# LOOKS AT THE PRESENT AND THE RECENT PAST

Ernest H. Muller, Dept. of Geology, Syracuse University and
R. K. Fahnestock, Dept. of Geology, S.U.C. Fredonia

## A WORD TO THE FORE

We wish to acknowledge the stimulus provided by our respective chairpersons, Daniel Merriam of Syracuse and Olcott Gates of Fredonia who volunteered our services, and the gentle prodding of the guidebook editor. All were essential to the completion of this manuscript. The cooperation of the New York State Geological Survey and its director, Dr. James Davis, in permitting the use of appropriate portions of a draft of Muller's Glacial Geology of the Niagara Sheet and materials is appreciated. Drafting help with maps was provided by John Walton of Fredonia. Illustrations were prepared by Don Burdick and Ron Warren of the Fredonia Instructional Resource Center.

E.H.M. was wise enough to leave for New Zealand immediately upon hearing of the assignment. R.K.F., having no place to go, has proceded to reproduce Muller's 1960 Friends of the Pleistocene Field Guide with few improvements and all the controversies and inconsistancies dictated by the western New York geologic record. Some new stops have been added in light of recent local geologic events and RKF's orientation toward processes and predilection for scenery, buried and otherwise. Due to RKF's slowness in producing a manuscript, EHM has had no opportunity to recant or to correct the errors of omission or commission found in the present attempt. We all look forward to EHM's explanations on the outcrops in the fall.

## WESTERN NEW YORK GLACIAL GEOLOGY: CHAUTAUQUA AND CATTARAUGUS COUNTIES (see fold out map at end of section "F")

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 of 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 (1956a) 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 (1957b) 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, 1957a, 1960).

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 Winconsin 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, 1963). 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, 1956a) in western Pennsylvania (Shepps et al. 1959) and Chautauqua County (Muller, 1963) 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 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.

Calkin (1970) presented the summaries of the chronology of deglaciation and lake succession reproduced here as Tables 1 and 2. Table 3 is reproduced from Muller (in press). It is hoped that these dates will provide a basis for discussion and an understanding of the rapidity of some glacial processes. They present a picture of extremely rapid deglaciation and the development of major beaches and deltas within a period of a thousand years beginning about 13,000 years ago.

TABLE 1
*Correlation of Late Wisconsin lakes† and moraines, western New York* **from Calkin (1970)**

| Years B.P. | Glacial Event | Lakes of Erie Basin (* evidenced in N.Y.) | Moraines in N.Y. |
|---|---|---|---|
| | St. Lawrence ice-free | | |
| −11,000 | | | |
| | Valders Advance | | |
| | Two Creeks Interstade | Iroquois (Ontario basin) | |
| | | *Early Erie (473?) | |
| −12,000 | Rome, N.Y. ice-free | | |
| | | *Dana (570) | Albion M. |
| | | *Early Algonquin (605) | Barre M. |
| | | *Lundy (620) | |
| | | *Grassmere (640) | Batavia M. |
| | | *Warren III (675) | Niagara Falls M. |
| | | *Wayne (660) | Buffalo M. |
| | | *Warren II (680) | Alden M. |
| | | *Warren I (690) | Marilla M. |
| | | | Hamburg M. |
| | Port Huron Advance | *Whittlesey (738)—? | Gowanda M. |
| | | | Lake Escarpment M. |
| −13,000 | Cary/Port Huron | Ypsilanti? (543–373) | |
| | | III (695) | |
| | | II (700) | |
| | | Arkona I (710) | |
| | Cary Advances | | Moraines of SW New York (see Muller, 1963) |
| −14,000 | | | |

†Elevations of glacial lakes south of respective zero isobases, (after Wayne and Zumberge, 1965).

## 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 (Figure 1). 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.

TABLE 2 **from Calkin (1970)**

*Summary of radiocarbon dates† defining late glacial history of the Lake Erie basin*

| Event | Date Number | Age-Years B.P. | Remarks | Reference |
|---|---|---|---|---|
| *A) Specifically Dating Pleistocene Great Lake Stages* | | | | |
| Lake Arkona III | *W-33 | 13,600 ±500 | Tree fragments from lagoon deposits (689 ft. A.T.) overlain by Whittlesey sand and silt. | Hough, 1958 (D)‡ |
| Lake Whittlesey | *W-430 | 12,920 ±400 | Wood from a peaty zone below Whittlesey gravels at Parkerstown, Ohio. | Alexander and Rubin, 1958 (D) |
| | I-3175 | 12,900 ±200 | Wood in Whittlesey beach, Elyria, Ohio. | T. Lewis and R. Goldthwait, 1963 personal communication |
| | *Y-240 | 12,800 ±250 | Wood fragments in Whittlesey sediments 4.5 miles southeast of Bellevue, Ohio. | Hough, 1958 (D) |
| | *S-31 | 12,660 ±440 | Driftwood from Lake Whittlesey gravel near Ridgetown, Ontario (minimum date). | McCallum, 1955 (D) A. Dreimanis, 1966 personal communication |
| Lake Warren or Lake Wayne | I-2918 | 11,200 ±170 | Wood from Lake Warren—Wayne beach, Cleveland, Ohio. | T. Lewis and R. P. Goldthwait, 1969, personal communication |
| Early Lake Erie | S-172 | 12,000 ±200 | Plant remains at 581 ft. near Tupperville, Ontario below beach deposits of Early Lake St. Clair 590-600 A.T. | Dreimanis, 1964 (D) |
| | GSC-211 | 11,860 ±170 | Same as above. | Goldthwait *et al.* 1965 (D) |
| | GSC-382 | 11,300 ±160 | Buried plant detritus western Lake Erie | Lewis *et al.* 1966 |
| | GSC-330 | 10,200 ±180 | Buried driftwood central Lake Erie | Lewis *et al.* 1966 |
| Lake Iroquois | W-861 | 12,660 ±400 | Organic material from Lake Iroquois sediments, Lewiston, N. Y. | Rubin and Alexander 1960 (D) |
| | I-838 | 12,100 ±400 | Wood in the Iroquois sediment 4.5 mi. north of Lockport, N. Y. | Buckley *et al*, 1968 |
| | W-883 | 12,080 ±300 | Organic material from Lake Iroquois sediments, Lewiston, N. Y. (previously run as W-861). | E. H. Muller, 1956a |
| | Y-391 | 11,570 ±260 | Wood from Lake Iroquois bar, Hamilton, Ontario | Dreimanis, 1966 |
| *B) Defining Glacial Recession on Northwestern N. Y.* | | | | |
| Minimum for recession from: | | | | |
| Gowanda and Lake Escarpment M. (may also date late Whittlesey early Warren I) | I-3665 | 12,730 ±220 | Organic detritus in lake silts, at 810 ft. A.T., 2.4 miles south of North Collins, Erie Co., N. Y. | Calkin and McAndrews, 1969 |
| Lake Escarpment M. (distal side) | W-507 | 12,020 ±300 | Wood over outwash, southeastern-most Erie Co., N. Y. (Nichols Brook at Cherry Tavern). | Muller, 1960, 63, 65a |
| " | I-4043 | 13,800 ±250 | Same as above except specimen of organic detritus taken 25 cm above outwash. Stratigraphically below spec. W-507. | This report |
| " | I-4216 | 14,900 ±450 | Same location as above (I-4043) except dated material from 2 cm above outwash (23 cm below I-4043). | This report |

†Dates reported are based on the standard half-life value for C-14 of 5568 years. Dates above must be increased by 350 to 400 years based on the more accurate half-life of 5730 years.

*According to Dreimanis (1966, this journal) these date the transition from Lake Arkona to Lake Whittlesey.

‡(D) in reference column notes that date is also referenced in summary of Dreimanis (1966, this journal).

Table 3. Radiocarbon Sites of the Field Trip Area (from Muller, in press)

| Site No. | Site Name Town Name | Quadrangle, County | Years B.P. | Lab Ident. | Remarks: Material, Stratigraphy, Location, Significance | References |
|---|---|---|---|---|---|---|
| A | Otto, Otto | Cattaraugus, Cattaraugus | 63,000 ±17,000 | GrN-2634 GrN-3213 | Peat beneath gravel, lake clay, 2 tills; left bank, S. Br. Cattaraugus Cr., S edge of Otto. Dates Otto Interstadial. | 6, 5, 4 |
| | | | 52,000 | GrN-2565 | Carb. silt in gravel beneath lake clay, 2 tills; left bank, S. Br. Cattaraugus Cr., S edge of Otto; <u>Picea</u> and <u>Pinus</u> dominate pollen spectra. | 6, 5, 4 |
| B | Clear Ck, Collins | Gowanda, Erie | 48,400 | GrN-5486 | Wood, probably <u>Picea</u>, in firm silty clay <u>imbedded</u> in 6.5 m till beneath 4 tills; left bank, Clear Ck. Rt. 39, 62 bridge. Minimum age of interstadial. | 7, 5 |
| C | Winter Gulf, N. Collins | N. Collins Erie | 12,730 ±220 | I-3665 | Organic detritus in gray clay beneath 1.08m of shale shingle, 14 m. below max. level of Lake Whittlesey; at level of Warren I; 3 km S of N. Collins limits. | 1 |
| D | Sheridan, Forestville | Sheridan, Chautauqua | 9200 ±500 | M-490 | Mastodon rib in Lake sand beneath 60 cm much in basin landward from Warren beach; Dahlman Farm; postdates Lake Warren. | 2, 3 |

References for Table 3.


1. Calkin, P. E., 1970, Strand lines and chronology of the glacial Great Lakes in northwestern New York; Ohio Jour. Sci. 70:78-96.

2. Crane, H. R. and J. B. Griffin, 1959, University of Michigan Radiocarbon dates IV: Radiocarbon Suppl. 1:173-198.

3. Hartnagel, C. A. and S. C. Bishop, 1922, The mastodons, mammoths and other Pleistocene mammals of New York State, N.Y.S.M. Bull. 241-242, 110 p.

4. MacClintock, Paul and E. T. Apfel, 1944, Correlation of the drifts of the Salamanca re-entrant, New York; Geol. Soc. America Bull 55:1143-1164.

5. Muller, E. H., 1960, Glacial geology of Cattaraugus County, N.Y. Guidebook 23rd Reunion, Friends of Pleistocene, Geology Dept. Syracuse Univ. 33 p.

6. Muller, E. H., 1963, Geology of Chautauqua County, New York, Part II: Pleistocene geology; N.Y.S.M. Bull 392, 60 p.

7. Rubin, Meyer and Corinne Alexander, 1960, U. S. Geological Survey radiocarbon dates V; Radiocarbon Suppl. 2:129-185.

These deposits include terrace remnants mapped by MacClintock and Apfel (1944) as Illinoian (Figure 2). 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, 1957b). The Illinoian gravels typically contain about 5 percent of igneous and metamorphic pebbles, and below the leached zone, 25 to 30 percent carbonate and associated rock types derived from north of the plateau. The depth of leaching averages about 15 ft. 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. Those able to read fine print may discover some of these terraces on Plate 1.

Pre-Farmdale organic sites

Stratigraphic sections exposed by Clear Creek near the Gowanda State Hospital *(STOP F3, Muller, 1960, Stop 3) and by South Branch Cattaraugus Creek near Otto (STOP D6, Muller 1960 Stop 4) 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 (STOP D6). 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 ft. 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. (Muller, 1957a) suggested that the Otto interglacial beds may represent a post-

*The lettered stops refer to the glacial field trips for this meeting. The Saturday all-day trip is Trip D and Sunday's half-day trip is Trip F.

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 percent at maximum abundance, but is missing above blocky peat, Unit 3-c (refers to a unit in STOP F3 description). The complete lack of Tsuga is in contrast to its typical presence in post-glacial boreal pollen counts. Brown (written communication) 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 they are 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 (written communication) identified the following assemblage:

> Tomenthypnum nitens about 95 percent
> Drepanocladus of D. aduncus, about 5 percent
> 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 (marsh) or steam-bank, 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 (written communication) 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, slit, 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 of channels playing occasionally against till bluffs at the base of the section, but with increasing regularity against bedrock bluffs upward in the section, may 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 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, 1964). 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 (STOP F3) 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.

Olean and Binghamton drifts - Includes Kent of Chautauqua County Figure 3.

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 reentrant. 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, 1956b). 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 (1960).

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 (Muller, 1963).

The age of 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) (see Tables 1, 2, and 3). 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, 1957a).

## 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 in. Eastward, the Lavery moraine has been traced across northwestern Pennsylvania (Shepps et al., 1959) and into Chautauqua County, N.Y. (Muller, 1963). In eastern Chautauqua County it cannot be distinguished with any confidence from the Lake Escarpment moraines.

The 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.

Lake Escarpment morainic system

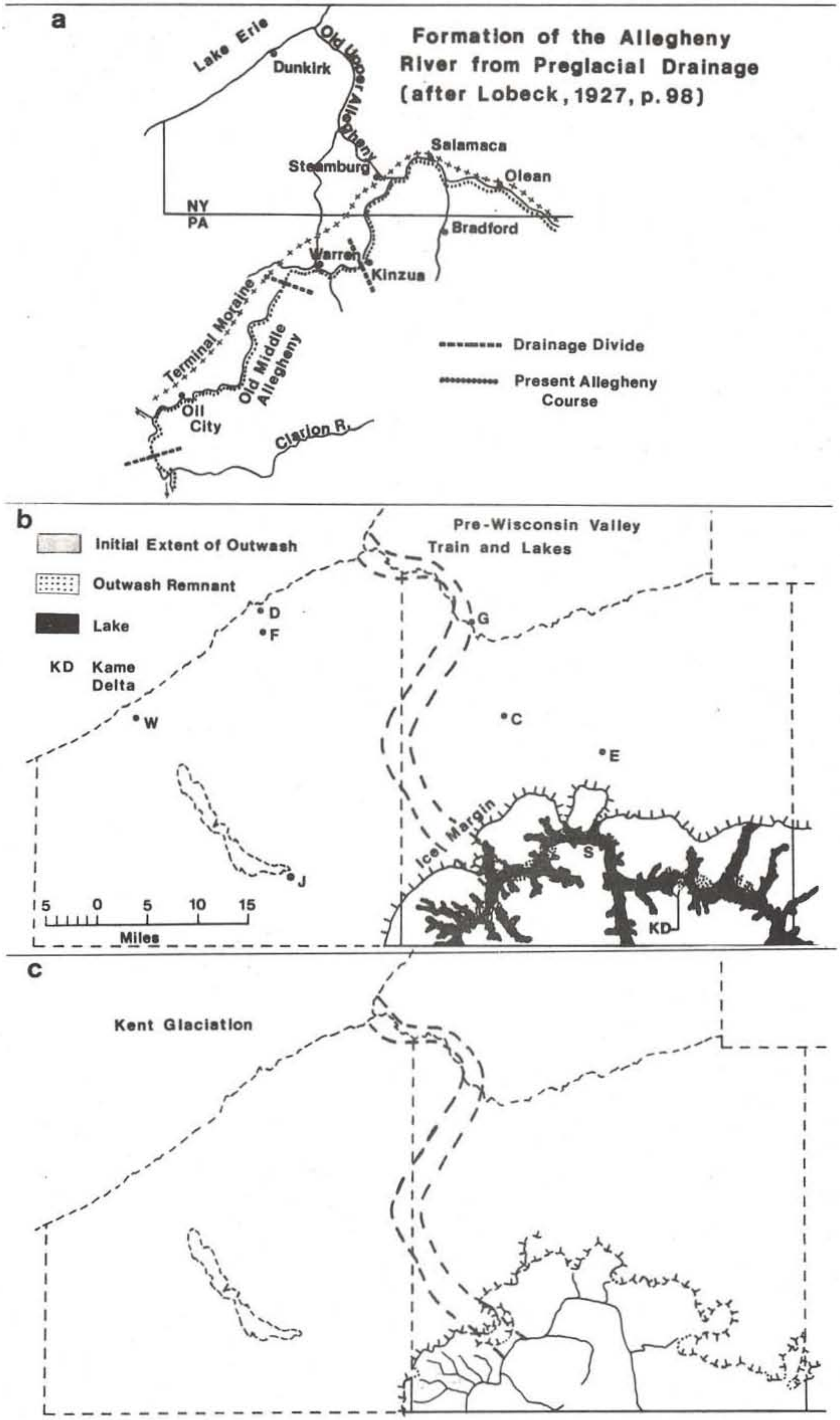
Leverett (1895) applied the name Dayton moraine to the massive valley-stopper moraine at the village of Dayton, New York. In 1902 he supplanted this name, discussing the overlapping moraine ridges of the north margin of the plateau, under the term Lake Escarpment morainic system, in recognition of the 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 spaced, continuous tracing is unreliable and, following Leverett, the complex is referred to as the Lake Escarpment morainic system.

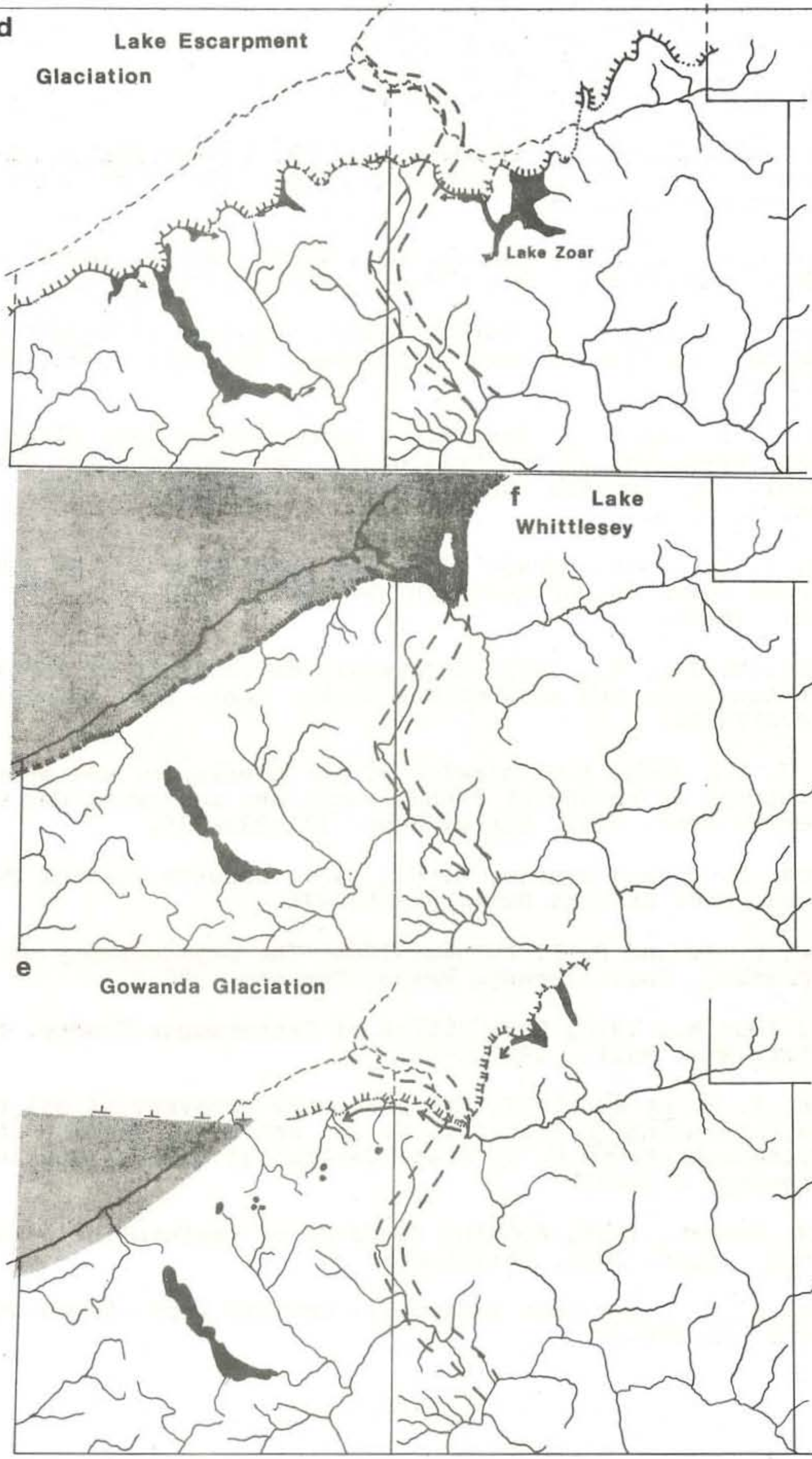
The Lake Escarpment morainic system has been considered equivalent to the Valley Heads moraine of central western New York. Radiocarbon dating of spruce wood from marly silt overlying outwash gravel near a mastodon site in the southeastern corner of Erie County yields a minimum age for recession from 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 (Plate 2, e and f).

The 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 1960; Terasmae, 1959; Flint, 1956; Karrow, 1963).

Plate 2. Stages in the evolution of the Western N.Y. Landscape

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Lake Escarpment
Glaciation
Lake Zoar
f
Lake
Whittlesey
e
Gowanda Glaciation

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APPENDIX

These are stops from Muller (1960). They may be added to or substituted for listed stops on either Trip D or F. The locations are shown on Plate 1.

STOP ONE. Twenty minutes. Weathering profile in silty clay till of moraine southeast of Markham. Dayton town, Cattaraugus quadrangel, 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?

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).

| Unit | Lithology | Thickness |
| --- | --- | --- |
| 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?

STOP THREE. of Muller, 1960, is STOP F3 of this guide.

STOP FOUR. of Muller, 1960, is STOP D6 of this guide.

STOP FIVE. 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?

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.

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

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

The Wisconsin drift border has been drawn along the ridge crest 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.

STOP EIGHT. of Muller, 1960, is STOP D6 of this guide.

STOP NINE. of Muller, 1960, is STOP D5 of this guide.

STOP TEN. 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.

TRIP D - FROM LAKE ERIE TO THE GLACIAL LIMITS AND BEYOND
(or What the Glaciers Did For Us)

E. H. Muller, Geology Department, Syracuse University
and R. K. Fahnestock, Geology Department, SUNY, Fredonia

Today's trip will take us from Fredonia southeastward to Olean returning by way of Otto (The route and features of this trip will be found on Plate 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 Otto.

The road log narrative begins at Barker Commons (town square) in downtown Fredonia. Proceed south on Water Street crossing Canadaway Creek. Continue up the Water Street hill, climbing above the creek terraces graded to the Lakes Warren and lower levels of the glacial Great Lakes. At the top of the hill the level plain is a beach-delta complex formed at the Lake Whittlesey level, 830 ft. at this point. Lake Whittlesey shoreline rises about 1 foot per mile toward Buffalo.

To the Southwest a drift-free bench (1) (The circled numbers refer to location on Plate 1.) marks one of the many ice marginal drainage channels. The north wall of this channel must have been the glacier. Beyond the bench lies the escarpment. 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 composed dominantly of shale. The Laona and Shumla Members, each about 30 feet thick are largely 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?

Turn east, crossing Canadaway again in the village of Laona. On the south side of the bridge, (2) a mill dam, its pond now filled with debris, raises the height of the waterfall over the Laona siltstone under the bridge. One hundred and fifty years ago Laona, like all towns was a major user of water power. The county historian points out that about 35 factories drew their power from the Canadaway and it is said that there were at least seven dams in Laona alone. Anyone considering floodplain landforms must keep in mind both man and beaver as geologic agents.

Turn right (S) in Laona onto Rt. 60 and continue south to Cassadaga.

Heading south on Route 60 we pass through a broad, open valley with only isolated patches of bedrock exposed (3). This is a post-glacial excavation of a complex of buried valleys. The streams of this area have made similar excavations each time the glacier retreated from the escarpment. The buried valleys (also featured on tomorrow's trip F) have a variety of forms from steep-walled canyons (Fig. F1) to broad, open valleys with gentle walls (Fig. F5).

The landslides along the road involve tills and lake clays.

STOP D1. Route 60 Landslide Area. This area will also be visited tomorrow on Trip E, Environmental Geology. You may wish to consult the descriptions of the landslides and associated problems with the Fredonia Reservoir.

The glacial sequence consists of till, lake rhythmites, and till. The landslides start with a failure at or near the lower contact of the lake beds. Although the upper contact of the lake beds has not been observed, it is thought to be relatively undisturbed. If so, a till flow, a la Hartshorn (1958, 1960) may be a possibility.

There are about 20 feet of interlayered clays and silts which may represent (A) annual pairs (varves) or (B) storm pairs resulting from disturbance and more rapid settling of the silts; or (C) maybe you have an idea. If (A), this small lake lasted longer than some or all of the Glacial Great Lakes. If (B) it didn't. Cloture will be invoked after 10 minutes to allow vote of all present to be taken to settle the matter for all time.

Continuing South on Rt. 60, a brief side trip to the Cassadaga Lakes will be made to show the evidence of formation from the melting if ice blocks buried in outwash. The Cassadaga Lakes (5) lie between the Lake Escarpment (4) moraines to the north and remnants of a slightly older moraine to the south.

Continue south on Rt. 60 through the Cassadaga Valley along the route shown on Plate 1 and Figure D1 which is filled about half way from the bedrock floor to the adjacent summits. A well near Gerry has penetrated 600 feet of fill. In contrast to the thickness of fill in the valleys, the streamlined drumlinoidal topography of the uplands is covered in most places by a veneer of ground moraine (basal till plastered on under the glaciers). Figure D2 shows the evolution of some of the morainal belts and lake and outwash deposits which make up the valley fill.

At Gerry leave route 60 and continue straight (SE) on Rt. 604.

Crain (1966) recognized that the Jamestown water supply was independent of the flow of Cassadaga Creek as heavy pumping of adjacent wells had no effect on the creek. This is thought to result from lake silts and clays near the surface of the valley fill acting as an aquiclude. The pumping did, however, show effects on permeable zones within the valley fill. These zones known as the Jamestown aquifer occur at lower elevations as one goes northward raising the question of what permeable deposit would dip northward, up glacier or up valley.

Obvious water losses, of the streams tributary to Cassadaga Creek, occur as they flow across the "alluvial fan-deltas" which occur along the valley margin where the relatively steep streams emerge onto a flat valley floor. These water losses suggested to Crain the relationships between the tributary stream deposits and the aquifer shown in Figure D3. The losses are not as obvious if one follows the streams out onto the valley floor where a major part of the "lost" water reappears. Here it flows in tightly meandering channels as the "deltas" thin toward their margins and the effects of the lake deposits are felt.

The Sinclairville (8), Gerry (6), Holmquist (9) and Folsom (10) "deltas" are among the "recharge" areas mapped by Crain.

Agnes caused considerable damage in many areas of New York, but a study of Holmquist Creek by Winter (1974) revealed that very little erosion or deposition occurred. The spring meltwater flows appeared to be significantly more effective in moving sediment and causing change. On high gradient streams with small drainage basins like Holmquist Creek, intense events covering much smaller areas are the prime movers and land sculptors. Events with a recurrence interval of 100 years or more play a much more important role than do events like Agnes with a 25 to 50 year interval.

On NY 394 (old route 17) we will head eastward crossing ice contact stratified drift (11) and skirt the north edge of the Hartson Swamp (12) which lies atop the Poland aquifer, a permeable zone in the Conewango-Cassadaga valley fill. Aside from the permeable

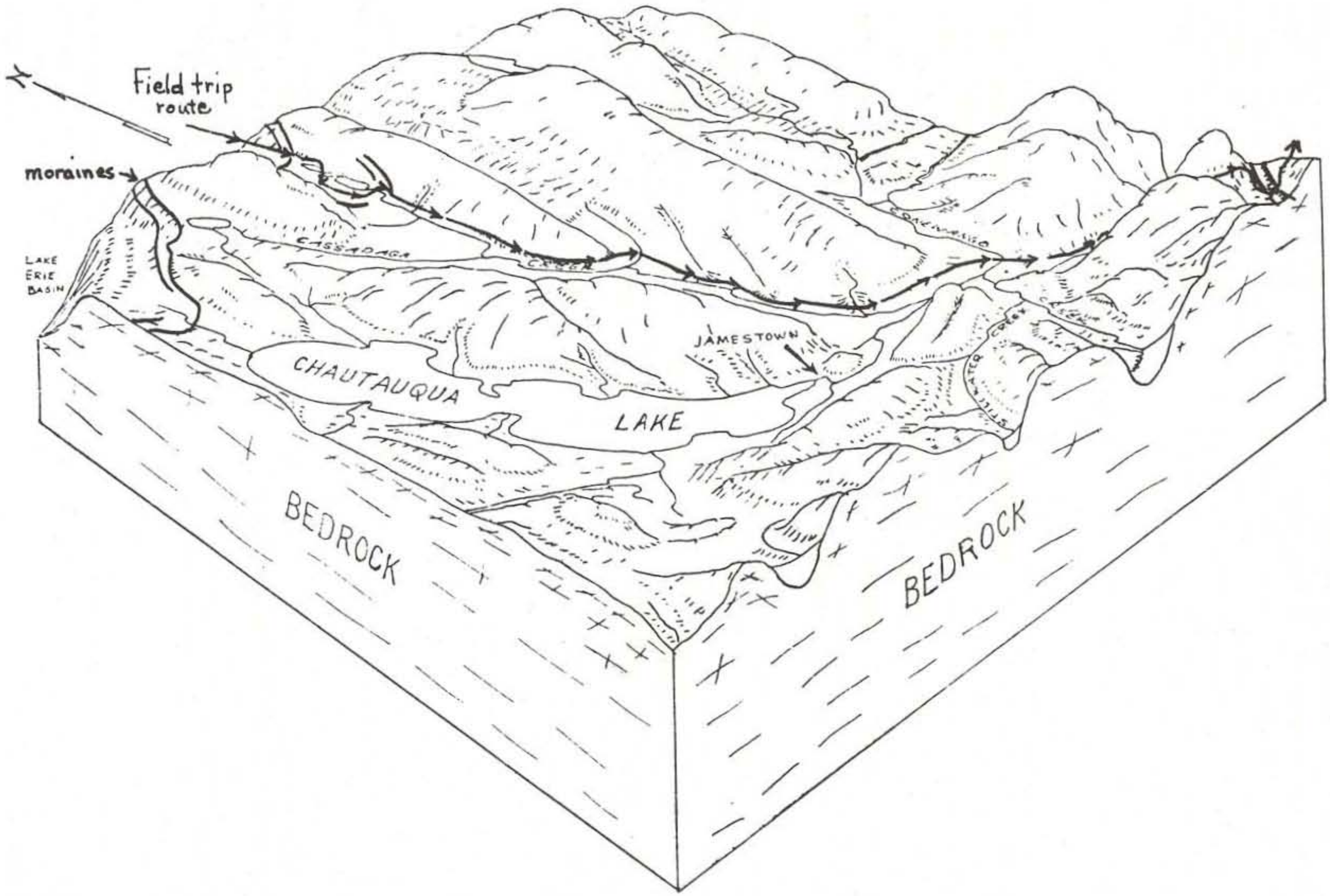


Figure D1. Topographic features of the Jamestown area (from Crain, 1966, Fig. 5)

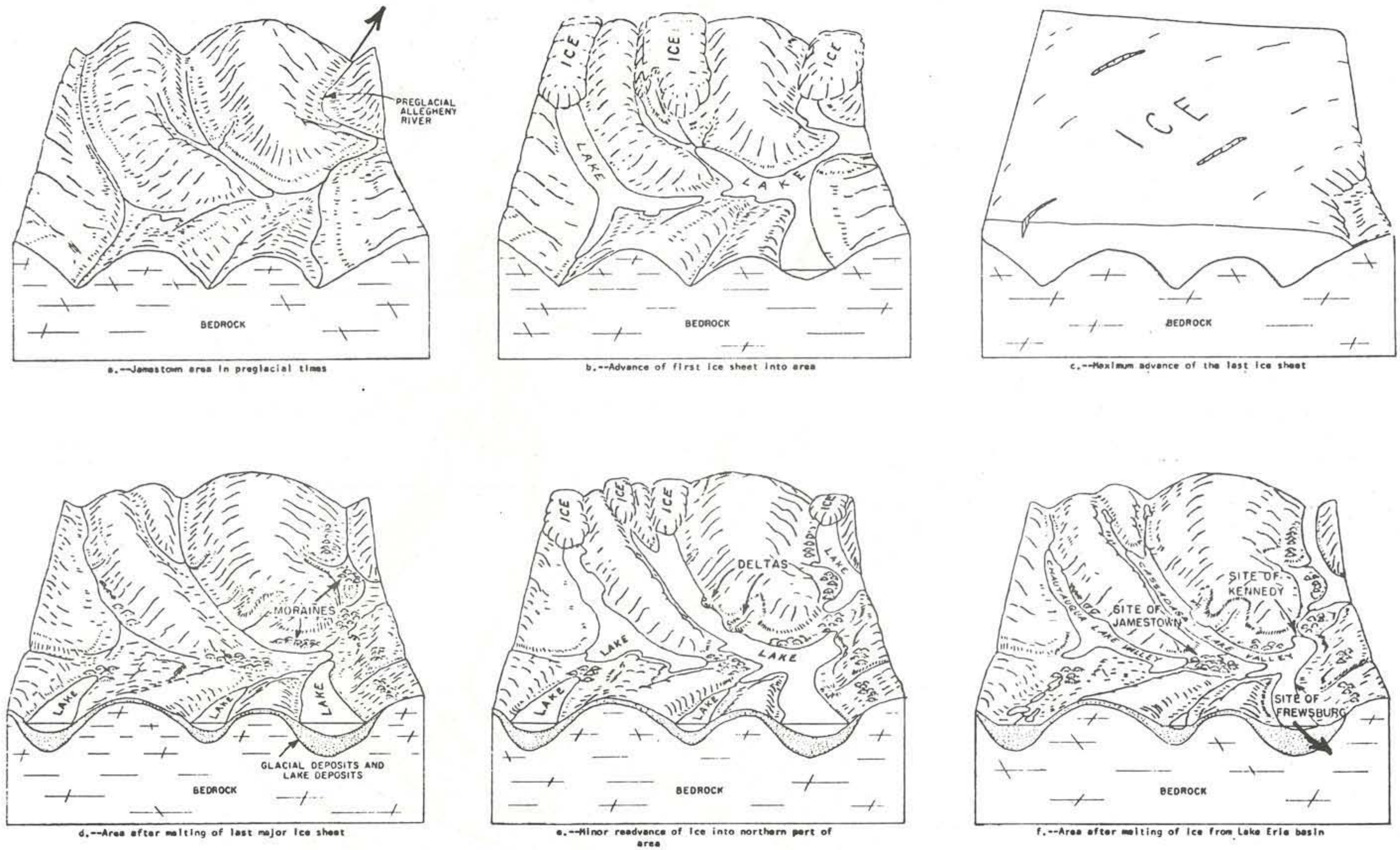


Figure D2. Glacial history of the Jamestown area (after Crain, 1966, Fig. 6)

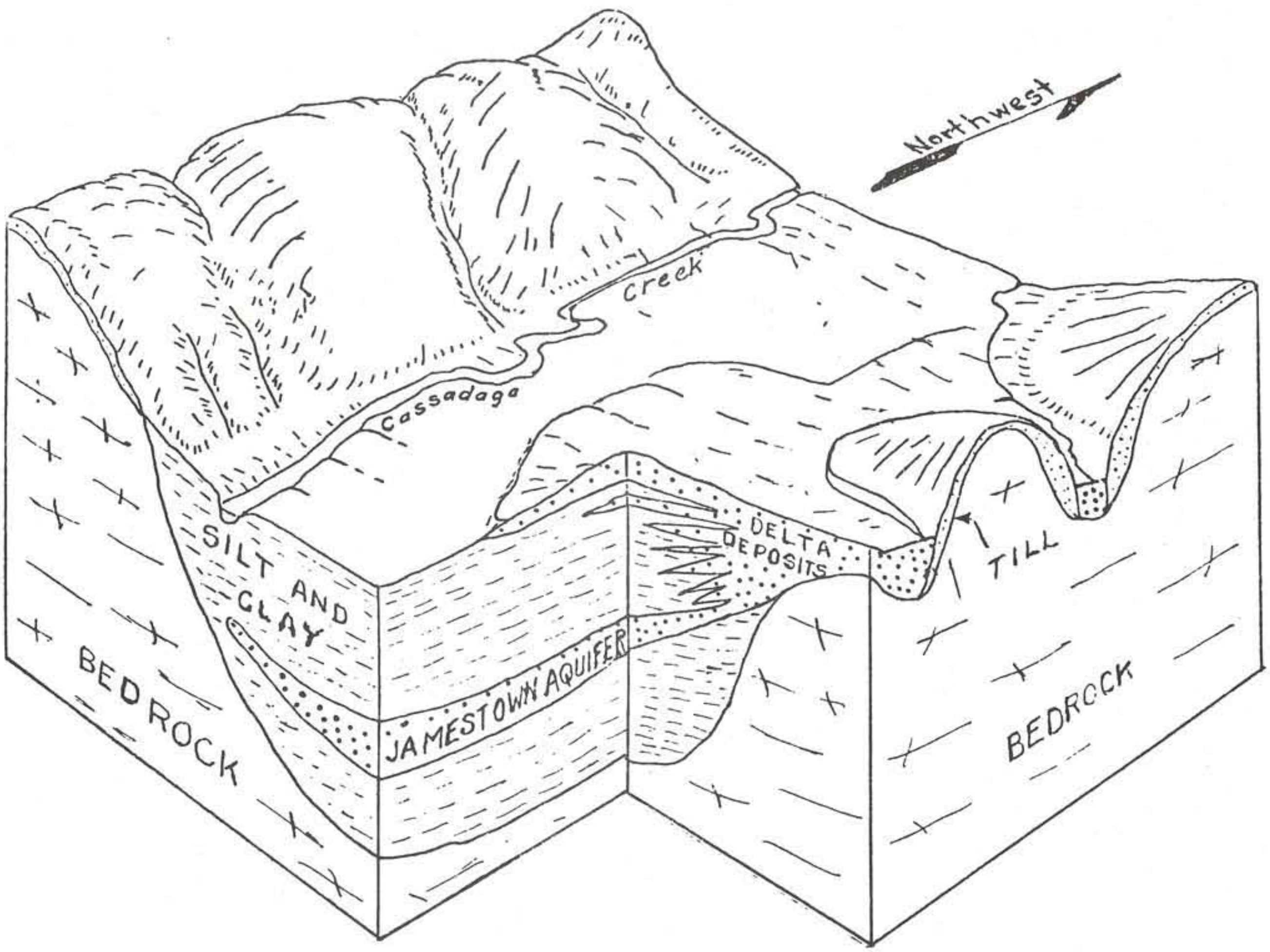


Figure D3. Cassadaga Creek valley in the vicinity of Folsom Creek (from Crain, 1966, Figure 22).

zones in the valley fills, groundwater is not abundant. In the uplands limited quantities can often be produced from zones of broken bed rock at the contact with overlying drift. Where the drift is thin or lacking and ground water must be produced from the local shales and siltstones, there is little of it and the quality leaves much to be desired.

Crossing the Conewango from Randand Center the route climbs the valley of Mud Creek (13). Note the gradient and character of the stream and valley floor. We will attempt to compare this valley with that of Elkins Brook (14), the next one to the north, in order to determine whether the present streams fashioned either valley.

On the upland, the route will traverse the glacial boundary crossing and recrossing it at several places. At some points we will be in knob and kettle topography with as much relief as any of the younger moraines to the north (15). While there are some evidences of glaciation such as foreign cobbles and boulders a few hundred yards beyond the obvious moraine, the changes in relief in the upland are not as striking as in the valleys. We will travel beyond the region affected by glaciation and along its fringes and then return through the sequence of moraines and filled valleys typical of New York State. A major point of this field trip is the contrast between unglaciated, marginal, and repeatedly-glaciated terrain.

Large quantities of gravel for the new route 17 (The Southern Tier Expressway) were removed from a large kame delta which has since been landscaped.

STOP D2. Refer to Plate 2c and d and the Steamburg and Randolph 7½ minute maps.

Dropping off the north side of the glaciated upland into the Ancestral Allegheny Valley now occupied by minor tributaries of the Conewango, we will pause for a view of the ice contact face (17) of the Kent terminal moraine and related features on the valley floor. The valley before us is the site of the reservoir advocated by Arthur Morgan (1971, Dams and other Disasters) as an alternate to the Kinzua Reservoir we will cross later. While Morgan was careful to not publish any maps, his plan would appear to make sense increasing the safety of the Allegany drainage while living up to George Washington's promises to leave the Indian lands untouched "so long as the sun rises and the river runs" in the works of the Pickering Treaty, the oldest existing U. S. Treaty (Morgan, 1971, p. 318).

The route winds by the most direct path now available, through the town of Steamburg on Rt. 394 (old Route 17) and south along the Kinzua Reservoir (18) on Reservoir Rd. in the post-glacial Allegany valley to Hotchkiss Hollow.

STOP D3. Quarry just into Hotchkiss Hollow. Refer to Plate 2b. "Devil's concrete" (conglomerate) has preserved the bedding of this quarry in striking contrast to most gravel deposits. What does the bedding indicate about the direction of the gravel source? What is the significance of the lithologies present in the gravel? What can you make of the feature blocking the mouth of the valley and of the form of its surface from which we just descended?

If the bus can turn around here, we will procede to Bradford, PA and to Rock City near Olean. If not...

In this portion of the trip we will traverse the glacial margin, but the final route has not been established as of this writing. In any case, we must return north to cross the Allegany on new Route 17. Wisconsin valley train has been quarried for the Route 17 fill (19). A terrace remnant of valley train (20) is deeply cut for the new route on the SE side of the river (Expletive deleted Landscaping!) (21) The new highway construction has triggered numerous landslides, rockfalls and mudflows. A route through Salamanca, Kilbuck, and Limestone, or an alternate route along the reservoir and south of the Allegany State Park may be taken (NY Rt. 220 to PA Rt. 346).

On either route, contrasts between glaciated valleys and valleys in which the only effects are those of lakes like the one in Hotchkiss Hollow and valleys untouched by any glacial effects will be seen.

As we approach Bradford (the home of Kendall Oil Co.), many wells producing in the manner of the early oil industry can be seen. A pump house and wells of this type will be seen at STOP D4 in Rock City. Turn east onto PA Route 646 at Foster Brook (22), staggering through Derrick City and up over the Knapp Creek (23) summit to Rock City. The route becomes NY 16 at the state line. It follows the old right-of-way of the Western New York and Pennsylvania RR interurban between Bradford and Olean which followed the route of a narrow gage railroad built in 1878 to haul oil.

Turn to the northwest into the private drive leading to "nature's own scenic wonder" at Olean Rock City Park.

STOP D4. 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?

The following paragraphs from Cochran (1957) on the production of oil is applicable to the oil fields around Rock City.

> In the Allegany (Bradford area) field primarily two different means are used in pumping wells, that is the individual well jack and the Oklahoma style jack pumped by a central power. The main difference in these tow methods is that the individual well jack is a unit complete in itself with a motor to supply power to the jack for lifting the rods and bottom hole equipment. The power to the Oklahoma style jack is supplied by a cable or rod line from the eccentric of the central power.
>
> Two different types of central powers are in use today, the gear power and the bandwheel power. The gear power uses a gear and pinion powered from the engine by a belt to motivate the eccentric whereas the bandwheel power uses a horizontal band wheel powered by a belt running from the engine to motivate the eccentric.
>
> Generally about 25 wells are pumped off of one central power. About four barrels of fluid per hour can be pumped from each well. Since this is normally more than will flow into the well bore it is not necessary to pump all the wells simultaneously, and the pumping times of the individual wells may be staggered throughout the pumping period.

Note: See Cochran (1957) for information on water flooding, well shooting and other aspects. A detailed and readable account of the early New York oil industry is contained in Herrick (1949).

Return (south) on NY Rt. 16A to Knapp Creek.

In village of Knapp Creek, turn right (north) onto County Road 61 which drops sharply into valley of Four Mile Creek. Harbell Farm Well no. 1 the state's oldest oil well which has produced continuously since 1877 (Herrick, 1949) lies in this valley.

Rockview (24) the first of six boom towns to spring up in and around the Four Mile valley in 1877 had 6 stores and 70 homes. Other towns included Rock City, Knapp Creek and Stateline.

West Brank Four Mile Creek lies to the west across the valley. Distribution of erratic pebbles and cobbles suggests that this is the approximate limit of glaciation in the valley of Four Mile Creek (25).

Turn left (W) onto River Rd. (County Rd. 60). Cross Four Mile Creek.

Turn left (W) onto Birch Run Rd. toward Birch Run Country Club.

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 imponding did not occur downstream from this point in Olean or later time.

Bear left at fork. Unmarked road to left leads to abandoned rock quarry and upper levels of STOP D5.

STOP D5. 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, forest 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 revealed none more than a mile south up the valley of Birch Run, nor could any be found on the south side of valley of Birch Run. A few erratics in the saddle at 1760 feet, 3/4 mile southeast of the pit confirm 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.

Turn Right (N) following dirt road.

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

Single lane bridge will not handle bus, continue west along south side of river.

Turn north on Rt. 219 to Bradford Junction (26).

Bradford Junction. Turn west on N.Y. Rt. 17 through Salamanca noting terrace remnants along the way. Salamanca is one town that cannot be given back to the Indians; they already own it and the lease does not have many years to run.

On the west side of town, turn north on NY 353 toward Little Valley. As we procede, try to spot the outermost evidence of ice action, the remnants of outwash terraces, the terminal and recessional moraines.

About 5 miles north of Little Valley we will bear right on Lovers Lane Rd. passing on the east side of the valley opposite the town of Cattaraugus to the East Otto Rd. and the Town of Otto.

STOP D6. Wisconsin stratigraphy.

Otto high bluff section, stream-bluff of South Branch Cattaraugus Creek, Otto town; Cattaraugus quadrangle, Cattaraugus County. ($78^{o}50'$W, $42^{o}21'15''$N).

The Otto site was initially described (MacClintock and Apfel, L944) 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 section on pre-Farmdale organic sites.

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.

| Unit | Lithology | Thickness |
|---|---|---|
| 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 decreasing 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 _Picea_ and _Pinus_ (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.+ |

_Questions_: 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?

Return to the southwest on East Otto Rd. to the town of Cattaraugus. This valley served as the outlet to Lake Zoar (Plate 2d). The first outlet [5] continuing further south and the later outlet turning north at Cattaraugus following the present course of the South Branch of Cattaraugus Creek and the route of the Erie RR westward through the low at Persia. No roads and few trains follow this route today.

If time permits we will stop at Muller Stop 1, [1] (Appendix A) on the Markham Rd.

The return trip will be through Markham (28) (a well penetrated 1100 ft. of fill near here), across the Conewango Valley (29) (the Ancestral Alleghany) to such famous places as South Dayton, Skunks Corner, Hamlet, Chicken Tavern, and Loana to Fredonia.