Geological Curiosities of the West Barnstable Conservation Area

by

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Introduction

The WBCA and adjacent public lands represent pristine glacial and fluvial geomorphic features formed more than fifteen thousand years ago, with very little cultural alteration or natural erosion or deposition since. Some of these features have received little or no attention in the geologic literature, in part because of the very subtle topography of the features and the wooded character of the area.

However, recent LiDAR surveys have revealed the topography as never before, since this technique can "see through" the trees and map the land surface with a sensitivity of 0.5 to 1.0 decimeters (2 to 4 inches). LiDAR is a portmanteau of "light" and "radar." Although people who have seen the imagery often think it is derived from satellite surveys, it is in fact obtained by aerial flyovers. Pulsed laser waves are sent to the land surface, and the received return waves are processed to produce very accurate maps. I have obtained the following three maps from the Massachusetts Geological Survey, which are quite large (90 by 130 centimeters, or 35 by 51 inches):

- hillshaded image at a scale of 1: 10,000, or 1 centimeter=100 meters
- hillshaded image at a scale of 1: 5,000, or 1 centimeter=50 meters
- slopeshaded image at a scale of 1: 5,000, or 1 centimeter=50 meters

The first image is useful for regional context of the WBCA and extends considerably into Sandwich as well as northward to the Great Marshes. I photographed portions of this image to obtain several of the figures that are appended to this report. The frontispiece of the appended figures is the first map in its entirety, which I framed and have hung in my home in France. I look at it often, as I get new ideas with nearly each new viewing.

The second map covers the entirety of WWBC with more detail, and is the basis for several of the appended figures. These two maps were the most useful for interpretations, but the third provided clearer images of certain linear ridges known as colluvial ramparts, and was used to showcase these features.

The interpretation of geologic features in the WBCA afforded by LiDAR should be of interest to the users of trails (some of which faithfully follow the features), as well as to amateur or professional geologists.

To keep this report brief and to the point, the focus of the following text is to explain the appended figures that provide an understanding of the geological curiosities of the WBCA as revealed by LiDAR. Also appended is an "About the Author" section, a brief résumé of my background in the Town of Barnstable, my experience as a geologist, and my interest in the Sandwich Moraine and associated deposits.

Several of the figures (6a&b, through 9a&b) are provided in a dual format, both with and without labelling of the features, since labels can at least partially obscure the underlying features. I have assumed that the reader will have a basic knowledge of Cape Cod geology. For broader context, I refer the reader to Robert N. (Bob) Oldale's excellent book, *Cape Cod and the Islands...THE GEOLOGIC STORY.* I have appended a brochure on the same topic, also by Bob Oldale, which should suffice for a general introduction to Cape Cod geology.

Explanation of the Figures

Figure 1, Geologic Map of Cape Cod

This figure shows the WBCA centrally located north of Mystic Lake, straddling the boundary of the Sandwich Moraine and the outwash plain to the south, based on mapping by Hartshorn, Koteff and Oldale as well as earlier mapping by Mather, Goldthwait and Theismeyer. Worth noting are that Hartshorn, Koteff, and Oldale were my mentors when I served as a geologic field assistant for the U.S. Geological Survey in the summer of 1966, and that I had obtained a report on the earlier mapping in 1964 (from Parnassus Book Service in Yarmouth Port).

Figure 2, Regional Features in and near the WBCA

This figure puts the Sandwich Moraine and the WBCA in a regional context including major ponds and marshes as well as cultural features that show up (Mid Cape Highway, Town Line with Sandwich).

Figure 3, Approximate Boundaries of the WBCA

These boundaries are very approximate, but provide a "window frame" for putting the WBCA in a broader topographic and geologic context (which the remaining figures will elucidate).

Figure 4, Geologic and Cultural Features in a Regional Context

This figure takes a closer look at some of the features that will be showcased in later figures.

Figure 5, Dominant Features in the Sandwich Moraine

The surface topography of the moraine is dominated by both wasting ice and active ice features. Models for the development of these features are presented in Figures 11a and 11b, respectively. The "possible lobate ice advance area" is located in the eastern portion of the WBCA and the adjacent Olde Fairgrounds Golf Course. This hypothesised readvance is based on both the LiDAR imagery and pre-construction geological investigations of the golf course. Detailed discussion of this possible readvance is beyond the scope of his report, but it is deserving of further study.

Figures 6a and 6b, Moraine Cut-through Valley Features

These figures show the major easterly and minor westerly (crossing the Barnstable/Sandwich line) valleys that were eroded through the higher ground of the moraine as the glacial ice was retreating, and small temporary lakes formed between the ice and the high ground of the moraine. I have not found anything about them in the geological literature. The topography of the valley floor in the easterly valley has a "washed-out" appearance, like the remains of a child's sand castles after the tide has washed over them. There must have been a considerable flow of water through these valleys as the small lakes were draining. These small lakes were much smaller and more short-lived than the Glacial Lake Cape Cod, which occupied what is now Cape Cod Bay. This large lake drained at a lower elevation, and on the floor of this lake layers of clay

formed—the clay used by the West Barnstable Brick Company.

Figures 7a and 7b, Multiple Stream Terraces and Clusters of Likely Munitions Craters

Figure 7a shows the multiple stream terraces originating from the westerly cut-through valley in more detail than previous figures (see also Figure 10 for a text book type diagram of multiple stream terraces). These terraces were cut when the glacial ice was melting rapidly, and consequently the water table was near the surface of the outwash. Currently the water table is 60 feet or more below the land surface, as indicated by the town water table elevation map. Thus these terraces are "fossil" features that do not indicate active flood plains. They have not been erased by recent erosion, nor have they been filled in by more recent sediment, but remain exactly as they were more than 15,000 years ago. As one walks southward from Popple Bottom Road along the Big Gear Trail, which follows he center of the valley, the terrace levels are expressed in a very subtle manner that would not normally be noticeable even to an experienced geologist. It is only because I had a version of Figure 7 with me at the time that I took notice of them. In fact, in looking at the valley on the LiDAR maps prior to going into the field, I thought the valley would be much deeper. This is the advantage of LiDAR, which picks up elevation changes at the decimeter level!

Also noted in this figure are clusters of likely impact craters with slightly raised rims. After initially wondering whether they could be meteor craters, based on their appearance, I noted something interesting in the *Images of America* series book titled *Marstons Mills.* The appended extract from this book mentions practice artillery fire in this area in the early 1900s. This seems like the most likely explanation for these round craters, which (like the stream terraces) are very subtle in the field and might escape detection unless one has the LiDAR imagery in hand and knows exactly where to look. Presumably the munitions exploded to form the craters, but the possibility of unexploded ordinance (UXO) cannot be excluded without further study. I have no expertise in this area, but this expertise should be available locally. These features are good examples of features that would go undetected without LiDAR. Or they could be assumed to be a result of tree uprooting during storms, though I very much doubt that this is the case, since they are clustered in certain areas that correspond to descriptions of events recorded in the Marstons Mills book. Page 97 of this book describes the National Guard "attacking" Pondsville from Sandwich, and later complaints by local

farmers that the soldiers had "wrecked their peach orchards."

Figure 8a and 8b, Colluvial Ramparts

This figure is intended to zero-in on one of the more interesting features revealed by the LiDAR imagery to the northeast and southwest of the Four Corners . *Colluvium* refers to unconsolidated material at the bottom of a slope or cliff, generally moved by gravity alone. In this case the "cliff" is the former wasting block of ice to the north of of what is now a a linear ridge similar to man-made ramparts constructed for military purposes. Figure 11a shows how these features develop in front of isolated masses of glacial ice that slowly waste away. One does not need to travel far from home to observe similar features on a much smaller scale in commercial parking lots in the late winter or early spring. In times of heavy seasonal snowfall (recent memory should suffice for that!), snow is dumped into gigantic piles that I like to call "parking lot glaciers." The snow in them is by no means clean, having incorporated sand from efforts to keep the roads and lanes open, plus whatever has been cast away by shoppers. The snow pile slowly melts and releases the debris contained within or on top of the ice, most of which ends up along the margins of the pile.

Figure 9a and 9b, Location of a Prominent Crater

This particular crater should be locatable with the distances indicated along Old Mill Road. The feature will not appear as deep in the field as it appears to be in the LiDAR image, bearing in mind that LiDAR reveals very subtle changes in elevation.

Figure 10, 3-D diagram of Multiple Stream Terraces

This diagram from *Wikipedia* is an excellent model to help visualise the formation of multiple stream terraces, as streams cut through soft sediments in response to lower base levels or falling water tables. In the case of the WBCA near the Sandwich line, the bedrock is well over a hundred feet deep and no stream presently exists in the center of the valley. However, as glacial ice was rapidly melting the scene was very different from what we observe today. The rate of ice front retreat may have been 50 meters (164 feet) per year on average, according to a major study of the formation of Cape Cod by scientists of the Woods Hole Oceanographic Institution. One must picture an

environment of "water, water everywhere" instead of the dry woodland environment in the area today.

Figure 11a and 11b, Models for Development of Moraine Features

Although the wasting ice features previously discussed and illustrated by Figure 11a are interesting, they are really just the icing on the cake, so to speak. The bulk of the Sandwich Moraine is generally thought to have been formed by the thrusting upwards of outwash sand and gravel deposits to form a linear belt of topography raised significantly above the main outwash plain to the south, as illustrated in Figure 11b. Some of these thrust ridges in the areas of the Sandwich Moraine dominated by active ice features (see Figure 5) provide good vantage points where even Martha's Vineyard and Nantucket can be seen (along the power line easement near the Sandwich line). Some trails follow these ridges, like the North Ridge Trail, for example. The highest point in the Town of Barnstable, at elevation 232 feet, lies along this trail.

Figure 12a and 12b, Regional and Localized Depiction of the Colluvial Rampart Hosting the Stonehenge Trail

The linear nature of the colluvial ramparts shows up much better with "slope-shading" version of LiDAR data processing. By contrast, the multiple stream terraces show up better with the "hill shaded" model, the basis for the previous figures.

Summary and Conclusion

The Sandwich Moraine and associated outwash plains to the south represent the bulk of the geologic framework of the Town of Barnstable. It is indeed fortunate that nearly two square miles of these features have been preserved within the WBCA. Glacial moraines of this type represent a relative standstill of the lobate margin of continental ice sheets—an important clue in establishing the history of ice advances and retreats. The WBCA is particularly suitable to showcase these relatively recent events in geologic history, owing to its location in a major vacation area within the Northeast Corridor. Given the pace of recent development in the area, the WBCA is to a large degree an island of remarkable glacial landforms with very little cultural alteration. The LiDAR data reveals more detail than previously available concerning landforms and implications for understanding local geologic history. This should be of interest to trail

users as well as students at local schools, colleges and universities.

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ABOUT THE AUTHOR

My career as a geologist had its beginnings in Barnstable Middle and High Schools in the late 1950s and early 1960s. Intrigued by the concept that Cape Cod is the product of great continental ice sheets, I began to read everything I could find on the subject. Fortunately, Parnassus Book Service of Yarmouth Port was able to meet my needs, and I still have some very informative publications that I obtained there.

Aided by what I could find in the literature, I began to explore exposures of glacial deposits. At times I was aided and accompanied by Loren Petry and Ransom Sommers of the Cape Cod Museum of Natural History as well as Ira Furlong of Bridgewater State College, now a state university. I took photographs, made sketches and began corresponding with scientists from Woods Hole and the U.S. Geological Survey, particularly with Clifford Kaye of the USGS. Ideas began to gel in my mind with the help and encouragement I got from these early mentors, and many of these ideas were useful to me in my professional career.

I studied geology at Western Reserve University and at the University of Massachusetts

in Amherst, where I completed a Master of Science degree in hydrogeology. My professional work has been mostly in water supply and ground water contamination investigations in Massachusetts and other New England States. Some of these investigations have been in the Town of Barnstable, including at the site of the Olde Fairgrounds Golf Course adjacent to the WBCA. Though currently retired and living in France, I maintain an interest in geology in general and glacial geology in particular. At various times in the past I have been certified as a professional geologist in Maine, Georgia, and Pennsylvania, and I am a Member Emeritus of the Association of Engineering Geologists.