As You Were: Finding the Island and the People in Governors Island

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Abstract

The formation of Governors Island and its archaeological contexts are reconstructed on the basis of stratigraphic, sedimentological, and geochemical studies. The island has a core of bedrock and glacial till. Particle size analyses of the capping sandy sediments identify glaciofluvial, fluviomarine, and shoreface depositional energies as well as some contribution of fines from human activity. Sediments from archaeological contexts are characterized by elevated levels of organic matter and phosphorus. Phosphate fractionation and the abundance of Ca, Mg, K, Pb, and Zn further help to identify residues from specific human activities in late prehistoric through 19th century contexts. Effects of postdepositional mixing and chemical alteration are more pronounced in the samples from Nolan Park than in those from north and south of Fort Jay.

Introduction

Governors Island sits in New York Bay between Manhattan and Brooklyn (see Figure 1). It is a place that has been busy with human activity for at least three hundred years, and it was settled sparsely by Native Americans for much of the Holocene epoch. In studying the formation of the island and its archaeological contexts, we found that geological and archaeological research problems were inseparably intertwined. Scientific methods from both geology and archaeology were therefore applied in a synthetic manner in order to understand deposits produced by processes that fall on a continuum between "natural" and "cultural" end-members (Butzer, 1982; Schiffer, 1987; Stein, 2001).

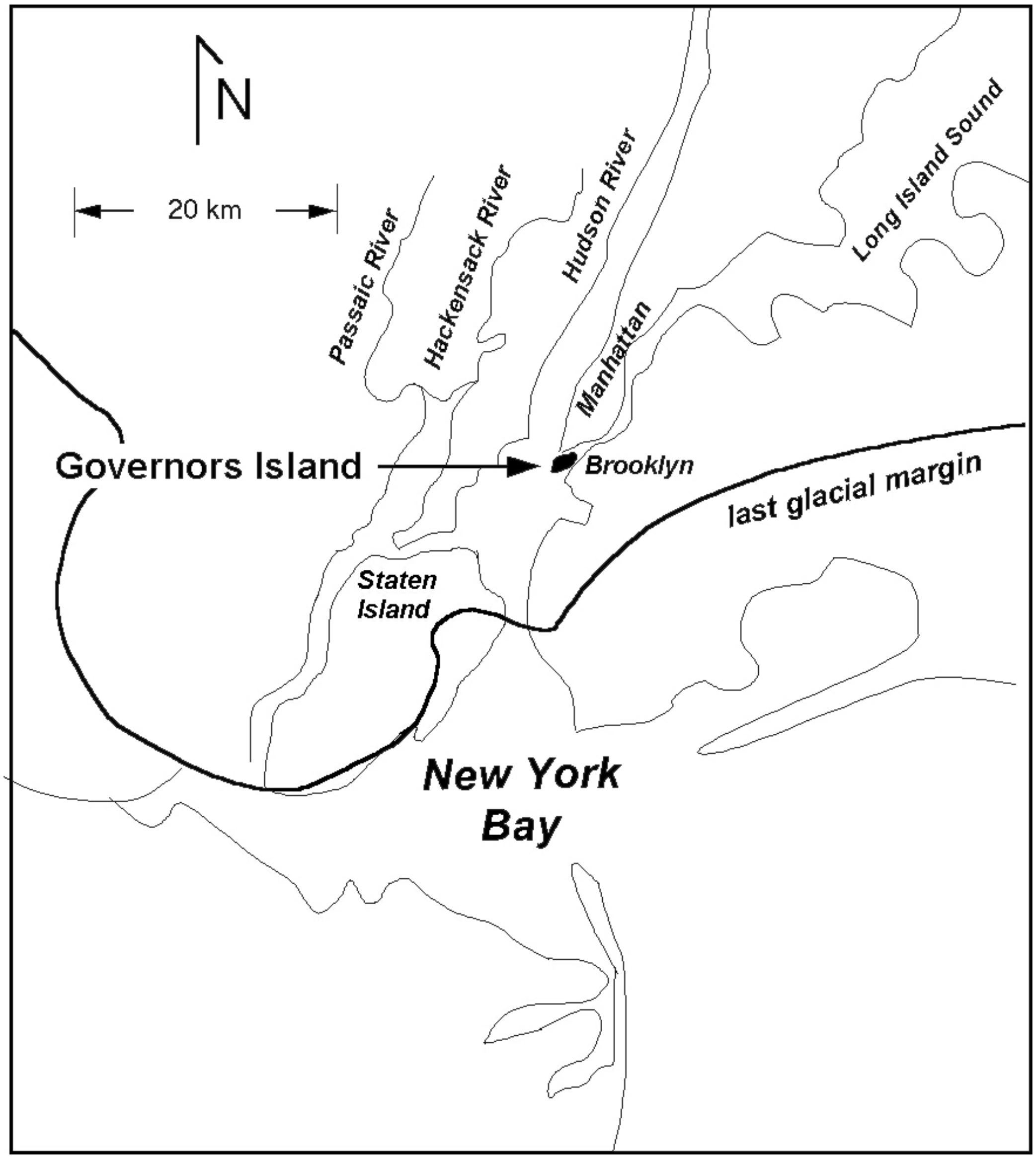

Figure 1: Location of Governors Island in New York Bay

Geoarchaeological field investigations involved mechanical excavation of sixteen small (1 x 5 m) stratigraphic trenches. The trenches identified paleoshorelines at the southeast and northwest edges of the island. Most of the trenches exposed Holocene sediments that date prior to the first Euroamerican presence on the island. One organic-rich deposit, in particular, is here interpreted to be the upper horizon of a buried soil (buried "A" horizon).

Beneath the deposits that contain either historic or prehistoric artifacts, there are up to two meters of quartzose sands which only rarely exhibit traces of soil development. Particle size analyses indicate that many of these basal sands were repeatedly reworked by waves along the paleoshorelines. Local relative sea-level fluctuations (Fairbridge and Newman, 1968; Newman et al., 1969) may have prolonged the reworking and inhibited soil development. In addition to shoreface deposition, glaciofluvial and fluviomarine depositional energies have been identified using particle size.

The fine sediments in the deposits in some cases point to different histories of physical transport. In other cases, however, the fines result from human activity on the island. As detailed below, the abundance of organic matter, phosphorus, and other chemical characteristics corroborate the particle size results in identifying the anthropogenic sediments. In a few cases, it is even possible to infer the type and time period of human activities that produced the sediments.

Study Area and Regional Stratigraphic Framework

Governors Island is less than a kilometer south of the southern tip of Manhattan in New York Bay (see Figure 1). The island presently totals over 70 ha, of which at most 38 ha existed prior to the addition of artificial fill to the southwest end of the original island between 1902 and 1911 (Garman and Herbster, 1996). The fill is material that was removed from Manhattan during the construction of the Lexington Avenue subway.

The most detailed previous description of the bedrock and glacial deposits in this portion of New York Bay comes from studies performed for the Brooklyn-Battery Tunnel (Sanborn, 1950; Schuberth, 1968). Manhattan schist is shown beneath less than 15 m of unconsolidated sediment on both of the cross-sections prepared from the borings (see Figure 2). Although

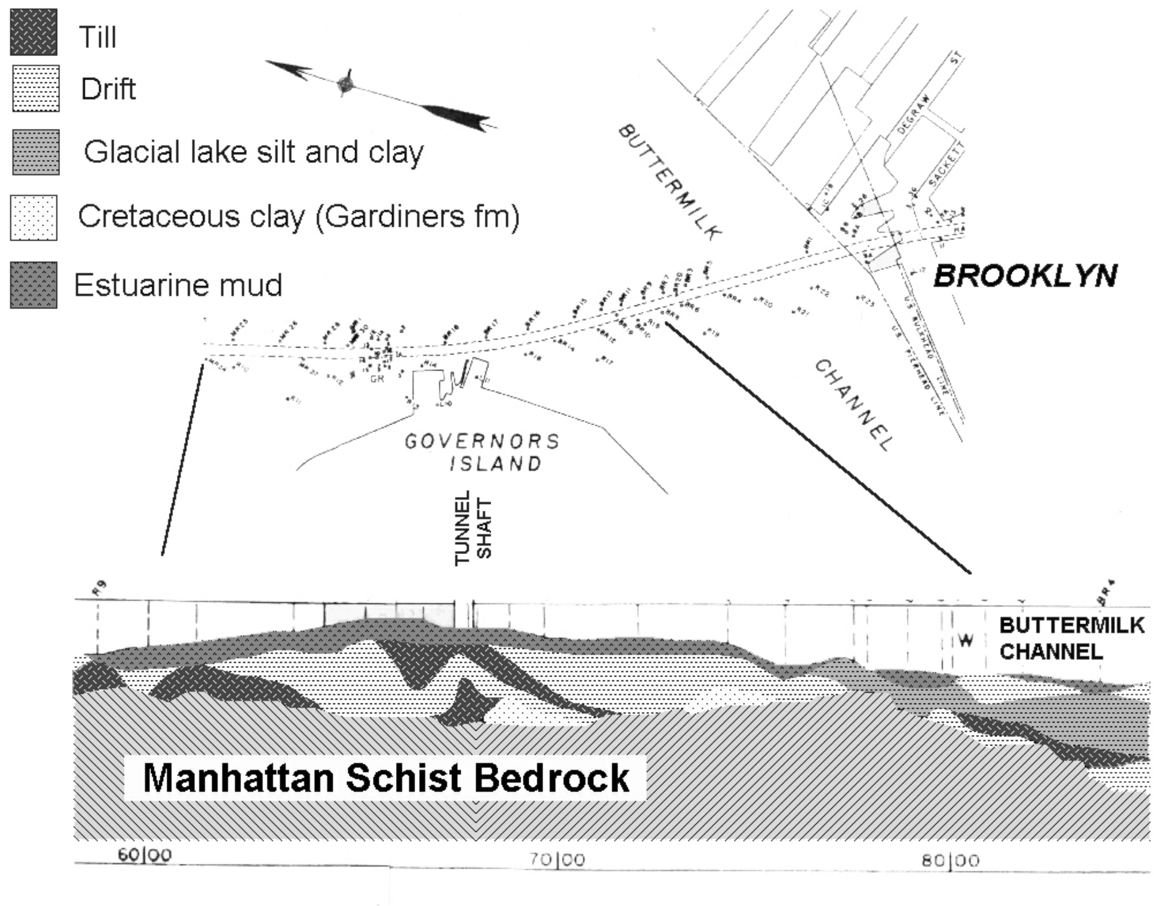

Figure 2: Cross-section of New York Bay prepared from borings for the Brooklyn-Battery Tunnel (Sanborn, 1950)

Governors Island cannot be called a bedrock island, mica schist does outcrop very near the surface. The schist bedrock was encountered at a depth of two meters below the land surface (2 m bls) in two of the trenches excavated for the present study.

The surficial deposits were mapped with a unit that includes "lake, ice contact, and outwash deposits" by Fullerton et al. (1992), while Cadwell (1989) mapped them as "till." At least two beds of till ("unstratified sand, clay, gravel, and boulders") are shown in the tunnel cross-sections, primarily in areas north of the ventilator shaft. The tills are from three to five meters thick, and at least one till was identified in two of the trenches excavated on the island itself in the present study. The till contains clasts of granite, diabase, gneiss, and other erratics in a matrix of yellowish brown sand and clay.

In both of the tunnel cross-sections, the tills alternate with "drift" (stratified sand and gravel). Stratified silt and clay, probably lacustrine in origin, are shown primarily on the south side of the island, extending beneath the Buttermilk Channel. Two borings performed for the U. S. Army Corps of Engineers prior to dredging of the Buttermilk Channel (GRA, 1999) also identified varved lacustrine sediment as well as glacial till with interbeds of organic mud. A radiocarbon date of 26,000±300 B.P. was obtained on bulk sediment from 4.6 m below the channel floor in one of the borings. The material dated was overlain by coarse, poorly sorted sand interbedded with brown clayey silt. This is probably a "flow till" (Hartshorn, 1958) of late Wisconsinan age. Varved lacustrine sediments were found at approximately the same depth in the other boring, suggesting that the ice was melting directly into the lake at this location. Gray-*green*, sandy "summer" varves alternate with reddish brown "winter" muds in the lacustrine sediment.

No varved sediments were identified in the trenches on the island itself. Sand interbedded with the glacial till does have the same reddish brown color found in the proglacial lake muds. The color comes from the Newark group sandstones and mudstones of the present Hackensack and Passaic drainages in northern New Jersey (Schuberth, 1968; Stanford and Harper, 1991). The sediments between the top of the till and the present land surface on Governors Island are mostly sand, coarser in texture than the estuarine mud at the top of borings in New York Bay (GRA, 1999; Sanborn, 1950; Weiss, 1974). This stratigraphic envelope of what appears to be relatively homogeneous "cover sand" with weakly developed soil profiles contains all of the archaeological contexts that have been identified on Governors Island.

Stratigraphy and Archaeology of the Original Island

Five areas that are known to have been part of the original island were investigated with stratigraphic trenches during archaeological survey ("Phase IB") and testing ("Phase II") by the Public Archaeology Laboratory (Herbster et al., 1997). The distribution of trenches within the five areas is summarized in Table 1, and the trench locations are plotted in Figure 3. In addition to the stratigraphic trenches excavated using heavy equipment, several smaller units which the archaeologists excavated with hand tools during the Phase II study were described and sampled as part of the geoarchaeological study.

Table 1: Distribution of Stratigraphic Trenches within Survey Areas on Governors Island in New York Bay

Symbol	Name	Stratigraphic Trenches
(B)	Fort Jay	MT-4, MT-12A, MT-12B
(G)	South Battery	MT-1
(H)	Nolan Park	MT-5, MT-19
(I)	Golf Course	MT-1, MT-6, MT-13, MT-14, MT-16, MT-17
(J-1)	Colonel's Row	MT-3, MT-8, MT-9
(J-2)	Hay Road	MT-7

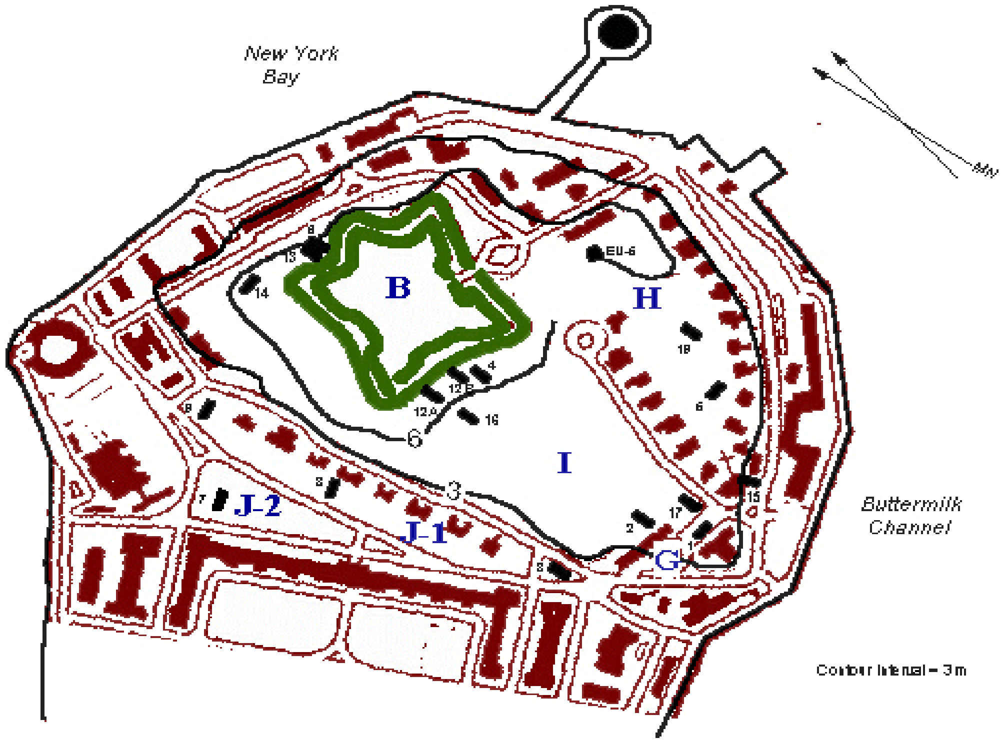

Figure 3: Map of the original portion of Governors Island showing the locations of stratigraphic trenches

By linking the profiles for trenches MT-1, MT-16, MT-12B, and MT-13(6), we have prepared a cross-section running from south to north across the original portion of Governors Island (Figure 4). A cross-section running from west to east has been prepared by linking the profiles for trenches MT-7, MT-9, MT-14, MT-5, and one of the archaeological excavation units (EU-5) in Nolan Park (Figure 5).

The schist bedrock was reached by coring with a hand auger through angular regolith at the base of trench MT-1 and through stratified glacial deposits at the base of trench MT-3. Safety precautions precluded the excavation of vertical exposures of more than 1.5 m deep in the small trenches used in this study. The occurrence of Manhattan schist at relatively shallow depths

(2-3 m bls) in the southern portion of the original island is consistent with the cross-sections for the Brooklyn-Battery Tunnel (Figure 2). The bedrock is folded up to the south in this part of New York Bay, and this resulted in the emergence of relatively resistant rock as sea level fell during the last glaciation. The bedrock core acted as a "snag" for glacial debris and other sandy detritus, building the island to the north (up ice).

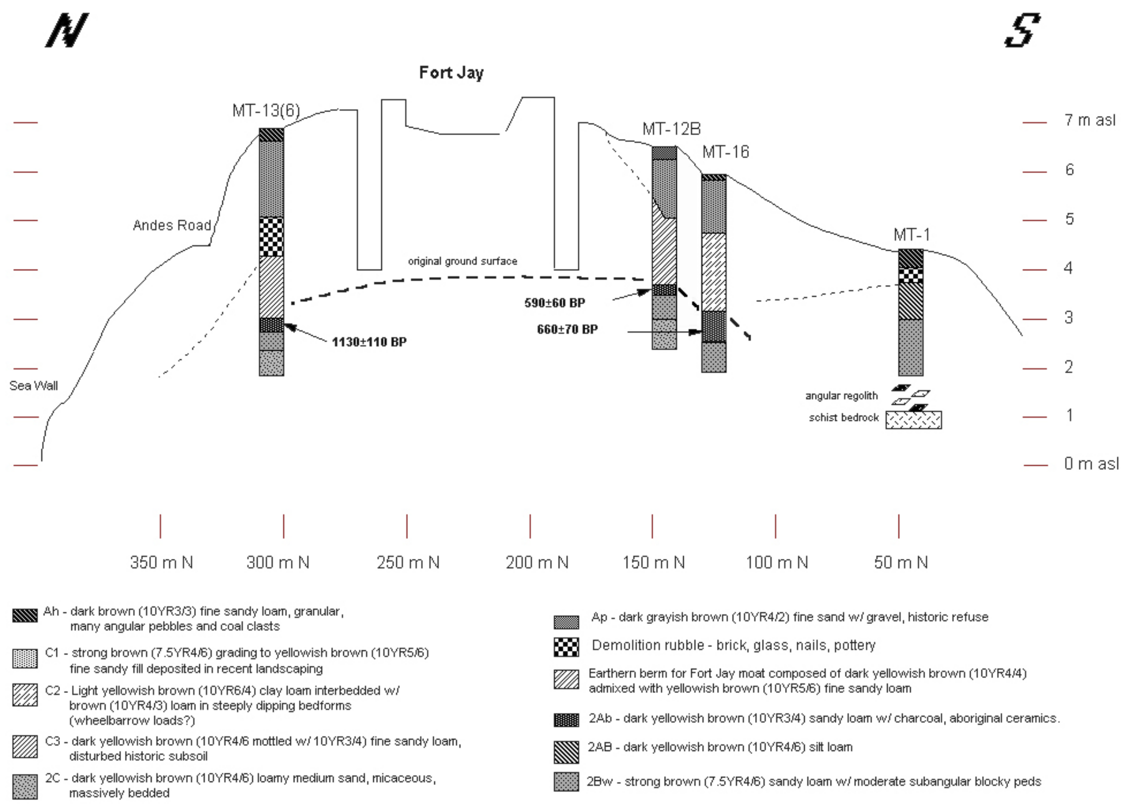

Figure 4: Cross-section running north-south across the original portion of Governors Island

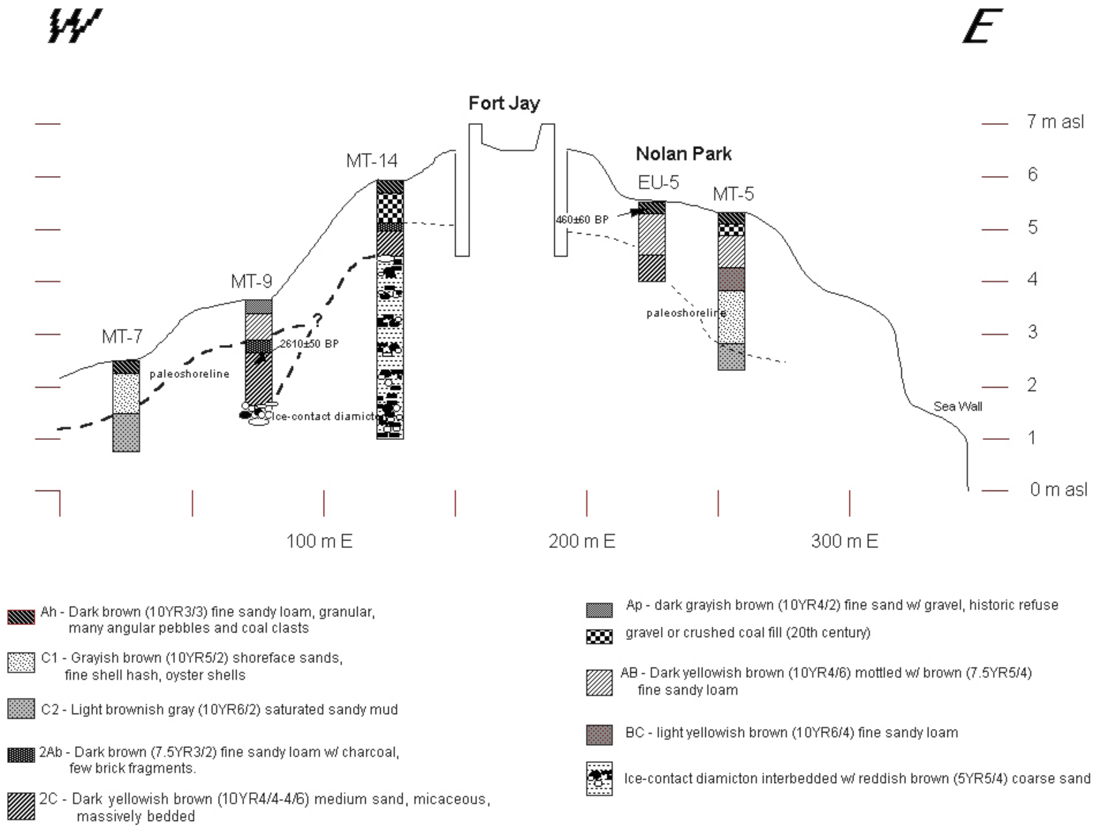

Figure 5: Cross-section running east-west across the original portion of Governors Island

The glacial till is thickest just west of Fort Jay (see Figure 5). Till was reached within the upper 1.5 m of excavation in trenches MT-14 and MT-9. Till probably also occurs beneath the sediments observed in the upper 1.5 m of the other trench locations on the Golf Course and in Colonel's Row. The till deposit could be either be an isolated drumlin feature or part of a more extensive recessional moraine that extends beneath New York Bay.

The western side of Fort Jay was evidently constructed so as to take advantage of the natural relief created by the thick glacial till deposit. In Trench MT-14, several sets of bouldery diamicton interbedded with reddish brown (5YR5/4) coarse sand were observed in an excavation that reached a total depth of over 5 m bls. The elevation at the top of the till slopes steeply westward at approximately the same grade as the land surface. In the MT-9 profile, a relatively well-developed buried soil was formed in sandy outwash that capped the till. A radiocarbon date of 2610±50 B.P. was obtained for a sediment sample collected from the buried soil at 80-90 cm bls (~3 m MSL) in trench MT-9 (see Table 2).

Table 2: Radiocarbon Dates obtained for samples collected during the archaeological investigations on Governors Island

Survey Area		Trench	Horizon	^{14}C yr B.P.	Cal Intercept	Lab No.
B	Fort Jay	MT-12A	2Ab	590±60	A.D. 1400	Beta-117732
H	Nolan Park	STP	A	460±60	A.D. 1570-1630	Beta-117725
I	Golf Course	MT-16	II	660±70	A.D. 1295-1400	Beta-117733
I	Golf Course	MT-6	2Ab	1130±110	A.D. 785-1015	Beta-107658
J	Colonel's Row	MT-9	2BC	2610±50	B.C. 800	Beta-107659

The shoreface sediments deposited along the northwest paleoshoreline are all stratigraphically younger than the buried soil observed in trench MT-9. In trench MT-7, the uppermost stratum of intact natural sediment (40-60 cm bls) consisted of well-sorted quartzose sand and fine shell hash. The shell hash was typically associated with reactivation surfaces where wave-rippled sands had been truncated by erosion. Less intense shoreface conditions were responsible for the beds which contain whole shells of the eastern oyster (*Crassostrea virginica*). Laminar beds containing whole shells were found at 60 and 80 cm bls. A reactivation surface at 100 cm bls was marked by a lag of fine shell hash. A hand auger boring in the trench floor showed that laminated sand and sandy mud occur at least 220 cm bls (~ 1 m MSL) at the MT-7 location.

The sandy mud facies represents estuarine deposition which preceded the sea level rise associated with the paleoshoreline.

The trenches in the berm around Fort Jay and on the Golf Course typically did not reach intact natural sediments of the original island within the upper meter. Human activities subsequent to the purchase of the island by the Dutch in 1637 have formed a complex sequence of deposits here. The cultural end-member of deposition on the island includes construction fill, demolition rubble, and refuse middens. Radiocarbon dates can only identify these deposits as "modern," so young that their radiocarbon abundance is within the range of the peaks produced by fossil fuel combustion (Aitken, 1990, p. 66-72; Suess, 1955). Ceramics, glass, and other artifacts recovered by the archaeologists provide more definitive age constraints, and time-sensitive artifacts are particularly abundant in the deposits beneath the Fort Jay berm and in Nolan Park. In addition to the archaeological data, maps and other documents record the construction of Fort Jay (1806-1809), Castle Williams (1807-1811), and other historic structures on the island (NPS, 2003).

Traces of Native American cultural activity on Governors Island are more sparse, and the prehistoric ceramic and lithic artifacts recovered by the Public Archaeology Laboratory were all from contexts that lack stratigraphic integrity (Herbster et al., 1997). There is potential for better preservation of prehistoric contexts in deposits that underlie the historic fill and refuse on both the north and the south sides of Fort Jay. Radiocarbon dates of 1130±110 B.P., 660±70 B.P., and 590±60 B.P. were obtained on scattered wood charcoal from a buried soil ("2Ab" horizon) that was intruded by the fort construction in between the trench profiles (see Table 2). Particle size and geochemistry of the sediments from this buried land surface are consistent with seasonal settlement by Native Americans during the Middle Woodland and Late Woodland periods of regional prehistory.

Particle Size Analysis and Sedimentology

Particle size analysis provides key data for reconstructing environments of deposition for archaeological sediments as well as for water-borne or windborne particles (Leigh, 2001; Stein, 2001). In the present study, the percent sand, silt, and clay were determined by hydrometer (Buoyocos, 1962) for a total of 29 sediment samples from both archaeological contexts and the intact deposits of the original portion of Governors Island. Sand-sized particles make up the bulk of all of the samples studied, but the sediment from archaeological contexts is much finer textured than that from the basal cover sand. The contrast can be clearly seen in a ternary plot comparing samples from middens and pit features in trenches MT-12A, MT-12B, MT-13, MT-16, and two of the archaeological excavation units (EU-5 and EU-7) with samples of basal sand from trenches MT-2, MT-5, MT-7, MT-8, MT-12B, MT-13, and MT-16 (Figure 6). The basal ("C" horizon) sand samples are over 90% sand, whereas the archaeological samples all have either sandy loam or loam texture (Birkeland, 1999; Soil Survey Staff, 1993, 1997).

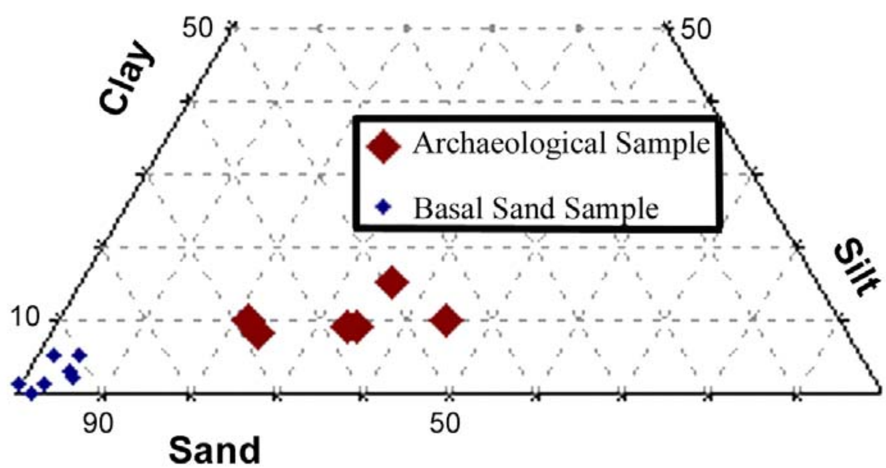

Figure 6: Ternary plot comparing sediments from archaeological contexts with basal sands on Governors Island

The amount of silt and clay in the archaeological deposits is probably within the range that would be found in a natural topsoil formed under deciduous forest on the island. Soil series recently mapped on Staten Island, for example, have loam or sandy loam textures in the A and B horizons (Hernandez and Galbraith, 1997). The abundance of artifacts and evidence for land modification in all of the deposits investigated on the original island prevented a controlled comparison with natural topsoil. In addition to the artifacts found and the stratigraphic relationships that suggest land modification, some of the physical and chemical attributes of the archaeological deposits are diagnostic for that type of deposit. Much of what altered the parent material to make the sediments from the archaeological contexts thus appears to have been the result of the changing cultural environment on the island.

Fourteen of the 29 samples in the particle size study were from the basal "cover sand" deposits on Governors Island. The basal sands contain mica and other weatherable minerals, in addition to quartz. Mica is particularly abundant in the glacial deposits and in deposits that appear to have been subjected to fluvial transport. Fluvial transport is indicated by the fact that some of the basal sands on the island contain slightly more silt and clay (Friedman, 1961, 1967).

The sand fraction (>0.05 mm) of the fourteen samples from the basal deposits was wet-sieved at one phi intervals (Day, 1965; Soil Survey Staff, 1984). Five were found to have the distinctive "fine tail" of muds characteristic of fluvial energy (Friedman, 1961, 1967). These are the five with over 20% in phi sizes greater than four ("> 4") on Figure 7 and represent basal sediments from trenches MT-3, MT-12A, MT-12B, and MT-13 as well as the 2BC horizon in MT-12A.

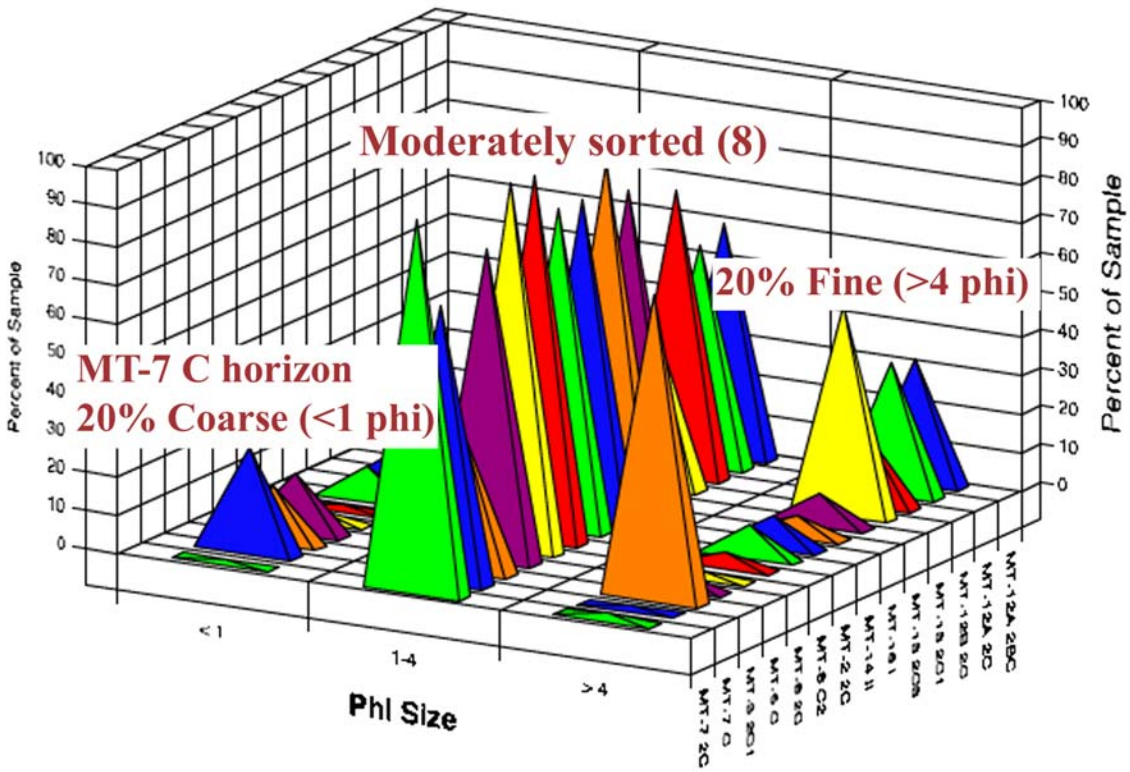

Figure 7: Particle size distributions for fourteen samples of basal sand from Governors Island

The distribution of particles by phi size for basal sands from Governors Island points to a number of specific depositional environments, not all of which were immediately evident from the stratigraphy. Figure 8 plots skewness versus sorting for the fourteen samples. The sorting index used is a simplified form of the standard deviation (Friedman and Sanders, 1978, p. 75). Better sorted samples have lower values and plot to the left. The samples with a fluvial "fine tail" are very poorly sorted and positively skewed, plotting in the upper right and inferred to be from a glaciofluvial environment.

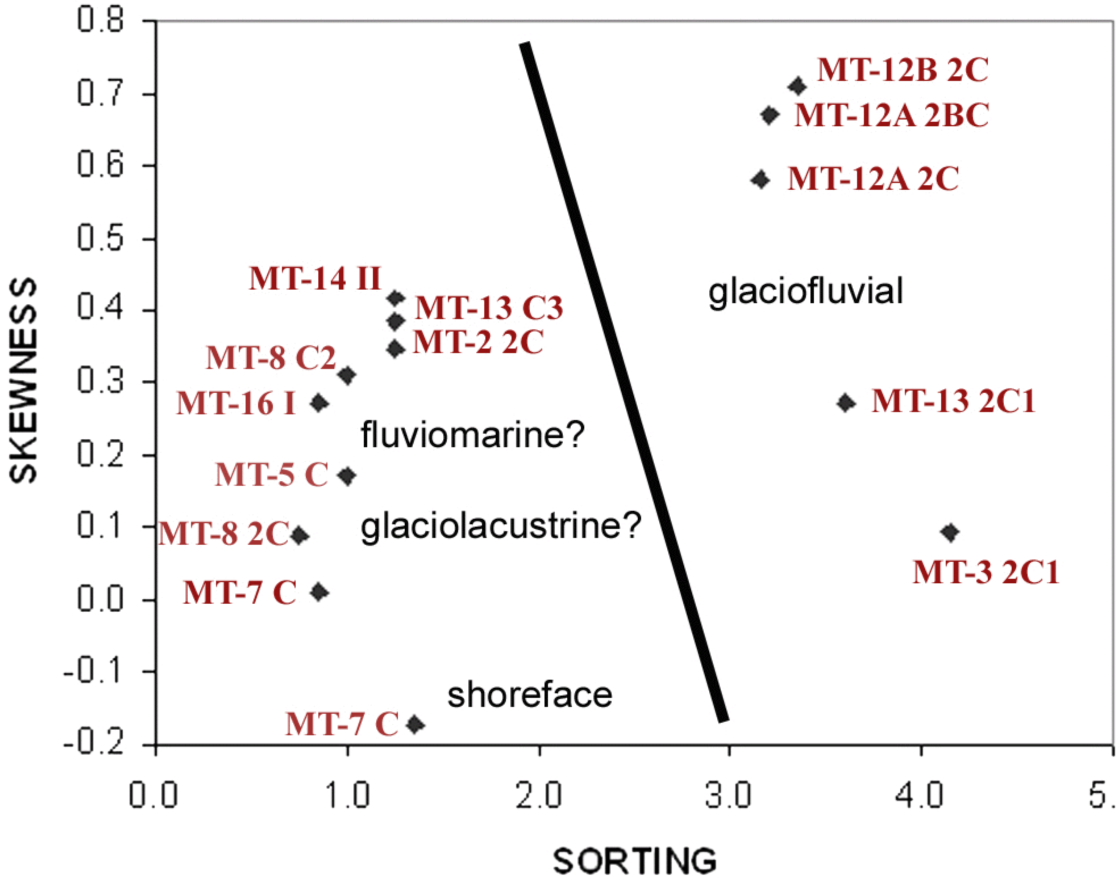

Figure 8: Plot of skewness versus sorting for basal sand samples

All but one of the glaciofluvial samples are from the trenches north and south of Fort Jay, flanking the large till deposit. They underlie contexts from which late Holocene radiocarbon dates were obtained. We believe that the channel was either contemporaneous with the till or slightly younger. Another outwash deposit occurred near the base of trench MT-3, 200 m south of Fort Jay in an area that was later submerged by late Holocene sea level rise. The MT-3 sample is extremely poorly sorted, with five percent gravel as well as abundant silt and clay (25%).

The remaining nine samples are moderately sorted, and these are the samples with the high peaks from 1-4 phi in Figure 7. Winnowing of fines by wave action could have occurred either on a bay shore similar to the present (fluviomarine) or on the shore of a glacial lake during the late Pleistocene (glaciolacustrine). The samples from MT-13 and MT-14 are deep in the stratigraphy and probably late Pleistocene. The samples from MT-5, MT-7, and MT-8 are from Holocene paleoshorelines. Two samples were actually sieved from MT-7, one of which is negatively skewed as is typical of an ocean beach in a shoreface depositional environment. Glaciofluvial, fluviomarine, shoreface, and possibly glaciolacustrine depositional energies are thus indicated by particle size distributions in samples of basal sand from Governors Island. The samples from archaeological contexts have more silt and clay than occur in the basal sands, and this is because they contain fines that were contributed by human activity.

Geochemistry of the Archaeological Contexts

Chemical analysis of sediment samples has been used in previous studies to identify archaeological sites, to evaluate their stratigraphic integrity, and even to distinguish residues from particular types of human activity (Barba et al., 1996; Entwistle et al., 1998; Foss et al., 1994a, 1994b; Kolb et al., 1990; Middleton and Price, 1996; Schuldenrein, 1995). A "nested" approach was used in the present study. Preliminary identification of samples that contain fine-textured anthropogenic residues was based on the particle size results and measurements of soil pH and percent organic matter for 21 of the 29 samples in the study. The pH was measured on a slurry prepared with a solution of 0.01 N $CaCl_2$ (McClean, 1982; Schulte et al., 1987). Organic matter content was measured by loss-on-ignition (Dean, 1974; Stein, 1984).

Available phosphorus and exchangeable Ca, Mg, and K were measured for sixteen samples from contexts whose formation could be reconstructed independently on the basis of stratigraphy and included artifacts. The extraction was done with 1 M ammonium acetate followed by atomic absorption spectrophotometry (Schulte et al., 1987). Although the procedure is designed to estimate the availability of nutrients for crop plants, it has also been used to identify anthropogenic residues in previous studies (Kolb et al., 1990; Schuldenrein, 1995).

The abundance of Pb and Zn was measured for ten of the samples to evaluate the utility of these two elements in distinguishing residues from specific activities. Atomic absorption spectrophotometry was used once again, but the extraction was done with DTPA (diethylenetriaminepentaacetic acid). Finally, total phosphate and the relative contribution by the three phosphate fractions defined by Eidt (1977, 1985) were measured for five samples from specific archaeological contexts around the perimeter of Fort Jay and in Nolan Park.

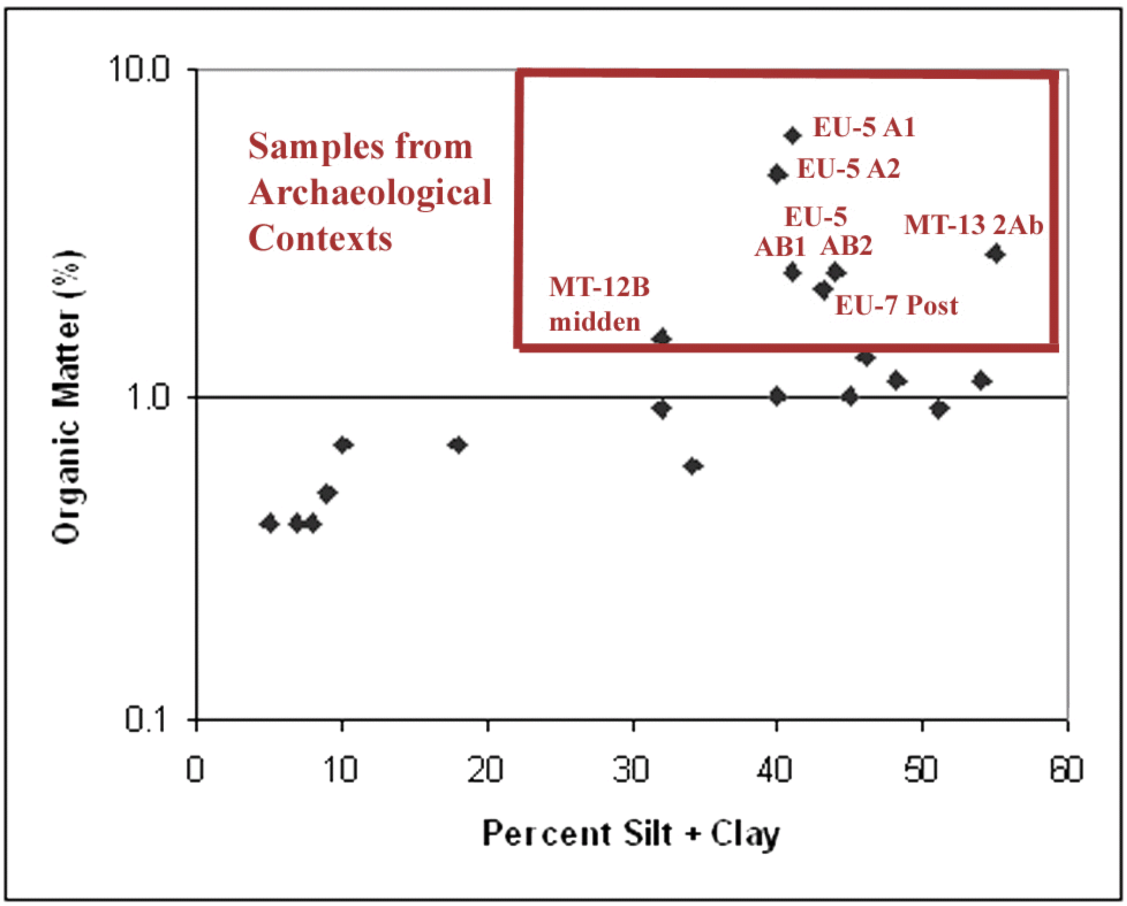

Figure 9: Plot of percent organic matter versus percent silt and clay for 21 sediment samples from Governors Island

The contexts containing fine-textured anthropogenic residues all plot in the upper right of Figure 9. Silt- and clay-sized particles make up at least 30% of each sample from these contexts, and the samples are all at least one percent organic matter. The contexts are in three locations. There is a buried soil ("2Ab" horizon) which underlies deep fill deposits on the north side of Fort Jay at trench MT-13(6). Prehistoric lithics, marine shell, and historic glass and ceramics were collected from the trench profile, although the buried soil has not yet been sampled by an archaeological excavation. On the south side of Fort Jay (Area B), there is a historic midden which is also deeply buried beneath the berm and in turn rests upon a buried soil that represents the intact late prehistoric land surface. Prehistoric ceramics as well as historic ceramics, glass, buttons, and even a gunflint were recovered from the archaeological test excavations within the three trenches located here (MT-4, MT-12A, and MT-12B). The trench MT-16 location is on the Golf Course (Area I), approximately ten meters south of the Fort Jay berm trenches and beyond the limits of the midden. The samples from MT-16 can therefore serve as controls against which to compare the samples containing anthropogenic residues.

The third location where fine-textured anthropogenic residues appear to occur in association with both prehistoric and historic artifacts is Nolan Park (Area H). Prehistoric ceramic sherds and chipping debris from stone tool manufacture were found at the location sampled by archaeological excavation unit 5 (EU-5). Unfortunately, the excavation of EU-5 did not yield cultural pit features or artifact concentrations that indicate a prehistoric living surface. The geochemical results for the column of six sediment samples collected from the north wall of EU-5 therefore provide key information about the contexts in which prehistoric artifacts occur in Nolan Park. The sediment texture, percent organic matter, and phosphate fraction amounts were also measured for a sample from a historic feature at the base of another archaeological excavation unit in Nolan Park, EU-7. The results tend to confirm the contribution of anthropogenic residues to this sample, as can be seen from Figure 9.

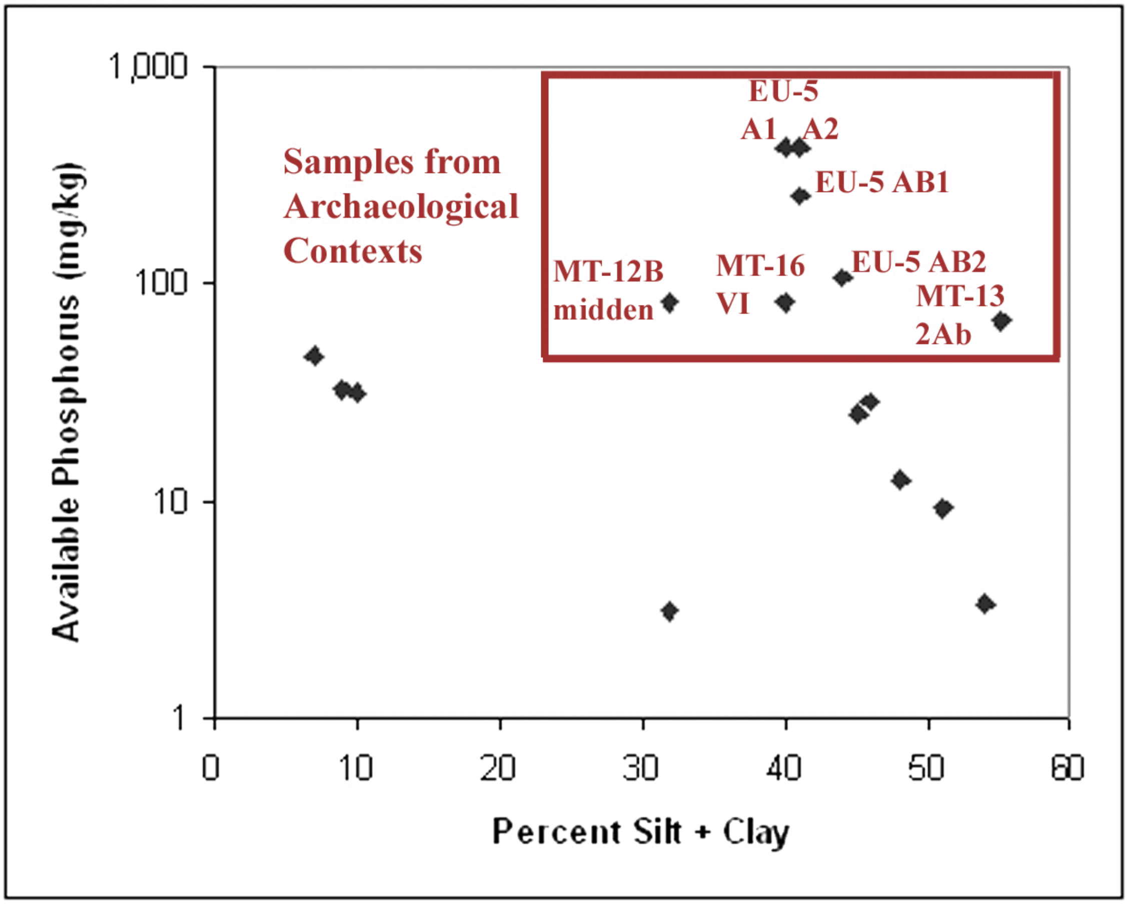

Figure 10: Plot of available phosphorous (mg/kg) versus percent silt and clay for 16 sediment samples from archaeological contexts on Governors Island

Very large amounts of available phosphorus (>200 mg/kg) in the upper three samples from EU-5 suggest that phosphate was added in recent decades to fertilize the grass in Nolan Park. The samples from the historic midden and the buried soil north and south of Fort Jay have from 50 to 100 mg/kg available phosphorus (see Figure 10). These values fall within the range for topsoil formed under forest vegetation in the eastern United States (Kleinman et al., 2002; Scott et al., 2001). Residual phosphate is thus preserved within the fine fraction of the deeply buried prehistoric and early historic sediments on Governors Island.

The total phosphate was between 250 and 500 mg/kg for the five phosphate fractionation samples (Figure 11), a range that is characteristic of residues from dwelling, gardening, manufacturing, and refuse disposal activities (Eidt, 1977; Schuldenrein, 1995). Fraction I, consisting of loosely bound iron and aluminum phosphates, accounts for over half of the total in the samples from trench MT-13, from the AB2 horizon in Nolan Park EU-5, and from the historic post feature in Nolan Park EU-7. The samples from the historic midden and the buried soil in trench MT-12B have much higher loadings on Fraction III (calcium-bound phosphates) but lower loadings on Fraction II (occluded iron and aluminum phosphates). There are two likely sources for calcium-bound phosphates in these contexts, lime mortar in the case of the historic midden and bone or marine shell in the case of both the midden and the buried soil.

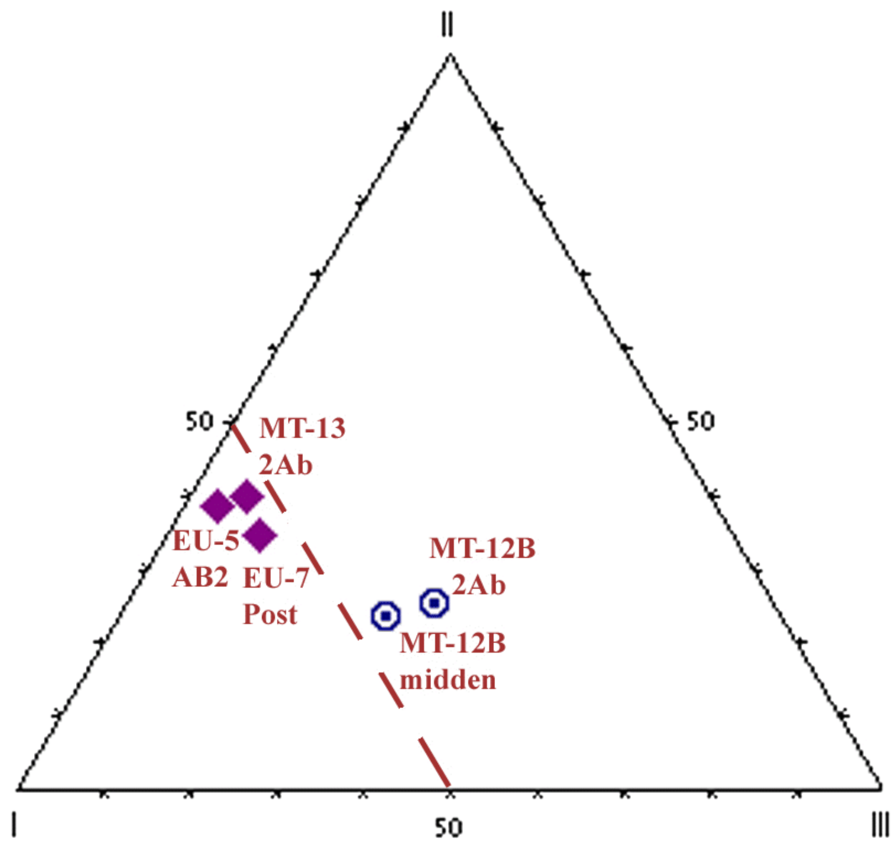

Figure 11: Ternary plot of phosphate fractionation results for five samples from archaeological contexts on Governors Island

In addition to organic matter and phosphate, calcium, lead, and zinc occur in the Fort Jay historic midden in greater amounts than in the underlying buried soil (2Ab) or its parent material (2C1). Because the midden sediment is actually slightly more acid, with a pH of 4.9 compared to 5.3 for the 2C1 horizon (see Figure 12), it is unlikely that these elements were precipitated after deposition. Previous studies have found calcium and zinc to be abundant in refuse that contains human excreta, fish bones, and shell (Kolb et al., 1990; Middleton and Price, 1996; Schuldenrein, 1995; Scudder et al., 1995). Lead levels greater than 50 mg/kg are common in residues from societies that practice metallurgy (Foss et al., 1994a, 1994b; Macklin et al., 1992). Lead therefore seems to be particularly suited to distinguishing residues from historic as opposed to prehistoric cultural activity in North America. In addition, lead may be particularly abundant in residues from military garrison areas where lead shot was stored and weapons were cleaned.

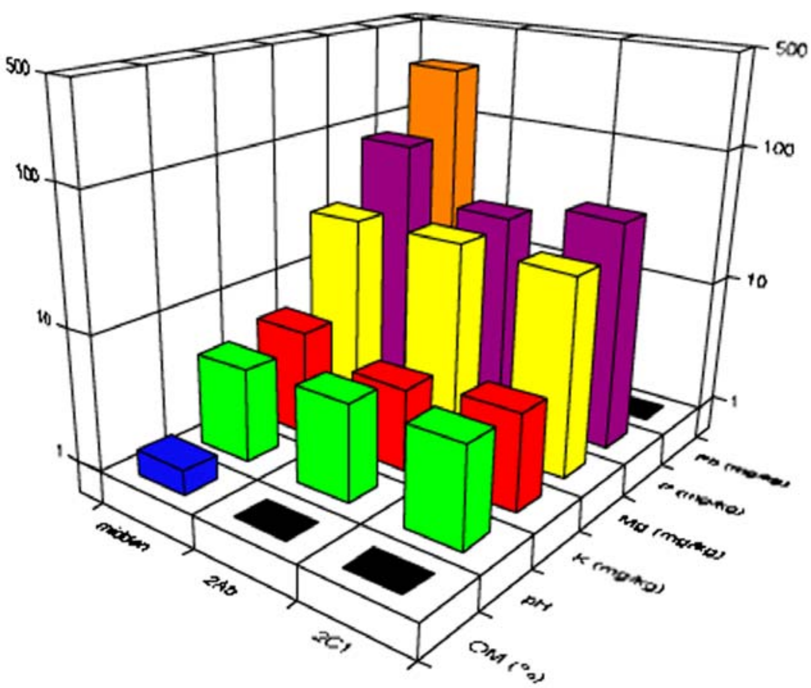

Figure 12: Geochemistry of three samples from trench MT-12B on the Fort Jay berm

The chemical profile for the three samples from beneath the Fort Jay berm (Figure 12) indicates discrete, relatively rapid episodes of deposition which produced contexts containing sediments with very different physical and chemical properties. This situation contrasts dramatically with that in Nolan Park, where deposition was so gradual that soil development kept up the same pace, mixing the sediment to produce gradual transitions in physical and chemical properties between horizons (Figure 13). The Pb values fall off smoothly down profile in EU-5 from over 350 mg/kg in the A1 horizon. There is still 14 mg/kg in the BC2 horizon at 65 cm below surface, an amount which is over twice that in any of the other samples from prehistoric contexts or culturally sterile deposits on the island. The available P falls off smoothly like the Pb while Ca, Mg, and K increase from the AB2 to the BC2 horizon. Lead has moved down profile at least 50 cm since it was first deposited at the land surface. Base cations and probably fine particles have also been translocated within a "cumulative" profile (Birkeland, 1999; Ferring, 1992) which built upward by gradual deposition at the land surface in Nolan Park.

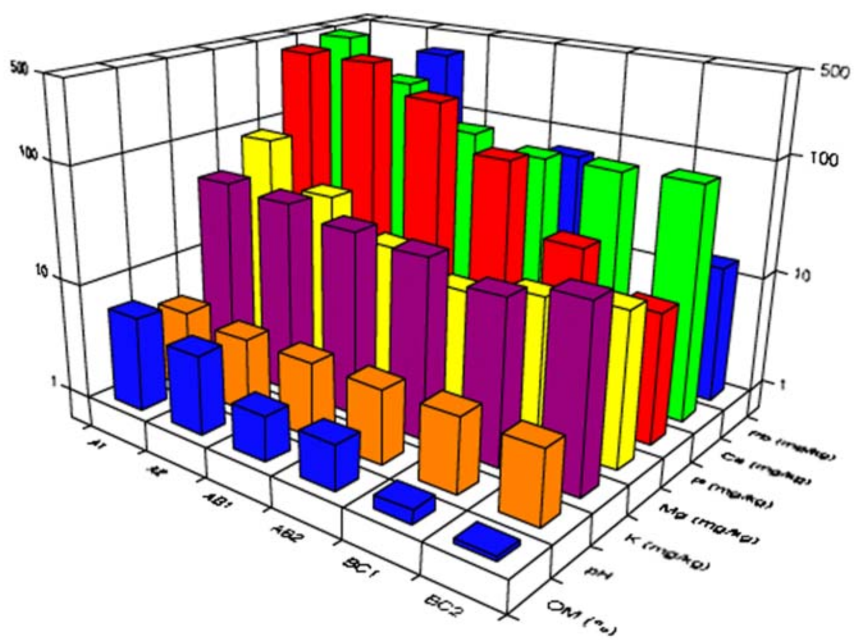

Figure 13: Geochemistry of the north wall profile in EU-5, Nolan Park

Discussion

The archaeological contexts in the original portion of Governors Island occur in late Quaternary "cover sand" deposits. Particle size results for fourteen samples from the basal sands identify glaciofluvial, fluviomarine, shoreface, and possibly glaciolacustrine depositional energies. Fine particles in samples from the archaeological contexts indicate the presence of anthropogenic residues, and the results of geochemical analyses identify some specific human activities that may be responsible for each type of residue.

Natural processes of deposition, mixing by pedoturbation, and geochemical weathering have affected the final form of all of the sediments studied, including those from the archaeological contexts. While simple crosscutting relationships define features of 19th and 20th century construction and landscaping on Governors Island, artifact-rich middens and dwelling areas have been mixed with topsoil material and buried up to four meters below the present land surface. These contexts are the most challenging to identify and interpret, because they were formed by both natural and cultural processes (Schiffer, 1987; Stein, 2001). Sedimentological and geochemical results presented above indicate significant differences between sediment that contains artifacts and sediment that is culturally sterile. These results should be useful to archaeologists who conduct excavations in the future on Governors Island and in other bayshore and harbor island settings along the Atlantic Coast of the United States.

The results obtained for the fourteen samples from the basal sands indicate that there was lateral variation in the initial texture and chemistry of sediments on the island. Some of the sands had a tail of fine particles, and this probably resulted from overbank flooding or tidal slackwater deposition as well as from the subsequent addition of anthropogenic residues. Because of their tendency to bind organic matter, phosphorus, and other nutrients, the sediments with more fine particles may have made locations such as Nolan Park more attractive for prehistoric and historic settlement. The location of Fort Jay appears to have been chosen to take advantage of a thick till deposit in the northwest corner of the island, and many of the coarser sandy deposits were used to construct the Fort Jay berm and other earthen architectural features on the island.

In the contexts where fine-textured residues were introduced by human activities, the sediment characteristics result from a combination of geogenic and anthropogenic processes. The geochemical results indicate that human excreta have incremented the percent organic matter, the available P, the loosely bound iron and aluminum phosphates, and possibly the trace amounts of Zn in sediments from archaeological contexts. Higher Zn values also appear to occur in sediments to which marine shell, animal bone, and other kitchen refuse were added, and these sediments also have abundant exchangeable Ca and calcium bound phosphates. Available P amounts in excess of 250 mg/kg probably result from artificial fertilizer added during the 20th century. Residual phosphate from earlier historic and possibly also prehistoric human activities can nonetheless be identified, particularly with the more discriminating phosphate fractionation developed by Eidt (1977, 1985).

Storing and firing lead shot as well as maintaining military weapons have increased the amount of Pb in 19th and 20th century deposits in the original portion of Governors Island. Because Pb is only abundant in residues from societies that practice metallurgy (Foss et al., 1994a, 1994b; Macklin et al., 1992), it seems to be particularly suited to distinguishing residues from historic as opposed to prehistoric cultural activity in North America. Values greater than 250 mg/kg, as found in two of the sediment samples in the present study. probably occur only in soils from specific cultural environments, such as the military garrison areas on Governors Island.

In sandy sediments of the Atlantic Coastal Plain, pedoturbation and chemical weathering are important natural processes which mix or alter archaeological contexts and their surrounding matrix (Leigh, 2001; Michie, 1990; Scudder et al., 1996). Beyond simply identifying the presence or absence of anthropogenic residues, it may be helpful to assess the stratigraphic integrity of archaeological contexts in such deposits using sedimentological and geochemical results. Profiles containing sediments with very different physical and chemical properties, such as that beneath the Fort Jay berm at trench MT-12B, indicate discrete, relatively rapid episodes of deposition. Profiles where deposition was so gradual that soil development kept up the same pace, such as that in Nolan Park EU-5, are considered to be "disturbed" and to lack stratigraphic integrity for archaeological purposes. Prehistoric and historic artifacts and residues need not be entirely mixed within such a profile, however. The Nolan Park contexts do preserve some traces of Middle Woodland and Late Woodland occupations in this portion of the original island.

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