Grain-size Modes in Long Island Sands and Silts may be Inherited from Grain-size Modes in Bedrock

Courtney Melrose* and Dr. Gil Hanson
Stony Brook University
*MS Candidate

Introduction:

During a study of loess-like deposits in Suffolk County, Long Island, New York, (Figure 1) it was noted that the grain sizes have a distinct set of modes at about 20µm, and 400µm in most if not all loess samples and modes of 20µm, 80 µm and 400µm (Figure 2) in samples of till and outwash on the Stony Brook campus (Zhong, 2002, Kundic, 2005, A. Olaofe, personal communication, 2012 and T. Clare, 2013). We found that the same set of modes were also present in Cretaceous sediments, weathered, Long Island, basement rocks and mechanically crushed rocks typical for Long Island. All of the samples were analyzed with a Malvern Mastersizer 2000.

Figure 1. Study locations in Suffolk County, Long Island New York.

Loess is windblown silt, predominantly composed of quartz. Deposits of loess display a lack of bedding, and are usually dun in color. Loess deposits are prevalent on Long Island, and are the reason for Long Island's rich agriculture. Mastersizer analysis of loess-like samples collected from Stony Brook showed a pattern of modes around 20µm and 400µm (Figure 2). The modes at 20 and 400 µm were assumed to be due to processes related to sorting by wind. The 400µm fraction would be a result of travel by saltation from proximal sources and the 20µm fraction would be a result of travel by suspension from more distal sources. This assumes that the source of a wind blown sediment has a wide range of grain sizes and a well graded distribution of grain sizes from silt through sand. That is, each grain-size fraction has a near equal proportion of grains by weight or volume in sediment sources. As we will show that is not necessarily the case for the loess that we have studied.

These same loess deposits also contained randomly placed pebbles, which is uncharacteristic of a wind blown silt or sand. This fact led to these loess deposits being called "pebbly-loess" or "loess-like" deposits. To investigate if these modes were unique to pebbly loess and glacial sediments, or whether they were also present in Cretaceous clays, sands and gravels or weathered granite, samples of Cretaceous sediments were collected at Caumsett State Park and sediments and weathered basement from cores from Brookhaven National Laboratory (DeLaguna, 1963). To test if these modes were inherent in the potential parent rock of the loess, three hand specimens of variably sheared granite gneisses found on the Stony Brook Campus (Fig. 3) which are similar to the Stony Creek granite in Connecticut were crushed, ground and

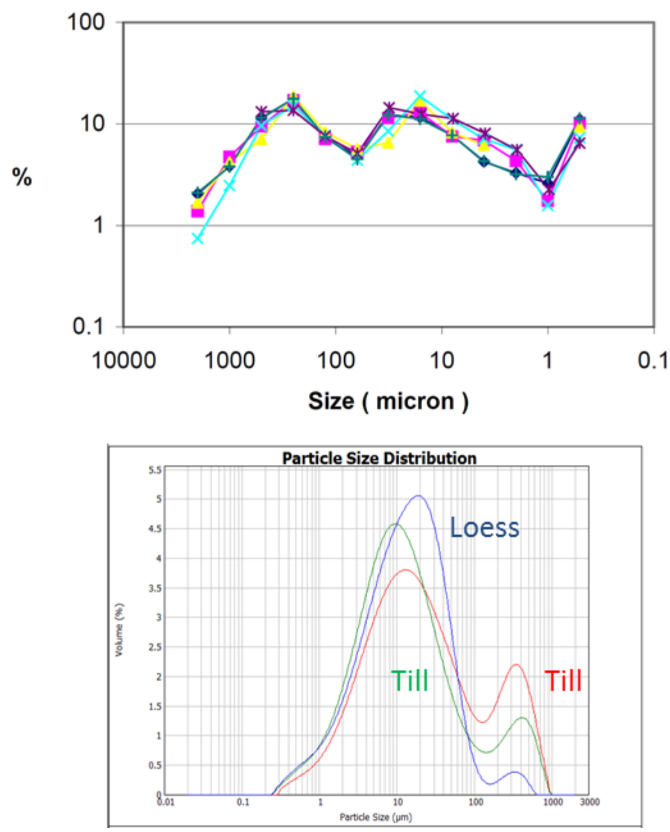

Figure 2. Histograms of grain-size for the less than 1 mm particles in loess and till found at one section on the Stony Brook University campus. The upper histogram is based on one phi fractions for 6 samples of loess determined using wet and dry sieving and settling tube (Zhong, 2005). The loess has modes at 250 and 20 and less than one micron.

The lower histogram (Clare, 2013) ,(note that the values on the abscissa are reversed.) was determined using the Malvern Mastersizer 2000 for loess and till at the same site as that for the samples in the upper graph. Essentially the same three modes are shown in the loess and also in the underlying till at 10 to 20 microns and a smaller clay mode at about 0.5 microns.

pulverized. While not every sample analyzed displayed modes at 20µm, 80 µm and 400µm, every sample shows a peak at or near one or more of these modes .

Methods:

A Malvern Mastersizer 2000 uses laser diffraction to accurately analyze the grain-size distribution of particles. "*During the laser diffraction measurement, particles are passed through a focused laser beam. These particles scatter light at an angle that is inversely proportional to their size. The angular intensity of the scattered light is then measured by a series of photosensitive detectors. The number and positioning of these detectors in the Mastersizer 2000 has been optimized to achieve maximum resolution across a broad range of sizes. The map of scattering intensity versus angle is the primary source of information used to calculate the particle size. The scattering of particles is accurately predicted by the Mie scattering model. This model is rigorously applied within the Mastersizer 2000 software, allowing accurate sizing across the widest possible dynamic range."* (http://www.malvern.com/Assets/MRK501.pdf)

The procedure for analysis is that of Sperazza et. al. 2004. The samples were passed through a 1mm sieve to remove the coarser fraction. They were then left in a solution of 5.5 g/l of sodium hexametaphosphate ($Na(PO_3)_6$), (a defflocculant) overnight. For analysis each sample was introduced by pipette into a beaker containing 500ml of the ($Na(PO_3)_6$),solution until the obscuration percent readout on the machine was between 15% and 23%.

Four different rock crushing procedures were used to convert the whole rocks from Stony Brook University campus into "artificial sediments". We first either broke or cut sections off of each rock (labeled rock A, rock B, and rock C) (figure 3). These sections were first weighed and then crushed. These methods were designed to mimic the effects of glacial action on these rocks. Five set samples of each of the three rocks was produced, and four separate crushing regimens were used. For the first set, the sections of rocks were crushed by hand in a metal mortar and pestle. This produced chunky gravel. The second set included a grinding by hand, in a ceramic mortar and pestle. The third set included both of the previous grinding methods, but the sample was subsequently placed in an agate shatterbox to pulverize the sample.

Each rock sample (rock A, B, and C), was processed this way for approximately two minutes. For the fourth set, the samples were processed in a metal grinding mill.

<u>Locations:</u>

Deposits of fine quartz rich silt, or loess, containing pebbles were sampled at Stony Brook where this loess overlies a one meter thick glacial till. According to Zhong, 2001, $^{40}Ar/^{39}Ar$ muscovite in the loess gives ages dominantly between 200 and 450 Ma which suggests that the muscovite is derived from basement rocks in New England, consistent with the direction of glacial advance to the south. OSL dating for this loess gives an age for deposition of 13 to 14 Ka (Kundic, 2005) long after the last glacier retreated from Long Island at about 20 Ka. This loess was deposited at about the beginning of the Younger Dryas when the climate returned to near Glacial Maximum conditions with lasted for some 1500 years..

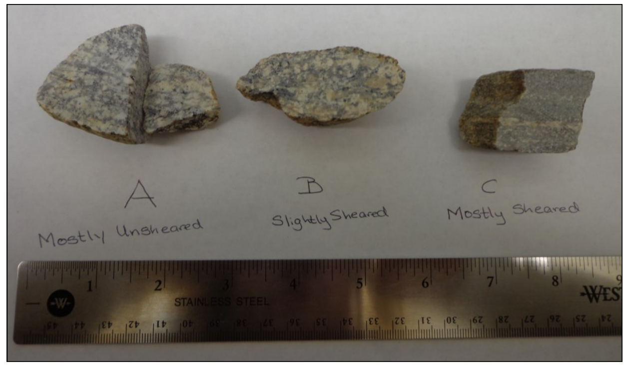

Figure 3. The three specimens of granite gneisses collected on the Stony Brook campus, used for whole rock

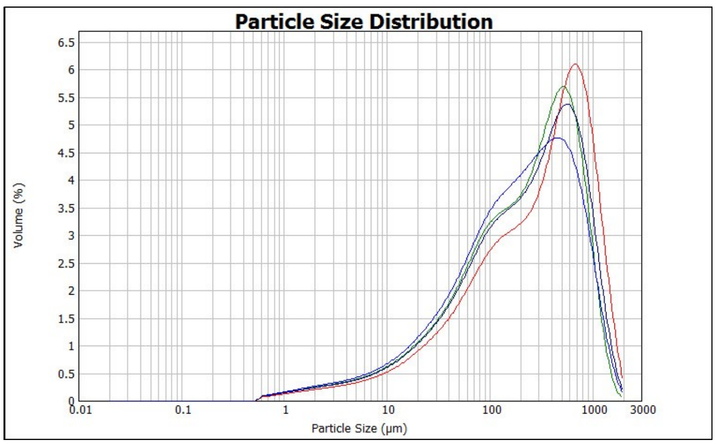

Figure 4. Histogram showing the grain-size modes for the whole rock first crushing series for Rock A.

Samples were collected at Caumsett State Park from both glacial (Pleistocene age) and Cretaceous sediments. Muscovite in the glacial and Cretaceous sediments give $^{40}Ar/^{39}Ar$ ages between 200 and 400 Ma again suggesting that the muscovite is derived from basement rocks in New England (Zhong, 2001)

Samples from Brookhaven National Laboratory were collected from two separate cores, S6409 and S6434 (De Laguna, 1963). Each sample was chosen for its sediment type, and location in depth according to Figure 3 of De Laguna, 1963. A total of 17 samples were analyzed, of these, five were from the Magothy formation, two were from the Raritan Clay, four were from the Lloyd sand and six were of weathered bedrock.

<u>Results and Discussion:</u>

The histograms show modes based on the volume percent of sediment of a particular size in the Mastersizer machine. The actual modes vary slightly between samples, but generally occur around 20µm, 80µm, and 400µm. The Cretaceous samples from Caumsett State Park in Fig. 9 illustrate this clustering.

One hypothesis that we developed before we analyzed the Cretaceous samples was that the modes in the glacial sediments were produced by the grinding action of the glacier. The same modes at about 20µm, 80µm, and 400µm were found in the whole rock crushing experiments (Fig. 4). This would support the hypothesis that the modes might either be inherent in the rocks, or are produced by the grinding by the glacier.

Each sample from Caumsett State Park, whether from glacial or Cretaceous sediments, has peaks at around 20µm, 80µm, and 400µm (figures 5 through 9). This would indicate that these modes could not have been produced by grinding by a glacier but may actually be inherent in the source bedrocks of these clastic sediments.

This is further supported by the findings obtained for samples from the cores at Brookhaven National Laboratory. Figure 10 shows modes at 20, 65 and 500µm for the weathered remains of granite.

These results suggest that for this set of Pleistocene and Cretaceous sediments, based on the weathering products of granite and crushed granite, the grain-size modes found in these clastic sediments are inherent in the bedrock source and are inherited by the sediments derived from such bedrock.

Acknowledgments:

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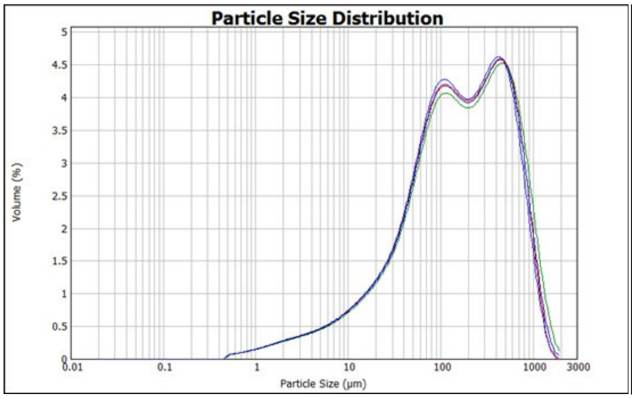


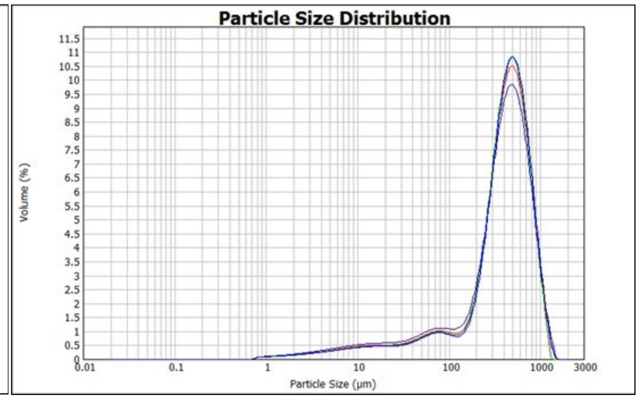
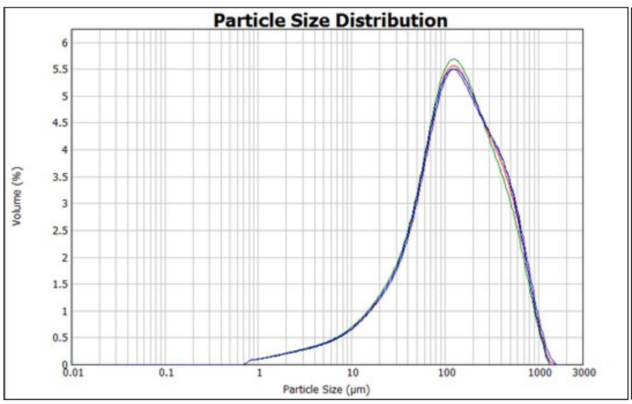


Figure 5. Histogram of glacial sand from Caumsett State Park with modes at 100μm and 400μm.

Figure 6. Histogram of Cretaceous sand from Caumsett State Park, with modes around 80μm and 300μm, with a small peak possible at 20μm.



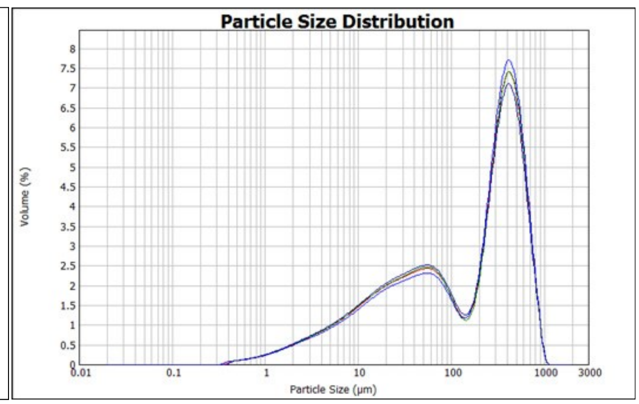
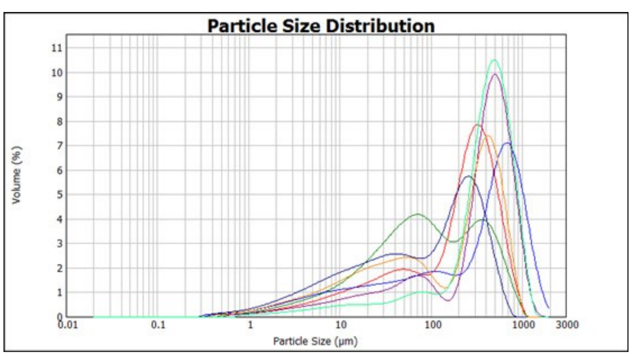


Figure 7. Histogram of glacial sand from Caumsett State Park with modes at around 100μm, and 400μm.

Figure 8. Histogram of Cretaceous silty sand from Caumsett State Park, with peaks around 20μm, 60μm and 300μm



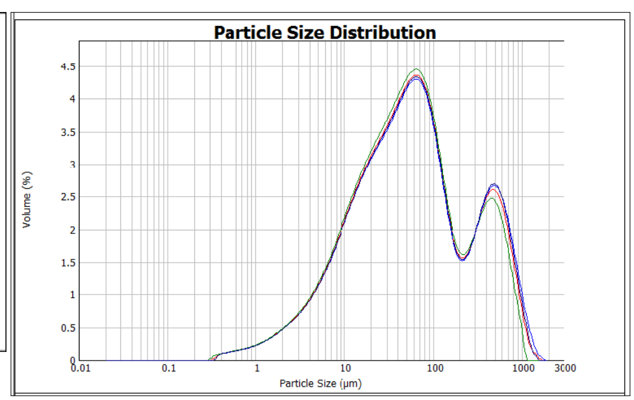


Figure 9. Histogram of the Cretaceous samples from Caumsett State Park, showing the particle size variation between samples, with a clustering at about 80μm and 400μm.

Figure 10. Histogram of the product of weathered granite from USGS core S6409 at a depth of 1501 to 1565 feet which shows the same three modes at about 20 , 65 and 500μ.