Sanders, J. E., and Merguerian, Charles, 1994a, Fitting newly discovered north-shore Gilbert-type lacustrine deltas into a revised Pleistocene chronology of Long Island, p. 103-116 *in* Hanson, G. N., *chm*., Geology of Long Island and metropolitan New York, 23 April 1994, State University of New York at Stony Brook, NY, Long Island Geologists Program with Abstracts, 165 p.

FITTING NEWLY DISCOVERED NORTH-SHORE GILBERT-TYPE LACUSTRINE DELTAS INTO A REVISED PLEISTOCENE CHRONOLOGY OF LONG ISLAND

John E. Sanders and Charles Merguerian, Geology Department, 114 Hofstra University, Hempstead, NY 11550-1090.

During the Quaternary deglaciation(s) of Long Island and vicinity, meltwater lakes formed in the low areas lying between the wasting ice to the north and Long Island and/or a terminal-moraine ridge on the south (Fig. 1). Newly exposed foreset beds of Gilbert-type deltas (Sanders, Merguerian, and Mills, 1993) are part of an extensive pro-glacial lake formation whose island-wide extent has not been previously recognized. We infer that the age of this large lake, which we propose to call "Long Island Lake" (or "Lake Long Island"), is mid- or even early Pleistocene and that it was enclosed on the S by the high parts of Long Island to the W and by a now-eroded pre-Ronkonkoma terminal moraine that extended S and E of Montauk and possibly also encircled what is now Cape Cod (Fig. 2). We fit the deposits of Long Island Lake into the new stratigraphic framework we are developing for the local Pleistocene deposits (Sanders and Merguerian, 1991a, b; 1992) as follows: they are younger than the oldest of the tills deposited by a glacier that flowed from the NNE to the SSW (Early Pleistocene?) and older than at least one of the tills deposited by a glacier that flowed from NNW to SSE, the older of which we think deposited the Ronkonkama moraine and the younger of which, the Harbor Hill moraine. We think that deposits of the youngest Wisconsinan glacier, the Woodfordian, are not present on most of Long Island (they are restricted to parts of Queens).

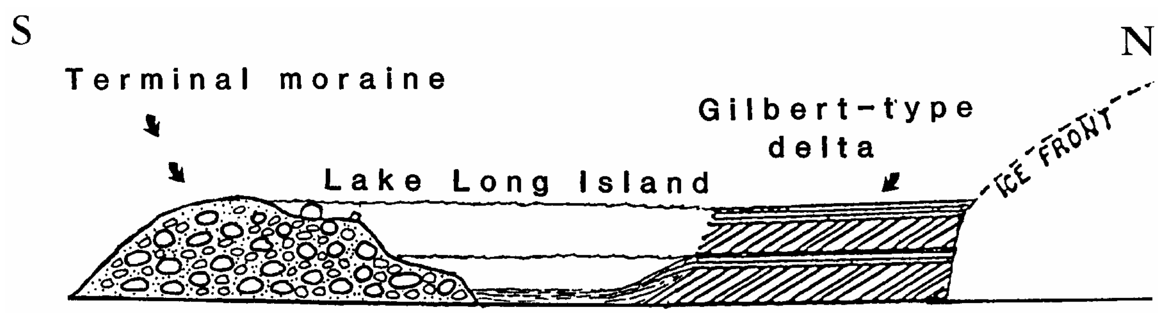

Figure 1. Schematic profile-section showing Gilbert-type deltas on N side of Lake Long Island, which formed in the lowland beteen the ice front on the N and the terminal-moraine ridge on the S. Two levels are shown: the lower at +40 feet and the upper at +80 feet (referenced to modern sea level). Highlands of Long Island, underlain by Cretaceous strata, could also serve as a dam for the lake on the S side. (Adapted from a figure in Woodworth, 1901.)

Numerous papers have been published about the varved clays, deposited in Late Wisconsinan proglacial lakes, which are present in every major lowland area in the New York metropolitan area (Long Island Sound, Hudson Valley, Hackensack Valley) and in central Connecticut-Massachusetts. (See references by Antevs; Reeds; Newman; Schaffel; Ashley; Shove; Frankel and Thomas; Bertoni, Dowling, and Frankel; and Lewis and Stone.) Such proglacial-lake deposits formed during the meltdown phase of the last Wisconsinan glacier (the Woodfordian). Their ages lie in the range of 13 to 11 ka.

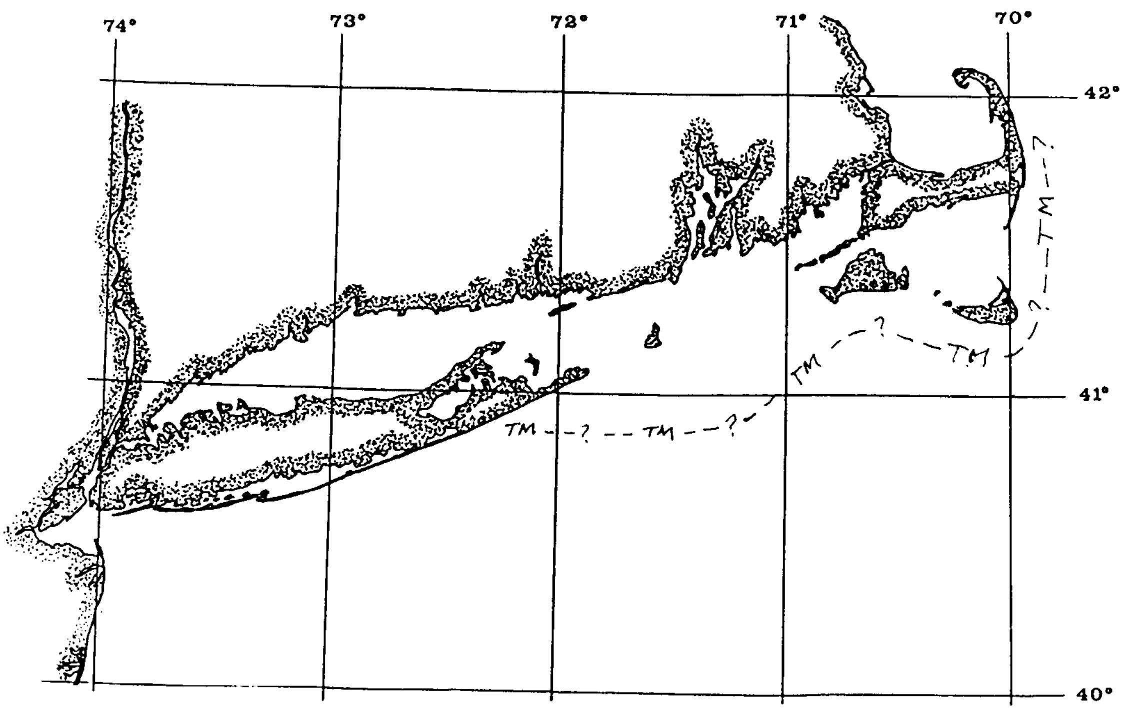

Figure 2. Outline map of southern New England and Long Island showing speculative position of a now-vanished terminal moraine marked by TM - - ? - - TM - - ? that we infer must have existed to serve as a dam for the lake in which the lacustrine strata in the coastal cliff at Montauk Point was deposited.

Described here are the results of our studies (1) of exposures at a few localities along the north-shore cliffs of Long Island that became visible after the severe storms of the winter of 1992-93 had undercut the lower parts of the cliffs and (2) of the cliffs at Montauk Point (Fig. 3) made before the sediments there were mostly covered by shore-protection structures. After the storms had "pulled back the drapes" formed by the ubiquitous slopewash from the top parts of the cliff to reveal the long-hidden strata lurking below, we found significant new pieces to the complex puzzle of the Quaternary history of Long Island that numerous geologists have been trying to fit together for many years.

Mather's sketch (1843) of a section at Lloyd's Neck exposed after storms had eroded the north-shore cliffs, published 42 years before G. K. Gilbert (1885) presented his analysis of the topographic features of lake shores in which he proposed the terms topset, foreset, and bottomset as the three kinds of lacustrine deltaic strata formed along the shores of ancient Lake Bonneville, Utah (and 47 years before Gilbert's Lake Bonneville monograph was published in 1890), shows series of dipping strata that had been truncated and are overlain by horizontal strata (Fig. 4).

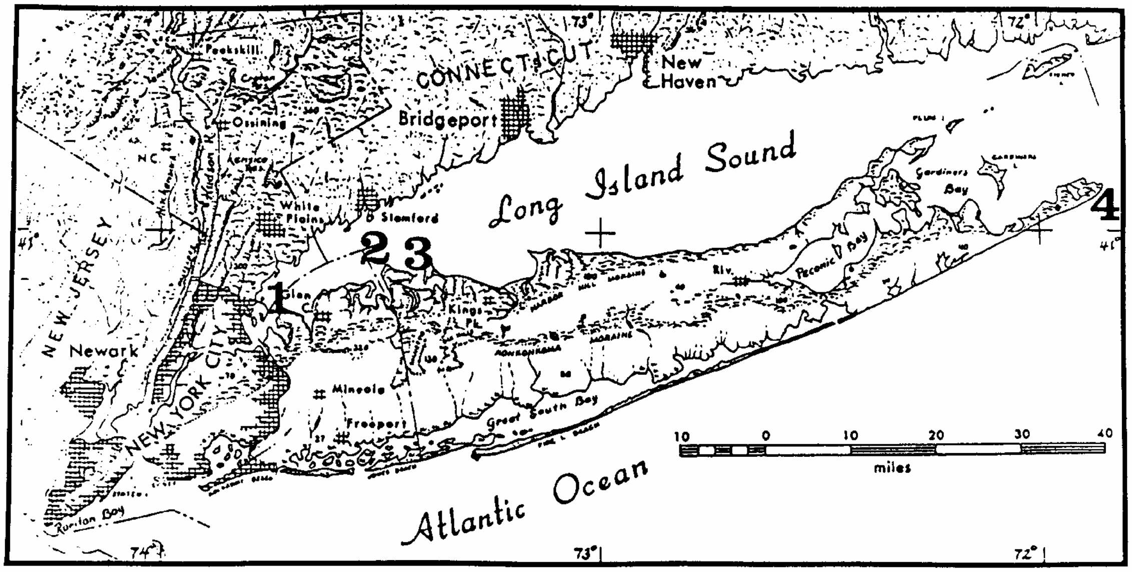

Figure 3. Physiographic index map of Long Island. Numbers show localities: 1, Sands Point; 2, Caumsett State Park; 3, Target Rock National Wildlife Preserve; 4, Montauk Point. (Base from J. A. Bier, 1964.)

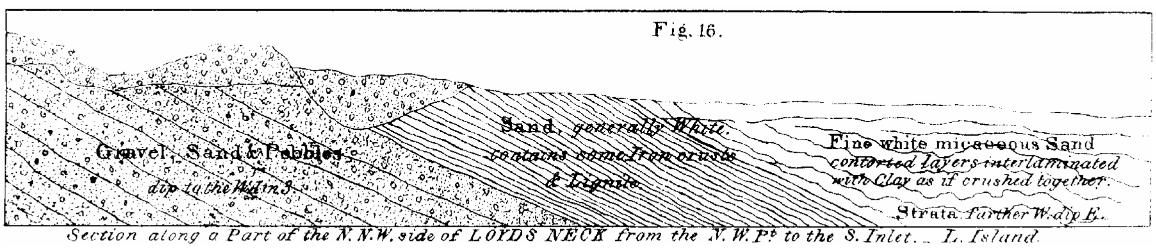

Figure 4. Sketch of foreset beds, with component of W dip (to R), that are discordantly overlain by till. Lloyd's Neck (now Caumsett State Park). (Mather, 1843, Plate 4, figure 16.)

Fuller (1914) showed many examples of cliff sections exposed by storms. A few of his sketches from Montauk Point and vicinity show what he referred to as "Montauk till" with interstratified gravel, sands, and clays in dipping layers (Figs. 5 and 6). Fuller inferred that such dips had resulted from the effects of glacier-flow ("ice-push") deformation of initially horizontal strata. Although we have not seen the exact localities shown in these two Fuller sketches near Montauk, we have seen dipping diamictons (Flint, Sanders, and Rodgers, 1960b) near Montauk Lighthouse that closely resemble dipping deposits that Fuller assigned to the "Montauk till." (What we consider to be the Montauk Till in the exposures near the Montauk Lighthouse displays no discernible dip. We infer that the dipping diamictons are foreset layers of a Gilbert-type delta complex consisting of the products of sublacustrine debris flows.)

Mather used the name "Long Island Formation" informally for the sediments that he thought underlie most of the island; he assigned this formation to the Tertiary. Mather's term has been abandoned, but we are considering the feasibility of reviving it for the pre-Wisconsinan, extensive suite of sediments deposited in Long Island Lake.

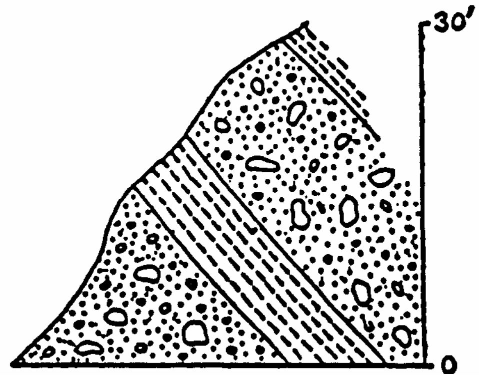

Figure 5. Fuller's sketch of exposure 1 mi W of Rocky Point, Montauk showing dipping diamictons and intercalated well-bedded strata. Based on what is exposed at Caumsett State Park, we infer that all these dipping layers are deltaic strata, the diamictons being products of subaqueous debris flows, not tills. (M. L. Fuller, 1914, fig. 156.)

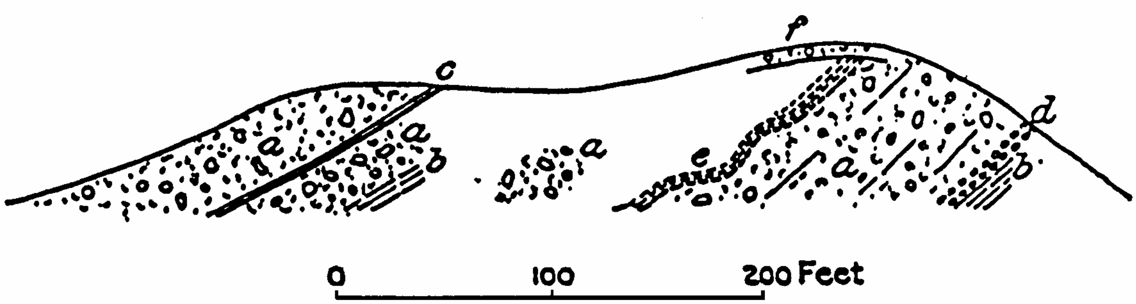

Figure 6. Fuller's sketch of exposure 0.5 mi S of Cullodan Point, Montauk, showing a dipping succession of diamictons and well-bedded strata and overlain by a horizontal till (f, at top; "Wisconsin till" in Fuller's caption. Other letter notations, after Fuller, are: a, "Montauk till member"; b, clayey sand; c, clay; d, gravel, and e, sand. (M. L. Fuller, 1914, fig. 157).

Woodworth (1901) reported on the Pleistocene geology of Queens County. His illustrations of delta foresets and -topsets came from the large sand pit in Port Washington during the early days of its active phase (Fig. 7). (This pit is no longer operating.)

Figure 7. Photo (by H. Ries) of horizontal topsets (top, beneath trees), and inclined foresets of a Gilbert-type delta exposed in 1901 in a Port Washington sand pit. (J. B. Woodworth, 1901, Plate 8.)

DESCRIPTIONS OF THE DELTAIC STRATA

Our descriptions are based on four localities in three of which are found new exposures created by storm erosion. In the fourth locality, Montauk Point, as mentioned, parts of the important exposures are no longer visible. (See Figure 3.)

1 - Sands Point

Except for a thin (1 m or so) till and overlying loess at the crest, the body of the cliffs E of the place where the trail ends at a wooden stairway to the beach at Sands Point is composed of outwash. The top third consists of pebbly, trough-cross-stratified typical coarse outwash, with flow indicated toward the S or SW.

At the E end of the first stretch of beach E of the trail, strata of sands dip steeply (ca. 45°) into the cliff. At first sight from a distance, this dip appears to be the kind of thing that results from rotational tilting on a slumped block. The proof that these are true Gilbert-type delta foresets is that horizontal sets of coarse, trough-cross-stratified pebbly outwash overlie the inclined foresets and truncate them along a horizontal surface. Moreover, the composition of the foresets differs from that of the topsets; the foresets are finer grained and regularly bedded.

Just to the W of where the stairway leads to the beach,is exposed a red-brown till filling a U-shaped valley carved into the delta deposits. We infer that this means the delta cannot possibly be of Wisconsinan age, but must be older than one of the tills deposited by a glacier that flowed from NW to SE (to deposit the red-brown till).

In an exposure E of where the road leads down to the seawall in distress, a small, shallow boulder-lined U-shaped trough had been cut into the delta topsets and backfilled with till, now totally reworked by outwash streams. (An exactly comparable relationship is shown in Mather's sketch of Fig. 4; and a closely analogous but larger, boulder-lined channel formerly was visible cutting into the lake sediments at Montauk Point that form the bulk of the eroding cliff S of the lighthouse.) By digging, we uncovered the truncated layers in the topset sands and the fact that any boulders containing biotite have decayed considerably.

2 - Caumsett State Park

The relationships found at Sands Point generally prevail also at Caumsett State Park. At Caumsett, however, inclined pebbly beds predominate in the foresets. Based on the increase in gravel in the delta foresets eastward from Sands Point to Caumsett State Park, we think that the vaguely stratified diamictites having displaying prominent dips do not represent deformed till but rather are deltaic deposits, products of sublacustrine debris flows. Among the pebbles are numerous decomposed mafic metamorphic rocks. We take these decomposed rocks as evidence that the age of this deltaic deposit is pre-Wisconsinan.

3 - Target Rock

At Target rock, the lower half of the cliff consists of till containing the green porphyritic mafic erratics from the Maltby volcanics W of New Haven, CT, indicating the ice flowed from NNE to SSW. We correlate this till with the oldest till at Croton Point Park (the gray till containing decayed granite stones; Merguerian and Sanders, 1992). Above this till is 1 cm or so of fine gray clay, and then come ripple-laminated silts/fine sands, with splendid examples of climbing ripples (as illustrated by Sirkin and Mills, 1975, description of Stop 3A). These rippled strata display lateral particle-size changes along the ripple profiles from coarser to finer, with superposition of these yielding "pseudo-bedding." We infer that these rippled sediments and the clay are the bottomset beds, if you will, of the delta foresets exposed at Caumsett State Park. Another thin till at the top of the cliff at Target Rock must have come from the NNW; it would have been deposited by a glacier that flowed from NW to SE, to bring the erratics of Inwood Marble and Cortdlandt Complex (Sanders and Merguerian, 1991b). If this is correct, then the age of the newly discovered delta deposits must be no younger than mid-Pleistocene (younger than old gray till from NNE and older than a till deposited by a glacier that flowed from the NW).

4 - Montauk Point

The significant relationship about the lake deposits at Montauk is that they are being eroded in a cliff that faces the open Atlantic Ocean. Given the requirement that a terminal moraine is required to serve as a dam along the southern margin of any proglacial lake that now faces the open ocean of extreme eastern Long Island, then the lake sediments near the Montauk lighthouse require us to infer that a terminal moraine, older than and lying south of the Ronkonkama Moraine, formerly existed seaward of the present S shore of eastern Long Island and has been eroded and submerged. (See Figure 2.)

REFERENCES

Antevs, Ernst, 1922, The recession of the last ice sheet in New England; with a preface and contributions by J. W. Goldthwait: New York, NY, American Geographical Society Research Series No. 11, 120 p.

Antevs, Ernst, 1925a, Retreat of the last ice sheet in eastern Canada: Canada Geological Survey Memoir 146, 142 p.

Antevs, Ernst, 1928a, The last glaciation, wtih special reference to the ice retreat in northeast North America: New York, NY, American Geographical Society Research Series No. 17, 292 p.

Antevs, Ernst, 1928b, Varved sediments: Washington, D. C., U. S. National Academy of Sciences National Research Council Reprint and Circular Series, no. 85, p. 17-20.

Ashley, G. M., 1972, Rhythmic sedimentation in glacial Lake Hitchock, Massachusetts-Connecticut: Amherst, MA, University of Massachusetts Department of Geology and Geography Contribution No. 10, 148 p.

Ashley, G. M., 1975, Rhythmic sedimentation in glacial Lake Hitchcock, Massachusetts, p. 304-320 in Jopling, A. V., and McDonald, B. C., eds., Glaciofluvial (sic) and glaciolacustrine sedimentation: Tulsa, OK, Society of Economic Paleontologists and Mineralogists Special Publication No. 23, 325 p.

Bertoni, Remo; Dowling, J. J.,; and Frankel, Larry, 1977, Freshwater-lake sediments beneath Block Island Sound: Geology, v. 5, p. 631-635.

Bier, J. A., 1964, Landforms of New York: Alpine Geographical Press, Illinois, Scale 1:1,000,000

Bokuniewicz, Henry; and Tanski, J. J., 1983, Sediment partitioning at an eroding coastal bluff: Northeastern Geology, v. 5, no. 2, p. 73-81.

Coates, D. R., 1976, Quaternary stratigraphy of New York and Pennsylvania, p. 65-90 in Mahaney, W. C., ed., Quaternary morphology of North America: Stroudsburg, PA, Dowden, Hutchinson and Ross, Inc., xxx p.

Davies, D. S., Axelrod, E. W., and O'Connor, J. S., 1973, Erosion of the north shore of Long Island: State University of New York at Stony Brook Marine Sciences Research Center Technical Report 18, 101 p.

deLaguna, Wallace, 1963, Geology of Brookhaven National Laboratory and vicinity, Suffolk County, New York: U. S. Geological Survey Bulletin 1156-A, 35 p.

Doriski, T. P.; and Wilde-Katz, Franceska, 1983, Geology of the "20-foot" clay and Gardiners Clay in southern Nassau and southwestern Suffolk counties, Long Island, New York: Syosset, NY, U. S. Geological Survey Water-

Resources Investigations Report 82-4056 (Prepared in cooperation with the Nassau County Department of Public Works and the Suffolk County Department of Health Services), 17 p.

Faust, G. T., 1963, Physical properties and mineralogy of selected samples of the sediments from the vicinity of the Brookhaven National Laboratory, Long Island, New York: U. S. Geological Survey Bulletin 1156-B, p. B1-B34.

Fetter, C. W., Jr., 1976, Hydrogeology of the South Fork of Long Island, New York: Geological Society of America Bulletin, v. 87, p. 401-406.

Fleming, W. L. S., 1935, Glacial geology of central Long Island: American Journal of Science, 5th series, v. 30, p. 216-238.

Flint, R. F.; Sanders, J. E.; and Rodgers, John, 1960a, Symmictite: a name for nonsorted terrigenous sedimentary rocks that contain a wide range of particle sizes: Geological Society of America Bulletin, v. 71, no. 4, p. 507-510.

Flint, R. F.; Sanders, J. E.; and Rodgers, John, 1960b, Diamictite, a substitute term for symmictite: Geological Society of America Bulletin, v. 71, no. 12, p. 1809.

Folger, D. W., Hathaway, J. C., Christopher, R. A., Valentine, P. C., and Poag, C. W., 1978, Stratigraphic test well, Nantucket Island, Massachusetts: U. S. Geological Survey Circular 773, 28 p.

Foord, E. E., Parrott, W. R., and Ritter, D. F., 1970, Definition of possible stratigraphic units in north central (sic) Long Island New York, based on detailed examination of selected well cores: Journal of Sedimentary Petrology, v. 40, no. 1, p. 194-204.

Frankel, Larry; and Thomas, H. F., 1966, Evidence of freshwater lake deposits in Block Island Sound: Journal of Geology, v. 74, p. 240-242.

Fuller, M. L., 1905, Pleistocene geology of Fishers Island: Geological Society of America Bulletin, v. 16, p. 367-390.

Fuller, M. L., 1914, The geology of Long Island, New York: U. S. Geological Survey Professional Paper 82, 231 p.

Gilbert, G. K., 1885, The topographic features of lake shores, p. 69-123 in U. S. Geological Survey, Annual Report, 5th (1883-1884), 469 p.

Gilbert, G. K., 1890, Lake Bonneville: U. S. Geological Survey, Monograph 1, 438 p.
Jensen, H. M.; and Soren, Julian, 1971, Hydrologic data from selected wells and test holes in Suffolk County, New York: Long Island Water Resources Bulletin 3, 35 p.

Jensen, H. M.; and Soren, Julian, 1974, Hydrogeology of Suffolk County, Long Island, New York: U. S. Geological Survey Hydrologic Investigations Atlas HA-501, 2 sheets.
New-delta notes, JES 22 APR 93, p. 4

Keller, W. D., 1956, Clay minerals as influenced by environments of their formation: American Association of Petroleum Geologists Bulletin, v. 40, p. 2689-2710.

Kilburn, Chabot, 1979, Hydrogeology of the Town of North Hempstead, Nassau County, Long Island, New York: Long Island Water Resources Bulletin LIWR-12.

Koszalka, E. J., 1980, Hydrologic data from the northern part of the Town of Brookhaven, Suffolk County, New York: Suffolk County Water Authority, Long Island Water Resources Bulletin 15, 80 p.

Krulikas, R. K., and Koszalka, E. J., 1983, Geologic reconnaissance of an extensive clay unit in north-central Suffolk County, Long Island, New York: Syosset, NY, U. S. Geological Survey Water Resources Investigations 82-4074, 9 p.

Lewis, R. S., and Stone, Janet Radway, 1990, Glaciolacustrine facies as seismic units in Long Island Sound (abstract): Geological Society of America Abstracts withPrograms, v. 22, no. 2, p. 30 (only).

Lewis, R. S., and Stone, Janet Radway, 1991, Late Quaternary stratigraphy (sic) and depositional history of the Long Island Sound basin: Connecticut and New York, p. 1-23 in Gayes, P. T., Lewis, R. S., and Bokuniewicz, H. J., eds., Quaternary geology of Long Island Sound and adjacent (sic) coastal areas: Journal of Coastal Research, Walter Newman Memorial volume, Special Issue No. 11, 215 p.

Liebling, R. S., and Scherp, H. S., 1975, Stratigraphic importance of chlorite in the Cretaceous Raritan Formation: Geological Society of America Bulletin, v. 86, p. 925-928.

Lohman, K. E., 1939, Pleistocene diatoms from Long Island, New York: U. S. Geological Survey Professional Paper 189-H, p. 228-237.

Lonnie, T. P., 1977 ms., A mineralogical study of Long Island clays: Garden City, NY, Adelphi University Department of Geology Master's Thesis, 44 p.

Lonnie, T. P., 1982, Mineralogic (sic) and chemical comparison of marine (sic), nonmarine (sic), and transitional clay beds on south shore of Long Island, New York: Journal of Sedimentary Petrology, v. 52, no. 2, p. 529-536.

Lubke, E. R., 1964, Hydrogeology of the Huntington-Smithtown area, Suffolk County, New York: U. S. Geological Survey Water-Supply Paper 1669-D, 68 p.

Mather, W. W., 1843, Geology of New York. Part I. Comprising (sic) the geology of the First Geological District: Albany, Carroll & Cook, Printers to the Assembly, 653 p., 46 pl. (Includes report of Prof. L. D. Gale on New York Island based on survey of 1828 and 1829.)

Merguerian, Charles; and Sanders, J. E., 1990, Trip 15: Glacial geology of Long Island, 17-18 November 1990: New York Academy of Sciences Section of Geological Sciences 1990-91 Trips on the Rocks Guidebook, 96 p.

Merguerian, Charles; and Sanders, J. E., 1991, Trip 16: Geology of Manhattan and the Bronx, 21 April 1991: New York Academy of Sciences Section of Geological Sciences 1990-91 Trips on the Rocks Guidebook, 141 p.

Merguerian, Charles; and Sanders, J. E., 1992, Trip 25, Geology of Croton Point and Peekskill Hollow, 21 November 1992, (revision of Trip 10, May 1990): New York Academy of Sciences Section of Geological Sciences 1992 Trips on the Rocks Guidebook, 107 p.

Merguerian, Charles; and Sanders, J. E., 1993, Trip 26, Cameron's Line and The Bronx parks, 08 May 1993 (revision of Trip 21, 24 November 1991): New York Academy of Sciences Section of Geological Sciences 1993 Trips on the Rocks Guidebook, 126 p.

Mills, H. C., and Wells, P. D., 1974, Ice-shove deformation and glacial stratigraphy of Port Washington, Long Island, New York: Geological Society of America Bulletin, v. 85, no. 2, p. 357-364.

Newman, W. S., 1966 ms., Late Pleistocene environments of the western Long Island area: New York, NY, New York University Department of Geology, Ph. D. Dissertation, 143 p.

Newman, W. S., 1977, Late Quaternary paleoenvironmental reconstruction: some contradictions from northwestern Long Island New York: New York Academy of Sciences Annals, v. 288, no. 7, p. 28-32.

Newman, W. S., and Fairbridge, R. W., 1960, Glacial lakes in Long Island Sound (abstract): Geological Society of America Bulletin, v. 71, no. 12, part 2, p. 1936 (only)

Newman, W. S.; Habib, Daniel; Krinsley, D. H.; and Burckle, L. H., 1968, Late Wisconsinan lacustrine (sic) and marine episodes in Long Island Sound, New York (abstract): Geological Society of America Special Paper 115, p. 281 (only).

Newman, W. S., and Pike, T. J., 1975, Late Quaternary geology of northern Queens County, Long Island (abstract): Geological Society of America Abstracts with Programs, v. 7, no. 1, p. 99 (only).

Newman, W. S., Thurber, D. L., Krinsley, D. M., and Sirkin, L. A., 1968, The Pleistocene geology of the Montauk Peninsula, p. 155-173 in Finks, R. M., ed., New York State Geological Association Annual Meeting, 40th, Queens College, Guidebook to field trips: Flushing, NY, Queens College of City University of New York Department of Geology, 253 p.

Nieter, William; Nemickas, Bronius; Koszalka, E. J., and Newman, W. S., 1975, The Late Quaternary geology of the Montauk peninsula: Montauk Point to Southampton, Long Island, New York, Trip A-7, p. 129-155 in Wolff, M. P., ed., Guidebook to Field Excursions: New York State Geological Association Annual Meeting, 47th, Hofstra University, Hempstead, NY, October 1975: Hempstead, NY, Hofstra University Department of Geology, 327 p.

Oldale, R. N., 1982, Pleistocene stratigraphy of Nantucket, Martha's Vineyard, the Elizabeth Islands, and Cape Cod, Massachusetts, p. 1-34 in Larson, G. L., and Stone, B. D., eds., Late Wisconsinan glaciation of New England. A symposium: Dubuque, IA, Kendall/Hunt Publishing Company, 242 p. (Symposium held at Northeastern section, Geological Society of America, 13 March 1980, Philadelphia, PA.)

Oldale, R. N., and Eskenasy, D. M., 1983, Regional significance of pre-Wisconsin till from Nantucket Island, Massachusetts: Quaternary Research, v. 19, p. 302-311.

Oldale, R. N., and Colman, S. M., 1992, On the age of the penultimate full glaciation of New England, p. in Clark, P. U., and Lea, P. D., eds., The last Interglacial-Glacial transition in North America: Boulder, CO, Geological Society of America Special Paper 270, 317 p.

Oldale, R. N., Valentine, P. C., Cronin, T. M., Spiker, E. C., Blackwelder, B. W., Belknap, D. F., Wehmiller, J. R., and Szabo, B. J., 1982, Stratigraphy (sic), structure (sic), absolute age (sic), and paleontology of the upper Pleistocene deposits at Sankaty Head, Nantucket Island, Massachusetts: Geology, v. 10, no. 5, p. 246-252. (ck order of authors; listed above as Cronin 2nd)

Perlmutter, N. M., and DeLuca, F. A., 1963, Availability of fresh ground water, Montauk Point area, Suffolk County, Long Island, New York: U. S. Geological Survey Water-Supply Paper 1613-B, p. B1-B39.

Perlmutter, N. M., and Geraghty, J. J., 1963, Geology (sic) and ground-water conditions in southern Nassau and southeastern Queens counties, Long Island, New York: U. S. Geological Survey Water-Supply Paper 1613-A, 205 p.

Pluhowski, E. J., and Kantrowitz, I. H., 1964, Hydrology of the Babylon-Islip area, Suffolk County, Long Island, New York: U. S. Geological Survey Water-Supply Paper 1768, 119 p. (Map of top of Magothy)

Reeds, C. A., 1925, Glacial Lake Hackensack and adjacent lakes: Geological Society of America Bulletin, v. 36, no. 1, p. 155.

Reeds, C. A., 1926, The varved clays at Little Ferry, New Jersey: American Museum Novitates, No. 209, p. 1-16.

Reeds, C. A., 1927, Glacial lakes and clays (sic) near New York City: Natural History, v. 27, p. 55-64.

Reeds, C. A., 1928, Varved glacial clays at Haverstraw, New York: Geological Society of America Bulletin, v. 39, p. 217-218.

Reeds, C. A., 1933, The varved clays and other features in the vicinity of New York City, p. 52-63 in Berkey, C. P., ed., International Geological Congress, 16th, United States, Guidebook 9, New York excursions, New York City and vicinity: Washington, D. C., United States Government Printing Office, 151 p.

Ricketts, H. C., 1986, Examination in boreholes of the subsurface Gardiners Clay (Pleistocene), in the context of the Cretaceous-Quaternary section of Great Neck, Long Island, New York: Northeastern Geology, v. 8, nos. 1/2, p. 13-22.

Ries, Heinrich, 1891a, The Quaternary deposits of the Hudson River between Croton and Albany: New York State Geologist Annual Report, v. 10, p. 110-155.

Ries, Heinrich, 1891b, The clays of the Hudson River Valley: New York Academy of Sciences Transactions, v. 11, p. 33-39.

Sanders, J. E., 1974, Geomorphology of the Hudson Estuary, p. 5-38 in Roels, Oswald, ed., Hudson River colloquium: New York Academy of Sciences Annals, v. 250, 185 p.

Sanders, J. E.; and Merguerian, Charles, 1991a, Pleistocene tills in the New York City region: New evidence confirms multiple (three and possibly four) glaciations from two directions (NNE to SSE (sic) and NW to SE) (abstract): Geological Society of America Abstracts with Programs, v. 23, no. 1, p. 123 (only).

Sanders, J. E.; and Merguerian, Charles, 1991b, Pleistocene geology of Long Island's north shore: Sands Point and Garvies Point to Target Rock: Long Island Geologists' Association Field Trip 29 June 1991 Guidebook: Hempstead, NY, Hofstra University Department of Geology, 40 p.

Sanders, J. E.; and Merguerian, Charles, 1992, Directional history of Pleistocene glaciers inferred from features eroded on bedrock, New York metropolitan area, SE NY (abstract): Geological Society of America Abstracts with Programs, v. 24, no. 1, p. 72 (only).

Sanders, J. E.; Merguerian, Charles; and Mills, H. C., 1993, "Port Washington deltas" of Woodworth (1901) revisited: pre-Woodfordian Gilbert-type deltas revealed in storm-eroded coastal bluff, Sands Point, New York (abstract): Geological Society of America Abstracts with Programs, v. 25, no. 6, p. A-308 (only).

Sanders, J. E., and Rampino, M. R., 1978, Wisconsinan stratigraphy, New York metropolitan area: interpretation of newly recognized units does not support modern concepts of the "Laurentide" ice sheet (abstract): Geological Society of America Abstracts with Programs, v. 10, no. 2, p. 84 (only).

Schaffel, Simon, 1969, A large-glacial fresh-water lake in Long Island Sound (abstract): Geological Society of America Special Papers 121, p. 372-373.

Schove, D. J., 1987, Sunspot cycles and weather history, Chapter 21, p. 355-377 in Rampino, M. R., Sanders, J. E., Newman, W. S., and Konigsson, L. K., eds., Climate. History, periodicity, and predictability: International Symposium held at Barnard College, Columbia University, New York, New York, 21-23 May 1984 (R. W. Fairbridge Festschrift): New York, NY, Van Nostrand Reinhold Company, 588 p.

Shaw, J., 1975, Sedimentary successions in Pleistocene ice-marginal lakes, p. 281-303 in Jopling, A. V., and McDonald, B. C., eds., Glaciofluvial (sic) and glaciolacustrine sedimentation: Tulsa, OK, Society of Economic Paleontologists and Mineralogists Special Publication No. 23, 325 p.

Sirkin, L. A., 1968, Geology (sic), geomorphology (sic) and late glacial (sic) environments of western Long Island, New York, p. 233-253 in Finks, R. M., ed., New York State Geological Association Annual Meeting, 40th, Queens College, Guidebook to field trips: Flushing, NY, Queens College of City University of New York Department of Geology, 253 p.

Sirkin, L. A., 1971, Surficial geology (sic) deposits and postglacial pollen stratigraphy in central Long Island, New York: Pollen et Spores, v. 23, p. 93-100.

Sirkin, L. A., 1982, Wisconsinan glaciation of Long Island, New York to Block Island, Rhode Island, p. 35-59 in Stone, B.; and Larson, G., eds., Late Wisconsinan glaciation of New England. A symposium: Dubuque, IA, Kendall/Hunt Publishing Company, 242 p. (Symposium held at Northeastern section of Geological Society of America, 13 March 1980, Philadelphia, PA.)

Sirkin, L. A., and Mills, H. C., 1975, Wisconsinan glacial stratigraphy and structure of northwestern Long Island, Trip. B-5, p. 299-327 in Wolff, M. P., ed., Guidebook to Field Excursions: New York State Geological Association Annual Meeting, 47th, Hofstra University, Hempstead, NY, October 1975: Hempstead, NY, Hofstra University Department of Geology, 327 p.

Sirkin, L. A.; and Stuckenrath, R., 1980, The Portwashingtonian warm interval in the northern Atlantic coastal plain: Geological Society of America Bulletin, v. 91, p. 332-336.

Soren, Julian, 1971b, Results of subsurface exploration in the mid-island area of western Suffolk County, Long Island, New York: Long Island Water Resources Bulletin No. 1, 60 p.

Soren, Julian, 1978, Subsurface geology and paleogeography (sic) of Queens County, Long Island, New York: U. S. Geological Survey Water Resources Investigations 77-34, 17 p.

Swarzenski, W. V., 1959, Ground-water supplies in Pleistocene (sic) and Cretaceous deposits of northwestern Nassau County, New York, p. 1077-1091 in Lowe, K. E., chm. and consulting ed., Modern aspects of the geology of New York City and environs: New York Academy of Sciences Annals, v. 80, art. 4, p. 1047-1169.

Tanski, J. J., 1981 ms., Episodic bluff erosion on the north shore of Long Island, New York: State University of New York at Stony Brook Marine Sciences Research Center M. S. thesis, 82 p.

Woodworth, J. B., 1901, Pleistocene geology of portions of Nassau County and the Borough of Queens: New York State Museum Bulletin 48, p. 618-670.