

Determining the Direction of Ice Advance Forming the Roanoke Point Moraine From a Survey of Hartford Basin Erratics

J Bret Bennington¹ and Tim Young²

¹Department of Geology, 114 Hofstra University, Hempstead, NY 11549;
geojbb@hofstra.edu

²Oceanside High School, Oceanside, NY, 11572; warrior12186@msn.com

Bennington, J Bret and Young, Tim, 2005, Determining the Direction of Ice Advance Forming the Roanoke Point Moraine From a Survey of Hartford Basin Erratics. 12th Long Island Geologists Conference on the Geology of Long Island and Metropolitan New York, SUNY Stony Brook.

Introduction

Glacial erratic boulders are plucked from bedrock by flowing ice, transported in the direction of ice flow, and deposited at the terminus of the glacier. If derived from a localized, distinctive region of bedrock, glacial erratics may be used as indicator stones to map the direction of ice flow. Furthermore, glacial erratics evolve during transport, becoming smaller and more rounded with increasing distance from their source. Thus the size and roundness of a population of erratics can record information about the bedrock geology over which the glacier flowed (Pacholik and Hanson, 2001). Erratic boulders are also pulverized during transport so that most large erratics are derived from nearby bedrock and few boulders survive more than 18 to 21 miles of transport (Goldthwait, 1968; Pacholik and Hanson, 2001). In Connecticut, the Hartford Basin forms a narrow corridor of Upper Triassic to Lower Jurassic sedimentary redbeds (sandstone, siltstone, and arkose) situated between the metamorphic bedrock of eastern and western Connecticut (Figure 1). Hartford Basin (HB) erratics are ideal indicator stones because they are distinctive, easily identified in the field, and have a limited source region. By identifying the area of maximum density of HB erratics along the north shore of eastern Long Island, we can connect this point to the southern end of the Hartford Basin (most proximal to Long Island) and determine an approximate direction of ice flow for the glacier that deposited the Roanoke Point Moraine. In addition, by comparing the size and roundness of HB erratics to metamorphic erratics, we can determine if some of the HB erratics were derived from a more proximal extension of the Hartford Basin beneath Long Island Sound. In this study, we surveyed glacial erratics at eight localities along the Roanoke Point Moraine on the north shore of eastern Long Island to determine the size, roundness, and relative abundance of erratics derived from the Hartford Basin in Connecticut. Analysis of these data indicate a N-NW to S-SE direction of ice flow accompanied deposition of the Roanoke Point Moraine. Furthermore, we find no evidence in our data for an extension of the Hartford Basin south beneath Long Island Sound.



Figure 1. Geologic map of Connecticut and Long Island
 From “Geological Highway Map, Northeastern Region”, AAPG

Methods

Based on prior studies of the size and roundness distribution of glacial erratics relative to their source and of clast attrition in glaciers (Drake, 1972; Goldthwait, 1968; Pacholik and Hanson, 2001; Salonen, 1986, 1987) this study is predicated on the following assumptions:

1. Hartford Basin erratic boulders should be most numerous at the point along the north shore of Long Island that is closest to the southernmost extension of the Hartford Basin (the most proximal source of HB rock) along the bearing of glacial ice movement. This is because there is constant breakage and attrition of boulders in a glacier with increasing distance of transport, with few erratics surviving more than 21 miles of transport (Goldthwait, 1968).
2. The complete absence of HB erratics along a significant portion of the shoreline implies absence of an HB source to the north along the bearing of glacial ice movement.
3. Most erratic boulders deposited on the north shore of eastern Long Island were derived from the bedrock underlying Long Island Sound (Pacholik and Hanson, 2001).
4. If HB erratics were derived from bedrock exposures in Connecticut, a minimum of 20 miles / 32 km distance, then they should be rare, small, and more rounded relative to the population of non-HB erratic boulders.
5. Large, angular HB erratics would indicate a more proximal source of Hartford Basin rock beneath Long Island Sound.

Erratics were surveyed at eight localities along the beaches of the north shore of Long Island from Crane Neck Point north of Stony Brook east approximately 36 miles to Duck Pond Point on the north fork (Figure 2). The erratics are derived from erosion of the Roanoke Point Moraine, which is exposed in the cliffs along the shoreline.

At each locality a section of the shoreline encompassing a minimum of 50 boulders was surveyed. All HB erratics were identified by lithology (arkose, conglomerate, sandstone), measured (length, width, depth), and classified by roundness (0.1 to 0.9 using visual comparison to the scale from Krumbein, 1941). Along the same section of

shoreline the total number of all erratics was counted and the number of HB erratics was divided by the total number of erratics to obtain the percentage of HB erratics at the locality. Finally, a transect was chosen at random and a minimum of ten non-HB erratics were measured and classified by roundness for comparison. At two localities (Roanoke Landing and Hagerman Landing) most of the erratics on the beach were moved to build groins at the point of beach access. However, in both cases the boulders in the groins were similar in size, shape and lithology to the erratic boulders found on nearby beaches and appear to have been derived from the shoreline immediately adjacent to the groin.

Many erratic boulders surveyed were partially buried in sand and thus one dimension of the boulder could not be accurately measured. Therefore, in analyzing the data we derived a proxy measure for size by taking the two largest dimensions and multiplying them. Because most erratic boulders are approximately spherical (having similar dimensions of height, width, and depth) this area measure accurately represents the relative sizes of the boulders.

Results

Percentage of HB erratics by locality:

Percentages of HB erratics at each surveyed locality are shown in Figure 2. No HB erratics were found at the two localities west of longitude 73°. The maximum percentage of HB erratics found was 4.3% at Wildwood State Park. Localities near Wildwood had comparable numbers of HB erratics (3.3% at Hagerman Landing and 3.7% at Roanoke Landing) except for the Wading River locality, which did not have any HB erratics. Erratics are scarce on the beach at the Wading River locality and it is possible that many smaller boulders have been removed by property owners to clear the beach. We view the Wading River locality as an anomaly. Farther east the number of HB erratics drops to 1.3% at Pier Avenue and 2.1% at Duck Pond Point.

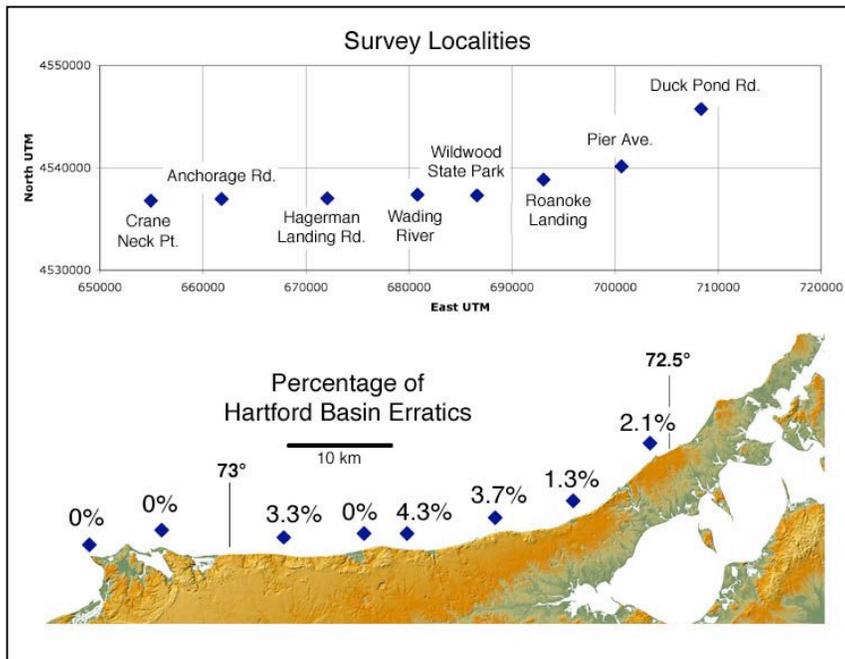


Figure 2. Survey localities and estimated percentage of HB erratics.

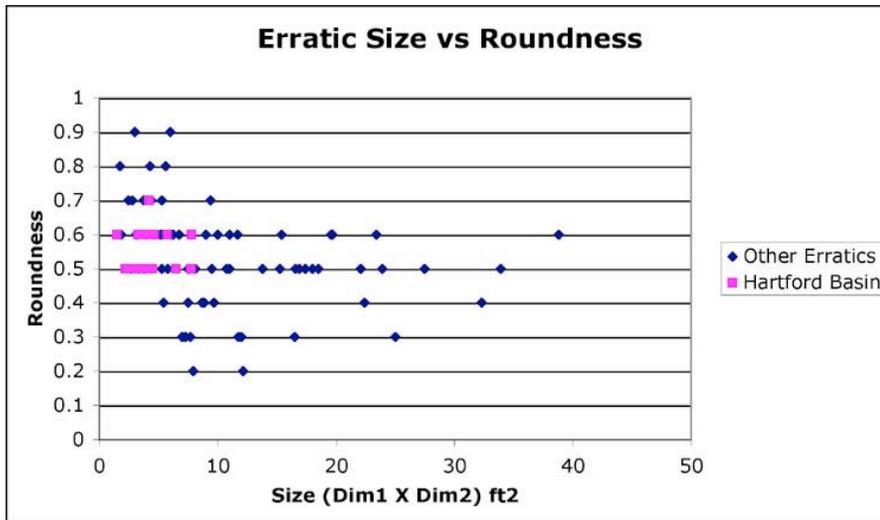


Figure 3. Graph of erratic size vs. roundness comparing HB and metamorphic erratics.

Size of HB erratics relative to metamorphic erratics:

Figure 3 is a plot of roundness vs. size for all erratics surveyed at all localities (18 HB boulders, 71 metamorphic boulders). HB erratics are all small relative to metamorphic erratics and all have a roundness of 0.5 or greater. A significant proportion of metamorphic erratics (24%) have roundness less than 0.5.

Interpretation

HB erratics on the eastern north shore of Long Island form a population of boulders that are small and more rounded relative to the larger population of metamorphic, non-HB erratics. HB erratics are also rare, composing between 0 and 4 percent of the total erratics at any locality. These observations indicate that HB erratics experienced a greater distance of transport than most other erratics and are consistent with a source area at the southern margin of the Hartford Basin, near the average survivable transport distance of 21 miles for glacial boulders (Goldthwait, 1968). The scarcity of HB erratics with roundness values greater than 0.6 reflects the tendency for boulders to maintain an equilibrium roundness near 0.5 while fracturing to smaller sizes (Pacholik and Hanson, 2001). Also, the tendency for sedimentary rock to fracture along bedding planes may prevent HB erratics from attaining high values of roundness at small sizes.

The maximum density of HB erratics on the eastern north shore of Long Island occurs between Hagerman Landing and Roanoke Landing, in the vicinity of Wildwood State Park (Figure 2). Connecting the boundaries of this section of the shoreline to the southern margin of the Hartford Basin near New Haven indicates a direction of transport and glacial ice flow from N-NW to S-SE, with a possible range of bearings between S 2° E and S 10° E. This flow direction is consistent with the NE-SW orientation of the Harbor Hills Moraine to the west. It has previously been suggested that the E-W orientation of the Roanoke Point Moraine argues for it having been deposited by a N-S advancing glacier at an earlier time than the more NE-SW trending Harbor Hills Moraine (Bennington, 2003). The results reported here do not corroborate this hypothesis, but instead indicate that both the Harbor Hill and Roanoke Point moraines were produced by

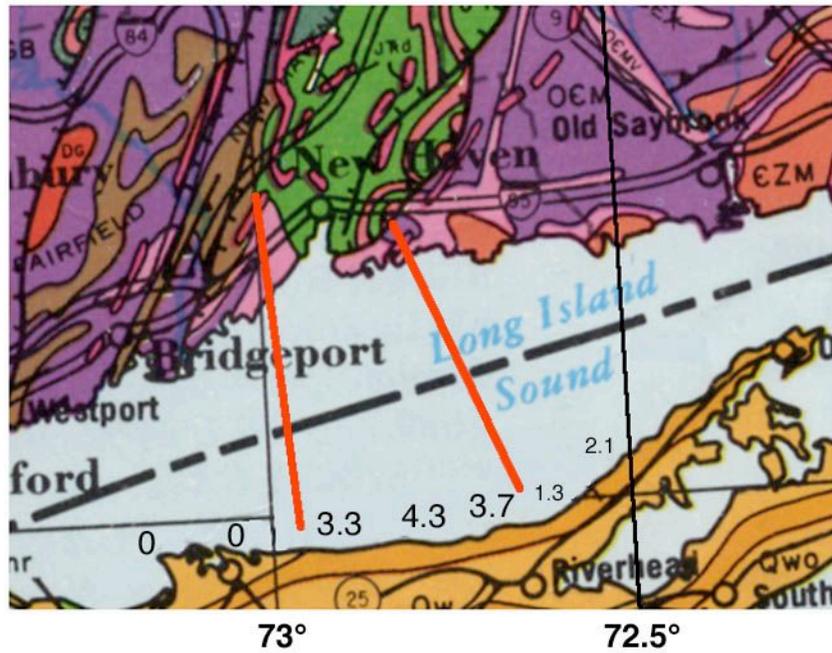


Figure 4. Geologic map of Connecticut and Long Island showing percentages of HB erratics found along the north shore of Long Island and inferred direction of transport and ice flow. Base map from “Geological Highway Map, Northeastern Region”, AAPG



Figure 5. Tectonic map of Connecticut showing inferred extension of Hartford Rift Basin southwestward beneath Long Island Sound. Black arrow indicates direction of ice flow across the basin extension toward the western end of the Roanoke Point Moraine. Base map from Rodgers (1985), figure modified from Pacholik and Hanson (2001).

SE flowing ice. The Roanoke Point Moraine appears to truncate or be truncated by the Harbor Hill Moraine in the vicinity of Crane Neck Point (Bennington 2003; See Figure 2). Thus, it may be the same age as the Harbor Hill Moraine or may be entirely older recessional moraine associated with the older and more southerly Ronkonkoma moraine which some have argued was derived from NW to SE flowing ice (Sanders and Merguerian 1998).

Seismic studies (Lewis and Stone, 1991) and a previous analysis of basaltic glacial erratics on the Stony Brook University campus (Pacholik and Hanson, 2001) suggest that an extension of the Hartford Basin may underlie Long Island Sound to the south-southwest (Figure 5). Our results contradict this hypothesis. A south-southwest extension of the Hartford Basin would bring HB lithologies much closer to the north shore of Long Island northwest of Stony Brook. If so, NW-SE ice flow should have deposited HB erratics along the shoreline west of 73° Longitude. However, we observed no HB erratics along extensive lengths of beach strewn with erratics at the Crane Neck and Anchorage Road localities (compare Figure 4 to Figure 5).

Acknowledgments

We thank Charles Merguerian and Christa Farmer for their helpful reviews of this work.

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