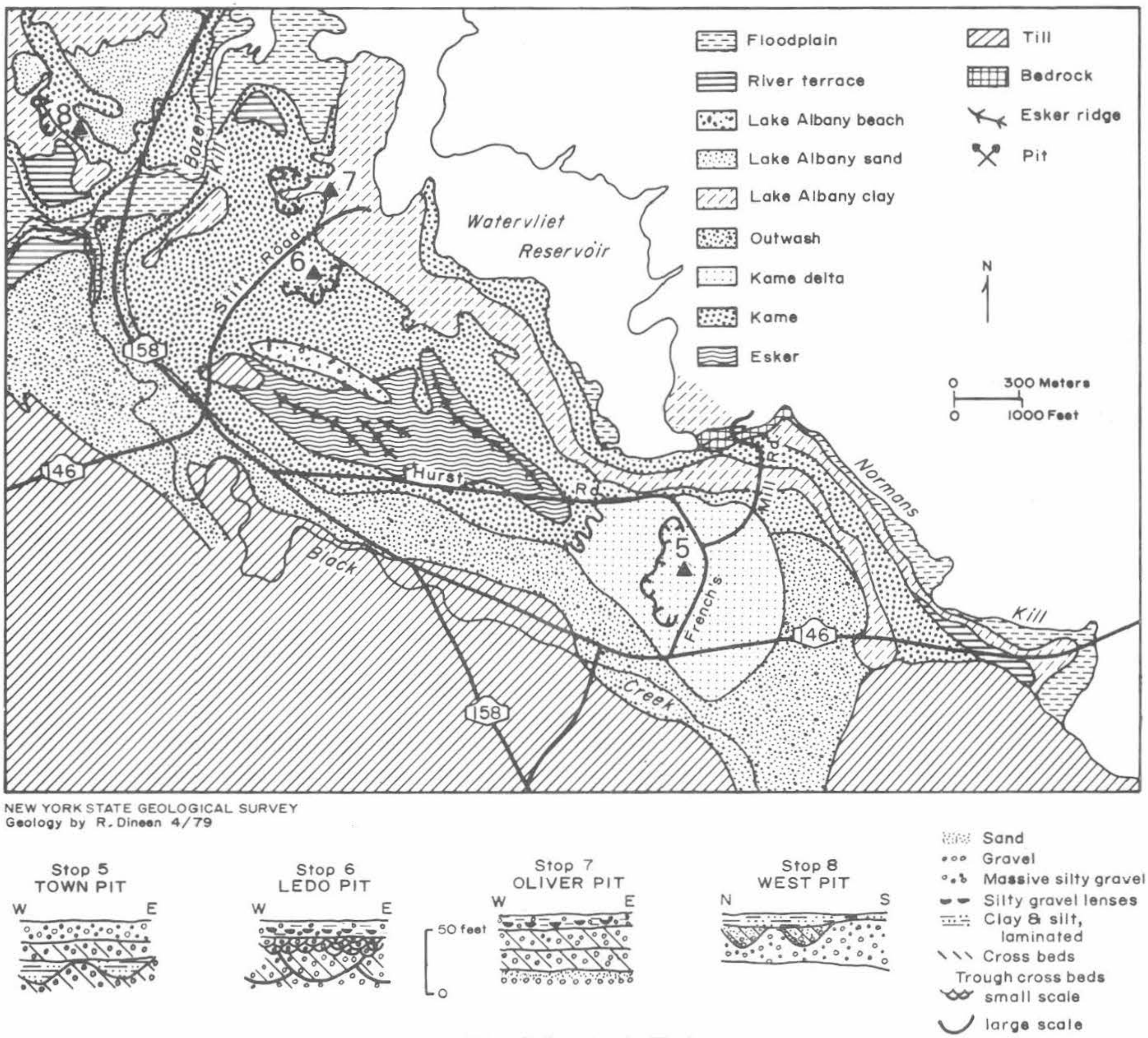
28.7	0.3	Leave Stop 3, proceed up (north) the access road to Curry Road. Turn right (east) on Curry Road.
29.0	0.3	Intersection of Curry and Morris Roads. Proceed right on Curry Road.
30.2	1.2	Intersection of Curry and Kings Road, turn right (east) on Kings Road.
31.1	0.9	Intersection of Kings and Old State Roads. Turn left (east) on Old State Road.
31.7	0.6	Intersection of Old State Road and NY 155. Turn right (south) onto NY 155 and park on access road that parallels NY 155.

Stop 4 Old State and NY 155 pits (Fig. 6b)
Cross NY 155 and follow the dirt road eastward for approximately 0.3 mile: We have walked along the northeast limb of a parabolic dune. The blow-out hollow lies to the right. Sand blown from this hollow was deposited at the dune crest. Migration of these two features leave the limbs trailing, and produces the parabolic dune form. The southwest limb of this dune is subdued. The slipface of another dune lies to the right (south). Several small hollows can be seen along the inside of the limb that we are on. These are blowouts that formed recently due to tree throw or denudation

of vegetation by fire. The taller trees are pitch pine, the low scrubs are dwarf or scrub oaks.
The pits to the northwest and west show aeolian cross-bedding in dune sand that disconformably overlies the lake sand. This dune is part of a large compound dune cluster. The dunes of the cluster are connected on their northeast limbs, which can be seen to the east of this dune crest. The connected northeast limbs form a continuous ridge that can be traced for over 3km.
Leave the dune crest and walk back to bus. Proceed south on NY 155.

32.4	0.7	Notice the till overlain by dune sand in the road cuts.
33.6	1.2	Intersection of NY 155 and US 20. A sand pit just northeast of here showed trough cross-bedded, gravelly, coarse sand. This gravelly sand underlies dune-shaped hills, implying that some "dunes" are erosional forms that have been wind-sculpted. The gravelly sand was probably deposited in a kame delta of the Delmar Readvance. Turn right (west) on US 20.
35.5	1.9	Intersection of US 20 and NY 146. Turn left (west) on NY 146. We are crossing the buried preglacial Mohawk Channel. A drumlin field buried by lake sediment cuts across the channel (Dineen, 1975). The drumlin field is flanked on the west by a thick gravel blanket. The drumlins act as underground dams by impeding the west-to-east movement of ground water in the gravel blanket.
36.4	0.9	Crossing the Normanskill. Climbing the south wall of the Mohawk Channel.
37.7	1.3	Intersection of French's Mill Road and NY 146. Turn right (north) on French's Mill Road.
37.9	0.2	Entrance to Town Pit on left.

Stop 5 Town Pit (Fig. 7)
This pit is cut into the distal, kame delta portion of the Guilderland kame terrace. This stop, and stops 6, 7, 8 will illustrate the distal-to-proximal increase in labile (shale) lithic clasts, in angularity of clasts, and in clast size, that accompanies the decrease in



STOPS 5, 6, 7, 8

Figure 7.

sorting typical in a kame terrace. The Guilderland kame terrace was first mentioned by Woodworth (1905) when he observed the existence of a large gravel terrace northwest of Guilderland Center. He considered the terrace to be an ice marginal kame. LaFleur (1965b) called attention to glacial lake beaches that are cut along the northern margin of the kame. LaFleur also reported southwest dipping gravel and irregular beds of rhythmic clay in the kame. Woodworth (1905) and LaFleur (1965b) interpreted the kame as having been deposited by meltwater streams in an elongate hole in the ice. LaFleur (1965b) suggested that the streams were the outflow of Lake Amsterdam in the Mohawk Valley. Dineen (1975) found that the kame is continuous with a buried gravel blanket which extends north to Schenectady.

The kame consists of well-sorted, sub-rounded, ice-contact sand and gravel to the east, and poorly-sorted, subangular, silty, bouldery sand and gravel to the west. The number of shale clasts and the overall grain size decrease from west to east. The surface of the kame slopes to the southeast, from +360 ft. at Stop 8 to +330 ft. at Stop 5. Stop 5 is in a kame delta that was built into Lake Albany, and shows planar cross-bedded, rhythmic silt and sand overlying trough cross-bedded, ice-contact sand and gravel. The rhythmites are overlain unconformably by planar-bedded, silty, cobbly sand that grades into clay to the southeast. These upper beds are delta foresets, and dip S20°E.

Leave Stop 5, proceed north on French's Mill Road to Hurst Road.

38.0	0.1	Turn left (northwest) onto Hurst Road.
39.3	1.3	Intersection of Hurst Road and NY 146. Turn right (west) on NY 146.
39.5	0.2	Intersection of NY 146 and Stitt Road. Turn right (north) on Stitt Road.
40.0	0.5	Stop 6 Ledo Pit (Figure 7)

Stop at entrance to pit and walk in. This pit contains large-scale, trough cross-bedded, cobbly, gravelly sand, dipping N20°E and overlying ripple trough cross-bedded, coarse sand. The cobbly sand grades upward into channels filled with rhythmic silt and clay. The channels trend N20°W. They are overlain by cobbly, silty gravel that is overlain by varved clay to the north.

Leave Stop 6, proceed north on Stitt Road to the access road (to the west).

40.4	0.4	Stop 7 Oliver Pit (Fig. 7) This pit contains planar cross-bedded, cobbly, sandy gravel that dips N80°E, and which overlies ripple-laminated coarse sand. These beds are overlain by pebbly, silty cobble gravel with channels filled with rhythmic silt and clay. Varved clay overlies the sequence to the north. The lower gravel layers extend north of the kame, where they partially fill the Mohawk Channel; and they are overlain by lake deposits northward. They can be traced to Schenectady. This gravel probably was deposited on the ice block that occupied the Schenectady area during the early Lake Albany time (see LaFleur, this volume). The channels that cut into the top of the gravel slope northeastward, perpendicular to the axis of the kame terrace.
41.5	1.1	Turn around in the Oliver Pit, and proceed south on Stitt Road to NY 158. Turn right on NY 158.
42.4	0.9	Proceed north on NY 158 to Becker Road. Turn left (west) on Becker Road.
42.6	0.2	Proceed to access road to Stop 8 (on north side of road). Pull off road. Stop 8 West Pit (Fig. 7) This pit contains poorly bedded, poorly sorted, shale-rich, silty, bouldery gravel, overlain by varved clay that fill erosional channels cut into the top of the gravel. Turn around in access road, proceed back to NY 158.
42.8	0.2	Turn right (south) on NY 158.
43.7	0.9	Intersection of NY 158 and NY 146. Turn left (east) on NY 146.
44.5	0.8	Intersection of NY 146 and School Road. Bear right (southeast) on School Road.
46.5	2.0	Intersection of School and Altamont Ave. Bear right (south) on Altamont Ave.
48.2	1.7	Intersection of Altamont Ave. and NY 156. Bear left on NY 156.
48.4	0.2	Intersection of NY 156 and NY 85A.

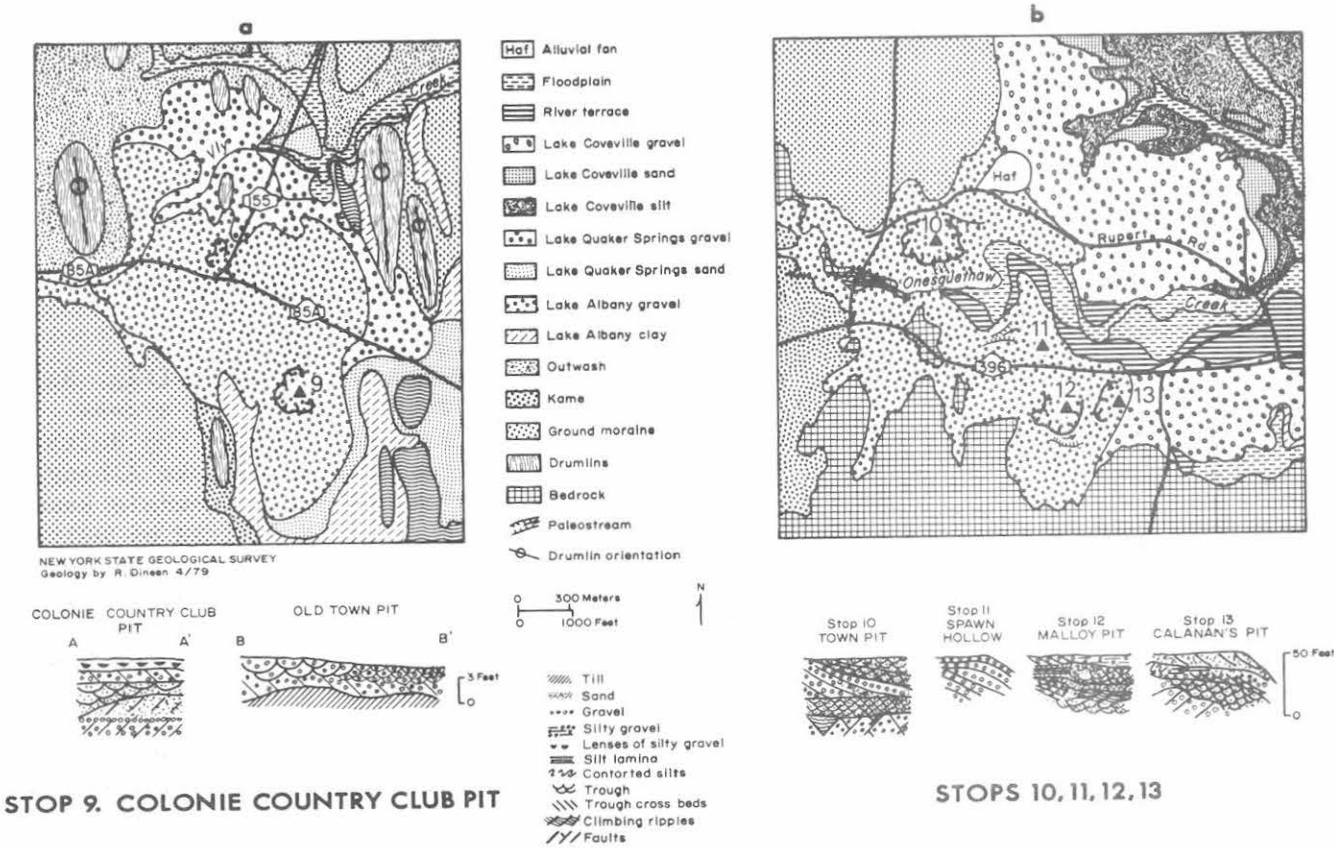


Figure 8.

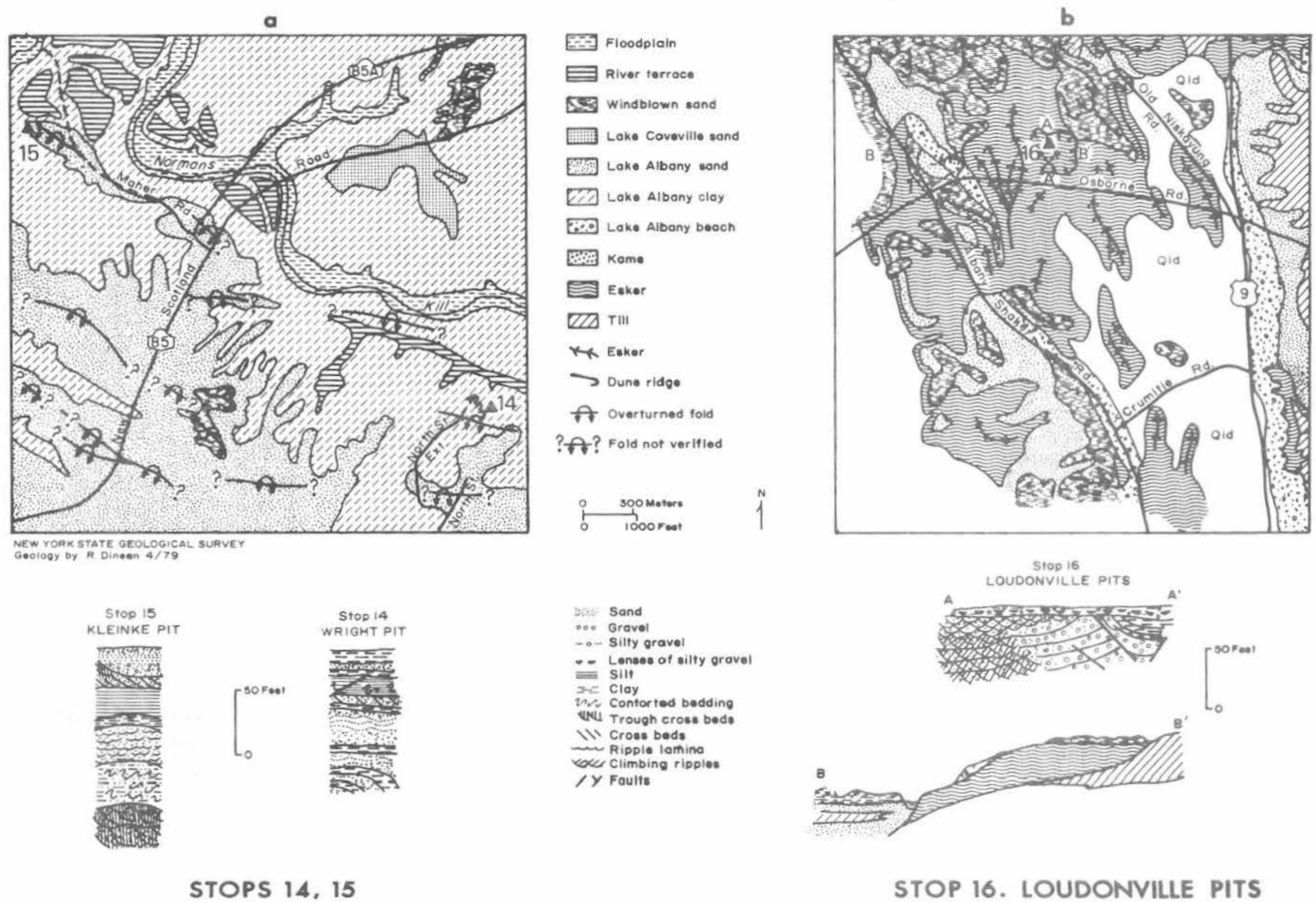


Figure 9.

		Bear left (east) on NY 85A.
50.0	1.6	Access road to Colonie Country Club. Turn right (south) on to access road.
50.3	0.3	Go to club house parking lot. Walk along the road to the west for 0.1 mile.
		Stop 9 Colonie Country Club Pit (Fig. 8a) This is the Voorheesville delta. The access road runs along the foreset slope of the delta. The delta was deposited into early Lake Albany, and is at the distal end of the Meadowdale kame and outwash complex that was deposited by meltwater from a stagnant ice block in the Guilderland Center-Voorheesville area (Dineen, 1977). The section in the pit consists of planar bedded, ice-contact gravel and sand at the base, overlain by planar cross-bedded, foreset sand and gravel, which are overlain by topsets of trough cross-bedded, silty, gravelly sand. The Town of Voorheesville derives its water supply from the delta. Leave the Colonie Country Club.
50.6	0.3	Turn left (west) on NY 85A.
51.2	0.6	Intersection of NY 85A and NY 155. Turn right (north) on NY 155.
55.2	4.0	Intersection of NY 155 and US 20. Turn right (east) on US 20.
57.6	2.4	Intersection of US 20 and Interstate 87. Turn left (north) on I-87.
58.3	0.7	Entrance to I-90. Turn on I-90 (east).
64.3	6.0	Intersection of I-90 and I-787. Turn on I-787 (south).
68.2	3.9	Intersection of I-787 and US 9W. Turn right on US 9W (south).
73.9	5.7	Intersection of US 9W and NY 396. Turn right (west) on NY 396.
76.5	2.6	Overpass-abandoned Penn Central railroad right-of-way, in the Village of South Bethlehem. We are travelling up the foreset slope of the South Bethlehem delta.

77.5	1.0	Intersection of NY 396 and Snyders Bridge Road. Turn right (north) onto Snyders Bridge Road. We are cutting across the apex of the delta.
77.9	0.4	Intersection of Snyders Bridge Road and Rupert Road. Turn right (east) on Rupert Road.
78.1	0.2	Intersection of Rupert Road and access road to Town Pit (to south).

Stop 10 Town Pit (Fig. 8b)

Park at the entrance to the access road and walk down into the gravel pit. The South Bethlehem deltas lie at +340, +300, +220, +190, and +170 ft. The +340 ft. delta is wholly contained within the Onesquethaw Creek Valley, and lies approximately 1 mile (1.6 km) west of Stop 10. The +300 ft. delta is the largest and best developed delta. The lower deltas prograde eastward across varved silt and clay. The +300 ft. delta was described as an ice-marginal kame delta by Woodworth (1905) and Cook (1930). Woodworth (1905) noted that the +300 ft. delta had a boulder and till covered, raised outer margin, with a southwest gradient. These features imply that the delta was deposited in the ice-contact environment. Airphoto and field observations suggest that the +300 ft. delta's outer margin is not raised more than 2m (5 ft.). Exposures in gravel pits and along the Onesquethaw Creek reveal a predominance of fining-upward beds of coarse sand and gravel, and some lenses of boulders. These beds dip to the northeast at Stop 10, and to the southeast at Stops 11, 12, and 13. No till has been observed in the pits, but gravity faults are common west of a rock ridge in Stop 10, and in ice-contact gravel that is exposed in Stops 10, 12, and 13. Boulders mantle the northeast slope of the delta along Rupert Road. Several channels cut southeastward across the delta's surface in the areas of Stops 10 and 12. Rhythmic silts and clays overlie the southeast and east margins of the delta (Stops 11 and 12). No kettle-holes were observed. A test boring 3500 ft. (1.3km) east of the delta showed a 70m (200 ft.) section of deltaic gravels interbedded with varved clay (Dineen, Waller, and Hanson, in prep.). The delta had been deposited in open ice-free water when the Onesquethaw Creek was carrying large quantities of very

coarse sediment. The sediment was probably derived from a rapidly melting ice block that lay in the upper Onesquethaw Valley. The lower deltas were deposited in lower lakes by the Onesquethaw recycling the upper deltas. This stop (Stop 10) is at the apex of the +300 ft. Lake Albany delta. This pit shows normal-faulted, ice-contact, gravelly, coarse sand at the base. The sand is overlain by trough cross-bedded, bouldery sandy gravel foreset beds. The foreset beds are overlain by trough cross-bedded to structureless, silty gravel topset beds. The bouldery cross-beds indicate that this is the proximal section of delta.
Leave pit, turning around in access road.
Turn left (west) on Rupert Road.

78.3	0.2	Intersection of Rupert and Snyders Bridge Roads. Turn left (south) on Snyders Bridge Road.
78.7	0.4	Intersection of Snyders Bridge Road and NY 396. Turn left (east) on NY 396. Intersection of NY 396 and Spawn Road.
79.4	0.7	Turn left (north) on Spawn Road.
79.6	0.2	Access road to Spawn Hollow pit. Park and walk in.

Stop 11 Spawn Hollow Pit (Fig. 8)
This pit is within planar cross-bedded, foreset beds of the central part of the delta. A thin section of topset beds is at the top of the pit. The exposed face shows the break in slope between the topset and foreset beds.
Leave Stop 11, turn vehicle around in the access road. Proceed south on Spawn Road.

79.8	0.2	Intersection of Spawn Road and NY 396. Proceed straight across road onto the access road to the Malloy pit.
80.0	0.2	Stop 12 Malloy Pit (Fig. 8b) Notice that the delta foreset beds here are finer grained, and tend to be trough cross-bedded rather than planar cross-bedded as they are at Stop 11. The topset beds are siltier and thicker than to the west.
80.2	0.2	Turn around in the pit, proceed out to NY 396. Turn right (east) on NY 396.
80.6	0.4	Intersection with access road to Callanan pit.

Turn right (south) into pit.

Stop 13 Callanan Pit (Fig. 8b)
This pit is on the prodelta slope of the +300 ft. delta. Ice-contact sandy gravel lies at the base of the pit. This is covered by bottomset beds of trough cross-bedded, coarse sand. The bottomset beds are overlain by foresets of planar cross-bedded, coarse sand and gravel. Very silty, trough cross-bedded, topset gravels and varved clays cap the sequence. Turn around in the pit, turn right (east) on NY 396.

83.2	2.6	Intersection of NY 396 and US 9W. Turn left (north) on US 9W.
88.2	5.0	Intersection of NY 32 and US 9W. Turn onto NY 32 (west).
88.8	0.6	Intersection of NY 32 and Kenwood Ave. Turn right (northwest) on Kenwood Ave.
91.2	2.4	Intersection of Kenwood Ave. and North St. Turn right (north) on North St.
91.7	0.5	Intersection of North St. and North St. Extension. Turn left (west) on North St. Extension.
92.2	0.5	Stop 14 Wright Pit (Fig. 9a) This stop shows lake silt and sand layers that were folded and faulted by ice shove during the Delmar Readvance. The section at this site consists of:

Top to 2.0m	yellow brown, varved clay and silt with laminae of fining upward, very fine sand. Layering is 6cm thick. The sand is ripple to planar-laminated, the planar-laminae are at the base of the beds over fine lag gravel and a truncation surface.
2.0 to 3.3m	yellow brown, compact, ripple to planar-laminated, very fine sand with 0.5cm laminae of clay. The sand fines upward. Bedding is faulted and folded, the fold axes trend N15°E and N80°E. The faulting is thrust up to the S40°W, soft sediment deformation is common.

3.3 to 3.7m	yellow brown, very fine sand with silt laminae. The varves fine-upward, and are 0.5cm thick. The varve sequence coarsens-upward to ripple-laminated sand, which fines-upward to varved silt.
3.7 to 4.7m	yellow brown, structureless, very fine sand, with contorted fragments of clay. Concretions are common at the base.
4.7 to 6.3m	gray brown, folded, very fine silt, clay, and fine sand in 5 to 20 cm thick coarsening-upward folded layers. The fold axes trend N60°E to N70°E. The tops of the folds are truncated and are covered by fining-upward, ripple cross-laminated, very fine sand.
6.3 to 13.3m	light gray, laminated silt.

Base of pit. Test boring log:

13.3 to 32.5m	pinkish gray to light gray, varved silty clay.
32.5 to 35.4m	light gray, varved, slightly silty clay
35.4 to 39.0m	light gray, varved, sandy, silty clay
39.0 to 63.0m	gray, varved clay
63.0 to 79.2m	light gray, varved clay
79.2 to 82.0m	gray, soft, varved clay with a trace (<5%) fine sand grading down to sandy clay with sub-rounded shale and quartzite clasts.
82.0 to 87.2m	Black shale.

The upper silty beds are folded parallel to the interfluve ridges that are present throughout the Delmar area. The upper part of the section was probably folded by the Delmar Readvance.

92.7	0.5	Leave Stop 14, proceed south on North St. Extension to North St. Turn right (south) on North st.
93.2	0.5	Intersection of North St. and Kenwood Ave. Turn right (west) on Kenwood Ave.
94.2	1.0	Intersection of Kenwood Ave. and NY 140.

		Turn right (north) on NY 140.
95.1	0.9	Intersection of NY 140 and NY 85. Turn right (north) on NY 85.
95.7	0.6	Intersection of NY 85 and New Scotland Ave. Turn left following NY 85.
95.8	0.1	Intersection of NY 85 and Maher Rd. Go straight on Maher Road.
96.4	0.6	Stop 15 Kleinke Pit (Fig. 9a) This pit is also developed in folded lacustrine silts and sands. The fold axes trend N40°E. The section is:

Top to 0.8m	very light yellow brown, planar-laminated, very fine sand. A truncation surface is at 0.8m.
0.8 to 3.8m	yellow brown silt to medium sand that coarsens-upward. This unit is mostly ripple cross-laminated with climbing ripples at its base and top. Ripples climb to the S80°S and N80°W.
3.8 to 5.0m	yellow brown, structureless silt.
5.0 to 11.0m	yellow brown, folded and convoluted silt to very fine sand. Dewatering structures are common. The fold trends N40°E.
11.0 to 11.5m	yellow brown, contorted, varved sand, silt and clay.
11.5 to 13.5m	yellow brown, ripple-laminated, fining-upward, fine sand to silt. Truncated and cemented at 11.5m.

		This area was probably folded by the Delmar Readvance.
96.9	0.5	Leave Stop 15, proceed east on Maher Road to NY 85. Turn left (north) on NY 85.
101.2	4.3	Proceed to I-90 (west). Get on I-90 (west).
102.9	1.7	Proceed to I-87 (north). Get on I-87.
106.0	3.1	Proceed to Shaker Road (Exit 4). Exit on Wolf Road. Turn left (northeast) on Wolf Road.
106.2	0.2	Intersection of Shaker Road and Wolf Road.

		Turn right (southeast) on Shaker Road.
107.9	1.7	Intersection of Shaker and Osborne Roads. Turn left (northeast) on Osborne Road.
108.1	0.2	Access road to Stop 16 on left. Turn left.
108.3	0.2	Stop 16 (Malloy) Loudonville Pits (Fig. 10b)

These pits are on the axis of the Loudonville esker complex. The Loudonville esker complex was described by Peet (1904) as a moraine-kame-delta complex that extended from North Albany to Newtonville. It is bounded on the north by a "boulder strewn" moraine ridge with elongate kettles (Woodworth, 1905). The esker system slopes to the south, with coarser gravels and cobbles to the north and finer gravel and sand to the south (Woodworth, 1905). Kettle holes are common, with faulted bedding near the kettles, and unfaulted bedding dominating to the south. The lenticular gravel at the north grades southward into horizontally bedded, fine-grained sediments (Woodworth, 1905). The eskers are overlain by cross bedded, gray and yellow sand (Cook, 1905). The esker complex grades southward into the Schodack kame terrace (Woodworth, 1905, Cook, 1930, LaFleur, 1965a, 1965b). Woodworth (1905) interpreted the Loudonville complex as being built by south-flowing, in-glacial streams. Cook initially interpreted the complex as a crevasse filling (Cook 1930), but later re-interpreted it as being deposited in a blind, lake water-filled, ice-walled tunnel (Cook, 1946). He misinterpreted the rounded bluffs surrounding the complex as being molded by over-hanging ice walls (Cook, 1946), rather than as beach-cliffs cut by Lake Albany waves (Fairchild, 1918, LaFleur, 1961b, 1965b). Stop 16 shows a 16m. fining-upward sequence of poorly-to well-sorted, ice-contact sand and gravel. The lower gravel contains boulders, silt, and cobbles in planar cross-beds which interfinger with cobble lenses. These lower beds are overlain by ripple-laminated sand that is overlain by lenticular, fining-upward, trough cross-bedded gravel and ripple-laminated sand. This sequence is overlain to the south by planar cross-bedded, ripple-laminated, deltaic fine silt and sand. The entire sequence is cut by gravity-faults that bound basins which filled with varved clay. The varved clay reaches an elevation of +400 ft. The +400 ft. varved clay and delta complex at Stop 16 was deposited in a lake that existed up-stream (north) from Lake Albany. The western edge of the esker complex was exposed in a building excavation at the corner of Osborne and Shaker Roads in 1976. This excavation contained a fining-upward sequence of trough cross-bedded gravel and sand. The gravelly sand beds were planed off, and were overlain by horizontally laminated, yellow brown sand. The entire sequence contained numerous gravity faults. The lower trough cross-bedded, gravelly sand was deposited in the esker. The upper, laminated sand was deposited in a Lake Albany beach. Stagnant ice lay in the area until after the lake dropped below the +330 ft. level, as indicated by the gravity faults. The area of this pit is probably the recharge of the Loudonville eskers' artesian groundwater system.

110.3	0.2	Leave Stop 16, turn left (east) on Osborne Rd.
111.3	1.0	Intersection of Osborne Road and US 9. Turn left (north) on US 9.
114.3	3.0	US 9 and NY 7 (Latham Circle).
119.1	4.8	Turn east on NY 7. Proceed to Houston Field House.