ORIGIN OF SAND AT CLAY PIT POND STATE PARK, STATEN ISLAND, NY: AN SEM STUDY

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Abstract:

Clay Pit Pond State Park is located in the southern portion of Staten Island, New York. Within the park are limited surficial outcrops of brightly colored layers of brown to yellow sand, gravel, and multicolored clay outcrops of the Cretaceous Raritan and Magothy Formations. On Staten Island, these formations are disconformably overlain by layers of poorly to well-sorted Pleistocene gray to brown sand and gravel and red cross-bedded outwash sand from the Harbor Hill Terminal moraine. An SEM study was conducted of quartz sand grains from recently exposed deposits to determine their origin and depositional environment, as this area of Kreischerville was extensively quarried from 1858-1873 for its fine clay deposits. Sand samples were washed, dried in a kiln, and split into two portions. One sand portion was coated with gold and one was not in order to determine the best visible grain SEM morphology using the criteria of Whalley & Krinsley (1974) and Culver, Bull & others (1983). Using an FEI Quanta 250 SEM, quartz grains were examined for their overall surface morphology including roundness, angularity, conchoidal fractures, striations, v-shaped pits, chemical weathering solution pits. Glacially transported angular to sub rounded quartz grains typically have ridges, curved and straight grooves, striations, and show little or no chemical weathering effects as they are geologically young. Well rounded to sub rounded Cretaceous quartz grains have dish-shaped concavities that may indicate pressure solution from overlying layers from long-term burial as part of the Raritan-Magothy formation. In addition V-shaped pits within sub-rounded Cretaceous quartz sand is more indicative of their prolonged presence in a buried chemical weathering environment. Quartz grains examined in several samples ranged from round to sub rounded with rare angular to faceted grains and there is a lack of conchoidal fracturing and suggest their transport within a glacier or as part of moraine material. Based upon these preliminary criteria, we conclude that these outcrops consist of mixed deposits from both the Harbor Hill Moraine and the Cretaceous Raritan-Formation perhaps from past mining activities.

Introduction:

Clay Pit Ponds State Park Preserve is located near the southwest shore of Staten Island and is approximately 265-acres. In the 19th century, the park was the site of extensive mining of white kaolin clay ($Al_2O_3 \cdot 2SiO_2 \cdot 2H_2O$ chemical composition that is composed of two-layer crystal structure) that was used in the production of bricks and terra cotta. When the quarrying operations had ceased, the pits became backfilled with water and vegetation.

The occurrence of the kaolin clay suggests that the material was picked up from the base of the Raritan formation by glacial ice of the Pleistocene glaciation and was transported for a short distance before being deposited in the terminal moraine that extends across not only Staten Island, but also Long Island and southern New Jersey.

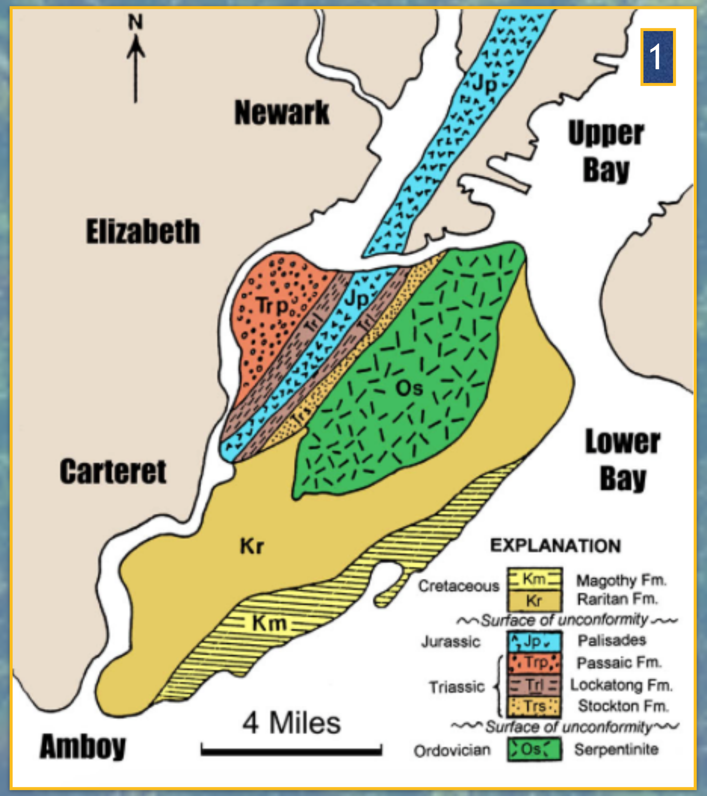


Figure 1: Geological map of Staten Island, with extension of Palisades intrusive sheet northeastward onto mainland. (After Epstein and Lyttle, 1987 and Okulewicz, 1988.)

Figure 2: Google Earth Map of Clay Pit Pond specimen sample close up.Figure 3: Google Earth Map of Clay Pit Pond in relation to Staten Island.

Methodology:

Sample Preparation Protocol for SEM:

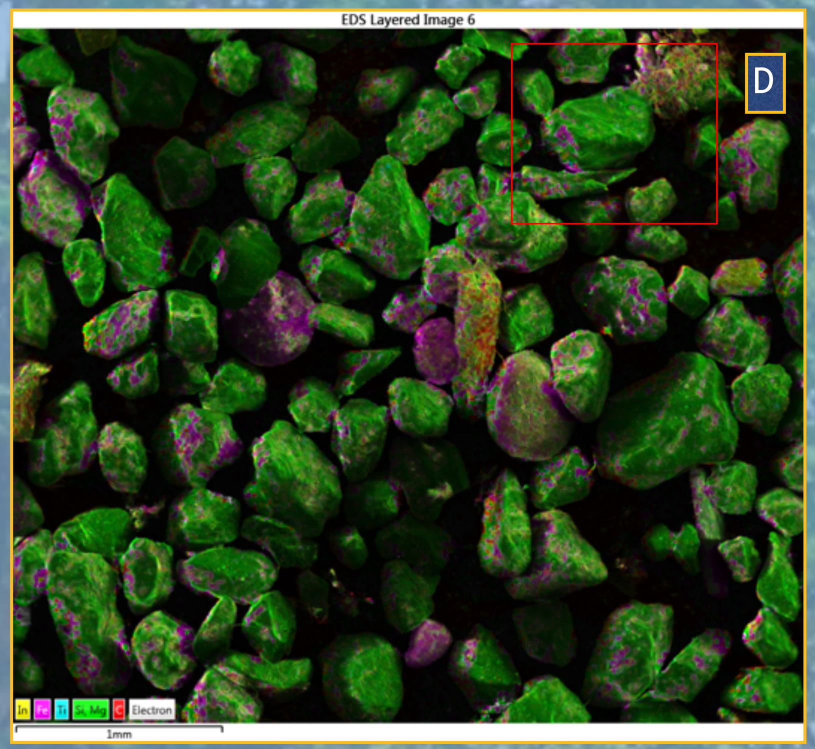
1. Sediment samples from three site locations were selected, washed with distilled water and dried in an oven at 40°C for three days.
2. Samples were then taken out of the oven and placed onto aluminum SEM stub and stored in a dissector overnight before analysis.
3. The studs were coated with 21mm of gold asian an EMS Sputter Coater before being placed into an FEI Quanta 250 SEM.
4. Using the process of simple random sampling where the SEM would be focussed on a group of grains at 40X magnification. From this close up of the grains, non-probabilistic sampling was implemented in selecting a specific grain for closer magnification of 160X.

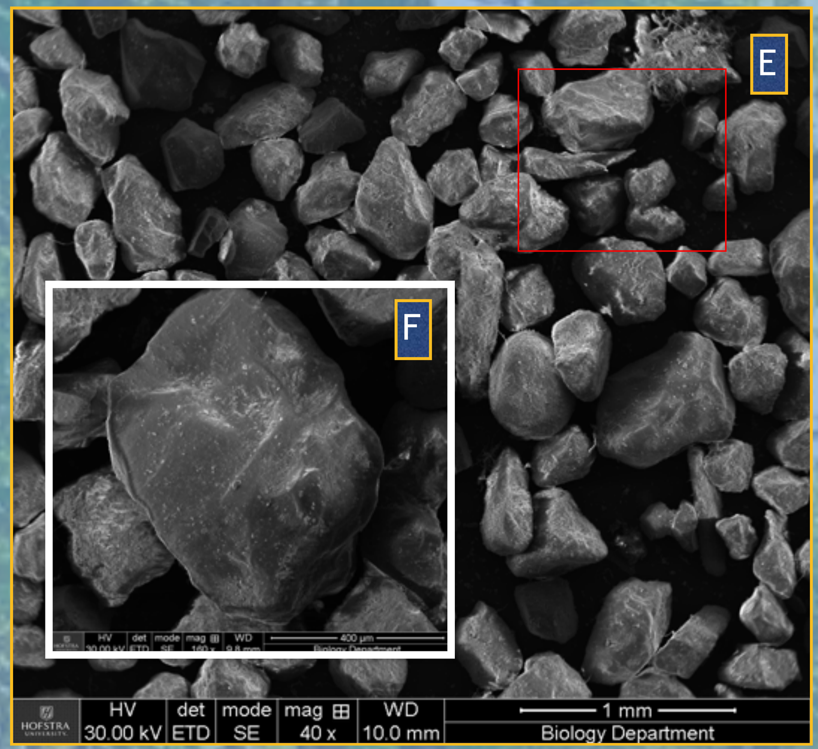
Sample Preparation Protocol for EDS:

1. Following the completion of the SEM, a standardized computer-assisted SEM/EDS analyses was performed by Aztec on all three samples.
2. The analyses was mapped on the same simple random sample from the SEM.
3. Aluminum and Gold was excluded from the map as to avoid possible detection of the stub that the sample was mounted on and the gold coating the specimens.
4. The total weight percentage was calculated based on the majority of elements present

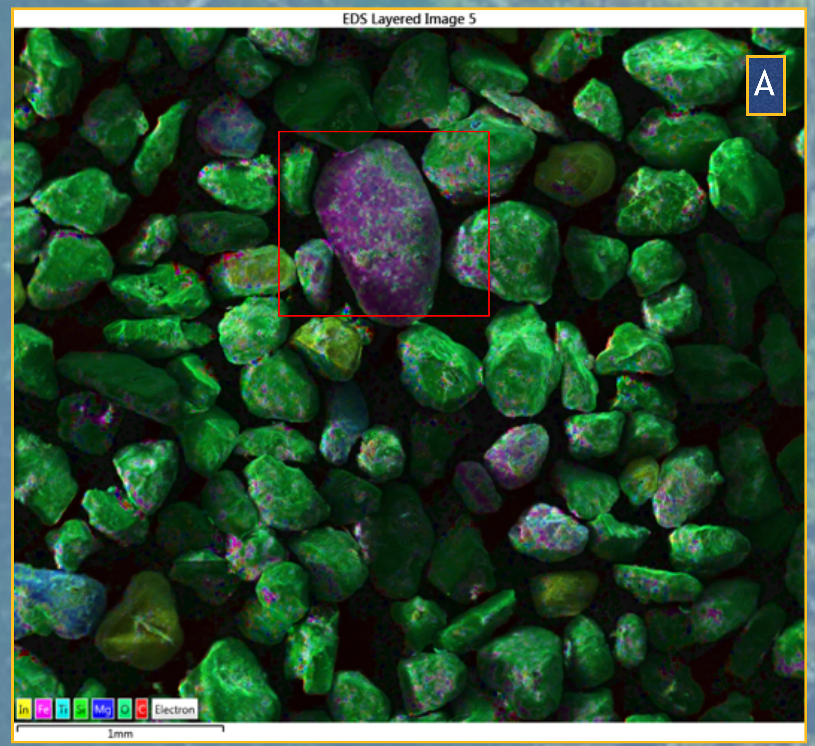
Results:

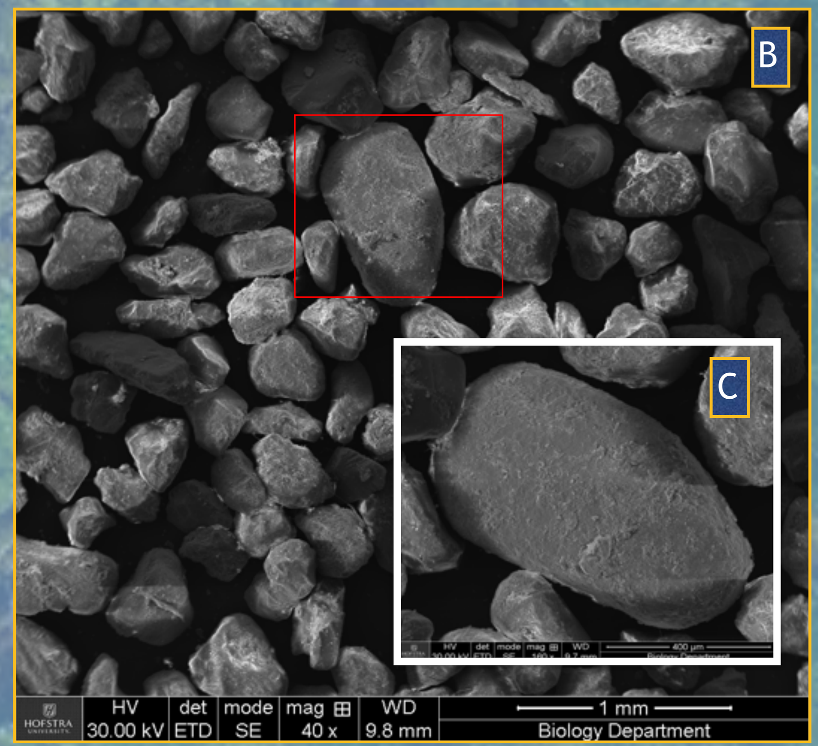
Specimen #3 - N4036



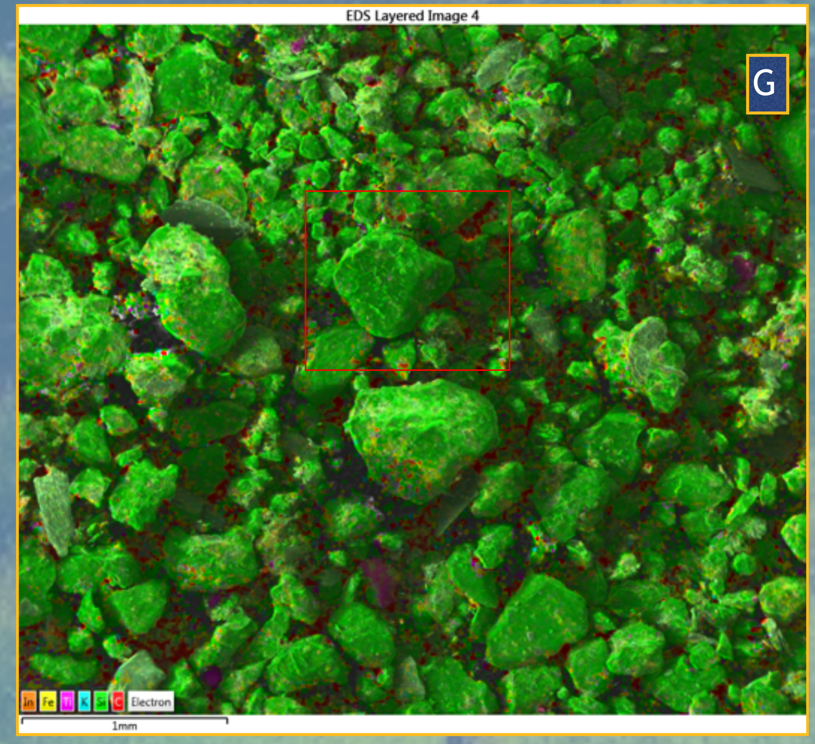


Specimen #2 - N4057





Specimen #1 - N4032



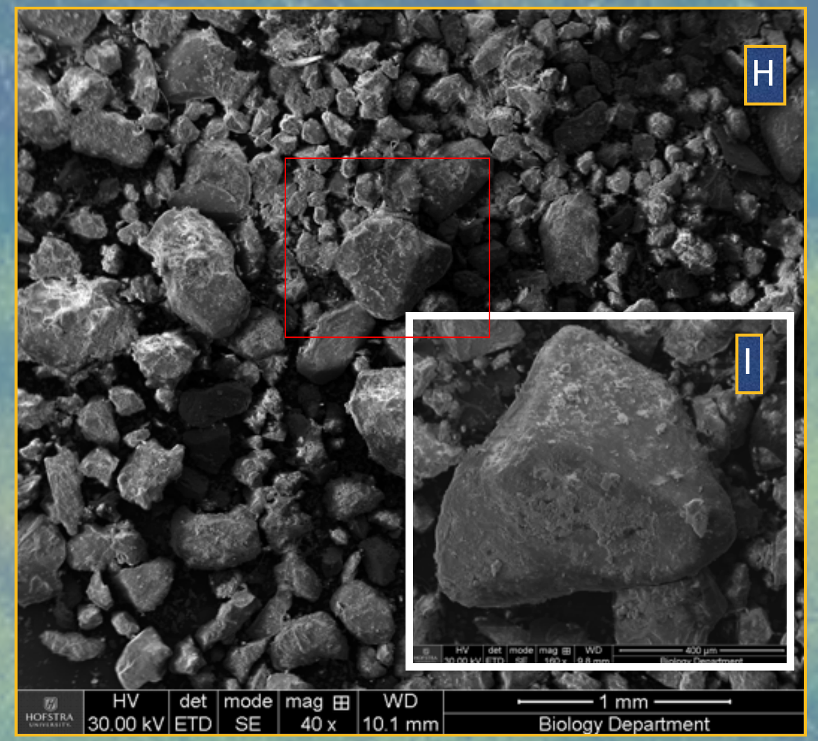


Figure A: (GPS Coordinates 40°32.561N, 074°13.708W) EDS of Sub-rounded Pleistocene Quartz Grains 40x mag. Figure B: SEM of Sub-rounded Pleistocene Quartz Grains 40x mag. Figure C: Sub-rounded Pleistocene Quartz Grain close up 160x mag. Figure D: (GPS Coordinates 40°32.576N, 074°13.700W) EDS of Angular to Sub-rounded Pleistocene Quartz Grains 40x mag. Figure E: SEM of Angular to Sub-rounded Pleistocene Quartz Grains 40x mag. Figure F: Close up of Angular to Sub-rounded Pleistocene Quartz Grain 160x mag. Figure G: EDS of Sub-rounded Pleistocene Clay Grains and Well Rounded Pressure-solution Pits in a Cretaceous Quartz Grains 40x mag. Figure H: SEM of Sub-rounded Pleistocene Clay Grains, Sub-angular and Well Rounded Pressure-solution Pits in a Cretaceous Quartz Grains 40x mag. Figure I: Close up of Sub-angular Pleistocene Quartz Grain 160x mag.

Chemical Analysis of Sediment Samples:

Specimen	#3 - N4036	
Element	Wt %	Wt% Sigma
C	32.83	0.18
O	51.90	0.15
Mg	0.39	0.01
Si	12.67	0.04
Ti	0.06	0.00
Fe	2.16	0.01
Total	100.00	

Specimen	#2 - N4057	
Element	Wt %	Wt% Sigma
C	31.64	0.15
O	52.04	0.13
Mg	0.46	0.01
Si	13.16	0.04
Ti	0.07	0.00
Fe	2.63	0.01
Total	100.00	

Specimen	#1 -N4032	
Element	Wt%	Wt% Sigma
C	26.83	0.38
O	56.19	0.30
Si	15.49	0.09
K	0.37	0.01
Ti	0.22	0.00
Fe	0.89	0.01
Total	100.00	

Results:

In the lab area, the three specimens examined and analyzed were determined to be predominantly transported by glaciers due to the angular to sub rounded quartz grains from the Pleistocene. The quartz grains that were examined in several sand samples ranged from round to sub rounded with rare angular to faceted grains and there is a lack of conchoidal fracturing which suggest their transport within a glacier or as part of glacial moraine or outwash deposit. The characterizations of each grain typically showed ridges, curved and straight grooves, striations, and showed little to no chemical weathering effects making them geologically young, **Specimen #2.** Well rounded to sub rounded quartz grains that had a dish-shaped concavities indicated possible pressure solution that occurs from overlying layers of long-term burial as part of the Cretaceous Raritan-Magothy formation, **Specimen #3.** In addition, V-shaped pits within sub-rounded Cretaceous quartz sand showed to be more indicative of their prolonged presence in a buried chemical weathering environment.

Due to the coloring of the sediments found that ranged from red/brown to yellow and the chemical analysis of the sediment, it was determined that oxidation had occurred. Free oxygen (O_2) is more common near the Earth's surface and can possibly react with clay minerals to change the oxidation state of the ion. All three samples contained Fe (iron) bearing minerals where Fe can have several oxidation states, Fe, Fe^{+2}, Fe^{+3}. Dehydration of Goethite to Hematite was also determined as part of the chemical weathering process where there was a removal of H_2O or OH^- ion from the mineral. Other chemical weathering processes that were determined due to the known presence of the kaolin clay showed that H^+ / OH^- replaced an ion in the mineral allowing for hydrolysis and leaching to occur within the area.

Discussion:

Some errors occurred with the samples of sediment when the EDS picked up large weight percentages of Indium that nearly matched peaks of potassium. For this project, the peak of potassium was used based on knowledge of the minerals and sediments present on site. However, the presence of Indium will be further analyzed in later research. Other errors occurred during research where moisture was introduced to the stubs for a short exposure, making whatever organic material become "alive" and "moving" under the SEM/EDS. The disturbance of moving organic material may have possibly affected the chemical analysis portion of the EDS protocol.

It is arguable, knowing that the site and general vicinity was heavily impacted by mining operations in the 19th century, creating uncertainty and error in the identification of origin of the sediment samples.
Further work: Examination and analysis of large percentages of Indium peaks corresponding to Potassium peaks were found and need further research to determine if the presence of Indium is just an artifact with the Potassium or is actually present within the sediment deposit.

Conclusion:

Based upon these preliminary SEM/EDS criteria, we conclude that recently exposed sand exposures in Clay Pit Pond State Park in Staten Island, New York consist of mixed deposits from the Pleistocene Harbor Hill Glacial Moraine and sands from the Cretaceous Raritan-Magothy Formation perhaps from past mining and excavation activities.

References:

[1] Okulewicz, Steven, and Charles Merguerian. *HOFSTRA UNIVERSITY 014F FIELD GUIDEBOOK* (n.d.): n. pag. Hofstra University, 28 Sept. 2008. Web.

[2] Kerr, Paul F. "Kaolinite from the Terminal Moraine of Staten Island." *The American Mineralogist* (n.d.): 29-34. Web. <http://www.minsocam.org/ammin/AM17/AM17_29.pdf>.

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