Subglacial Tectonics and Tunnel Valley at Hither Hills: Evidence from GPR Studies

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Introduction

Ground-penetrating radar (GPR) studies are being conducted at Hither Hills State Park, in Montauk, to determine the origin of the features located in the area. The area consists of a series of regularly spaced and linear hills, about 20 meters in height, trending in an ENE-WSW direction. The features in the area are ocnsistent with warm-based glacial dynamics, with most of the deformation occurring within the first few hundred meters of the glacier. The area also has a unique large valley running through the park which appears to be connected to a larger dendritic pattern of valleys. This network is believed to be the remnants of a tunnel valley. Our radar surveys have shown complex folding beneath the surface, but we have been able to image a strong, continuous deep reflector throughout the study area. The prime focus of my studies is the tunnel valley feature and a smaller branch within the dendritic network

Background

The basis of my studies was an extension of the surveys done by Kurt T. Goetz as part of his MS Thesis at Stony Brook University. The major component of the thesis was a series of GPR studies along the north-trending Power Line Cut (PLC). His studies revealed complicated folding below the hills, though structures are often hard to distinguish because of the poorly stratified nature of the sediments that compose them. The folds visible on the radargrams are complex in nature and are not always present as continuous reflectors. An interesting feature found throughout the transect is the presence of a remarkably continuous deep reflector. This deep reflective zone (DRZ) is found as a strong, discontinuous reflective area no more than one to two meters thick throughout the over 1.6 km length of his 50 MHz (low radar frequency) transect. The most notable feature of the DRZ is that it appears to be very flat in comparison to the overlying topography. The geophysical studies combined with later photographic evidence have found that the DRZ appears to be at or below a “decollement” feature that provided a detachment surface for the glaciotectonic folding. His transect cuts across the main conduit of the tunnel valley, as well as several smaller branches off of it. These features are part of a fluvial network which today appears to drain to the northwest. The transect has several smaller branches, some of which appear to include several meters of fill. The thickness of the fill is far too great to have been from post-glacial processes, because the branches are not draining a large enough area to produce this volume of sediment. The more likely explanation, described below, is that the fill is from an area that is not in the plane of the cross-section, and dating from its time as an active subglacial feature, rather than post-glacial subaerial processes.

Study Area

The study area is part of a dendritic network which includes both the tunnel valley along with several sediment-clogged branches off of it. Surveys concentrated in the tunnel valley and one particular valley, ~750 meters into the transect, in which the sediment fill was very thick (~8m). It was found that the tunnel valley was essentially denuded of sediment, leaing us to conclude that this was a high energy area of the subglacial fluvial system - either depositionally neutral or dominated by erosional processes. GPR surveys were conducted using 50 MHz (lower resolution, deep penetration) and 200 MHz (higher resolution, shallow penetration) antennae. Due to the low altitude of the base of the tunnel valley, this area provided the best window with which to image the reflector utilizing a higher resolution antenna. The earlier 50 MHz studies had imaged the DRZ as a single stratigraphic layer. The higher-resolution 200 MHz antennae showed the layer as a more complex and less distinct reflector. By utilizing different frequencies it was possible to place bounds on the sizes of the sediments composing the DRZ, indicating that it consists of a series of closely-spaced cobble-sized reflectors. The DRZ exposed at the shoreline to the north of the transect, where it appears as a relatively flat layer composed of cobbles of sized consistent with the inferences made on the basis of the GPR data. High frequency (high resolution) 3-D GPR imaging on a clogged branch of the tunnel valley (~750m) was performed to assess the nature of that low depositional (and, presumably, low energy) zone.

Conclusion

The presence of the tunnel valley confirms suspicions that the genesis of the area was not pro-glacial, but rather frontal proximal (first several 100m). The tunnel valley also reveals that the Hither Hills were created by a warm-based glacier in a period of overall retreat. Aerial photos combined with the GPR imaging and topography suggests that the tunnel valley drained to the southeast. The topography to the southeast is subdued and it has also been found that the fingers of the network are clogged in that area. In addition, the GPR imaging of the DRZ and its subsequent correlation with the exposure at the north shore have contributed to a new history of the Hither Hills. The DRZ provided a “decollement” for what is considered the Hither Hills. Furthermore, the surface exposure reveals that the DRZ truncated glaciotectonic folding which occurred prior to the Hither Hills event. The folds exposed along the north shore of the Hither Hills area, therefore, resulted from a glacial folding event that preceded the one responsible for the prominent series of folded hills that make up Hither Hills Park.