Geophysical Investigation of a 19th Century Archeological Site, Boston College
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ABSTRACT

In 1998, Timelines, Inc. contracted with Hager GeoScience, Inc. of Waltham, Massachusetts to perform a geophysical investigation at the Hammond Street House on the Boston College campus in Chestnut Hill, Massachusetts. The survey was performed in support of Timelines’ archaeological investigation of the site prior to construction of a new building by Boston College. At the time of the survey, the property consisted of a large, undeveloped area containing lawn, scattered bushes, and a section of large evergreens. Plans obtained by Timelines indicated that this area was occupied during the 19th century by a number of structures – including one house, a barn, and a blacksmith shop. Shallow test pits over an area 120 by 70 meters in size had unearthed pottery shards and portions of rock walls related to these former structures. The objectives of the geophysical survey were twofold: 1) locate additional buried structures for further excavation, and 2) help Timelines produce a map showing the distribution of buried features. Geophysical data were acquired along the grid established by Timelines using a GSSI GEM multi-frequency terrain conductivity profiler and SIR System 2 ground penetrating radar system. The survey located a number of buried features, including piping, cisterns, and walls. The project provided HGI with the opportunity to study the response of electromagnetic signals to buried archaeological features, and to
INTRODUCTION

During late 1998, Hager GeoScience, Inc. (HGI) performed a geophysical survey at Boston College in Chestnut Hill, Massachusetts. The work was performed for Timelines, Inc., in support of Timelines’ archaeological study of the site prior to construction of a new office building. The main objective of the survey was to locate buried remnants of 19th Century structures and related features (foundations, walls, privies) in and around the proposed building footprint. A secondary objective was to accurately distinguish between nonmetallic manmade and natural subsurface features. The product of the geophysical survey was to be a plot showing the relative positions of old foundations and privies on Timelines’ base plan.

METHODS

The archaeological field area on the Boston College campus was surveyed using a combination of electromagnetic (EM) terrain conductivity and ground penetrating radar (GPR) techniques. HGI grid geometry was referenced to the Timelines test pit locations, which were on 5-meter centers. The 2-meter spacing of EM and GPR traverses was chosen to delineate relatively small subsurface features. Traverses were made in both the north-south and east-west direction.

Electromagnetic Terrain Conductivity

The EM survey was performed using a Geophysical Survey Systems, Inc. GEM-300 multi-frequency electromagnetic profiler. The GEM-300 is a handheld electromagnetic induction-type instrument that measures...
in-phase and quadrature-phase terrain conductivity without electrodes or
direct soil contact. The GEM sensor contains a transmitter and receiver
coil separated by about 5.5 feet, along with a third “bucking coil” that
removes the primary field from the receiver coil. All coils are molded
into a single board in a fixed geometry.

The GEM-300 can collect multi-frequency data between 90 Hz and
22000 Hz continuously at a walking pace. At this site data were
collected at frequencies of 13350, 15990, and 19230 Hz. Frequencies at
the high end of the range were selected in order to focus on shallow
targets. This choice was based on artifacts recovered from Timelines’
test pits, which were excavated to a depth of approximately 2 feet. All
data were simultaneously recorded to memory within the EM system
and subsequently downloaded to a PC and processed. Surfer for
Windows® software was used to create filled color contour plots of EM
values.

Ground Penetrating Radar

GPR data were collected using a Geophysical Survey Systems Inc. SIR2
ground penetrating radar system. Since our depth of interest was 10 feet
or less, we used an antenna with a center frequency of 400 MHz, which
has a maximum penetration depth range of approximately 15-20 feet.
GPR data were collected in survey wheel mode. Data were displayed in
real time on a computer monitor and simultaneously recorded on a hard
drive for later processing and interpretation using RADAN for
Windows® software. Figure 1 shows our survey grid in relation to the
locations of 19th Century structures formerly present at the site. It is
important to note that the structures were not all present at the same
time, since they reflect different phases of construction.
Figure 1. Survey grid shown in relation to structures formerly at the site.

Existing buildings outside of survey area are also shown

**SURVEY RESULTS**

**EM Terrain Conductivity**

The results of the EM survey, presented in Figures 2 and 3, are filled color contour plots showing relative EM values in parts per million (ppm) across the survey area at two different frequencies. Contour parameters were chosen to enhance subtle conductivity variations within the survey area because the difference in conductivity between manmade
targets and natural buried features was quite small. Using this approach, we located a number of potential targets that were subsequently related to buried archaeological objects. Figure 2, an EM contour plot of in-phase values collected using a frequency of 13350 Hz, shows multiple targets located within the survey area. Figure 3, a plot of quadrature-phase data collected using a frequency of 19230 Hz, emphasizes more shallow features. Noticeable in the quadrature-phase data is an area of anomalous values in the western portion of the grid that appears to be caused by the main house foundation (Figure 1). The large zone of negative values in the southern portion of the survey area is probably related to variations in conductivity of different soil types.

Figure 2. Filled contour plot of in-phase EM data collected at 13350 Hz. (Values in ppm.)
Figure 3. Filled contour plot of quadrature-phase EM data collected at 19230 Hz. (Values in ppm.)

Ground Penetrating Radar

Ground penetrating radar data were used to refine the EM interpretation and identify the sources of EM anomalies. There was generally good correlation between GPR and EM targets, although the GPR method was better able to detect shallow fieldstone walls, pipes, and foundations. Figure 4 is an example of a radar record from a traverse across the foundation of the main house in the northwest part of the survey area. The GPR record supports historical data that the main house contained a basement, which is visible in the left side of Figure 4. The basement may also be present on the right side, but if so, it appears to have been filled with debris.
Figure 4. Radar record showing a portion of a traverse over the main building foundation

ADDITIONAL INTERPRETATION

Interpretation of the geophysical data helped the client select areas for additional test pits and trenches. A subsequent site visit after removal of the upper several feet of soil cover allowed us the rare opportunity to examine our interpretation maps in light of actual features. Figure 5 shows a radar record from an area that was highlighted by HGI for further investigation, along with the corresponding feature that was subsequently excavated. The feature in Figure 5 was found to be a beehive-shaped cistern interpreted by Timelines as part of a complex hydrologic system used to supply water to a large garden east of the main house. Figure 6 is a combined EM and GPR interpretation map showing the locations of targets highlighted by HGI. Notable features within Figure 6 include pipes and foundations related to the main house.
Figure 5. Top: Radar record showing cistern and clay pipe. Bottom: Photograph showing cistern and pipe
CONCLUSIONS

The results of the geophysical survey at Boston College demonstrate the usefulness of multiple geophysical techniques—in this case, EM and GPR—at archaeological sites in New England. A number of buried targets, including foundations, walls, clay piping, and brick cisterns, were detected. However, the results also show that, in the absence of additional information from such sources as test pits or trenches, it may be difficult to identify the feature producing an electromagnetic anomaly and distinguish it from natural materials with similar electromagnetic properties. At this site the combination of multiple geophysical techniques with other sources of information such as geological and
historical data, test pits, and client feedback after excavation all helped refine the geophysical data interpretation.

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