GEOCHEMISTRY OF LOESS ON LONG ISALAND

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Loess is unconsolidated, wind deposited sediment composed mainly of silt-sized particles with diameters between 15-50 µm. Loess deposits are homogeneous and show little or no stratification. Loess deposits on Long Island range from a few centimeters to several meters in thickness. The provenance of Long Island loess in Caumsett State Park and on the Stony Brook University campus was previously studied by Zhong and Hanson (2002) using single mica grain $^{40}Ar/^{39}Ar$ ages. Almost all of her mica ages fell within the age range for micas from the bedrock in Connecticut and eastern New York. We have continued the provenance studies in a 2.7 meter loess deposit in a kettle in Wildwood State Park and also dated the time of deposition of the loess using OSL (Optically Stimulated Luminescence) and radiocarbon dating (Kundic et al, 2003). The OSL ages were 13,780 ±1,100 years for the bottom of the deposit, 13, 400±1,250 years for the middle and 7,730±690 years for just below the soil line. ^{14}C age of 9,792±55 (calendar age of 11,200 Ka BP) was measured on charcoal grains found below the 7,730±690 OSL age in the section.

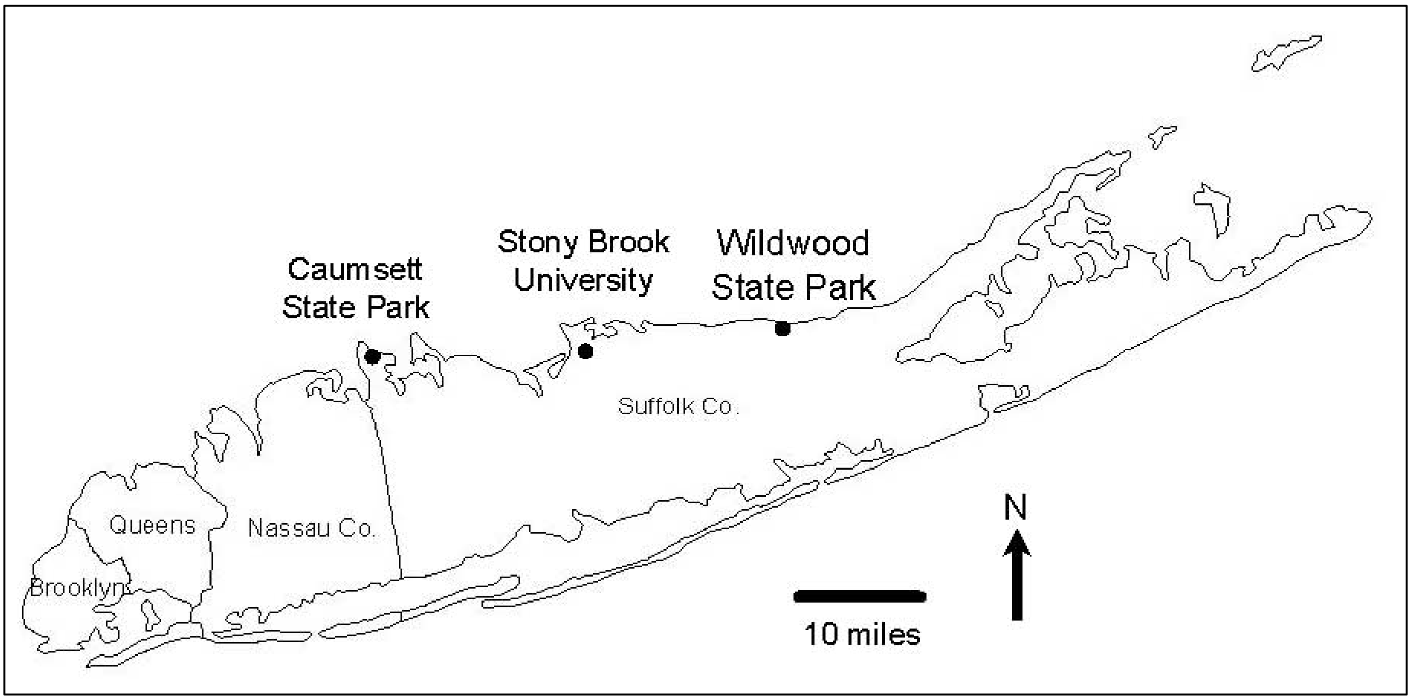

Fig. 1 Map of Long Island showing locations of loess studies

The provenance of loess from Wildwood State Park was also studied using single grain $^{40}Ar/^{39}Ar$ muscovite ages. Muscovite gives ages mainly between 200 and 400 Ma consistent with ages for mica in loess in other localities on Long Island Zhong and Hanson (2002) which confirms that the source of Long Island loess is glacial sediment derived from the basement rocks to the north in Connecticut and Massachusetts. The micas from Wildwood state park have a similar distribution to those from the Stony Brook University campus with a slightly greater proportion of 300-400 Ma ages.

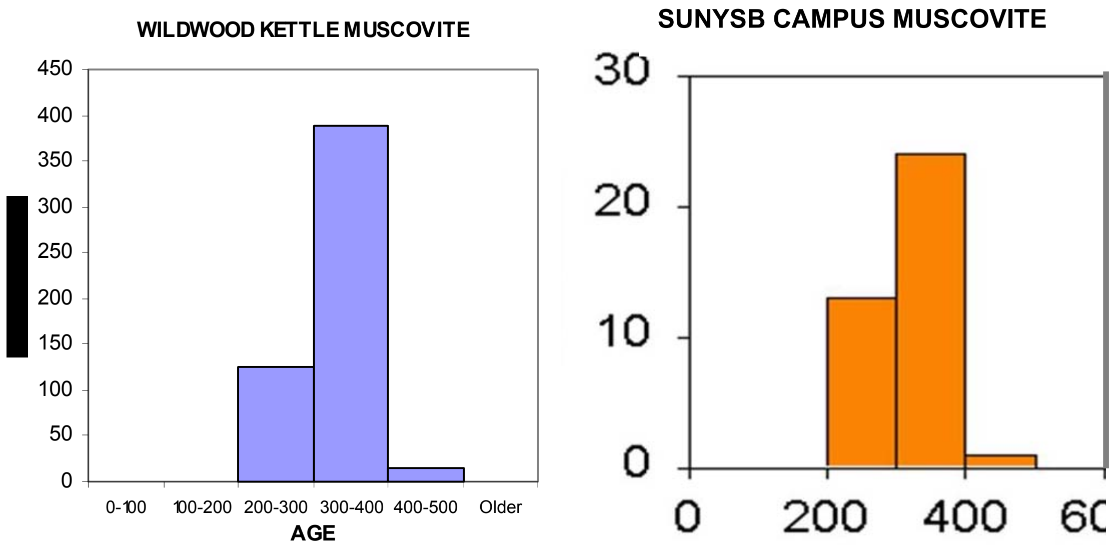

Fig.2. $^{40}Ar/^{39}Ar$ ages of Biotite from Wildwood State Park and SUNYSB campus. Less from Wildwood SP has larger proportion of ages in the 300-400 Ma age range.

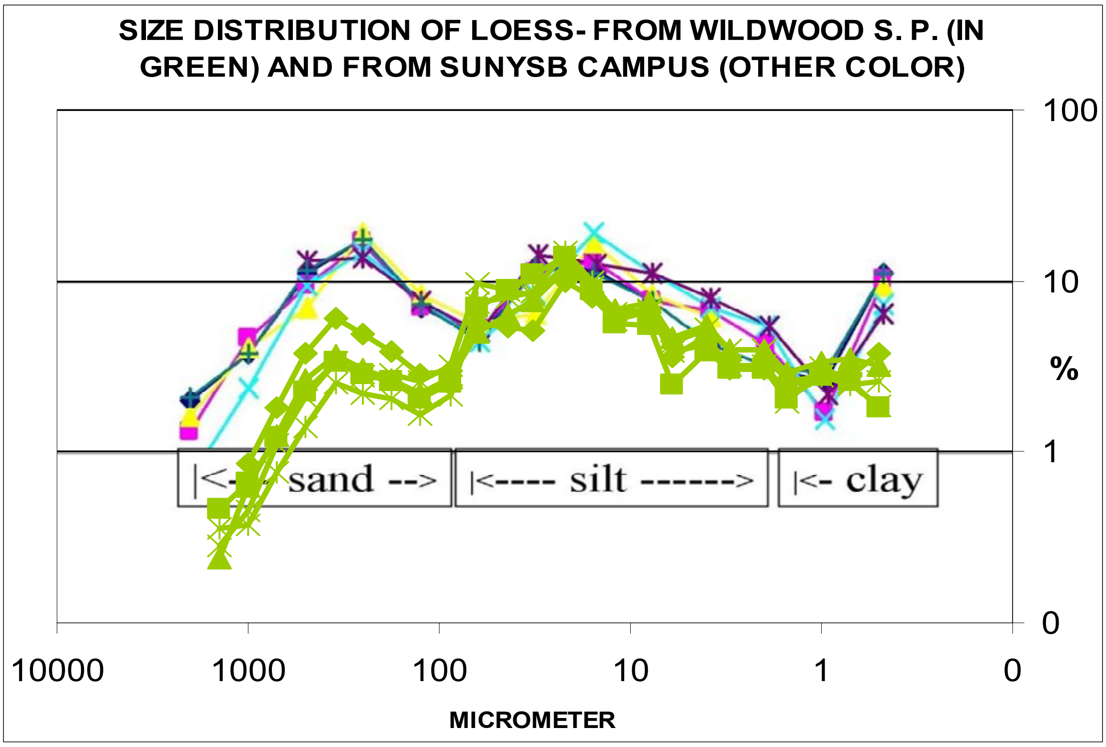

Fig. 3. Grain size distribution of loess from Wildwood State Park is shown as green lines and distribution from SUNYSB campus shown as blue, yellow, pink and light blue lines. Wildwood State Park loess is missing the clay peak and much less sand.

Grain size analysis shows a bimodal distribution with small sand and a larger silt peak which suggests proximal source. The Stony Brook campus loess has more sand and clay than the loess from Wildwood State Park. The higher fraction of sand and the occurrence of what appears to be eolian sand below the loess, suggests that the source of the campus loess was even more proximal Zhong and Hanson (2002). The clay may be a result of soil processes in that the loess was only one meter thick and the upper 50 cm which was not studied was clearly affected by soil process.

MAJOR ELEMENTS

Chemical Index of Alteration (Taylor, McLennan (1985)) for Wildwood State Park loess is 62. On a scale where 50 is fresh and 100 is highly weathered rock a value of 62 suggests mild weathering. The weathering may have occurred at the source rock, while the material was in transit or at the site of deposition. Fig. 4 compares the data for loess from Wildwood State Park (wwk) from near the top, the middle and bottom of the deposit with average loess given by Schentger, 1992. Fig. 5 compares the loess from Wildwood State Park with the average of loess samples collected by Vesna Kundic, from Colorado, the Midwest and Long Island. Fig 6 compares the data for loess from Wildwood State Park with the average of stream sediments in New England, the likely source of Long Island loess. Wildwood State Park loess major element data compare very well with the New England stream data, except that the Wildwood Sate Park loess is depleted in Ca and enriched in phosphate. The depletion in Ca may be a result of leaching of Ca associated with mild weathering of the loess. It is not clear why the loess is enriched in phosphate. The phosphate content of Wildwood loess is highly variable with values that range about the average for loess from Colorado, the Midwest and Long Island. Loess is commonly enriched in zircon. It may be that loess is similarly enriched in apatite.

Fe is strongly enriched in Wildwood loess compared to average loess from Schentger (1992) but when compared to the average of loess from the Midwest, Colorado and Long Island, and the stream sediments from New England there is no Fe enrichment (Fig. 5). Thus, the difference in Fe content is probably a characteristic of the different sources for average loess as compared to Wildwood State Park loess.

Mn is 2-2.5 times enriched relative to average loess and shows a fairly large variation about 1 compared to the Midwest and Colorado loess and the New England stream sediments. Mn is easily affected by redox conditions and variation in Mn in the samples may reflect addition and leaching of Mn during mild weathering.

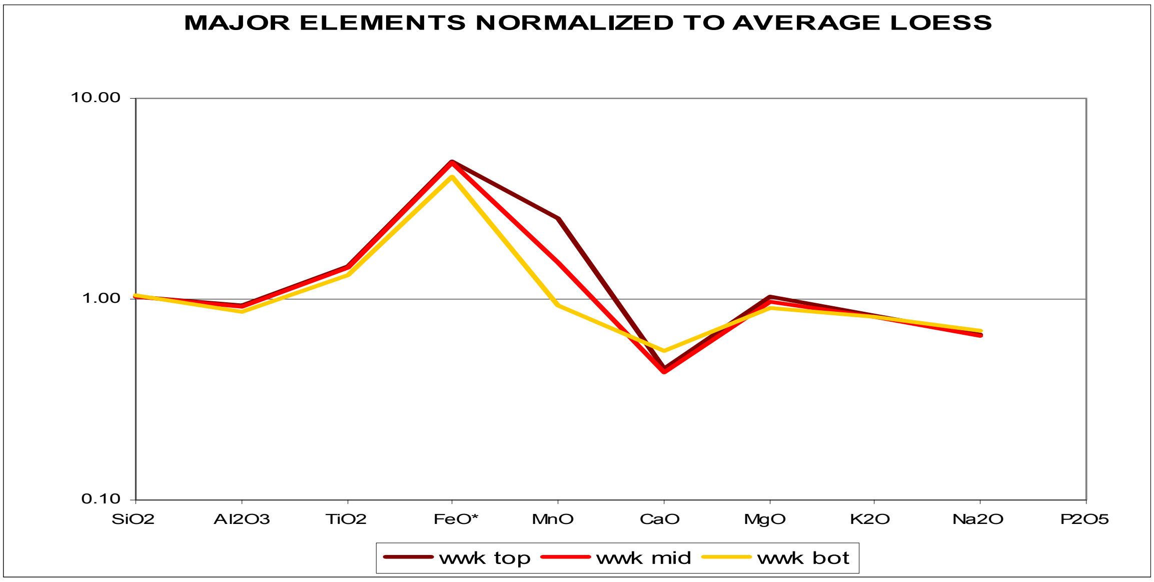

Fig. 4. Wildwood State Park loess normalized to average loess from Schentger , 1992. shows large enrichment in Fe and depletion in Ca. Ca is probably leached from the soil because Long Island soil is acidic.

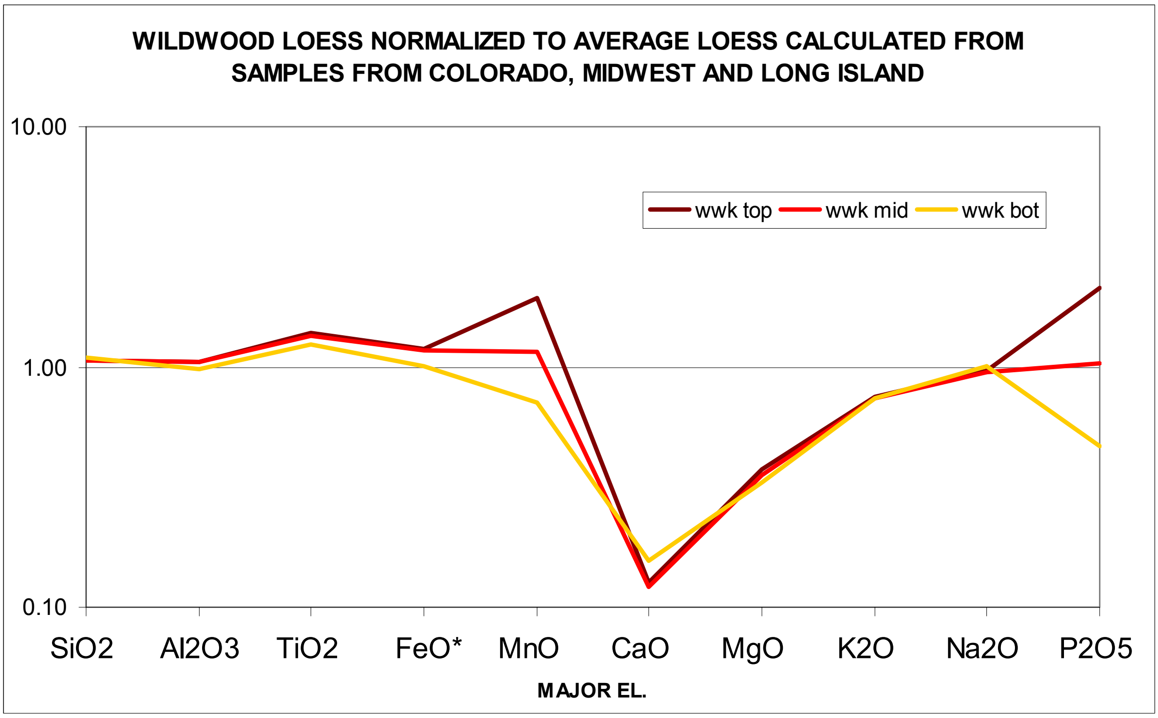

Fig 5 Wildwood loess compared with the average of loess calculated from samples collected in Colorado, Midwest and Long island. There is no large Fe enrichment but there is Ca depletion is still present

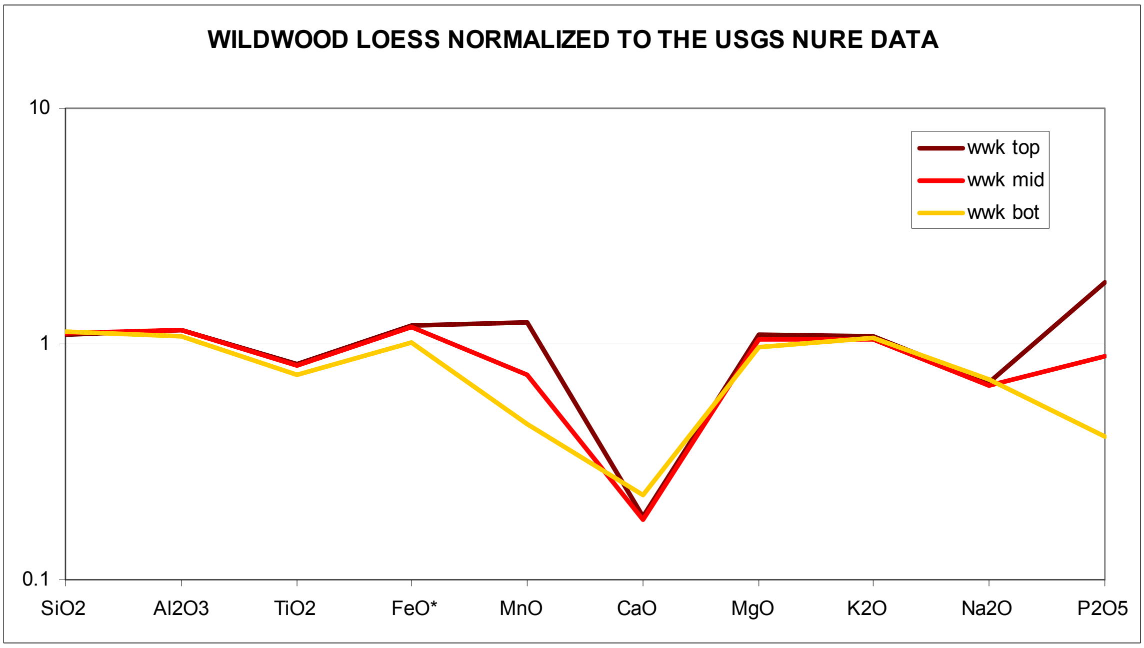

Fig 6. Long Island loess normalized to the likely chemistry of the source shows the Ca depletion and a change in Mn concentration with depth which may be a consequence of soil processes. P is enriched in comparison with the potential source.

Our initial hypothesis for the source of the loess at Caumsett State Park, Stony Brook University campus and Wildwood State Park was stream deposits in the bottom of Glacial Lake Connecticut after the lake drained. To test this hypothesis we converted radiocarbon ages to calendar ages in New England and Long Island in order to compare the OSL ages with the radiocarbon ages.

Table 1 Calendar age and radiocarbon ages associated with Glacial Lake Connecticut

Calendar Age Ka BP	Radiocarbon Age Ka BP	Event
24 to 22	21.8 to 19	Retreat of ice from the Harbor Hill moraine
20	17.6	Ice sheet at Connecticut shoreline
18	15.5	Glacial Lake Connecticut drained
14.3	12.4	Seawater covered Glacial Lake Connecticut bottom

Table 2 Calendar age and radiocarbon ages relating to Glacial Lake Hitchcock bottom and stream sediments as source of loess (Ridge et al 1999).

Calendar Age Ka BP	Radiocarbon Age Ka BP	Event
17.2	14.3	bottom of the eolian sand
16.9	14.1	between lake beds and eolian Sand
15.8	13.1	between lake beds and eolian Sand
15.3	12.6	lowest peat layer in pingo scar
14.3	12.4	base of the lowermost peat body
14.1	12.2	age from a small peat bog
14.0	12.1	basal peat sample
13.9	11.9	lower most section of the peat body
13.4	11.5	top of dune

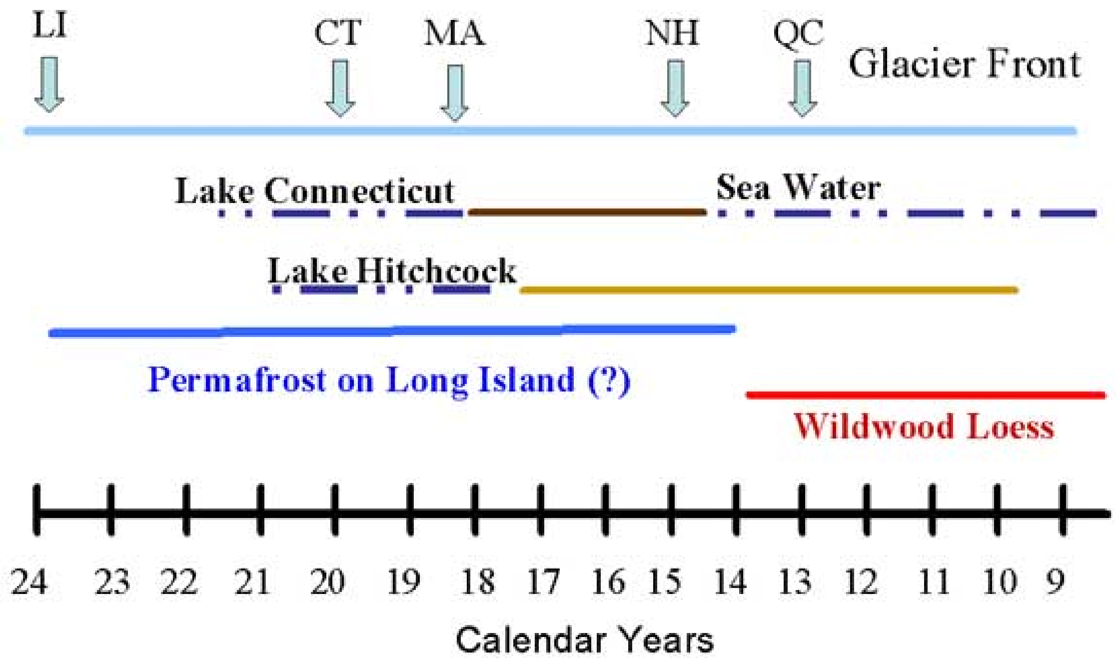

Fig.7. Calendar ages in Ka BP, horizontal lines represent approximate time span of events. Radiocarbon ages have been converted to calendar ages (Stuiver, et al, 1998) The position of the front of the continental glacier after retreating from Long Island (LI) when it first reached Connecticut (CT), Massachusetts (MA), New Hampshire (NH) and Quebec (QC). Light and dark brown lines represent time after Glacial Lake Hitchcock and Glacial Lake Connecticut drained and their lake bottoms were dry with glacial melt water streams crossing the lake bottoms. Broken blue line represents the time when fresh water or sea water was occupying the lake basins. The dark blue line is the time when Long Island may have had permafrost. The Red line shows period of deposition of loess in Wildwood State Park kettle hole as measured with OSL and radiocarbon ages.

DISCUSSION

Most of the $^{40}Ar/^{39}Ar$ ages are in the 200-400 Ma age range from both locations Wildwood State Park and SUNYSB Campus. Therefore, provenance study shows that the source of loess is bedrock to the north of Long Island Sound.

Major elements in Wildwood loess correspond well with the average major elements from North England stream sediments (USGS NURE 2000NE). Wildwood loess is lower in Ca which might be result of weathering. CIA (Chemical Index of Alteration) of 62 corresponds to mild weathering. Phosphorus is highly variable which might be a consequence of Apatite enrichment or soil processes. Mn also shows large variations which is probably a consequence of weathering.

Grain size distribution of loess from Stony Brook and Wildwood State Park shows some differences. Stony Brook loess has three peaks; sand, silt and clay, whereas Wildwood loess has sand and silt but no clay peak. The source of clay in Stony Brook loess could be in the exposed lake bottom sediments to the north or due to the effects of weathering since this deposit is thinner and more affected by soil processes than the Wildwood loess deposit. Furthermore, Stony Brook loess has a larger sand peak than Wildwood State Park loess which suggests that its source was closer. The tunnel valley at Stony Brook is shallow and probably had no ice in it after deglaciation and could have accumulated loess soon after deglaciation. If there was permafrost until about 14,000 years BP on Long Island, the buried ice in the Wildwood kettle would probably not have melted until that time. The kettle could not accumulate loess until the ice melted. The deposition of loess on the campus might have started about 18Ka after Glacial Lake Connecticut drained and while streams were traveling along the bottom of the Long Island Sound basin. Deposition of loess in the kettle at Wildwood State Park may have started later after Glacial lake Hitchcock drained and the area was no longer affected by permafrost.

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