FRIENDS OF PLEISTOCENE GEOLOGY

Eastern Section

23rd Reunion

May 21 and 22, 1960

Dunkirk, N.Y.

GLACIAL GEOLOGY OF CATTARAUGUS COUNTY, NEW YORK

by

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Contribution

of the Department of

Geology

Syracuse University, Syracuse, N. Y.

1960

SCHEDULE FOR THE 23rd REUNION

Friday, May 20, 1960

2:00	P.M.	Excursion through Niagara Power Project excavations at Niagara Falls, led by Charles Benziger, Project Geologist with Uhl, Hall and Rich for PASNY (Power Authority of fhe State of New York). For Friends arriving by way of Niagara Falls.
7-10:00	P.M.	Registration and informal get-together in Administration Building of Dunkirk Conference Grounds, 3 miles east of downtown Dunkirk on north side of Route 5.
		Lodging in cabins on the Conference Grounds, Dunkirk.

Saturday, May 21, 1960

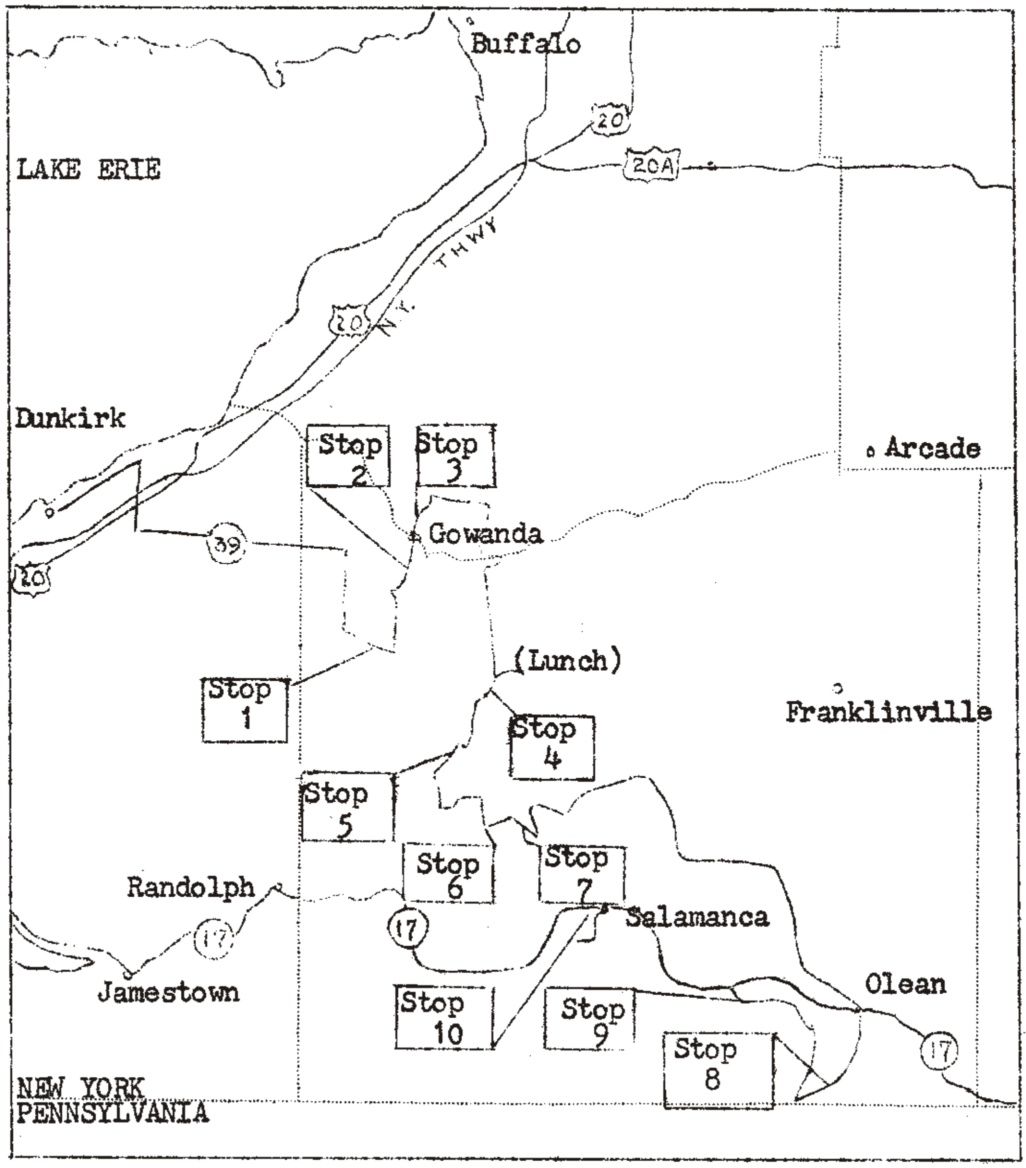
7:30	A.M.	Breakfast in dining hall, Dunkirk Conference Grounds. Registration for late arrivals immediately following breakfast.
8:15	A.M.	Assemble in caravan behind lead car, heading east on looping drive through Dunkirk Conference Grounds. Depart at 8:30 on TRIP ONE, southeast to Forestville, Gowanda, Cattaraugus, Little Valley, Ellicottville and Olean. Traverse from Lake Warren and Lake Whittlesey beaches to the Salamanca re-entrant, with major stops at Gowanda and Otto bluffs. Lunch to be served by ladies of Immanuel Lutheran Church, Otto.
7:00	P.M.	Traditional dinner in main ball room of Olean House, Olean. Business meeting is customarily brief. In view of past differences of interpretation of problems considered on these trips, the floor will be open for courteous but uninhibited comment.
		Lodging in Olean House, Olean.

Sunday, May 22, 1960

7:45	A.M.	Breakfast at Olean House.
8:30	A.M.	Assemble in caravan behind lead car, southbound on Route 16A, Union Street just north of bridge across Allegheny River, and across from Leo's Super Market. Depart at 8:45 on TRIP TWO, south and west to Olean Rock City, Birch Run, Salamanca and Allegany State Park.
12:30	P.M.	Disband at Observation Tower, Allegany State Park. Continue homewards. Hope to see you next year!

Year	Place	Leader
1934	Durham, N.H.-Hanover, N.H.	J. W. Goldthwait, G. W. White
1935	New Haven-Hartford district	R. F. Flint
1936	Rhode Island shore-Cape Cod	K. Bryan
1937	Hanover-Mt. Washington, N.H.	J. W. Goldthwait, R. P. Goldthwait, R. J. Lougee
1938	Black Rock Forest, N..Y..	C. S. Denny, H. M. Raup
1939	Northern N. J. (3 drifts)	Paul MacClintock
1940	Cape Cod, west end	K. F. Mather, R. P. Goldthwait, L. Thiesmeyer
1941	Catskills	J. L. Rich
1942-45	Inactive during war.	
1946	Lowell, Mass., area	L. W. Currier, with K. Bryan as associate.
1947	Finger Lakes (Cazenovia, NY)	E. T. Apfel
1948	Toronto-Barrie, Ontario	A. K. Watt, R. E. Deane, D. F. Putnam, W. M. Tovell
1949	Pensauken formation in N.J.	Paul MacClintock, Meredith Johnson, Jack Graham, John B. Lucke
1950	Ithaca, N. Y.	O. D. von Engeln
1951	Waldorf, Md.	J. T. Hack Paul MacClintock, coordinator
1952	Columbus - Xenia, Ohio	R. P. Goldthwait
1953	Ayer - Cambridge, Mass.	L. W. Currier, J. H. Hartshorn
1954	Wellsboro, Pa.	C. S. Denny, W. H. Lyford
1955	Malone, N. Y.	Paul MacClintock
1956	Drummondville, Quebec	N. R. Gadd
1957	Potsdam, N. Y.	J. N. Harris
1958	Harrisonburg, Va.	J. T. Hack
1959	London, Ontario	Aleksis Dreimanis
1960	Dunkirk - Olean, N. Y.	E. H. Muller

Information from files of R. F. Flint



ACKNOWLEDGEMENTS

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FIELD TRIP GUIDE

First Day, Saturday, May 21, 1960

The first day's traverse is southeastward from Dunkirk through Forestville, Gowanda, Cattaraugus Little Valley and Ellicottville to Olean (see fig. 1). Leaving the Erie lake plain in the morning, the route crosses the glaciated plateau to the edge of the unglaciated Salamanca re-entrant. Topographic features and surface glacial deposits are progressively older southward, ranging from nearshore deposits of Lake Warren across moraines of the plateau margin to early Wisconsin features of the Olean drift border. Deposits of post-Sangamon, pre-Farmdale age will be studied in exposures at Gowanda and Otto.

0.0 Assemble at 8:15 a.m. in single file of cars behind lead car on Dunkirk Conference Grounds driveway. Departure at 8:30.

Shore bluffs at the north edge of the Conference Grounds expose several feet of tan lacustrine silt with thin, discontinuous till over gray Hanover shale, the top of the Chemung formation as exposed in Chautauqua County. Striae on the shale surface at Point Gratiot just west of Dunkirk indicate ice movement from N 35° E. The Conference Grounds are on nearshore deposits of proglacial Lake Warren (see fig. 2). Soils are of the Dunkirk series on lacustrine sediments, except for patches of Lordstown shale loam, where bedrock is exposed.

Leaving Conference Grounds, turn left (east) on Lake Shore Drive (N. Y. Route 5).

3.3 Turn right (south) on Center Road.

5.7 Cross New York State Thruway on overpass.

CWG 6.0 Note Warren strand at approach to U. S. Route 20 in Sheridan (see fig. 2). The surface of this gravel terrace is at 755 feet above sea level. This beach trends east-northeast, rising about 50 ft. in elevation in 45 miles.

6.3 Cross U. S. Route 20 at blinker light. CAUTION: ROUTE 20 IS AN ARTERIAL HIGHWAY. Continue south on Center Road.

7.1 Note Whittlesey strand at approach to King Road (Cook Rd. of Forestville 7½ minute Quadrangle). A shallow borrow pit .3 mile southwest off King Rd. In 1957 exposed the following:

3.	Shingle gravel, stratified dipping southeast; dominantly of clastic pebbles; matrix coarse-textured; structure, open.	10 ft.
2.	Laminated lake silt with thin sand and pebble layers	4 ft.
1.	Gravel, coarse, poorly sorted with numerous erratics and rounded boulders suggesting derivation by wave washing of proglacial sediments	4 ft.

CWG 7.5 Note low knolls of thin till over bedrock on the right. These knolls comprise the westernmost remnants of the Gowanda moraine which extends discontinuously eastward as a low rise, separated from the base of the escarpment by a meltwater drainage-way. The meltwater stream channel is traceable for about ten miles from West Perrysburg to its debouchment into Lake Whittlesey.

7.7 Turn left (east) onto N. Y. Route 39 which rises steadily along the edge of the escarpment.

CWG 8.5 The escarpment which separates the lake plains from the plateau has been called the Portage Escarpment, but it is developed on the Canadaway formation in this area. The escarpment bears no relationship to the Portage Group, which does not crop out in Chautauqua County. The Canadaway formation totals about 950 feet and is dominantly composed of shale. The Laona and Shumla members, each about 30 feet thick are dominantly siltstone and somewhat thicker-bedded than the other members. These two siltstone members may account for details of the character of the scarp as developed eastward toward Forestville.

Question: In view of the dominantly shale lithology exposed in this portion of the escarpment, is structural control an adequate explanation of the origin of this scarp? Regional dip is very gentle toward the south. If the topography be truly cuestaform, where are the resistant capping strata responsible for the scarp which is 700 to 1100 feet high in eastern Chautauqua County?

CWG 9.4 Note shallow marginal meltwater channel leading northwest from divide .3 miles south of highway.

CWG 10.1 Note absence of glacial drift, presumably because of non-deposition or erosion by west-flowing meltwaters at the shifting margin of the waning ice sheet. Thin-bedded siltstone and shale are exposed in shallow road cuts.

Commence descent into Walnut Creek Valley.

10.8 Enter Forestville. Continue east on Route 39.

Stream cuts along Walnut Creek for a distance of several miles south of Forestville expose silty clay till with interbedded stratified units, overlain at the surface by as much as 25 ft. of laminated lacustrine silt and clay. Unless exposures are unusually good at the time of the Reunion, they will be passed up in favor of the Gowanda bluffs, as per the following log.

14.7 Cross Silver Creek headwaters

15.2 Cross Hanover Road at Parcells Corners. Continue east on N.Y. Rte 39

Roadcut at northwest corner in 1956 exposed 4 ft. of laminated lake silt over blue-gray, stony, silty till.

17.0 Leave Chautauqua County. Enter Cattaraugus County.

CWG The Lake Escarpment moraines lie in a two-mile wide belt south of the highway. Although massive where they bulge southward to block shallow through-valleys as north of Wango and Cottage, the proximal border of the moraine is not impressive as seen from the highway. The Nashville gas storage field of Iroquois Gas Co. lies mostly south of the highway for several miles affording limited data on thickness of drift. A well 1.3 miles east penetrated 157 feet of drift to reach bedrock and a well at East Mud Lake 2.6 miles southwest failed to reach bedrock at 186 feet.

22.8 Turn right (south) on N.Y. Route 353 in Perrysburg.

CWG Rising southward onto the plateau surface, cross moraine belt. The low ridge angling across toward the southeast at Mile 24 is the outermost moraine in this complex. South of this ridge the till cover is only a few feet thick and bedrock is exposed in shallow roadcuts. This till is silty, moderately pebbly (channery), yellow-brown and leached 3-4 feet. The soil is mapped as Erie silt loam.

25.5 Leave Cherry Creek quadrangle. Enter Cattaraugus quadrangle.

26.1 Join U.S. Route 62, southbound, at STOP sign. Proceed straight south toward Markham. In .8 mile Route 62 angles sharply to the right. This short stretch is across a valley marginal outwash fan.

26.5 Shortly after crossing railroad tracks curve left in Markham, leaving U.S. Route 62. Cross Johnson Creek and proceed south-

CWG east on Markham-Wesley Road. Small borrow pit to left of road at Johnson Creek exposes outwash gravel.

28.2 STOP ONE. Twenty minutes. Weathering profile in silty clay till of moraine southeast of Markham. Dayton town, Cattaraugus quadrangle, Cattaraugus County (78°56'42" W, 42°26'10"N).

Till, chocolate brown, very sparsely pebbly; matrix silty clay. Leached to about 40" except deeper where overlain by selvage of sand and gravel. Washed selvage ranges from 0 to 4 ft. Soil is mapped as Mahoning silt loam with very limited patches of Otisville gravelly loam on a few knolls.

This moraine lies south of the massive, composite Lake Escarpment moraines. Similar till is at the surface in Chautauqua trough and near the Pennsylvania State Line where it seems to protrude south from beneath Lake Escarpment till. Topographic expression at this stop is similar to that of the Defiance moraine in Ohio and weathering profile of the till suggests correlation with the Hiram till of Ohio and Pennsylvania.

Stop One is over axis of bedrock valley of the Ancestral Allegheny River. A well drilled for gas 2 miles northeast was abandoned at depth of 935 ft. without encountering bedrock. Maximum thickness of drift probably exceeds 1000 feet. From Steamburg and Randolph the Ancestral Allegheny had its course northward past Dayton and Gowanda to the present Erie basin.

Question: Does the character of this till reflect incorporation of lacustrine silt in basal load of the glacier during flow up axis of Ancestral Allegheny River? If so, is till character a valid criterion for correlation with similar till north of Chautauqua Lake and at Pennsylvania State Line? To what extent is this topography characteristic of clay-rich till and therefore only as valid as texture in relating this to Defiance moraine and Hiram till?

Continue southeast on Markham-Wesley Road

CWG 29.6 Turn left (north) on N.Y. Rte 18. At turn, shallow channel on right between moraine and bedrock upland is the Persia channel of Fairchild which briefly drained proglacial lake in basin of South Branch Cattaraugus Creek. For 3 miles the route lies across complex of moraine ridges, generally trending east-west.

31.2 Leave N.Y. rte 18, continuing north across railroad tracks. Cross highest of moraine ridges, then commence winding descent toward Gowanda. Cuts expose till and stratified sand and silt.

33.0 Immediately after crossing creek, turn right (north) at STOP sign onto U.S. Rte 62.

33.6 STOP TWO. Forty minutes. Please park close to car in front and off pavement. Keep highway clear. This is a major highway. Late Wisconsin stratigraphy.

Gowanda high bluff section. Stream bluff, West Branch Thacher Brook. Persia town, Cattaraugus quadrangle, Cattaraugus County. (76°56'44" W, 42°26'10"N).

8	Stratified sand and gravel; leached to 6 ft. oxidized to 14 ft.	17.0 ft.
7	Till (?), silty-clay matrix, calcareous, sparsely pebbly; includes sand parting	9.0 ft.
6	Stratified sand and gravel; oxidized in part	19.0 ft.
5	Till, blue-gray, calcareous throughout; matrix silty-clay; pebbles very sparse; basal contact undulatory; compact; silty toward base	9.0 ft.

4 Stratified, well-sorted gray silt; lamination obscure; very sparsely pebbly; bedding contorted in part; basal 8 ft. sandy grading to gravel 25.0 ft.

3 Till, silty-clay matrix; calcareous at top; sparsely pebbly; contains obscure silt partings 30.0 ft.

2 Stratified sand and gravel 12.0 ft.

1 Till, silty to silty-clay, chocolate blue-gray; pebbles very sparse; base obscured 6.0 ft.

Questions: What criteria distinguish basal till from glacionatant till (deposited beneath shelf ice) and from lacustrine deposits at the ice margin? What history of fluctuation is represented by this section? What interval is represented by these four similar tills? Has the situation here a modern analog in, for instance, Moreno Glacier's intermittent sealing of Canal de los Tempanos in Argentina?

Proceed north on U.S. Route 62.

35.0 Enter Gowanda, astride Cattaraugus Creek in Erie and Cattaraugus Counties. Pass under railroad tracks.

Gowanda in the Seneca language means "a beautiful valley between hills". The Seneca Nation of Indians maintains its business office in downtown Gowanda, but the reservation is north of town, extending along Cattaraugus Creek to Lake Erie.

Cattaraugus in the Seneca language means "odorous waters", an epithet given new meaning by the white man's tannery and glue factory on the southern outskirts of Gowanda. Cattaraugus Creek is the largest creek in New York west of the Genesee River to flow north across the Lake Escarpment - Valley Heads moraines. In so doing it has inherited the valley of the Ancestral Allegheny River where it descended from the plateau in a constricted gorge. Bedrock exposures on opposite sides of the valley at Gowanda are only .7 mile apart, yet a municipal well is reported to have penetrated 320 feet of drift.

35.6 Bear right to cross Cattaraugus Creek. In .1 mile turn left (north) still following U.S.Route 62.

36.2 Turn right (east); pass under railroad and bear left at top of rise, continue on U.S. Route 62 north toward Buffalo.

37.3 Turn left (west) onto grounds of Gowanda State Hospital and proceed to designated parking space.

37.6 STOP THREE. One hour. Wisconsin stratigraphy.

Gowanda State Hospital section. Stream bluffs, Clear Creek at Route 63, 39, 18. Collins town, Cattaraugus quadrangle, Erie County. (79°55'50"W, 42°25'20"N). Composite section.

11	Alluvial gravel; oxidized, many pebbles and cobbles deeply weathered; rounded to sub-rounded; exotic pebbles numerous	3.3 ft.
10e	Silt, dark olive-gray; stratified, includes fine sand laminae; oxidized and leached	1.0 ft.
10d	Silt, tan to olive, oxidized but unleached	1.3 ft.
10c	Fine sand, finely laminated, yellow-brown	1.2 ft.
10b	Clay and silty clay interlaminated with sand and silt; pairs are $\frac{1}{2}$ to $\frac{1}{4}$ inch thick, finer toward top. Clay-rich layers are unoxidized.	6.5 ft.
10a	Silt and fine sand, light to medium gray; un-oxidized, unleached; laminated to medium-bedded; sparsely pebbly towards base	10.0 ft.
9	Till, silty matrix, blue-gray, sparsely pebbly with shale and siltstone dominant. Includes sand and silt lenses but is more compact than overlying laminated units	4.0 ft.
8	Stratified sand, silt and sandy gravel; unoxi-dized	1.0 ft.
7	Till, silty matrix, dark blue-gray, compact, sparsely pebbly. Upper contact marked by seep. Includes minor light gray silt part-ings.	8.0 ft.
6	Stratified silt, sand and gravel; unoxidized; upper contact transitional, lower contact sharp	2.0 ft.
5	Till, silty matrix, dark blue-gray, compact; moderately pebbly with relatively high pro-portion of exotic pebbles. Faint seep shows better-sorted lens.	6.0 ft.
4	Gravel, pebbles and cobbles in coarse sand. Crude imbrication suggests flow to northwest. Pebbles dominantly rounded with diverse lith-ology. Unit thickens southwest to about 20 ft. at the stream bend.	3.0 ft.
3	Till, calcareous throughout; color ranging from olive-brown to orange-brown, suggesting incomplete assimilation of diverse materials. Compact. Sparsely to moderately pebbly. Toward base appears to incorporate and deform underlying stratified sediments.	20.0 ft.

2 Silty and carbonaceous clay; stratification disturbed enough to suggest crushing and sliding. One layer contains sparse invertebrate tests and several contain twigs and other plant remains. Wood is more than 38,000 years old (W-866). This unit abuts northward against Unit 3 15.0 ft.

1b Till, pink, silty matrix, (Color 5Y 4/1), fairly pebbly. Surface rises east cutting out part of overlying stratified section. Relationship to Unit 3 not clear as contact is nowhere exposed. Base obscured west of bridge but transitional relationship to underlying is suggested 200 ft. upstream. 18.0+ ft.

1a Till, medium blue-gray (5B 5/1), with abundant channers and flaggy bits of local blue-gray siltstone. Basal contact concealed, but upstream a few hundred yards this unit rests on bedrock. This may be a color phase of the overlying pink till, different only in assimilation of abundant local rock. 6.0+ ft.

(Note: Sequence of deposition of lower, contorted and disturbed portion of bluff is not certainly established because of discontinuity of exposure and obscured relationships.)

About .8 mile west of highway bridge a well is reported to have penetrated 620 feet of unconsolidated material to about 240 feet above sea level. If correct, this information gives a measure of depth and sharpness of the bedrock valley.

38.0 Return to U.S. Route 62 and turn left (north) toward Buffalo.

(NOTE: If road conditions should prevent following the route logged below from Gowanda to Otto, the caravan will turn right (south) on U.S. Route 62, returning through Gowanda to Dayton via U.S. Route 62; thence south via N.Y. Route 18 to Cattaraugus and by County Road 12 to Otto.)

38.4 Turn right (east) following N.Y. Route 39 through Collins

39.9 Cross Gowanda moraine, marking recessional position north of the Lake Escarpment moraines.

41.1 Turn right (south) on Zoar Valley Road

CWG 43.9 Begin rise onto proximal slope of massive Lake Escarpment moraine complex.

44.4 Commence descent into Zoar Valley following Zoar Valley Road. CAUTION: This is a long steep grade. USE LOWER GEAR.

Cattaraugus Creek flows across the grain of bedrock topography, crossing bedrock uplands through confined, steep-wall gorges and crossing drift-filled lowlands in broad, mature reaches. One such open reach is Zoar Valley ahead to the southeast, whereas due south at this point, Cattaraugus enters a 3-mile long gorge deeply incised in bedrock.

Silt and silty-clay till and lacustrine sediments in slumped moraine topograph in left. Soil is mapped as Mahoning silty clay loam, steep phase.

46.0 Turn right (south) past Burt's Zoar Valley Park and across Cattaraugus Creek. Leave interval between cars in crossing wooden bridge. Cross mature floodplain. Leave Erie County. Enter Cattaraugus County.

47.3 Pass Girl Scout Camp. Waterfalls ahead mark edge of drift-filled bedrock valley. Commence climb out of Zoar Valley on steep, winding road.

48.6 Continue south on County Road 11. North Otto Road. The low ridge arcuate across the valley to the left is correlated with the moraine at Stop One. Although it once formed the drainage divide, this moraine is now being dissected by north-flowing tributaries of Cattaraugus Creek descending the short, steep south wall of Zoar Valley.

The open valley ahead extends south to Otto and East Otto. These flats are the bottom of the proglacial Lake Zoar. The soil is mapped as Mahoning silty clay loam. Drift is about 450 feet thick.

53.3 Turn left (east) onto County Road 13, the main street in Otto. Proceed east through town.

54.0 LUNCHEON STOP. Turn left (north) off Eddyville Road into parking lot of Lutheran Church.

After lunch, return through Otto, following County Road 12 southwest to village limits. Park along right side of road and in abandoned church driveway.

54.9 STOP FOUR. Ninety minutes. Wisconsin stratigraphy.

Otto high bluff section, stream-bluff of South Branch Cattaraugus Creek, Otto town; Cattaraugus quadrangle, Cattaraugus County. (78°50'W, 42°21'15"N).

The Otto site was initially described (MacClintock and Apfel, 1944) as exposing Binghamton till, Olean outwash and Sangamon interglacial deposits. As exposed in recent years (Muller, 1957) the lower portion of the section has been alternatively interpreted as evidence of post-Sangamon, pre-classical Wisconsin environments. Both interpretations are permitted by radiocarbon dating of the uppermost organic zone, 15 ft. above the river at an age of greater than 52,000 years (GRO 2565). See discussion in text.

Upper part of the section is obscured by slump. Units 6 through 11 below were measured at the south end of the exposure. Units 2 through 6 were measured nearer the north end where material for radiocarbon and pollen analyses was also collected. Bedrock is exposed only at the south.

11	Stratified sand, silt and clay	3 ft.
10b	Till, gray-brown, sparsely pebbly silty clay loam matrix. Oxidized but unleached; bright pebble lithology; silt streaks	20 ft.
10a	Till as above, unoxidized	10 ft.
9	Stratified sand, silt and clay with very sparse pebbles	3 ft.
8	Till, gray, sparsely to moderately pebbly, silt to sandy silt matrix; includes partings of washed drift suggestive of oscillatory conditions of deposition	40 ft.
7	Pebble gravel, grading downward with cecreasing coarseness	5 ft.
6	Lake clay, contorted, laminated; red and "fat", in part.	3 ft.
5	Gravel, coarse, consisting largely of angular to sub-rounded pebbles and cobbles of plateau rock (sandstone and siltstone). Carbonate and crystalline cobbles are very sparse. What current direction is suggested by imbrication? A thin but continuous layer of silt and carbonaceous silt about midway up in this unit was dated at greater than 52,000 years (Gro-2565).	20 ft.
4	Stratified silt, muck, sand and pebbly silt. Both contacts transitional, not indicative of abrupt change of environment.	4 ft.
3	Boulder gravel, in a lens with maximum thickness at north end of exposure. Exact position in the organic sequence of units 2 and 4 is not certain. Boulders are tightly wedged with coarse sand to pebble gravel matrix. Platy cobbles and flatstones are dominant. Erratics and glacial striae are very sparse. Top of this unit is discolored by hydrous iron oxide deposition. Difficult to obtain effervescence with hydrochloric acid except on cobble coatings, which suggests secondary deposition.	3 ft.

2 Stratified silt, muck, peat, suggestive of floodplain deposition. Twigs are flattened and peat highly compressed. Imbrication suggests deposition from southwest. Base of section concealed below river at north. Pollen from near the base (2a-7) includes primarily <u>Picea</u> and <u>Pinus</u> (Brown and Benninghoff, personal communication, see p.25f. 7.0 ft.

1 Boulder gravel, coarse with abundance of crystalline boulders, apparently lag concentration in channel which eroded preexisting drift. A smear of till may exist beneath and among the boulders. 3.0 ft.

0 Bed rock; blue-gray siltstone with gradient northward 6.0 ft.+

<u>Questions</u>: What is the significance of the oxidized horizon at the top of Unit 3? How is the Sangamon represented? What is the character of the interval(s) represented by Units 1 through 4? What change caused the transition deposition of cobble gravel, Unit 5?

<u>Continue southwest on County Road 12, crossing South Branch of Cattaraugus Creek, toward Cattaraugus</u>.

55.5 OPTIONAL STOP. Depending on time and conditions of exposure, a 20-minute stop may be made to observe deformed silty-clay till and laminated lake deposits, exposed in creek bed .1 mile west of highway bridge.

CWG 56.2 Bright gravel in kame and kame delta deposits exposed in New Albion town gravel pit at left (southeast) of road.

CWG 57.0 <u>Bear left (south) at fork and continue south on County Road 76</u>. Lacustrine deposits and blue-gray silty-clay till are exposed in banks of north-flowing tributary to South Branch Cattaraugus Creek. Wooster (Woostern) gravelly loam is mapped on ablation till and stagnant ice deposits of the valley side adjacent to the highway.

59.2 <u>Turn right (north), angling back sharply at STOP sign onto N.Y. Rte. 18</u>.

CWG 59.7 <u>Turn left (east), angling back sharply onto County Road 6 toward New Albion</u>. Leave bed of proglacial Lake Zoar which occupied the basin of South Branch Cattaraugus Creek, imponded during Binghamton recession and deposition of Lake Escarpment moraines.

60.6 <u>STOP FIVE</u>. Fifteen minutes. Binghamton till.

Roadcut, Cattaraugus-New Albion Road (County Road 6), New Albion town, Cattaraugus quadrangle, Cattaraugus County (78°52'45" W, 42°18' N)

Till in roadcut contains numerous pebbles of bright appearance, e.g. carbonates, crystallines and red sandstone. MacClintock and Apfel (1944) characterized Binghamton drift and especially kame gravel as possessing typically 5-7% crystallines and 12-25% carbonate pebbles.

The New Albion outlet of Lake Zoar, with controlling level at approximately 1435 feet is visible due east, up-valley. This outlet is intermediate in elevation between the primitive southeastward overflow toward Little Valley and the subsequent Persia outlet marginal to the Lake Escarpment moraine. Note truncated kame at channel edge. Was the confined gorge of the easternmost .6 mile of this channel cut by rapid nick-point migration or even plunge-pool drilling, while the southwestward portion involved only filling and widening of an existing valley?

CWG 61.6 Continue straight across intersection at New Albion toward Leon on County Road 6. Contrast the open valley northeast of New Albion with the gorge southwest of this intersection. Each was cut by a tributary to north-flowing Conewango Creek, but one was broadened by outflow from Lake Zoar.

62.6 Turn left (south) onto County Road 10, toward Pigeon Valley

CWG 63.1 Earlier this spring an active slump moved across the shoulder to the edge of the highway pavement.

CWG 64.9 Leave Cattaraugus quadrangle. Enter Randolph quadrangle. Waterman Swamp to left rear is the source of Little Valley Creek. The swamp owes its existence to blockage of headward end of Conewango Valley by stagnant ice deposits.

65.8 Turn left (east) on County Road 7 toward Pigeon Valley. In .2 mile turn left (north), continuing on County Road 7.

66.6 Turn right (east) on dirt road which climbs sharply out of Pigeon Valley. Bedrock controls topography for about a mile, beyond which the route enters constructional topography of the proximal margin of Binghamton moraine.

68.1 Turn right (south) on dirt road, paralleling main ridge of strong constructional topography.

68.7 STOP SIX. Fifteen minutes. Postulated location of divergence of Binghamton and Olean moraines.

Constructional topography, .8 mile north of The Narrows, Napoli town, Randolph quadrangle, Cattaraugus County (78°51' W, 42°14'N).

West of the Salamanca re-entrant, MacClintock and Apfel (1944) mapped the Binghamton moraine (Kent moraine of Pennsylvania and Ohio) at the Wisconsin border. From The Narrows eastward they mapped the Olean moraine at the Wisconsin border, emerging from beneath the Binghamton drift. The Binghamton border is marked northeastward by massive valley-choking deposits of calcareous drift. Although topography and drift lithology support this interpretation the interpretation will be strengthened when superposition of Binghamton over Olean deposits is demonstrated.

69.5 Turn left (east) onto N.Y. rte 242 toward Little Valley. Leave Binghamton moraine.

CWG 70.5 Turn right (southeast) onto Bucktooth Run Road. Low kame on right. Olean till exposed in road cuts on left a short distance south of intersection.

NOTE: A short southward jog is made for the next 5 miles expressly to observe fossil boulder nets. If last minute reconnaissance indicates the feature has been defaced, or if time is too short, the caravan will not make the turn indicated above, but will continue northeast on N.Y. Rte 242 into Little Valley, thence turning southeast on N.Y. Rte 18, rejoining this road log at mile 75.1.

71.8 STOP SEVEN. Fifteen minutes. Evidence of periglacial frost action.

Boulder nets, .8 mile WNW of Bucktooth School, Little Valley town, Randolph quadrangle, Cattaraugus County (78°48'W, 42°13'N).

The Wisconsin drift border has been drawn along the ridge crest west of this stop. It is suggested that these boulder nets originated in rigorous climatic conditions at the Olean ice margin. Although most of the boulders are of local lithology, sparse crystalline boulders suggest that an earlier glaciation, or an attenuated margin of Olean till extended south of the boulder net locality.

Proceed southeast.

CWG 72.8 At second fork, angle back sharply toward the north and proceed into Little Valley. Note deep weathering in Dekalb silt loam in road cut. No till has been recognized across the crest of Bucktooth Hill. The Wisconsin border is not clearly marked at the north end of Bucktooth Hill but till is encountered at 2100 ft. and constructional topography is marked on the lower slope. Descend into marginal meltwater channel at village limit.

CWG 75.1 Turn right (south) on N.Y. Rte 18 in Little Valley. Olean kames, kame terrace remnants and short marginal meltwater channel segments are visible near base of west wall of valley for next several miles. Binghamton outwash in valley bottom.

CWG 76.6 Take left at fork, continuing on N.Y. Rte 242 toward Ellicottville. Road rises on kame complex in medial position at juncture of Dublin Hollow and Little Valley. View south down Little Valley towards the Allegheny Valley. A low moraine loop across Little Valley at Elkdale about a mile south may mark the Wisconsin terminus.

CWG 77.7 Sharp marginal meltwater channel notches spur to right ahead.

78.0 Take right at fork, continuing on N.Y. Rte 242 toward Ellicottville. Commence climb from Dublin Hollow to summit of Murder Hill.

78.8 Leave Randolph quadrangle. Enter Salamanca quadrangle.

CWG 80.4 At summit. Note subaccordance of glacially rounded summits, suggesting minimum reduction of level below the preglacial peneplain surface.

83.2 Enter Ellicottville. Take right at first fork, then curve left, continuing on N.Y. Rte 242 to red blinker and STOP sign. Turn right (south) on U.S. Rte. 219.

87.2 Cross Great Valley Creek. At STOP sign continue across intersection on Humphrey Road (County Road 18) toward Humphrey.

CWG 87.8 On Olean kame terrace in medial position between Great and Wrights Valleys. Olean border is 2½ miles southwest down Great Valley. A rather continuous kame terrace is preserved along south side of Wrights Valley for 3 miles. Olean ice pressed into but not over the upland south of Wrights Valley.

93.2 At Humphrey turn right (southeast) on Chapel Hill Rd. (County Road 51) toward Allegany and Olean.

CWG 95.2 Cross Chapin Hill at 2240 feet, slightly below level of Upland peneplain. Olean border was south of Chapin Hill and scattered erratic pebbles 4 miles southeast indicate that pre-Olean ice had somewhat greater extent. Bedrock is exposed in road cuts with residual mantle and Lordstown soil. Overlook east and south into Five Mile Valley.

Descend into valley of Five Mile Creek. Steep grade. Use lower gear.

96.6 Join County Road 19, turning right at t-intersection and following signs toward Olean.

100.4 Bear left at fork, bypassing downtown Allegany and proceeding toward Olean on Buffalo Street Extension. Leave Salamanca quadrangle. Enter Olean quadrangle.

CWG 101.4 Terrace to right of road has been interpreted as Illinoian gravel, overridden by Olean ice. This terrace, 2 miles long and 1 mile wide, is at 1480 to 1520 feet. Gravel pits in western part expose calcareous, discontinuously cemented gravel capped by 12 feet of silt loam interpreted by MacClintock and Apfel (1944) as silty leached till (silttil).

Constructional topography along the northeastern margin of this terrace is considered to be of Wisconsin age.

103.8 <u>Overpass over railroad tracks</u>.
Enter Olean, a town of 28,000 population which until about 8 years ago was a petroleum refinery center. Abandoned Socony Vacuum Oil Co. plant on left.

Proceed south on Twelfth Street to traffic light on State Street.

Turn left (east) on State Street. Proceed twelve blocks to Union Street. Traffic light and new City Hall on NE corner at intersection.

Turn left (north). Olean House is on the east about 150 yards north of intersection. Just beyond Olean House turn into alley at sigh "Park Olean House".

FIELD TRIP GUIDE

Second Day. Sunday, May 22, 1960.

The Second day's traverse is generally westward from Olean to Salamanca, with stops at Olean Rock City, the Birch Run gravel pit of Buffalo Slag and Gravel Co. and in Allegany State Park. Much of the traverse lies south of the drift border in the unglaciated Salamanca re-entrant.

0.0 Assemble at 8:30 in single file of cars on Union Street (N.Y. Rte 16A on which the Olean House is located) opposite Leo's Super Market, southbound toward the Allegheny River. Starting on the Olean quadrangle.
Note that in New York the correct spelling is Allegany as in Allegany town, Allegany County, Allegany State Park. In the interests of harmony, New York submits to central authority where a feature is shared with adjoining states, as in Allegheny River and Allegheny Plateau.

0.2 Cross Allegheny River. Continue south on N.Y. Rte 16A toward Knapp Creek.

CWG 0.4 Route 16A climbs southward from Allegheny Valley (1420 ft.) at Olean to summit level above 2300 feet in next four miles.
On right (west) just after crossing river was cemetery on modified moraine knolls which choke north end of small tributary valley just south of its juncture with Allegheny River. Olean drift border has been mapped about 1.2 miles south into this valley (Bryant, 1955).
Camel Back at right across the tributary valley is a bedrock knoll, separated from the uplands to the south by a short meltwater channel walled by rubble-mantled bedrock slopes. The Camel Back consists of two crests separated by a shallow swale at 1640 feet. The northern crest is till-mantled, whereas the southern is block-strewn on weathered bedrock.

3.0 Bear right at fork, following N.Y. Rte 16A.

CWG 3.6 Roadcut exposing Cattaraugus red beds overlain by Oswayo formation consisting dominantly of greenish-gray sandy shale.

CWG 3.9 Entering northern extension of Bradford Oil Field into New York State. Olean conglomerate, massive, corrsely-jointed pebble conglomerate at the base of the Pennsylvanian system underlies summit ridge followed by road for next several miles. Less massive conglomerates occur in several lower zones, but the Olean is a principal source of large joint blocks which in places have moved well down slope from their former outcrop.

4.6 Turn right (northwest) onto private drive to "nature's own scenic wonder" at Olean Rock City Park. Row of crude oil stock tanks on left.

5.0 STOP EIGHT. Forty-five minutes. Olean conglomerate weathering escarpment.

Olean Rock City, Allegany town, Olean quadrangle, Cattaraugus County (78°28'30"W, 42°1' N).

This is the type locality for the Olean conglomerate (Lesley, 1875), exposed in weathering scarp 64 ft. thick. Cross-bedding, joint cracks and ellipsoidal quartz pebbles to more than 30 mm in length are characteristic. This unit occurs on summit remnants of the Upland peneplain as far east as Alma Hill in Allegany County at 2548 feet above sea level, the highest elevation in western New York. Southward into Pennsylvania the formation loses its conglomeratic character in 20 to 30 miles.

This ledge consists of joint blocks separated by interconnecting passages which widen toward the exposed scarp face. Near the parent ledge the joint blocks show a minimum of rotation and subsidence but outwards they show varying amounts of tilt and downward movement. Noting that the blocks appear now to be immobile and disintegrating in place, Smith (1953) identified this and other nearby "rock cities" as periglacial features. A similar though less striking rock city in the area of Early Cary glaciation is at Panama Rocks, Chautauqua County.

Question: What evidence is there as to the relative importance of weathering, wedging, creep, sapping or other processes to produce this display of joint enlargement? What evidence shows the blocks to be immobile and the rock cities to be relics of periglacial environments?

Leaving parking lot, return by private road to N.Y. Route 16A.

5.5 Turn right (south) on N.Y. Rte 16A toward Knapp Creek. This road parallels former right of way of Western New York and Pennsylvania Railroad, a trolley route from Olean to Bradford via Rock City and Knapp Creek.

7.3 In village of Knapp Creek, turn right (north) onto County Road 61 descending sharply into valley of Fourmile Creek.

CWG 11.3 West Branch Fourmile Creek at left (west) across valley. Distribution of erratic pebbles and cobbles suggests that this is the approximate limit of glaciation in the valley of Fourmile Creek.

12.3 Turn left (west) onto River Road (County Road 60). Cross Fourmile Creek.

13.1 Cross Pennsylvania RR tracks south of Allegany. Leave Olean quadrangle. Enter Salamanca quadrangle.

13.2 Turn left (west) onto Burch Run Road toward Birch Run Country Club.

CWG 13.7 Foundation excavations at left exposed terrace gravels with several per cent of crystalline pebbles, leached more than 8 ft.

To the right, ahead, a flat-topped ridge extends northwest, confining the flood plain to one-third of the valley width. This terrace remnant is poorly exposed but is believed to consist of gravel, leached to 8 or 10 feet and overlain by several feet of yellow-brown silt and silt loam. The elongate form of the ridge suggests ice-marginal deposition, perhaps as an outwash delta. A tempting explanation for ponding in the Allegheny Valley is by glacial damming. Such impounding did not occur downstream from this point in Olean or later time.

14.9 Bear right at fork. Unmarked road to left leads to abandoned quarry.

15.2 STOP NINE. Thirty minutes. Kame delta complex.

Allegany Sand and Gravel Pit, Buffalo Slag Company. Birch Run at edge of Allegheny Valley, .9 miles SE of Russell, Allegany town, Salamanca quadrangle, Cattaraugus County. (78°32'50"W, 42°5'25"N).

Exposures in kame delta at several levels. Gravel is leached 9 to 12 ft. Carbonate content low, comprising only a few per cent of pebbles. Cementation by secondary carbonate is limited. Cobble imbrication, foreset bedding and slump structures suggest deposition toward west. In upper level as exposed in 1959, 40 feet of boulder-free cobble gravel overlay 15 feet of sand over 10 feet of till. Till is olive brown, silt loam matrix, low in lime, with coarse fraction consisting primarily of streamworn pebbles and flaggy boulders.

Search for erratic pebbles reveals none more than a mile south up the valley of Birch Run; none also on south side of valley of Birch Run. A few erratics in the saddle at 1760 feet, 3/4 mile southeast of the pit bear out the inference that proglacial meltwaters drained across the saddle south from Allegheny Valley into the valley of Birch Run.

Continue west on Birch Run Road.

15.9 Turn right (north) following dirt road.

16.8 Turn left (west) on Ninemile Road. Lippert Sand and Gravel Pit about one mile east produces from outwash gravel below river level.

17.0 Turn right (north) across Allegany River over single lane bridge.

17.1 CAUTION: Cross mainline ERIE RAILROAD and turn left (west) onto N.Y. Rte 17. THIS IS A MAJOR HIGHWAY!

19.5 Bradford Junction. Continue west on N.Y. Rte 17.

CWG 25.1 Rise on gravel terrace in outskirts of Killbuck (East Salamanca). Terrace at 1420 to 1440 feet, composed of gravel leached 15 to 20 feet, but fairly calcareous below leached zone. Local cementation by secondary calcium carbonate. Boulder-free character suggests outwash, considered by MacClintock and Apfel (1944) to be Illinoian.

25.7 Cross mouth of Great Valley onto Olean outwash terrace west of Great Valley Creek.

26.6 Bear left on N.Y. Route 17, following "State Park" signs. After crossing Allegheny River, bear left again, leaving N.Y. Route 17, but following "State Park" signs.

CWG 27.3 View north over Allegheny Valley and upstream in both Great Valley (NE) and Little Valley (NW). Note that flood plain of the Allegheny is no more than one-quarter of the total valley width. Post-glacial modification of the valley bottom by the Allegheny River is trivial. Evidence of glaciation on uplands in the near distance is negligible, but a patch of Illinoian drift occurs below this road, just inside the park boundary to the west. Flow rolls exposed in road cut on left.

27.6 Enter Allegany State Park. View up Little Valley and west down Allegheny Valley.

29.9 Cross divide at 2365 feet above sea level. Bear right onto dirt road to Observation Tower.

30.5 STOP TEN. Fifteen minutes. Vista of Upland peneplain.

Observation Tower, Allegany State Park, Salamanca town, Salamanca quadrangle, Cattaraugus County (78°43'15"W, 42°7'50"N).

Upland peneplain at 2300-2400 feet above sea level. Uplands, well-wooded with second growth show no signs of glaciation. Soil mapped widely as DeKalb and Ernest silt loams. Salamanca conglomerate occurs below summit. Red House Lake and Allegany Park Headquarters visible to south in basin.

Continue on dirt road, bearing left (south).

31.0 Friends heading southwest and west, turn right (south) descending to intersection of Allegany Park Roads 1 and 2 at edge of Red House Lake. Thence turn right (west) toward Red House and N.Y. Route 17 westbound.

Friends heading north and east, turn left (north) recrossing divide and retracing route to N.Y. Route 17 in Salamanca. From Salamanca proceed north on U.S. 219 or east on N.Y. Rte 17.

Friends heading south, turn right (south) descending to intersection of Allegany Park Roads 1 and 2 at edge of Red House Lake. Turn left (east) on Route 2 and proceed to Pennsylvania State Line, continuing south on Pennsylvania 46 to Bradford.

PROPOSED INTERPRETATION OF TIME, ROCK STRATIGRAPHIC AND MORPHOSTRATIGRAPHIC UNITS IN THE PLEISTOCENE OF WESTERN NEW YORK

TIME			MORPHOSTRATIGRAPHIC		ROCK	EQUIVALENT
PLEISTOCENE	Wisconsin		Albion moraine Barre moraine Batavia moraine Niagara Falls moraine Alden moraine	Warren beach	red till	
		Port Huron	Marilla moraine Hamburg moraine Gowanda moraine	Whittlesey beach		
			Lake Escarpment morainic system (12,000 B.P.)	Lake Zoar		Dayton moraine of Leverett, 1895 Euclid, Painesville, Ashtabula, Girard moraines of Leverett, 1902 Valley Heads moraines of Fairchild, 1932 Ashtabula moraine of Shepps et al, 1959
			Defiance (?) moraine		Hiram till	
		Cary	Findley moraine Clymer moraine Binghamton moraine (14,000 B.P.)		Binghamton till	Inner Cleveland moraine of Leverett, 1902 Outer Cleveland moraine of Leverett, 1902 Kent moraine of Shepps et al, 1959
		Tazewell	Olean moraine		Olean till	
			(more than 52,000 B.P.)		Otto org. horizons	
	Illinoian		Illinoian terrace remnants and possible moraine		Stratified drift	

WESTERN NEW YORK GLACIAL PROBLEMS

1. Introduction

J. W. Goldthwait and G. W. White led the first field conference of the Friends of the Pleistocene in 1934, studying the Durham-Hanover area of New Hampshire. With interruption only during the war years, 1942-1945, the Friends have held subsequent reunions annually (see page 2). This, the 23rd Annual Reunion of what is now the Eastern Division, Friends of Pleistocene Geology, is the 6th to be held in New York State.

2. Literature review

Drift borders in western New York were described by Chamberlin (1883) and Lewis (1884), but Leverett's massive monograph (1902) is still the most extensive summary of glacial geology for the region.

Knowledge of the landscape at the onset of glaciation is based on interpretation of erosion levels and through-valleys. Tarr (1902) assigned upland remnants in southern New York to a Cretaceous peneplain. Campbell (1903) and Cole (1938) identified multiple erosion levels. Denny (1956-a) examined evidence of structural control during equilibrium reduction of the former erosion surface in Potter County, Pennsylvania. Carll (1883) and Leverett (1902) discussed evidence of the northward course of the Ancestral Allegheny River.

Evidence of pre-Wisconsin glaciation is limited. MacClintock and Apfel (1944) describe Illinoian terrace remnants in the Allegheny Valley near Salamanca. Bryant (1955) and Muller (1957-b) traced ice marginal features in the Quaker Bridge and Red House areas indicative of pre-Wisconsin glaciation across Allegheny Valley. The stratigraphic section at Otto probably indicates pre-Wisconsin glaciation, whether the organic zones are interpreted as Sangamon (MacClintock and Apfel, 1944) or as post-Sangamon, pre-Farmdale (Muller, 1957-a).

Features of the Wisconsin drift border mapped earlier (Lewis, 1884; Leverett, 1902; Lobeck, 1927) were interpreted by MacClintock and Apfel (1944) as including two drifts, the Olean drift of the Wisconsin border east of Little Valley and the younger, brighter Binghamton drift at the Wisconsin border west of Little Valley. The present detailed interpretation of the drift border is based on soil survey work (Pearson et al, 1940; Bryant, 1955). Two recessional positions of the Binghamton ice margin, incorrectly identified as the Inner and Outer Cleveland moraines by Leverett (1902) are renamed the Clymer and Findley moraines (Shepps et al., 1959; Muller, in prep.). Proglacial lake history in the plateau valleys is related to recessional positions of the ice border (Chadwick and Dunbar, 1924; Fairchild, 1896; 1928; Cuthbert, 1927).

Lavery and Defiance moraines mapped on the basis of texture and weathering profile (White and Shepps, 1952; Shepps 1953; 1955; Muller, 1956-a) in western Pennsylvania (Shepps et al, 1959) and Chautauqua County (Muller, 1956-b) appear to mark glacial readvances intermediate between the Binghamton recessionals and the Lake Escarpment moraines. Eastward correlation into Cattaraugus County is uncertain.

The Lake Escarpment moraines (Leverett, 1902) were correlated with the Valley Heads moraine (Fairchild, 1932) of the Finger Lakes region and have been recently dated at more than 12,000 years B.P. (Merritt and Muller, 1959). Shepps et al (1959) have applied to this complex of moraines in western Pennsylvania the name Ashtabula moraine, initially proposed by Leverett (1902) for one of the several Lake Escarpment moraines.

The succession of proglacial lakes imponded between the receding ice border (Leverett, 1902; Taylor, 1913; and Fairchild, 1932) and the northern margin of the Appalachian Plateau was described by Leverett and Taylor (1915), Fairchild (1932), Leverett (1939) and Taylor (1939). Correlation based on radiocarbon dating (Flint, 1956; Hough, 1959) has associated proglacial Lake Whittlesey with the Cary ice recession and at least the latest phase of Lake Warren with a post-Two Creeks readvance. Recent radiocrrbon data suggest that the entire lake succession may be of Two Creeks age (Karrow, in press; MacClintock & Terasmae, 1960; Terasmae, 1959).

3. Pre-Wisconsin glaciation

No direct evidence remains as to details of early glaciations. Prior to glaciation the Ancestral Allegheny River, rising in Pennsylvania flowed generally northwestward in a valley past Salamanca toward Steamburg, Randolph, Conewango, Dayton and Gowanda, with outflow into the Erie basin. A left-bank tributary of this stream flowed north from near present Kinzua, Pennsylvania to confluence with the Ancestral Allegheny between Salamanca and Steamburg. Although the Labradoran ice sheet may have experienced subordinate development during the Kansan and Nebraskan stages, it must have extended into New York far enough to block the Ancestral Allegheny, diverting its flow southward. The former divide at Kinzua had been reduced essentially to its present elevation before deposition of the earliest preserved glacial materials in Cattaraugus County.

These deposits include terrace remnants mapped by MacClintock and Apfel (1944) as Illinoian. Three saddles north of Quaker Run, aligned generally north-south were pointed out by Bryant (1955). These aligned notches together with glacial deposits blocking valleys of Quaker Run, Hotchkiss Hollow and Meetinghouse Run, are evidence that pre-Wisconsin glaciation extended southeast across the Allegheny Valley (Muller, 1957-b). The Illinoian gravels typically contain about 5% of igneous and metamorphic pebbles, and below the leached zone, 25 to 30% of carbonate and associated rock types derived from north of the plateau. Leaching averages about 15 feet deep. Secondary cementation is not uncommon at greater depth. Granitic boulders with one-half inch thick, kaolinitized weathering rinds occur on some of these benches. Illinoian terrace remnants stand 120 to 180 ft. above present river level, as opposed to 10 to 30 ft. for Wisconsin terraces.

4. Pre-Farmdale organic sites

Stratigraphic sections exposed by Clear Creek near the Gowanda State Hospital (see p.8f) and by South Branch Cattaraugus Creek near Otto (see p.11f) contain organic zones dated by radiocarbon as older than 38,000 years B.P. Both are overlain by one or more tills and underlain by evidence of earlier glaciation. Neither contains the strong paleosol or evidence of climate warmer than the present which would be conclusive evidence of the Sangamon interglacial. Both, however, contain evidence of an interval of subaerial erosion, which may in part account for absence of the more conclusive evidence.

The Otto high bluff is exposed where the South Branch of Cattaraugus Creek cuts sharply against its left bank in the southern outskirts of the village of Otto, Cattaraugus County, New York. The exposures extend a couple of hundred yards downstream from the highway bridge, from which they are clearly visible. Although the upper portion of the bluff is slumped and disturbed, the lower portion containing organic deposits is exposed in a face 40 to 100 feet high.

MacClintock and Apfel (1944) first described the exposures at Otto. Quoting a brief characterization of the peat flora by Paul B. Sears, they interpreted the section as representing from the base up, Illinoian glaciation, Sangamon peat, Olean outwash and Binghamton till and proglacial lake deposits. The present writer suggested (1957-a) that the Otto interglacial beds may represent a post-Sangamon, pre-Farmdale interval of partial deglaciation. In connection with present investigations the Otto organic material has been studied and interpreted by Clair A. Brown of Louisiana State University, William S. Benninghoff of the University of Michigan, Edward H. Ketchledge of the New York State College of Forestry at Syracuse and Howard Crum of the Canadian National Museum. Radiocarbon dating has been attempted by the Washington and Groningen Laboratories.

Pollen analyses show complete dominance of coniferous species, with *Pinus* generally in excess of *Picea*. *Abies* is present in the lowest horizons, comprising less than 4% at maximum abundance, but is missing above blocky peat, Unit 3-c. The complete lack of *Tsuga* is in contrast to its typical presence in post-glacial boreal pollen counts. Brown suggests that two species of spruce may be present, for the smaller pollen grains suggest identification as *Picea mariana* (black spruce). Some of the pine pollen is small enough to suggest *Pinus Banksiana* (jack pine). Isolated grains of oak (*Quercus*), birch (*Betula*), maple (*Acer*), linden (*Tilia*) and (*Carya*) are too sparse and erratic in distribution to be representative.

Non-arboreal pollen grains are not abundant, perhaps because derived from a more restricted area than are grains of the taller trees. Sparsely represented in the lower horizons are vegetation of drier upland sites. The uppermost horizon on the other hand shows predominance of marsh and lake shore elements such as cat-tail (*Typha*), arrowleaf (*Sagittaria*) and pond-weed (*Potamogeton*).

Two moss zones are separated by about 4 ft. of sediment and peat (Units 3-b to 3-g). The general pollen spectrum of the upper moss zone suggests close relationship to the lower in which E. H. Ketchledge identified the following assemblage:

> Tomenthypnum nitens about 95%
> Drepanocladus of D. aduncus, about 5%
> Paludella squarrosa, distinctive but very subordinate.

Of these species, Paludella squarrosa is essentially lacking in the active flora of New York, and Tomenthypnum is not encountered in the rather pure stand suggested by this assemblage. These species suggest a wet environment, whether fen or streambank, with waters of relatively high pH and climate slightly colder than present.

The botanical assemblage represents the southern aspect of the boreal forest, such as grows today near Ottawa, for instance, under climatic conditions which suppress hardwood species. No clearcut change in environment is indicated during deposition of Units 2-4 inclusive but Benninghoff reports an internally consistent upward decrease in spruce-pine ratio, suggestive of slight climatic amelioration.

No strictly lacustrine deposits occur in this portion of the Otto sequence. Units 2-5 inclusive include blocky peat, moss and twig layers, muck, silt, sand, channery gravel and a coarse boulder layer. This range of stratified deposits can be accounted for best, perhaps by a floodplain situation. The side of the bedrock valley is within a few hundred feet south and east. Shifting channels playing occasionally against till bluffs at the base of the section, but with increasing regularity against bedrock bluffs upward in the section account for the coarser beds. Oxidation of peat prior to burial is suggested near the base, but deposition was generally in reducing environment under conditions of high water table. Oxidation of the boulder layer is almost surely attributable to ground-water seep in recent years, rather than to pedological processes during deposition. For intervals probably measured in centuries the channel was situated across the valley, permitting development of boreal forest with peat accumulation favored perhaps by nearby seep conditions of cold carbonate charged waters.

Glaciation predating deposition of the organic sediments is indicated by a basal boulder gravel (Unit 1) in which crystalline erratics are conspicuous. This deposit is a lag concentration resulting from stream erosion of till banks. Although no till is now exposed, a trace of blue-gray clay, suggestive of till matrix is to be seen in places between tight-fitting boulders and in bedrock joints. Striae are distinguishable on a few boulders in Unit 4, but not on bedrock beneath the basal gravel, which is not surprising in view of the closely-spaced jointing and incompetence of the rock. This glaciation is Illinoian or advance Wisconsin, depending on interpretation of the magnitude of the non-glacial interval. This in turn must depend on dating, on inferred depth of erosion or volume of subaerial deposition, on intensity of pedologic development, and on inferred climate during the interval of non-glaciation.

No floral indication of climate as warm as postulated for the maximum of Sangamon climatic amelioration has been recognized at Otto. Radiocarbon dating has failed to establish a finite age for this material. Initial assay by the U. S. Geological Survey Laboratory (Suess, 1954) established peat (probably Unit 3-g) as radioactively inert, with age given as greater than 35,000 years. Analysis of carbonaceous silt midway up in Unit 5 by the Groningen Laboratory yielded age greater than 52,000 years (Gro 2565). The organic section is older than most of the Port Talbot section in Ontario (Dreimanis, 1959) where gyttja near the base of the bluff has been dated at 47,500 B.P. (Gro 2597 and 2601) (Dreimanis, in prep.). It is hoped that isotopic enrichment of the more carbon-rich material near the top of Unit 3 may establish or disprove the tentative correlation of this unit with advance Wisconsin refrigeration as represented by the St. Pierre interval in Quebec (Terasmae, 1958).

The bluff near Gowanda State Hospital, exposed by undercutting at a bend of Clear Creek, 50 yards west of U. S. Route 62 reveals a succession of tills separated by stratified sand and silt and underlain by flood plain deposits comparable to those at Otto, though less rich in organic remains. Wood (from Unit 2) submitted for radiocarbon dating is older than 38,000 years (W-866). Initial pollen analyses have shown the presence of _Picea_ and _Pinus_ but pollen was too scarce for statistical treatment (Brown, personal communication). Sparse tests of _Ostracoda_, _Pelecypoda_ and _Gastropoda_ occur in a marly layer in Unit 2, but have not yet been studied by suitable specialists. Preliminary indications are that the non-glacial interval represented at this site, like that at Otto may well represent advance Wisconsin conditions.

5. Olean and Binghamton drifts

MacClintock and Apfel (1944) distinguished drift of relatively high lime content, relatively shallow leaching of carbonates and unmodified constructional topography from drift of very low lime content, deeper leaching of carbonates and somewhat greater modification of constructional topography. The latter they mapped at the Wisconsin drift border from Little Valley eastward. They named it the Olean drift for exposures near that city. The former they distinguished at the Wisconsin border west of the Salamanca re-entrant. By reconnaissance mapping and spot-checking eastward, they correlated it with kame gravels near Binghamton, assigning them the name Binghamton drift.

Olean drift and the Olean drift border have been correlated with the Iowan or the Tazewell substage of the Wisconsin (MacClintock and Apfel, 1944) the Iowan-Tazewell complex (Flint, 1953), the Tazewell (MacClintock, 1954) and the pre-Bradyan Wisconsin (Denny, 1956-b). These authorities concur in assigning pre-Cary, Wisconsin age to the Olean drift and moraines. No more specific basis for dating or correlation has been recognized to date.

In 1956, Denny questioned the existence of Binghamton till in the Elmira area, thereby casting doubt on the validity of correlation of till west of the Elmira area with kame deposits near Binghamton. Merritt and Muller (1959) point out the close association of upland drift of Olean lithology adjacent to valley-filling drift of Binghamton lithology south of the Valley Heads drift border in central New York in situations where no creditable glacier margin could be drawn between the two contrasting drifts. For these reasons serious reservation is felt regarding long distance correlations based on similarity of till constitution, particularly with respect to the coarse fraction. Merritt and Muller (1959) suggested using the term "Binghamton drift" in a purely lithological sense, without necessary connotation of time equivalence, pending resolution of the "Binghamton problem".

Objections to the criteria for distinguishing between Binghamton and Olean drift were not unforeseen by MacClintock and Apfel who wrote in 1944: "The question naturally arises as to whether the Olean is not simply the outermost part of a single drift sheet containing fewer erratic stones than the part of the same drift sheet back nearer the outcrops from which the stones were derived. There seems little unanimity of opinion among glacialists on whether or not there should be more concentration of erratics at the margin of a drift sheet or farther back. However, in either case change of lithology has not been found; the change from one type of drift to the other is sharp and abrupt. The Olean drift has the same lithology from its margin northward to a sharp line of demarcation at which line the limestone and igneous content of the drift suddenly increases. The contrast is so sharp that in the field even the first glance at a good exposure reveals the difference."

The Binghamton moraine where it borders the Salamanca re-entrant on the west has been correlated with the Kent moraine of Ohio and Pennsylvania (Shepps et al, 1959) on the basis of continuous tracing. On the basis of present correlations Binghamton is Kent. In New York the name Binghamton has priority and must be retained unless disqualified by failure of correlation with the type area.

The age of the Kent (=Binghamton) moraine in Pennsylvania is approximately demonstrated by radiocarbon dating of material from the Corry bog, northwest of Corry, Pennsylvania (Droste, et al, 1959). Internally consistent dates on marl and basal peat collected by drill-coring and analyzed in the Washington Laboratory indicate probable abandonment of the terminal Kent moraine slightly prior to 14,000 B.P. (W-365)(Rubin and Alexander, 1958). This dating is consistent with the assignment of Kent to early Cary (Shepps et al, 1959) and Binghamton to Cary (Flint, 1953; MacClintock, 1954) or early Cary (Muller, 1957-a).

6. Lavery and Defiance moraines

Shepps (1955) applied the name Lavery moraine to part of Leverett's (1902) Cleveland moraine. Associated till typically has silt matrix, and is light gray, moderately pebbly and leached to average depth of 45 inches. Eastward the Lavery moraine has been traced across northwestern Pennsylvania (Shepps et al, 1959) and in Chautauqua County (Muller, 1956-a). In eastern Chautauqua County it cannot be confidently distinguished from the Lake Escarpment moraines.

Sparsely pebbly, calcareous gray clay to silty clay till above the Lavery till in northeastern Ohio and Pennsylvania has been mapped as the Hiram till (Shepps et al, 1959). The principal end moraine composed of Hiram till is correlated with a certain amount of reservation with the Defiance (= Blanchard) moraine of Ohio (Leverett, 1931; White, 1953). Similar till is mapped in several discontinuous areas in Chautauqua County where it projects south from beneath overlying till into through-valleys. Till with characteristics similar to the Hiram till composes the moraine at Markham and south of Zoar Valley. No Lavery drift occurs south of these two moraines and it is therefore concluded that the Lavery till is overridden and concealed in this area.

Shepps et al (1959) consider the Lavery moraine to represent middle Cary glaciation, but there is indication of closer relationship to the succeeding Late Cary (= Mankato(?)) moraines in Chautauqua County.

7. Lake Escarpment morainic system

Leverett (1895) applied the name Dayton moraine to the massive valley-stopper moraine at the village of Dayton, New York. In 1902 he supplanted this name, discussing the overlapping moraine ridges of the north margin of the plateau under the term Lake Escarpment morainic system, in recognition of the complexity of the belt. Westward in Ohio and Pennsylvania he mapped diverging ridges of the complex as the Euclid, Painesville, Ashtabula and Girard moraines. Shepps et al (1959), following White (in press) apply the name Ashtabula moraine to the entire complex as mapped in northeastern Ohio and Pennsylvania. In New York the belt is characterized by multiple ridges, but because they are so closely appressed continuous tracing is unreliable and, following Leverett, the complex is referred to as the Lake Escarpment morainic system.

The Lake Escarpment morainic system has been considered equivalent to the Valley Heads moraine of central western New York. Radiocarbon dating of spruce wood from marly silt overlying outwash gravel near a mastodon site in the southeastern corner of Erie County yields a minimum age for recession from the terminal moraine at 12,020 B.P. (W-507). Confirmatory evidence which seems to indicate rapid recession of the ice border is found in the 11,410 year age (Y-460) for wood associated with mastodon remains north of King Ferry east of Cayuga Lake and about 30 miles north of the Valley Heads moraine.

Recession from the Lake Escarpment morainic system is marked by a series of moraines of which only the Gowanda moraine is seen on the field trip route. Like the succeeding Hamburg and Marilla moraines it imponded waters of proglacial Lake Whittlesey which predated the Two Creeks interval.

Youngest glacial feature in the field trip area is the Lake Warren strand. Although Lake Warren has been considered to have existed during Valders time, recent lines of evidence suggest that the proglacial lake history of the eastern Great Lake basins may have terminated during the Two Creeks interval (MacClintock and Terasmae, 1960; MacClintock in press; Terasmae, 1959; Flint, 1956; Karrow, in press).

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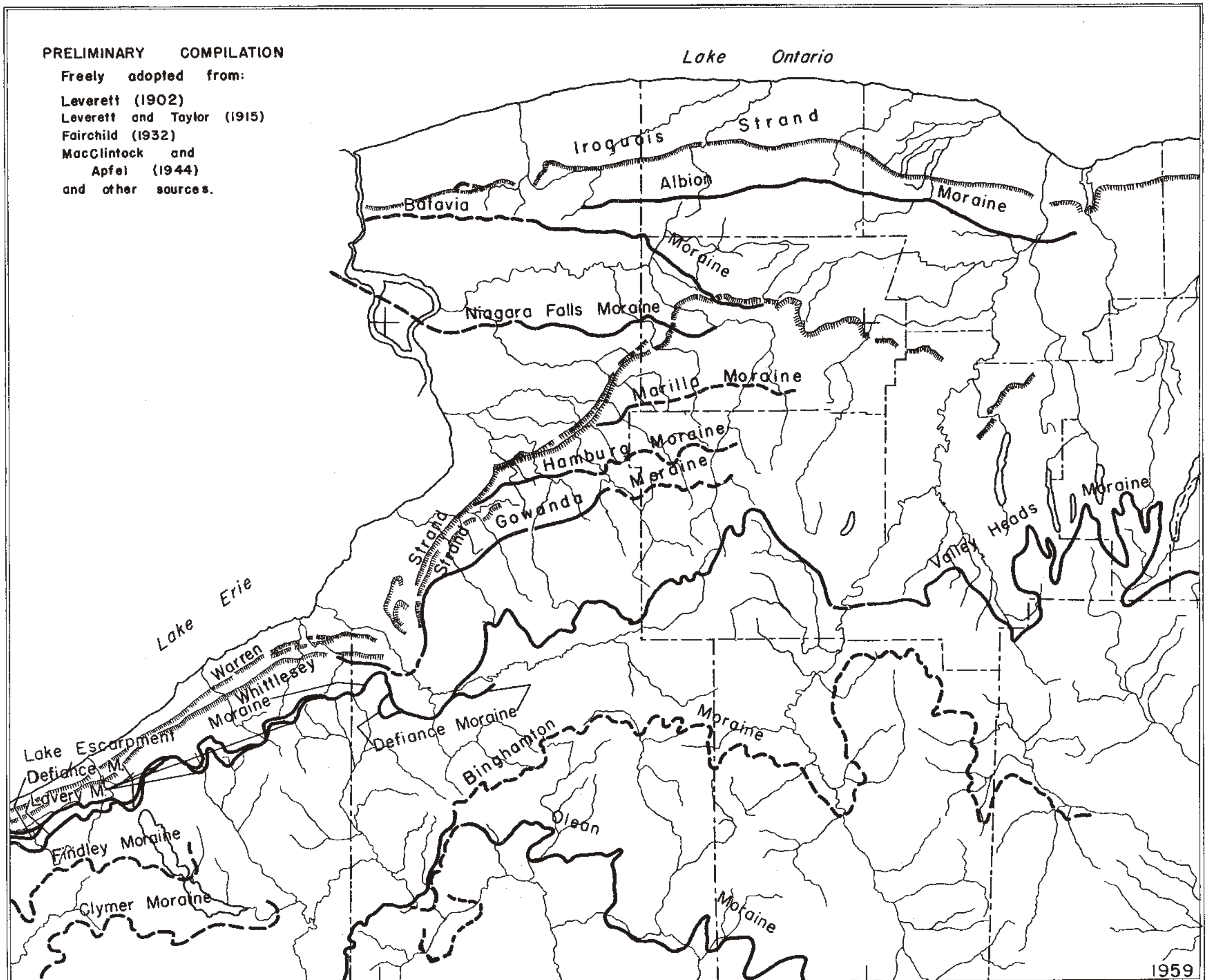
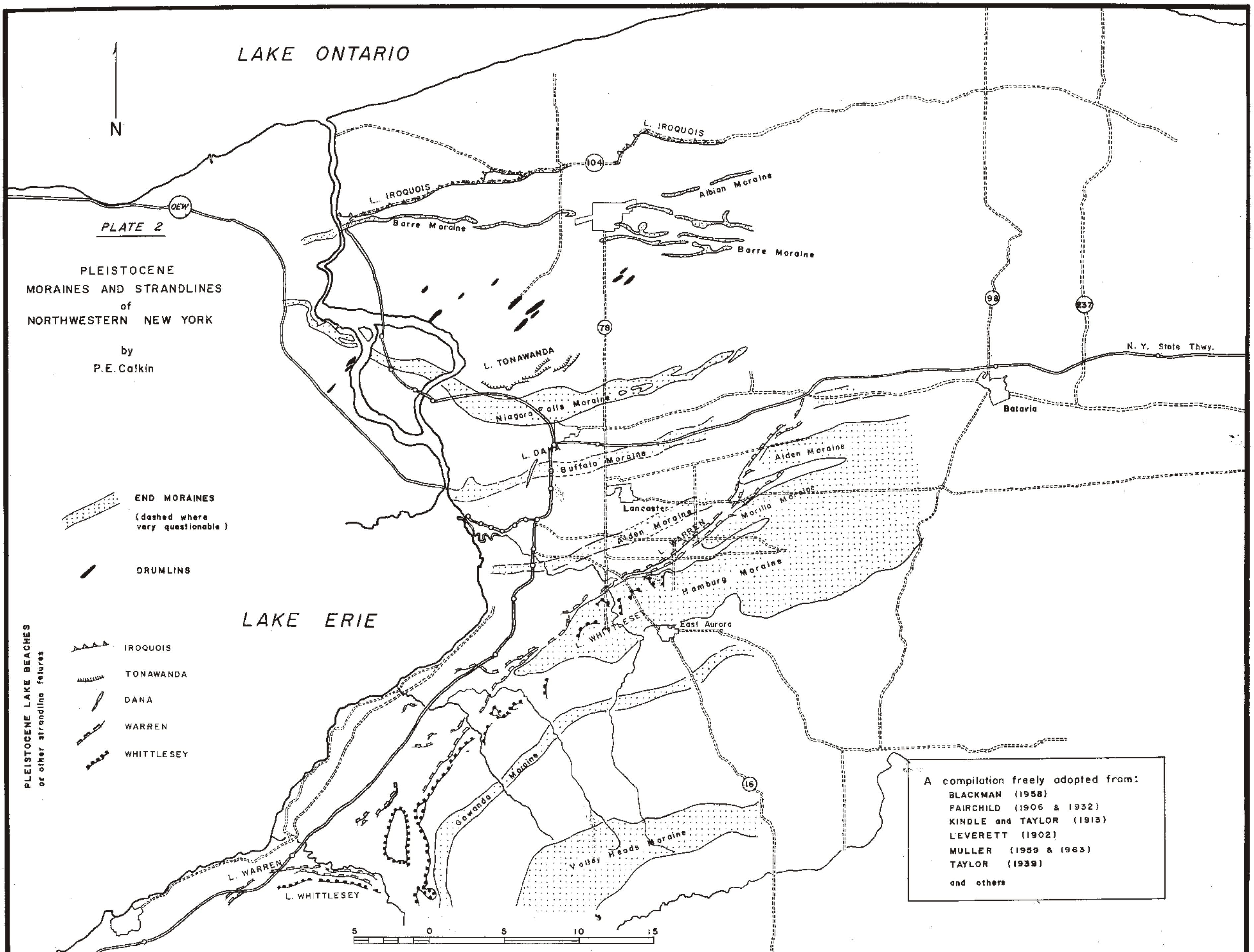


DRIFT BORDERS IN WESTERN NEW YORK



LAKE ONTARIO
N
PLATE 2
PLEISTOCENE
MORAINES AND STRANDLINES
of
NORTHWESTERN NEW YORK
by
P. E. Calkin
QEW
L. IROQUOIS
L. IROQUOIS
104
Albion Moraine
Barre Moraine
Barre Moraine
78
98
237
N. Y. State Thwy.
Batavia
L. TONAWANDA
Niagara Falls Moraine
L. DANA
Buffalo Moraine
Alden Moraine
Lancaster
Alden Moraine
L. WARREN
Marilla Moraine
Hamburg Moraine
East Aurora
L. WHITTLESEY
LAKE ERIE
Gowanda Moraine
Valley Heads Moraine
16
L. WARREN
L. WHITTLESEY
END MORAINES
(dashed where very questionable)
DRUMLINS
PLEISTOCENE LAKE BEACHES
or other strandline features
IROQUOIS
TONAWANDA
DANA
WARREN
WHITTLESEY
5
0
5
10
15
A compilation freely adopted from:
BLACKMAN (1958)
FAIRCHILD (1906 & 1932)
KINDLE and TAYLOR (1913)
L'EVERETT (1902)
MULLER (1959 & 1963)
TAYLOR (1939)
and others

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SYRACUSE UNIVERSITY
SYRACUSE 10, NEW YORK

DEPARTMENT OF GEOLOGY

May 3, 1960

Dr. Paul F. Karrow
Ontario Department of Mines
Parliament Buildings,
Toronto, Ontario

Dear Paul:

The suggestion was made last fall that the Friends Reunion this spring might afford a good sounding board for opinion on the significance of the southern border of carbonate-rich drift in western New York.

Unfortunately in mapping out a route it became clear that the long distances involved and the size of the group responding to the first mailing made it impractical to consider the Binghamton problem except in Cattaraugus County, with the group as a whole.

Because it may never be possible again to get together this same group of men with experience and interest in the problems involved in the Binghamton interpretation -- and particularly with the hope that Paul MacClintock, Earl Apfel, Charlie Denny, John Moss and a few others who like myself are directly concerned, I am proposing that those of us who can, comprise ourselves a working group to pursue the Binghamton border eastward.

It would be interesting, having visited the same exposures together, to obtain expressions of opinion as to what they have signified. As you know MacClintock and Apfel mapped the southern limit of carbonate-rich drift in western New York as the southern border of Binghamton drift. Charlie Denny found no Binghamton till in the Elmira area, by inference indicating that it does not exist in the Binghamton area. East of that, Moss would prefer to consider this a facies change within a single till sheet, if I understand him correctly. Merritt and I felt that south of the Finger Lakes the upland drift was rather commonly of "Olean litholgy" while the through valleys might contain "Binghamton lithology"

This is not your specific headache, but you are in a position of experience and interest such that you could contribute to resolving the problem. If you are able to make an additional day -- pursueing the carbonate-rich border eastward as long Monday as the law of diminishing returns warrants -- to join this working group, we would be very glad to have you do so. There is no intention on my part to be restrictive and I would like to include all who have a specific interest in the problem. I am writing those who I suspect may be interested or who have had past relationship to the problem. I would welcome suggestions of names of others who should be reached. ... I note that you may be traveling with Robert Ostry. By all means we would be glad to have him join us also if his commitments permit.

Sincerely,

Ernie

Ernest H. Muller

Palynology of the Otto Bluff, Otto, N. Y.

Prepared for the 23rd Annual Reunion of the Friends of the Pleistocene

by
Clair A. Brown, Professor of Botany,
Louisiana State University, Baton Rouge, La.

Dr. E. H. Muller assisted in taking 12 samples from the carbonaceous clays and peats from the Otto Bluff. These were placed in polyethylene bags and shipped to Louisiana. Representative samples were transferred to 5-gram vials. These were filled about 3/4 full and 95% alcohol was added as a preservative and deflocculant. After mixing thoroughly, 0.5 gm. aliquots were processed through hydrogen peroxide, hydrofluoric acid, hydrochloric acid, and the acetolysis process. The residue was transferred to 1-dram vials and 1 cc of glycerin jelly added, mixed, and slides were made from this mixture. The slides were scanned under high power at 2 mm intervals. The tree pollen count ranged from 162 to 182 in samples containing pollen. The carbonaceous clays had an abundance of organic debris, fungus mycelium, but were too deficient in pollen to make statistical counts.

Pollen content of peat samples.

	2A3		2A6		2B1		2C1		2D1		2E1	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Abies	1		5	2.	6	3.7	4	2.4	6	3.5	2	1.
Picea	34	20.7	57	33.7	36	22.2	43	26.3	71	41.7	43	23.1
Pinus	132	78.8	107	63.3	113	72.2	114	63.8	90	52.9	138	74.5
Alnus	-		-		-		-		1			
Betula	1		-		4	2.5	-		2	1.	2	1.6
Quercus	1		-		2	1.2						
Juglans	-		-		1		-		-		-	
NAP												
Chickweed type	-		1		-		-		-		-	
Lycopodium	-		1		-		-		-		-	
Grasses	-		-		2		-		-		3	
Sedges	-		-		2		-		-		1	
Compositae	-		-		3		-		1		3	

2A3, Upper peat.
2A6, Lower peat.
2B1, Compacted peat downstream 100 feet from 2A6.
2C1, 2D1, Compacted peat upstream 100 feet from 2A6.
2E1, Downstream 400 feet from 2A6 and may be fusion of 2A6 and 2B1.

Two samples of spruce wood were taken from layer 2D1.
The following mosses were isolated from the mossy peat:

<u>Tomenthypnum</u> <u>nitens</u>. Bogs and swamps in cool, elevated regions across the continent south to New Jersey.

<u>Paludella</u> <u>squarossa</u>. Infrequent and local, in cool bogs, more frequently in Arctic-alpine regions, Alaska, Greenland, S. to Vt., N. Y., Wy., and Rocky Mts.

<u>Drepanocladus</u> cf. <u>aduncus</u>. Widely distributed throughout North America, especially the northern two-thirds.

Analyses of the clays and peats showed several outstanding items.

1. Absence of statistical quantities of pollen in the clays.
2. A number of interesting peculiarities in the pollen spectrum.
   a. Lack of non-arboreal pollen.
   b. Absence of hemlock pollen.
   c. Absence of hardwood pollen in statistically significant quantities.
   d. Ratio of Picea to Pinus.
   e. The ratio of Picea and Pinus in layers 2A3 and 2A6.
   f. Picea pollen had a quantity of small grains which suggested black spruce and larger grains which suggested white spruce.
   g. Size differentation of Pinus pollen suggested jack pine and white pine.
3. C14 analyses of the upper peat layer was more than 40,000 years by USGS, and the Dutch laboratory obtained a date of 53,000 years.

Previous **t**estigations.

MacClintock and Apfel published the following observations by P. S. Sears relative to the palynology of the peat: "All specimens contained a great predominance of coniferous pollen with only suggestions of any deciduous material. With the exception of two specimens which seemed to contain only fir and pine, the rest contained fir, spruce and pine. There were some interesting variations in the nature of the peat, some being mainly silt, some wood, some moss, and some mainly sphagnum. In the absence of any information as the stratigraphy of these samples, however, there would be no point in drawing conclusions from this or from certain fluctations in the proportion of pollen. The indication is clear that the interglacial represented agrees in character with early post glacial condition throughout the north central states when the climate had not warmed sufficiently to permit the dominance of conifers by deciduous forms."

Terasmae published the palynology of a buried peat on the south side of the St. Lawrence River at St. Pierre - which has some analogous but not homologous conditions. The peat was dated as more than 40,000 years and later at about 65,000. This peat lacks hemlock.

His ratio of spruce to pine in the maxima were 83% spruce to 13% pine and 61% spruce to 36% pine. The miscellaneous hardwoods such as Quercus, Fagus, Tilia, Carpinus, Acer, Ulmus, Fraxinus, and Carya formed only 2 to 5 per cent of the pollen. Terasmae considers St. Pierre deposit an inter-stadial interval of 6000 to 7000 years duration and not an interglacial period. He believes this non-glacial interval is a part of the Wisconsin advance rather than a retreat phase.

Interpretations.

1. The low fir, moderate spruce, and predominate pine ratios indicate a boreal forest between the middle and northern limit. The absence of hemlock and hardwoods supports this concept. However, there are some ecological anomalies. This could be a forest near the southern limit, a successional stage, prior to the invasion of hemlock and hardwood, and thus not an indicator of climatic conditions. Certain normal associates of these plants are absent, probably because of differential preservation. The presence of both black spruce and white spruce, jack pine and white pine, would predicate both wet and dry sites.

2. The absence of non-arboreal pollen suggests a forest cover too dense for wind pollinated herbs, or else their complete absence. Although there is a quantity of herbs in the dense spruce stand today, most of them are not wind-pollinated. The higher pollen rain of the trees would also minimize the low volumes of non-arboreal pollen.

3. The moss species are indicators of cool to cold climates, wet swamp, fen, or bog conditions. If these layers were from two independent successions, one would expect a more diverse spectrum.

4. Although strongly compressed, the thinness of the peat layers indicates short time intervals.

5. The occasional grain of Quercus should be considered as (a) windblown from a distance; (b) as from an erratic plant and not a relict; and (c) less probable, a redeposited grain from older sediments.

6. The absence or greatly reduced quantity of pollen in the carbonaceous clays, in view of the quantity of fungus mycelium, suggests the destruction of the pollen by oxidation or by microorganisms. It also suggests rapid deposition or deposition during a time when pollen was not being shed.

POLLEN ANALYSIS OF OTTO HIGH BLUFF SECTION, WESTERN NEW YORK STATE

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In August, 1958 Dr. E. H. Muller sent eight samples of organic-rich sediments from the Otto Creek area of western New York State to the senior author for analysis of pollen and other plant remains. Twigs and fragments of wood occurring in some of the samples are in advanced states of decay, and so far portions suitable for identification have not been recovered. Pollen and spores are relatively scarce in most of the samples, but are sufficient for an approximate indication of vegetation prevailing near the depositional area.

All of the sediments are composed dominantly of mineral fraction, which was removed by treatment with concentrated hydrofluoric acid at room temperature; length of treatment varied from two days for samples with fine-grained mineral particles to ten days for those with coarser particles, and several additions of fresh reagent were made during treatment. The organic residue was washed with 7% hydrochloric acid, then processed by the standard Erdtman acetolysis technique. Three of the samples contained no recognizable pollen or spores, and in all the samples the organic matter was found to be moderately to strongly humified. General observations on the samples and interpretations of them are listed in Table 1.

Table 2 contains the tabulated results of the pollen and spore counts. Only sample 58-10 approached the richness of pollen and spores commonly found in bog peat deposits of cool temperate forest regions. The table shows a remarkably regular shift from spruce (<u>Picea</u>) dominance to pine (<u>Pinus</u>) dominance. This internal consistence in the pollen statistics indicates the strong probability that the sediments contain predominantly pollen that was fresh at the time of deposition. The erratic occurrence of hickory (<u>Carya</u>), linden (<u>Tilia</u>), and maple (<u>Acer</u>) pollen, which is inconsistent with the strong dominance of spruce and pine, probably indicates that a fraction of the pollen was derived from older sediments and was "re-bedded." These erratically occurring grains and a small proportion of the other grains are eroded and battered, further suggesting re-bedding.

Undoubtedly spruce and pine were almost the only forest trees in the region, although balsam poplar and aspen (<u>Populus</u>), notable for the inconsistancy of representation in pollen profiles, could have been present. The relatively low proportion of non-tree pollen implies either that cover by wind-pollinated genera was too sparse to compete with treae pollen rain carried from distant spruce-pine forests. We believe that local cover by spruce-pine forest was most likely.

The non-tree pollen and spores, derived from a more restricted area than is pollen of the taller tree genera, represent in the lower horizons vegetation of drier or more upland sites (grasses and composites) and forest understory types (polypody fern, shield ferns like <u>Dryopteris</u>, and the two groudd pines, <u>Lycopodium</u>). The uppermost horizon shows predominance of marsh or lake shore elements, such as cat-tail (<u>Typha</u>), arrowleaf (<u>Sagittaria</u>), and pond-weed (<u>Potamogeton</u>). There is a notable absence of the distinctive spores of Sphagnum in these deposits. Sphagnum is absent today from active floodplains and other sites of silt deposition, and Sphagnum is absent fro from late-glacial phases of most eastern North American post-glacial pollen profiles.

Table 1. Descriptions of samples, and observations and interpretations of the organic fractions.

Sample No.	Description	Organic remains	Interpretation
58-2	Carbonaceous silt. Highest of organic horizons in Otto High Bluff. Exposed 15 ft. above river in Spruce Gully. (Unit 5)	Pollen and spores absent. Strongly humified.	Alluvial deposit, exposed to aeration du during or after deposition.
58-6	Blue-gray to blue-green silt, grading into muck. Overlies sample 58-7. Pine Gully. (Unit 3-e)	Pollen and spores absent. Very strongly humified.	Alluvial deposit, exposed to aeration during or after deposition.
58-7	Pebbly peat and muck, including moss layer. Overlies sample 58-8. Pine Gully. (Unit 3-e)	Pollen and spores sparse.	Marsh deposit in water subject to seasonal change in depth.
58-8	Interlaminated muck, silt, peat with scattered twigs. Overlies sample 58-9. Pine Gully. (Unit 3-d)	Pollen and spores moderately sparse.	Alluvial deposit.
58-9	Orange-brown to brown peat, containing dark brown twigs; firm, resists pick. Twigs compressed. Blocky; flakes on drying. Overlies samples 58-10. Pine Gully. (Unit 3-c).	Pollen and spores common.	Shrub swamp deposit.
58-10	Brown muck, sparsely pebbly; in transition zone from peat to pebbly muck. Pine Gully. (Unit 3-b)	Pollen and spores moderately abundant.	Deposit of quiet, shallow water.
58-3	Silt with plant remains. Lowest organic horizon, exposed 0.5 ft. above bedrock contact in Low Peat Gully. (Unit 3-a)	Pollen and spores common, but many eroded and humified. Many fungal hyphae.	Wet meadow deposit, subject to occasional drying.
58-17	Peat and wood fragments in gravel pocket enclosed in blue till. Overlies and postdates red till. Clear Creek Cut at Gowanda State Hospital.	Pollen and spores absent. A few fungal hyphae present.	Organic material probably washed out of glacial sediments.

Table 2. Pollen and spore precentages in samples from Otto High Bluff Sectiona Analysis by W. S. Benninghoff and Darlene Helmich, 1960. Percentages calculated on basis of Σ AP-100%.

Sample number	58-7	58-8	58-9	58-10	58-3,
Stratigraphic unit	3-e	3-d	3-c	3-bx	3-a
Sediment type	Peat & muck	Muck & peat	Peat	Muck	Silt
Σ AP counted	16	58	111	253	97
No. of traverses on slides	19	18	19	20	20
TREE POLLEN					
Coniferous trees					
Picea	12.5	36.2	48.6	54.9	58.8
Abies	18.7	-	-	1.6	4.1
Pinus	6215	60.3	51.4	43.5	35.1
Larix	-	1.7	-	+	-
Broad-leaved trees					
Betula	-	1.7	-	-	-
Carya	-	-	-	-	1.0
Acer	6.2	-	-	-	-
Tilia	-	-	-	-	1.0
Total arborial pollen	99.9	99.9	100.0	100.0	100.0
NON-TREE POLLEN & SPORES					
Monocotyledons					
Typha	6.2	-	-	-	-
Sagittaria	218.7	-	-	-	-
Potamogeton	12.5	-	-	-	-
Cyperaceae	-	-	-	3.5	2.1
Gramineae	-	-	-	0.8	1.0
Liliaceae	-	-	0.9	-	-
Dicotyledons					
Chenopod-Amaranth.	6.2	-	0.9	-	-
Nuphar ?	-	-	0	-	1.0
Umbelliferae	6/2	-	-	P	-
Compositae	-	-	0.9	0.4	1.0
Ferns and fern allies					
Polypodium	-	1.7	-	-	1.0
Dryopteris-type endospore	-	-	-	0.4	4.1
Lycopodium clavatum	-	-	0.9	-	1.0
Lycopodium annotinum	-	-	-	-	1.0
Total non-arboreal	231.2	1.7	3.6	4.7	12.2
Bryophyte spores	225.0	8.6	-	5.2	5.2
Fungus spores	-	-	-	-	8.2
Unidentified pollen & spores	6.2	3.4	0.9	0.8	7.2