

PLEISTOCENE STRATA NEWLY EXPOSED IN CUTS NEAR DOBBS FERRY METRO-NORTH RAILROAD STATION

John E. Sanders
Geology Department, 114 Hofstra University
Hempstead, NY 11549-1140
e mail: S7632077@aol.com

INTRODUCTION

Ever since 1974 when I published a summary of the geomorphology of the Hudson Valley and suggested that the glacial history of New York City and vicinity was more complicated than the contemporary literature suggested (Sanders, 1974), I have been on the lookout for new stratigraphic evidence bearing on the Pleistocene history. My first effort in this direction came from study in the summer of 1974 of the new cuts made during enlargement of the Westchester County sewage-treatment plant in the Ludlow section of Yonkers. The excavations there showed a reddish-brown till containing a gigantic erratic of coarse dolerite from the Palisades. Overlying this till were fine-textured reddish-brown lake deposits within which were well-rounded dropstones. The finer-textured layers had been recumbently folded on a small scale. (For a view of these recumbently folded layers, see Figure 9-36 p. 366 in Friedman and Sanders, 1978.) These reddish-brown lacustrine sediments were overlain by yellowish brown fine-textured lake sediments.

During the next decade, I was able to examine various sections from Hastings-on-Hudson to Irvington.

In 1983, in connection with a research project at the Lamont-Doherty Geological (now Earth) Observatory of Columbia University aimed at determining if sedimentary evidence resulting from neotectonic activity were present in the Hudson Valley, Leonardo Seeber, Martitia Tuttle, and I studied several sites along the E side of the Hudson River. One of the localities we examined was the cut along the service road into the Livingston Ridge site in Dobbs Ferry that had been made for use by a drilling rig. Here, we observed yellowish-brown fine-textured lake sediments (probably of Unit F as described in a following section).

The sediments exposed in all these localities suggested the possibility that the local record consists of products of multiple glaciations, but I did not observe any definitive relationships for proving this possibility.

In contrast to the foregoing are the newly exposed sections made at the Livingston Ridge town-house site, E side of the Hudson River near the Dobbs Ferry Metro-North Railway station (Figure 1). I describe these, organize them into units and present some preliminary laboratory results on selected samples from the units exposed. Then follows my attempt to correlate these units with the standard section that Charles Merguerian and I have established at Croton Point Park, 17 km (11 mi) N of Dobbs Ferry and W of the Croton-Harmon Metro-North/Amtrak Railway Station.

Figure 1. SE corner of Nyack 7.5-min topographic quadrangle map of the U. S. Geological Survey showing location of Dobbs Ferry Metro-North Railroad station UTM coordinates 594.17 E; 4540.50 N and vicinity (UTM kilometer grid lines added).

SEDIMENTS NEWLY EXPOSED AT LIVINGSTON RIDGE TOWN-HOUSE SITE NEAR THE DOBBS FERRY METRO-NORTH RAILWAY STATION

Starting in August 1998, the cuts made in connection with construction work for the Livingstone Ridge town-house development situated between Livingston Avenue and the Metro-North Railroad tracks near the Dobbs Ferry Station in Westchester County, NY, have exposed four units of till and six, of outwash. Some of the deposits display the characteristic reddish-brown color indicating provenance from the reddish-brown Newark-Supergroup strata present in Rockland County, New York, whose outcrop also continues southwestward into adjacent northern New Jersey. By contrast are grayish- to yellowish-brown deposits that indicate provenance from the pre-Newark rocks exposed to the N and

NE. These non-reddish sediments underlie, overlie, and are interbedded with some of the fine-textured reddish-brown sediments. No diagnostic interglacial sediments of any kind have been exposed.

I have subdivided the newly exposed sediments into eleven units that I designate informally by capital letters starting with A at the bottom (the oldest) and extending to K at the top (the youngest) (Table 1). I have not assigned any letter to the artificial fill locally present at the top of some of the cuts.

TABLE 1. Composite stratigraphic section exposed in cuts made for the Livingston Ridge town-house development, Dobbs Ferry, NY.

Unit	Description; remarks	Thickness (m)	Inferred Product of Glaciation Number of Sanders- Merguerian Scheme
K	Yellowish-brown sandy silt (loess?).	ca. 0.5	Post-I
J	Yellowish-brown outwash consisting of fine sand (exposed on N side) and coarse, pebbly sand (exposed on S side). Lateral relationships between the two are not visible.	ca. 2 ex- posed	I
I	Reddish brown till,	ca. 1	II
H	Fine-textured reddish-brown lake deposits including two meter-thick subunits of current-bedded fine sands interbedded with darker-colored silt. Contacts with older units have not yet been exposed; unit extends from level of the work road (ca elev. 30 ft) in the middle of the excavations upward to elev. 60 ft. along the S side.	Est'd. 10	IIIA
G	Reddish-brown till; well-rounded clasts.	Est'd. 1	IIIA
F	Fine-textured lake deposits; interbedded light-gray fine sands and reddish-brown silty clays. Relationship to Unit E not visible.	Est'd. 3	IIIB
E	Reddish-brown till resting on thin (5 cm) dark reddish-brown clay.	Est'd. 1.5	IIIB

D	Yellowish-brown and reddish-brown fine-textured lake deposits showing effects of glacial deformation. Abrupt lateral contact to the N with coarse reddish-brown sediments containing very well-rounded clasts.	IIC
		Ca. 1 exposed; base not visible.
C	Reddish-brown coarse outwash containing very well-rounded clasts. Top not exposed in cut that shows base.	IIC
		Est'd. 2
B	Reddish-brown till; sharp contact with Unit A; top exposed at elev. 30 ft near newly installed fire hydrant at entrance of work road.	IIC
		Est'd. 3
A	Coarse outwash sand. Sample DF-01-99. Resembles outwash present beneath reddish-brown till at base of cliff Princes Bay, Staten Island.	IV
		Ca. 2.5 exposed; base covered

The contacts between some of these units were exposed in the excavations. By scraping with a GI trenching tool, I was able to expose other contacts. However, some contacts have not yet been exposed. Accordingly, certain critical relationships are not yet demonstrated. This applies particularly to the basal contacts of Unit H, whose general relationships suggest that it fills a valley eroded into older units, possibly extending down to Unit D. As the digging has not yet been completed, the possibility still exists that the earth-moving machines may yet uncover some critical contacts .

LABORATORY PROCEDURES

The laboratory investigations, carried out in the sedimentology laboratory in the Department of Geology, Hofstra University, consisted of ultrasonic cleaning (10 min, using a Branson sonifier), wet sieving [first with a No. 60 sieve, 0.25 mm or 2 ϕ , and afterward with a No. 230 sieve, 0.0625 mm or 4 ϕ), drying, dry sieving using sieves at 0.5- ϕ intervals in the sand grades using a Tyler Ro-tap for 10 minutes. The contents of each sieve (and the pan) were weighed using an Allied Model 7160A digital balance that displayed weights to 0.1 gram. Later the cleaned- and separated sand fractions were examined using an Olympus research binocular-stereo microscope Model SZH10. The particles that were washed through the No. 230 sieve have been saved along with the wash water, but have not yet been analyzed.

Figure 2 shows histograms of the results of the sieving of 4 samples. In preparing these histograms, only the sand-grade fractions were included. Their weights were summed and the total considered to be 100%. The less-than-4 ϕ fractions consist of two parts: (a) what collected in the pan

during the sieving of the dry samples in the Ro-tap (these dry fractions were weighed) and (b) the fines that are still contained in the wash water from the wet sieving. The amounts of sediment that collected in the pan during dry sieving are to some extent expressions of the efficiency of the first two steps, sonifying and wet sieving. Had sonification and wet sieving been 100% effective, then during dry sieving, nothing should have collected in the pan; all the fines would have washed through the No. 230 sieve and be in the wash water. Only minor amounts of sediment coarser than the No. 10 sieve [2 mm (-1.0 ϕ)] were present in the samples selected for analysis.

Figure 2. Histograms of four samples from units exposed in cuts made for Livingston Ridge town-house site, Dobbs Ferry, NY. Further discussion in text.

The mineralogic data support the obvious color contrasts of the sediments. The reddish-brown sediments contain debris from the Newark Supergroup, whereas the grayish and yellowish-brown sands do not. A distinctive feature of the non-reddish sediments is well rounded clasts of dark gray aphanitic rocks, probably cherts and graywackes from areas to the N in the Hudson Valley. Other distinctive rock fragments include a granoblastic hornblende-plagioclase rock in which the luster of the plagioclase is glassy (vitreous) and a kyanite schist in which kyanite forms about three-quarters of the volume. Only a few granitic rocks and granitic gneisses are present.

Several varieties of angular, in some cases, almost shard-like quartz are present. These include clear (glassy--vitreous), rose, translucent, and yellowish varieties. Other individual-mineral fragments include plentiful hornblende and garnet. In many of the coarser sand grades individual feldspar fragments are generally rare but these become more abundant in the finer-sand fractions. Likewise, micas, such as biotite and muscovite, are generally absent from the coarser grades but become more abundant in the finer fractions.

RELATIONSHIP OF SEDIMENTS EXPOSED AT LIVINGSTON RIDGE, DOBBS FERRY, WITH STANDARD SUCCESSION AT WESTCHESTER COUNTY PARK, CROTON POINT

My first geologic visit to Croton Point Park (Figure 3) was made in 1986 in the company of Leonardo Seeber and Martitia Tuttle, of Lamont Doherty Geological (now Earth) Observatory of Columbia University, and Gary Zern, an archeologist living in northern Westchester County. We examined the low bluff along the water's edge N of Teller's Point (Figure 3). We excavated through the gray clay [a proglacial lake deposit related to the retreat of Glacier I (of the Sanders-Merguerian modified Fuller classification; Table 2), the "Woodfordian" of authors, which is known to have flowed down the Hudson valley] to expose an underlying reddish-brown till deposited by an older glacier that had flowed across the Hudson valley.

In October 1989, I attended a field trip to Croton Point Park led by Sirkin, Cadwell, and Connally (1989). Subsequently in preparation for two On-The-Rocks field trips to Croton Point Park (Merguerian and Sanders, 1990a, 1992), Charles Merguerian and I spent several days walking the entire shoreline, at low tide, from Teller's Point on the S to Enoch's Nose on the N. From what we observed, we inferred that the deposits of four glaciers are present here. (See Figure 3.)

Inferred Correlations between Dobbs Ferry and Croton Point Park

Based on their stratigraphic relationships, I infer that the newly exposed sediments at Livingston Ridge, Dobbs Ferry, are products of at least four glaciations. In the right-hand column of Table 1, I have indicated my guesstimates of how the various units are distributed with respect to the Sanders-Merguerian modified Fuller five-glacier classification of the Pleistocene deposits of New York City and vicinity. (See Table 2.)

The deposits of Unit J, made after the youngest glacier (No. I) had melted, are not reddish brown, but display a typical yellowish-brown color. Glacier I flowed from NNE to SSW. Underlying these non-reddish materials are four units of reddish-brown till and five bodies of outwash, Units I

through B of Table 1. I infer that these are products of glaciers II, IIIA, IIIB, IIIC, and IV of the Sanders-Merguerian scheme.

Figure 3. Westchester County Park, Croton Point, New York.

A. Surficial deposits, compiled by John Muenzinger in mid-1960's, prior to beginning of major garbage dumping. (Slightly modified from Geraghty and Miller, Inc., 1976 ms, fig. 2, p. 10). A A' marks line of profile-section of B.

B. Profile-section from Enoch's Nose to Teller's Point showing exposures of Tills I through IV of the Sanders-Merguerian classification. (See Table 2.)

The thick body of fine-textured, reddish-brown lake deposits (Unit H) in the middle of the site evidently occupies a valley that was cut into the subjacent older reddish-brown till(s) and outwashes. The youngest reddish-brown till (Unit I) overlies this body of lacustrine sediments. Below the oldest reddish-brown till (Unit B) is grayish-brown coarse sandy outwash (Unit A), that I assign to glaciation IV of the Sanders-Merguerian classification. This outwash is the oldest unit exposed; I correlate it with the gray till exposed at water's edge at the SW end of Teller's Point, Croton Point Park.

DISCUSSION

During the last several years, Merguerian and I have been applying to the local Pleistocene deposits the principle that each of the continental glaciers that invaded the New York City region followed, on a subregional scale, a single rectilinear flow direction. Application of this principle, plus a study of the extensive literature written by previous workers and analysis of the effects of a major storm in December 1992 that exposed the otherwise-covered strata in some of Long Island's north-shore coastal cliffs, have led us to resurrect Fuller's (1914) four-glacial classification of the Quaternary deposits of Long Island (Table 3). In addition to advocating that Fuller's classification be resurrected, we have

TABLE 2. Sanders-Merguerian's modified Fuller (1914) classification of Pleistocene sediments in New York City and vicinity. (Sanders and Merguerian 1997.)

TABLE 3. Pleistocene formations on Long Island as classified by Fuller (1914) and three subsequent workers. (After E. H. Muller, 1964, table 2, p. 104.)

proposed several modifications, including adding a fifth glaciation and recognizing the importance of the large-scale proglacial lake deposits in Fuller's Manhasset Formation.

CONCLUSIONS

I conclude that the Pleistocene sediments newly exposed during construction at the Livingston Ridge town-house site near the Dobbs Ferry Metro-North Railway station are products of four glaciations, Nos. I, II, IIIA, IIIB, IIIC, and IV of the Sanders-Merguerian proposed new modification of Fuller's (1914) classification of the Pleistocene sediments on Long Island. What is more, these newly exposed sediments very closely match those exposed at the Westchester County Park, Croton Point. The yellowish-brown outwash deposit of Unit J was deposited after Glacier I had melted. I infer that The yellowish-brown till that forms a N-S-trending drumlin at Enoch's Nose, Croton Point Park (which is overlain by gray clay in which dropstones are present) was a direct deposit of Glacier I.

The reddish-brown till (Unit I) is the youngest of four reddish-brown tills that I am not sure how to correlate with the two reddish-brown tills exposed at Croton Point Park. Unit I overlies the body of "deep-water" reddish-brown, fine-textured lake sediments (Unit H) that fill a valley that was cut into older units. Unit G, also a reddish-brown till containing very-well-rounded clasts, is an inferred product of Glacier IIIA. Unit E, another reddish-brown till (assigned also to IIIA) overlies another body of lacustrine sediments that have been deformed by small-scale normal faults, and that consists of interbedded grayish-brown and reddish-brown sediments (Unit F). Below these lacustrine sediments is another reddish-brown till (Unit E) an inferred product of Glacier IIIB. Below it is still-another body of fine-textured lake deposits (Unit D) that show small-scale fold structures. The underlying Unit C is a coarse-textured outwash containing well-rounded stones set in a coarse-sand matrix. Unit B is a

reddish-brown till containing at least one large schist boulder. I infer that Units D and C are products of Glaciation IIIC.

Unit A, the oldest exposed, is a grayish coarse sand whose base is not visible. I correlate the coarse outwash sand of Unit A with the gray till exposed at water's edge at the S end of Teller's Point, Croton Point Park (inferred production of Glaciation IV), which is not accompanied by outwash.

ACKNOWLEDGEMENTS

I express my grateful thanks to Mr. Peter Tringali, construction manager for the Livingstone Ridge town-house project, Dobbs Ferry, for granting me access to the site and for providing information about the engineering test borings. Without his enthusiastic support, this study would not have been possible.

Leonardo Seeber, of Lamont-Doherty Earth Observatory, was the impetus for some of my trips to examine the Pleistocene sediments along the E side of the Hudson River. Seeber and Martitia Tuttle (formerly of Lamont-Doherty Geological Observatory, now of the University of Maryland, College Park) organized and provided transport for my first geological trip to Croton Point Park. Gary Zern was our local guide.

Tom Kelly, Westchester Parks Department, provided several maps of Croton Point Park.

I thank Charles Merguerian, Hofstra University, for accompanying me into the field at various times and places during the last 15 years or so when we have collaborated in studying many aspects of the geologic relationships in the New York City region and also for assistance in putting together the camera-ready copy of this paper. J Bret Bennington, also of Hofstra University, has also been an enthusiastic and astute field partner on several occasions and made arrangements for me to analyze the samples in the Hofstra sedimentology laboratory. Dr. Baiying Guo, of Ridgewood, Queens, assisted with the laboratory analyses.

REFERENCES CITED

- Friedman, G. M., and Sanders, J. E., 1978, Principles of sedimentology: New York, John Wiley and Sons, Inc., Publishers, 792 p.
- Fuller, M. L., 1914, The geology of Long Island, New York: United States Geological Survey Professional Paper 82, 231 p.
- Geraghty and Miller, Inc., 1976 ms., Ground-water investigation at the Croton Point Landfill: Port Washington, NY, Summary Report to Westchester County, 47 p.
- Markl, R. G., 1971, Pleistocene geology of Croton Point, New York: New York Academy of Sciences, Transactions, series II, v. 33, no. 5, p. 505-515.
- Merguerian, Charles; and Sanders, J. E., 1990a, Trip 10: Croton Point and Peekskill Hollow, 12 May 1990: New York Academy of Sciences Section of Geological Sciences 1989-90 Trips on the Rocks Guidebook, 74 p.
- Merguerian, Charles; and Sanders, J. E., 1990b, Trip 15: Glacial geology of Long Island, 17-18 November 1990: New York Academy of Sciences Section of Geological Sciences Trips on the Rocks Guidebook, 96 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., 1996d, Glacial geology of Long Island: Guidebook for On-The-Rocks 1996 Fieldtrip Series, Trip 39, 01 + 02 June 1996, Section of Geological Sciences, New York Academy of Sciences, 130 p.

Muller, E. H., 1964, Quaternary geology of New York, p. 99-112 in Wright, H. E., and Frey, D. G., eds., The Quaternary of the United States: Princeton, NJ, Princeton University Press, 922 p.

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, 1994a, Fitting newly discovered north-shore Gilbert-type lacustrine deltas into a revised Pleistocene chronology of Long Island (extended abstract), p. 103-113 in Hanson, G. N., *chm.*, Geology of Long Island and metropolitan New York, 23 April 1994, Stony Brook, NY: Stony Brook, NY, Long Island Geologists Program with Abstracts, 165 p.

Sanders, J. E.; and Merguerian, Charles, 1994b, Glacial geology of the New York City region, p. 93-200 in Benimoff, A. I., ed., The geology of Staten Island, New York: Geological Association of New Jersey Annual Meeting, 11th, Somerset, NJ, 14-15 October 1994, Field guide and proceedings, 296 p.

Sanders, J. E. and Merguerian, Charles, 1995a, Evidence for pre-Woodfordian ages of Long Island's terminal moraines (extended abstract), p. 91-106 in Hanson, G. N., *chm.*, Geology of Long Island and metropolitan New York, 22 April 1995, Stony Brook, NY: Stony Brook, NY, Long Island Geologists Program with Abstracts, 135 p.

Sanders, J. E.; and Merguerian, Charles, 1995b, New York City region: Unique testing ground for flow models of Quaternary continental glaciers (abstract): Geological Society of America Abstracts with Programs, v. 27, no. 6, p. A-168 (only).

Sanders, J. E.; and Merguerian, Charles, 1996, Trip 39: Glacial geology of Long Island, 01-02 June 1996 (revision of Trip 15, 17-18 November 1990): New York Academy of Sciences Section of Geological Sciences Trips on the Rocks Guidebook, 129 p.

Sanders, J. E.; and Merguerian, Charles, 1997a, Geologic setting of a cruise from the mouth of the East River to the George Washington bridge, New York Harbor: New York, NY, American Rock Mechanics Association, NYRocks 97, hosted by Columbia University Field-Trip Guidebook, 147 p.

Sanders, J. E.; and Merguerian, Charles, 1998, Classification of Pleistocene deposits, New York City and vicinity--Fuller (1914) revised and revised (extended abstract), p. 130-143 in Hanson, G. N., *chm.*, Geology of Long Island and metropolitan New York, 19 April 1997, Stony Brook, NY: Long Island Geologists Abstracts, 161 p.

Sirkin, L. A., Cadwell, D. H., and Connally, C. G., 1989, Pleistocene geology of the eastern, lower Hudson Valley, New York, p. 231-240 in Weiss, Dennis, ed., New York State Geological Association Annual Meeting, 61st, 12-15 October 1989, Middletown, NY, Field Trip (*sic*) Guidebook, 302 p.