PROVENANCE OF GLACIALLY TRANSPORTED QUARTZ PEBBLES ON LONG ISLAND: USE OF Pb ISOTOPES TO IDENTIFY FAR-TRAVELED COMPONENTS

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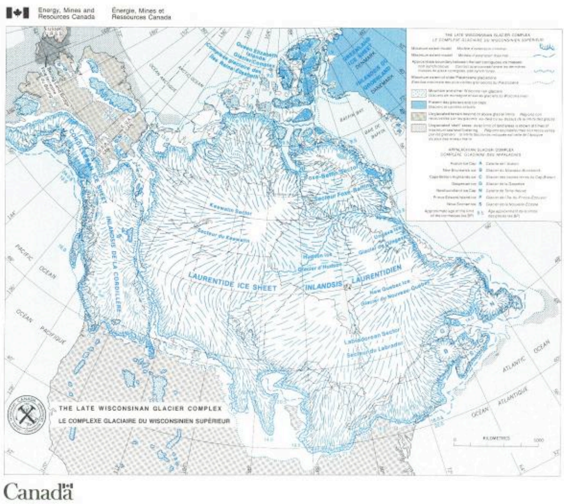
Introduction

Quartz is ubiquitous, it is the most abundant detrital component in sandstones due to its hardness and resistance to chemical alteration. A review of Pb isotope systematic in quartz demonstrates that it may be a powerful tool for constraining the provenance of detrital quartz grains (Hemming, et al., 1994). Pb isotope studies of quartz from the Canadian Shield shows high thorogenic Pb compared to quartz from Appalachian sources (Sunderman et al. in press). This study aimed to identify provenances of quartz pebbles on West Meadow Beach through Pb isotope analysis by systematically collecting and separating them into groups according to their physical characteristics. Based on physical and isotopic data, the quartz pebbles analyzed on West Meadow Beach have local origins similar to those of the boulders on Long Island.

Based on an understanding of the transport mechanisms, breakage and rounding, petrographic evidence and because the boulder compositions are comparable to the outcrop belt of Connecticut, a strong case is made that boulders have not been transported more than about 12 miles (Patcholik, 1999). The glaciers originate in the Canadian Shield (Figure 1a). Because pebbles are smaller than boulders, they may have been transported from a farther distance (Figure 1b), however there are no published studies of the provenance of pebbles. In this study we determined the percentage of rock types in the pebble population. We split quartz pebbles into bins of color and textural differences and recognize 14 types. There are several populations that are very abundant, and many more that cannot easily be grouped. Since it is known that much of the glacial material on Long Island is locally derived, we expected that the quartz populations that had few representatives had the best potential for being exotic.



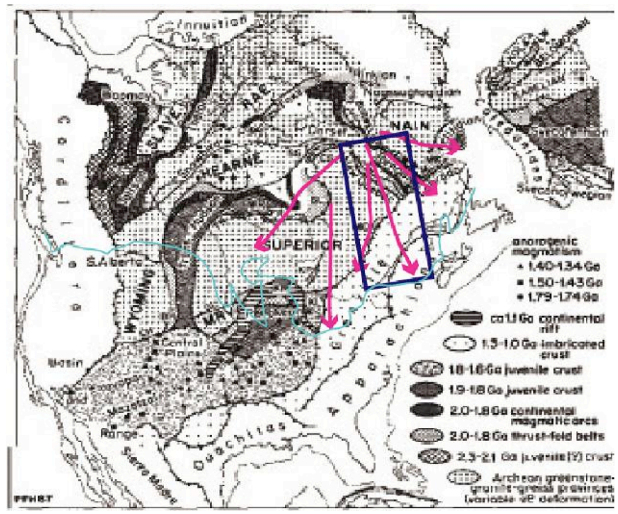


Figure 1a. Extent of the Laurentide Ice Sheet, the southern-most extent along the eastern portion is Long Island. 1b. Pink arrows show the flow directions based on the reconstruction in Figure 1. The blue box shows the area that might have been sampled to provide sediments to Long Island. The light blue curve shows the maximum extent of the Laurentide Ice Sheet. Because of their small size, pebbles may be transported from a farther distance, perhaps with origins in the Canadian Shield (Map modified from Hoffman, 1987).

West Meadow Beach is a north-south oriented peninsular spit located northwest of the Village of Stony Brook. It is bordered to the east by West Meadow Creek and the Harbor Hill Moraine (Figure 2a). Southward longshore transport of sand, pebbles, and cobbles eroded from morainal headlands of Crane Neck Point and Crane Neck north of the beach, making West Meadow Beach a depositional feature. Clasts within the morainal headlands are mainly sand and gravel topped by unsorted glacial till. This till is a mixture of sand, clay, gravel, and boulders. The clasts were initially rounded by glacial ice and further rounded and sorted by Long Island Sound wave action (Ippolito-Hatten, 2009).

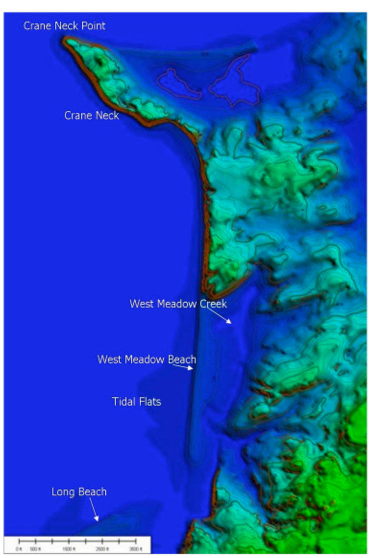


Figure 2a. A Digital Elevation Model with contours of West Meadow Beach and surrounding areas. The beach is an elevated feature depicted by the shadowed strip of 5 meter high beach and extended tidal flats (Ippolito-Hatten, 2009). 2b Photograph of West Meadow Beach.

Dredging in Stony Brook Harbor in the early 1950s has changed the geology of West Meadow Beach. In 1980 the southern 2000ft of West Meadow Beach was covered with dredged material. In 1997, further dredging covered the beach with additional unsorted sands and gravels (Figure 2b), however no material is added or taken away. It is simply rearranged so that West Meadow Beach should provide a faithful record of the categories of quartz pebbles that were delivered to the Stony Brook lobe of the Harbor Hills moraine. The upper beach/berm is covered with an unsorted mixture of dredged sand and gravel. Smaller, flatter rocks more easily transported away from the shoreline by waves are found in the high tide area. Also found in the high tide area are seaweed and sand blown from the dunes. This sand is predominately white quartz sand. During low tide, large cobbles in the swash zone are exposed (Ippolito-Hatten, 2009).

Methods and Results

Pebbles for analysis were collected using a 2x2 foot grid. The pebbles were then sorted according to size. Sediments less than 1cm were removed by passing through a sieve. After sieving, pebbles were sorted according to their physical appearance (Figure 3). For analysis, the most common quartz pebble types; clear, milky, clear/milky with cavities, rose, rose with cavities, smoky, smoky with cavities, citrine, and citrine with cavities were grouped and referred to as common quartz, representing the largest population of quartz types identified (Figure 4).

Figure 3a. sample of categories for binning. 3b. quartz pebbles after binning

To test the possibilities that the West Meadow pebbles were far traveled or from local sources, common quartz pebbles were analyzed first. Other unique quartz types such as sheared quartz, quartz with banding, quartz with other minerals, and speckled quartz each represented a smaller portion of the total quartz pebbles collected (Figure 4). The unidentified quartz category is of particular interest; those pebbles are not clearly representative of any defined group. We predicted that those exotic smaller sample sizes could have traveled to West Meadow Beach from a greater distance.

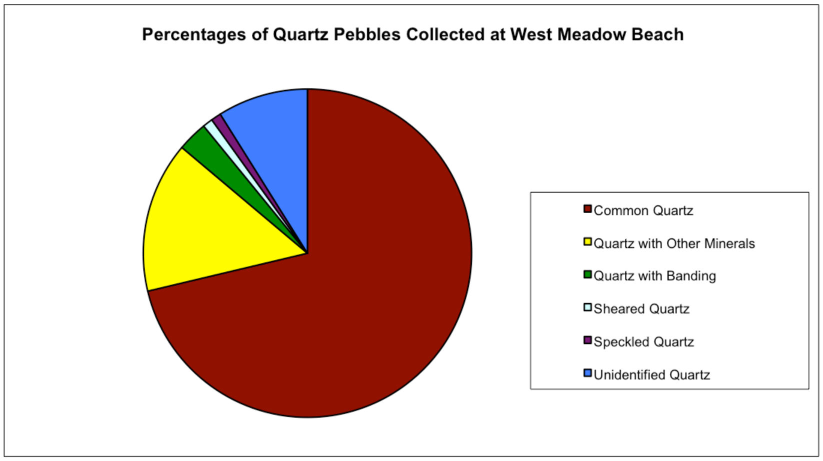


Figure 4. Percentages of quartz pebbles collected at West Meadow Beach in relation to the total.

Individual pebbles were crushed and handpicked aliquots of approximately 100 mg were selected to avoid inclusions. The aliquots were cleaned ultrasonically with 1 N HCl for 30 minutes. The samples were dissolved in approximately 1 ml of concentrated HF mixed with HNO_3 on a hotplate for 2-3 days. After dissolution, the vials were uncapped, the solution dried down and then re-dissolved in 6 N HCl for Pb anion exchange chemistry. Quartz has a wide range in Pb concentrations with lowest measured concentrations (Hemming et al. 1994) around 0.05 ppm. Thus, considering the aliquot size, and with the common Pb ratios measured, the blank will have no significant impact. Samples were analyzed on a Finnigan MAT 262 multi-collector mass spectrometer at Stony Brook. Measurements were made in static mode. Pb was loaded on Re single Re filaments with an H3PO4-silica gel loading solution. Fractionation was monitored through multiple runs of the standard SRM 982 and samples were corrected for the 0.08% per atomic mass unit fractionation.

Pb isotopes from all of the quartz pebbles sampled are unradiogenic and do not show the extreme enrichment in $^{208}Pb/^{204}Pb$ that seems to be characteristic of the ancient quartz from the Canadian Shield. Table 1 shows data collected for this study. The $^{208}Pb/^{204}Pb$ data from this study are nearly invariant ranging from 36.79-39.02 and are consistent with known values of underlying Connecticut bedrock. None of the pebbles sampled were distinct from that data requiring an exotic source. In contrast, glacial drift studied in an Indiana paleosinkhole showed high and extremely variable $^{208}Pb/^{204}Pb$ values ranging from 35.58-105.98 Ga (Sunderman et. al., in press), which are indicative of exotic origins in the Canadian Shield.

	$^{206}Pb/^{204}Pb$	% uncert 2σ	$^{207}Pb/^{204}Pb$	% uncert 2σ	$^{208}Pb/^{204}Pb$	% uncert 2σ
WM 1 c	18.10013		15.11981	0.03	37.2448	0.02
WM 1 e	17.6333	0.01	15.24859	0.002	36.78709	0.003
WM 1 d	17.89943	0.01	15.54873	0.001	37.63674	0.002
WM 1 a	18.61015	0.07	15.59839	0.01	37.87545	0.01
WM 1 l	18.46155	0.05	15.65217	0.012	37.90923	0.013
WM 1 b	18.71997	0.01	15.6657	0.002	38.36174	0.005
WM 1 o	18.71255	0.07	15.71162	0.002	38.49036	0.002
WM 1 m	20.65573	0.05	15.75709	0.002	38.3027	0.003
WM 0 9	19.84962	0.51	15.62055	0.06	39.0211	0.03
WM 0 r	18.43129	0.01	15.68513	0.003	38.48046	0.004
WM 0 5	18.47888	0.01	15.67904	0.002	38.61773	0.003
WM 0 d	18.56796	0.05	15.62323	0.007	38.33751	0.006
WM 0 n	19.88669	0.13	15.74793	0.01	38.15983	0.03
WM 0 t	22.39871	0.17	15.85707	0.02	38.60582	0.02
WM 3 p	19.01596	0.14	15.70765	0.02	38.83664	0.01

Table 1. Pb isotopic data from West Meadow quartz samples.

Conclusions

From the samples analyzed it can be inferred that those pebbles on West Meadow Beach have local origins similar to the boulders on Long Island. Because we have predicted that the unidentified quartz category is most likely to have traveled farther from their source due to the fact that they weren't representative of any other defined group we will continue Pb isotopic investigations on those samples.

Acknowledgements

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