Glaciotectonic Processes And Glacigenic Sediments On Eastern Long Island

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INTRODUCTION

Long Island Pleistocene geology is mainly composed of glacial and peri-glacial sediments. Many of these glacigenic sediments have undergone significant glaciotectonic deformation. There are a small number of published sedimentological/facies studies on outcroping strata examined on Long Island revealing that glaciotectonic deformation of these sediments occurs not only after deposition but syntectonically as well. Syntectonic deformation is likely due to sediment proximity to actively moving glacial lobes. Constructing stratigraphic columns and eventually geologic cross sections in glaciotectonic regions on Long Island is important because these data can help us improve our understanding of Long Island's surface geomorphology and near surface hydrology. Combining aerial photomosaics, measured sections, and geophysical information aids in the development of depositional and glaciotectonic models intended to unravel complex glacial sedimentary, stratigraphic, and structural relationships.

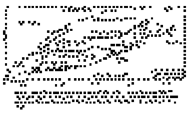


Fig. 1 Click on thumbnail image to get larger image.

Since many outcrops on Long Island are transitory it is important to examine them in detail before they disappear. Current studies of Long Island's glacial geology compared with previous studies may help to differentiate the fundamental mechanisms responsible for variation in both glacial stratigraphy and styles of glaciotectonic deformation. The goal of this study is to examine Hither Hills of eastern Long Island (Figure 1) by stratigraphic column and aerial imagery. This is done in order to accurately interpret and evaluate the glacial sedimentary facies, stratigraphy, large and small-scale glaciotectonic deformation, and to determine the utility of conducting future shallow surface geophysical surveys of the region.

HITHER HILLS: WELL ORGANIZED DESPITE THE MESS

Hither Hills is on the south fork of Long Island approximately twelve kilometers west of Montauk Point. The study area includes Hither Hills State Park and other hills that provide a unique environment for examining visible glaciotectonic processes and glacigenic sediments. The hills forming the topography at Hither Hills are extremely well organized. Generally, the hills have amplitudes of approximately 10-15m and spacings of about 90m. As a series of ridges these hills trend, on average, northeast - southwest, in orderly series of antiforms. The stratigraphic and structural features found at Hither Hills are highly complex. Through numerous field trips during the summer of 1998, we found appreciable evidence of structural deformation exposed in a sea cliff along the region's northern coast (Figure 2). This photomosaic depicts folding in beds of very poorly sorted, unconsolidated sands and gravels. Since the region is a relatively recent glacial formation, the structural features in the glaciotectonic areas are believed to coincide closely with topography. The locations of three stratigraphic columns shown on a small-scale topographic map indicate where sedimentary facies were measured in the sea cliffs along the northeast coast of the region (Figure 3).

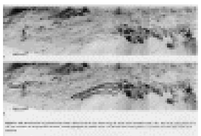
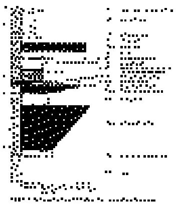


Fig. 2


Fig. 3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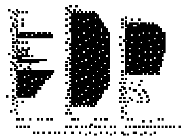
Fig. 5

We found numerous complicated small folds along the entire north coast of Hither Hills. A small anticline superimposed with centimeter to meter scale size folding and faulting within the structural core became the subject for a detailed stratigraphic column (Figure 4). The facies recorded in the sea cliff contain glacigenic sediments including glacial diamicts and a 10cm thick folded clay layer. Glacial diamicts exist in at least two distinct stratigraphic units within the sea cliff. The lower diamict unit forms the base of a weak hill structure and appears to be intensely folded and severely deformed. The upper diamict unit caps the lower glaciated stratigraphy. Diamicts are a broad mix of particle sizes ranging from mud to boulder all incorporated into a poorly sorted matrix. Diamict deposition found at Hither Hills can provide important clues for interpreting glacigenic deposition and glaciotectonic processes. The diamict unit at the base of the sea cliff appears to be a subglacial basal till deposit. The remainder of the stratigraphic layers and the hill formations themselves appear to be the result of proglacial deformation with subglacial deformation only occurring very early in the depositional history of the area.

Initially, we speculated that the large multi-hill thrusted structures found at Hither Hills formed within small-scale thin-skinned fold-and-thrust belts, pushed by the glacier. This type of proglacial deformation can result in the formation of large thrust moraine complexes like those seen in Hither Hills. In this small-scale thin-skinned fold-and-thrust belt scenario, the stratigraphy found in each hill set should be similar from hill to hill, but we find consistently that this is not the case.

Two nearby stratigraphic columns (at 'Rocky Point' and 'the dominant hill structure' in Figure 3) record substantial lateral variation in the thickness and arrangement of sedimentary facies, suggesting episodes of significant syntectonic deposition during active glaciotectonic periods (Figure 5). One hundred meters to the southeast of the small anticline, at 'Rocky Point' (Figure 5b), the diamict appear three times thicker than the diamict recorded at the small anticline (Figure 5a). The stratigraphic column measured at the dominant hill (Figure 5c) of the region just another one hundred and thirty meters to the southeast of 'Rocky Point", exhibits a thick gravel and sand layer beneath the lower diamict unit. The diamict deposit in the lower unit is roughly twice as thick as the diamicts recorded at the small anticline. These lateral variations in the stratigraphy over distances on the order of tens of meters suggest separate glacial advances, probably seasonal, rather than one prolonged glacial advance.

SIMPLIFIED HILL FORMS MODELS FOR GLACIOTECTONIC REGIONS

There are two simple ways to make glaciotectonic hill forms. One is the small-scale fold-and-thrust belt schematically illustrated as a glacial lobe steadily advancing much like an oversized bulldozer blade pushing through loose sediments (Figure 6). The largest hill of the hills forms first and is most proximal to the glacial lobe. Each subsequent hill is more distal to the glacial lobe and forms later in time than the each previously formed hill. Eventually the cross-sectional shape approaches a critical taper.


Fig. 6

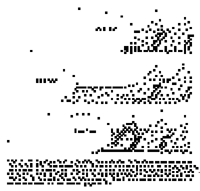
Fig. 7

Annual push moraines, according to [Aber, et al., 1989] and [Boulton, 1986] are also suspected to be play a large role in hill formations in many glaciotectonic regions (Figure 7). Annual pushes or surges of the icesheet provide the stress necessary to shorten or extend nearby landforms and allow for substantial variation in depositional environments. The 10cm thick folded layer recorded in the stratigraphic column of the small anticline probably formed during glacial lobe retreat. A nearby hill probably acted as a barrier to melt water allowing a shallow lake to form.

DISCUSION

Since the present day topography of Hither Hills was likely created by an annual (or, at least, semi-periodic) push in the Pleistocene, this area might be analogous to Iceland's modern glacial environment. In Iceland, hill structures were made by the Breidamerkurjokull ice sheet and were recorded earlier this century by Boulton. The smaller Icelandic structures are similar to the structures found at Hither Hills. A productive way to examine the jumbled glacial sediments and glaciotectonic process at Hither Hills incorporates stratigraphic and structural analysis of the region by a variety of geophysical methods. For instance, shallow surface seismic reflection and refraction surveys could image folds and faults along with major sedimentary facies changes above and below clay layering. Ground penetrating radar can image the top surface of a folding clay layer along with the sediments above that layer. In addition, ground penetrating radar can image sediments down to the water table in areas of Hither Hills where there are no clay layers present.

SUMMARY AND CONCLUSION

In the Hither Hills region of eastern Long Island, we found numerous complicated small folds among the exposed sea cliffs along the northern coast of the area. A small anticline became the initial focus a detailed stratigraphic column. We found that a thick diamict unit at the base of the sea cliff appears to be a subglacial basal till deposit whereas the other stratigraphic layers and the hill formations themselves appear to be the result of proglacial processes. Subglacial deformation only occurred very early in the depositional history of the area. Nearby stratigraphic columns record the substantial lateral variation in the thickness and arrangement of sedimentary facies suggesting syntectonic deposition during seasonal glacial advances rather than a prolonged glacial advance. Two obvious ways to make glaciotectonic hills are by small-scale fold-and-thrust belt and by the repeated push of a cyclically advancing glacier during a period of overall retreat. The Hither Hills terrain appears to have been formed by the latter mechanism, as are the hills in some of Iceland's modern glacial environments. Hither Hills stratigraphy and glaciotectonic formations need to be further explored using a variety of geophysical methods.

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