Using Ground Penetrating Radar to Locate Historical Graves in Western New York

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Abstract

Ground penetrating radar (GPR) is a very useful geophysical tool for the detection of subsurface layers and structures. Because of the non-invasive nature of GPR, it was used here in two public outreach projects undertaken by the SUNY Buffalo State Archaeological Field School and members of the Earth Sciences and Science Education department in summer 2012. The first project aided the Ellicottville Town Historical Society in an exploration of the Jefferson St. Cemetery in Ellicottville, NY. Although detection of old graves is difficult, GPR data revealed several dozen graves, both marked and unmarked. The second project aided People, Inc., the leading non-profit human services agency in Western New York, in their effort to restore the Niagara County Almshouse Cemetery in Lockport, NY. The results of the projects are being used to erect central markers to memorialize unmarked burials at each cemetery and to restore the boundary of the Almshouse Cemetery.

Introduction

Forensic geophysics is a science which uses geophysical methods in crime investigation and anthropological application. Ground penetrating radar (GPR) is one of the most used methods, because it allows for relatively quick data collection and provides good accuracy, both of which are very useful for locating pipes, burials, drums and other objects (Dupras et al., 2006, Conyers, L. B., 1997 and Borges, W. R., 2007).

Similar to seismic reflection, GPR is based on wave reflection, but in this case they are electromagnetic waves. Those reflections are caused by contrasts in the physical properties of the media, such as electrical conductivity, dielectric permittivity and magnetic permeability.

Although very precise, this technique is best used on a local scale, especially when using antennas with relatively high frequency, since the higher the frequency, the lower the radar's penetration.

This paper is divided into two parts. The first part of the study occurred at Jefferson St. Cemetery, focusing on finding unmarked graves. The second part took place at Niagara County Almshouse Cemetery, with the purpose of identifying the cemetery's boundaries and if possible, map burials within the site.

Methodology

The projects discussed in this paper took place near Buffalo, the second most populous city in the state of New York. The city is located on the border between the U.S. and Canada, as shown in Figure 1.

The transects along which GPR data were collected were determined based on existing grave markers (Jefferson St. Cemetery) and the location of a stone wall (Niagara County Almshouse Cemetery). Archaeological Field School students laid out and measured the transects and recorded other information such as locations of existing markers. Most GPR data were collected at 400 MHz using a GSSI SIR-3000 system (Figure 2), and some data were collected at 200 MHz. Data were collected in both directions along each transect and at two different depths. Although initial data interpretation was performed on-site, more in depth analysis was completed in the weeks following data collection.

Figure 1: Location of Buffalo, NY, on U.S. map.

Results

Although concrete burial vaults are easily identified in GPR data, older burials are more difficult to locate. They can be detected in GPR data as areas of disturbed ground and/or as a reflection that may be caused by the flat bottom of the original grave.

The data transect in Figure 5A shows two old burials that appear as hyperbolic shapes (yellow boxes). The data transect in Figure 5B shows other old burials in addition to other reflections that are interpreted to be boulders (red boxes).

Jefferson St Cemetery, Ellicottville, New York (in use 1830-2005):

Buffalo State was first contacted by Project Manager Gail Carucci about restoration of the Jefferson St. Cemetery in Ellicottville, NY, in September 2011. Ms. Carucci and Town Historian Mary Elizabeth Dunbar, in addition to many volunteers, had been working for over a year at that point to complete an inventory of existing headstones, to restore the cemetery through the cleaning and righting of

the existing headstones, compiling genealogical histories of the represented individuals and to apply for status to the National Historic Register. Several challenges to the project included a loss of town records pertaining to the cemetery in a fire and damage to the existing headstones through the effects of time and weather. Ms. Carucci and Ms. Dunbar have been able to piece together a list of at least an additional 16 individuals for which family stories, newspaper articles and/or obituaries state that they are buried in the cemetery though they do not appear in the existing headstone inventory. Buffalo State was asked to assist in locating any unmarked graves within the boundaries of the existing cemetery through use of ground penetrating radar.

Small groups of Buffalo State Archaeological Field School students set up fifteen transect lines to help have a unified search area and guide for the GPR project. Each transect line consisted of nonreactive measuring tapes and flags placed at predetermined distances, along which the GPR antenna could be moved. Each transect line crossed a portion of the cemetery that seemed to be partially open space, in an effort to identify as many unmarked graves as possible. Existing headstone locations were recorded from their midpoints so that the GPR data could be reconciled with the transect line locations.

Figure 2: Data acquisition at the Jefferson St Cemetery.

Data from the Jefferson St. Cemetery were used to identify 39 unmarked burials. Another 15 burials were also identified that are associated with markers. In Figures 6 and 7, possible burials are highlighted with yellow boxes. These burials were identified by observing disturbance and hyperbola -like reflections. Also, the depths of the reflections were crucial for determining whether they were due to boulders or possible graves. Because the GPR data did not detect burials for all of the marked graves, it is likely that some unmarked burials were also not detected.

Results from the GPR analysis were used to compare identified burials to existing markers. The inset for the cemetery map in Figure 3 shows this comparison for four of the transects. Open squares show markers where no burial was observed in the GPR data, filled squares are markers with a corresponding burial in the GPR data, and the filled circles show burials identified in GPR data that do not have corresponding markers.

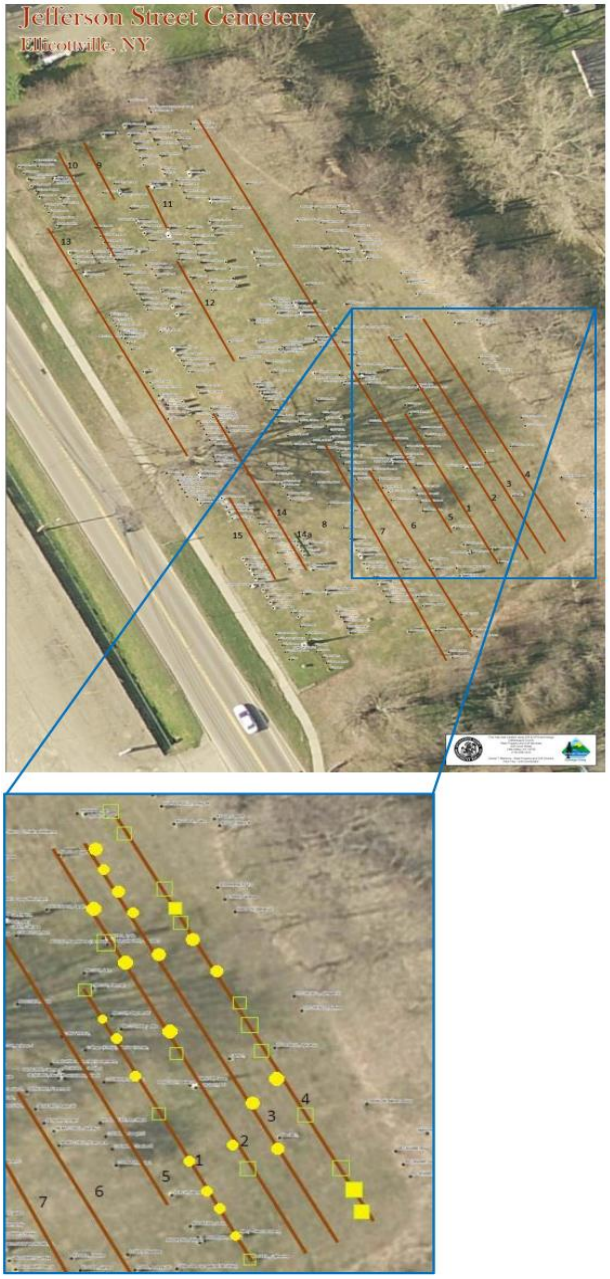

Figure 3: Transects acquired at the Jefferson St. Cemetery. Filled box: Marker with corresponding burial in data. Empty box: No match between data and marker. Circle: Burial found in data with no marker on site.

Niagara County Almshouse Cemetery, Lockport, New York (in use 1830-1916):

Buffalo State was first contact by Project Manager David Mack Hardiman of People Inc. in May of 2012. People Inc. has been engaged in an effort to restore the resting places of persons such as those served by their agency today: The elderly, the poor, the disabled and/or the mentally ill. To date, People Inc. has been successful in restoring/honoring the deceased at four Western New York cemeteries, including at the cemetery associated with the Niagara County Almshouse.

Buffalo State was asked to identify and clarify the boundaries of the cemetery and to identify individual graves within these boundaries if possible, using GPR. Unfortunately, several challenges to the project existed from the poorly recorded original location of the cemetery to the nearly hundred-years' worth of overgrown vegetation. A major factor in the identification of individual graves was the tiered burial system in practice at the cemetery while it was in use. There were at least four tiers of burials in many of the burial shafts at the site. Buffalo State Archaeological Field School students, assisted by two students from the Earth Sciences and Science Education department, set up four initial transects at the site, in a somewhat 'open' area in the Northeast quadrant. After further clearing by the county and Calamar Construction, an additional seven transects were laid out: Five in the Southeastern quadrant, one each in the North-central and West by Northwest areas. The majority of transects ran perpendicularly to the 'known' stone walls marking this area in an effort to delineate the boundary of the cemetery itself.

GPR data collected at the Niagara County Almshouse Cemetery were collected along the red lines in Figure 4. Figures 8 and 9 show two lines acquired on site. Although almost all of the headstones were missing at this site, Figure 8 shows two reflections under a remaining headstone . In Figure 9, evidence of possible graves (yellow boxes) was also observed. The vertical yellow line was placed where there is a slight change in the pattern observed in data. The green arrows in the Figure 4 show the interpreted extent of the cemetery. The yellow arrows identify locations of reflections in the GPR data that could be burials outside of the stone wall boundary, but the reflections could also be due to boulders in the subsurface.

Conclusions

GPR has been used in many forensic applications such as criminal investigation and archeology/anthropology. With the collected data from the Jefferson St Cemetery, several possible burials were identified where there are currently no markers. However, there were only 15 matches between data and headstones, meaning possible existence of more unidentified burials.

At the Almshouse cemetery, GPR data was used to delineate the borders of the cemetery. In addition, three possible burials were found outside the edge of the cemetery.

These results endorse GPR as a great method for such forensic applications. For further studies, it is recommended to collect 3D data for better identification of possible burials.

Acknowledgments

The 2012 Buffalo State Archaeological Field School Students, Megan Spencer (ESSE student), Ellicottville Town Historian Mary Elizabeth Dunbar and Jefferson St. Project Manager Gail Carucci, People, Inc., especially Dr. Jim Boles and David MackHardiman, Nicole Forgione, Nancy Palumbo.

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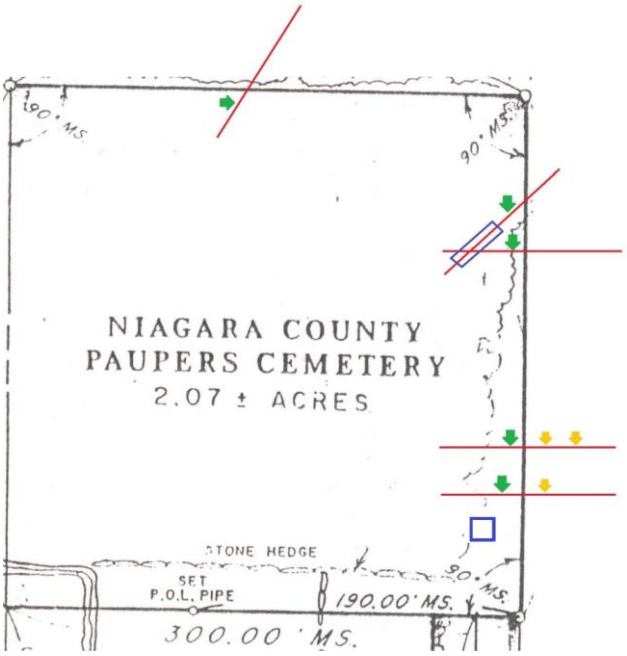

Figure 4: Cemetery map. GPR data collected along red lines. Green arrows represent the edge of the cemetery (stone wall). Yellow arrows correspond to possible burials outside stone wall. Blue square. Area with three headstones found at the cemetery.

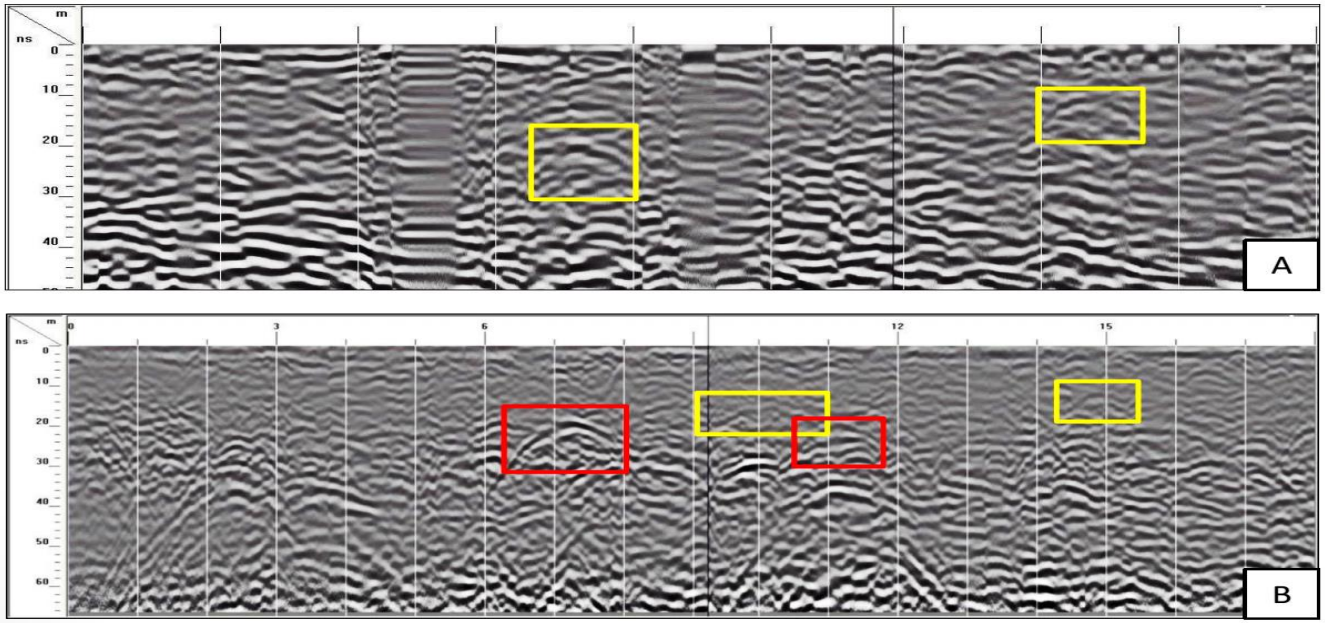

Figure 5: Interpretation of two transects from the Jefferson St. Cemetery. The yellow boxes correspond to burials and red boxes were interpreted as boulders.

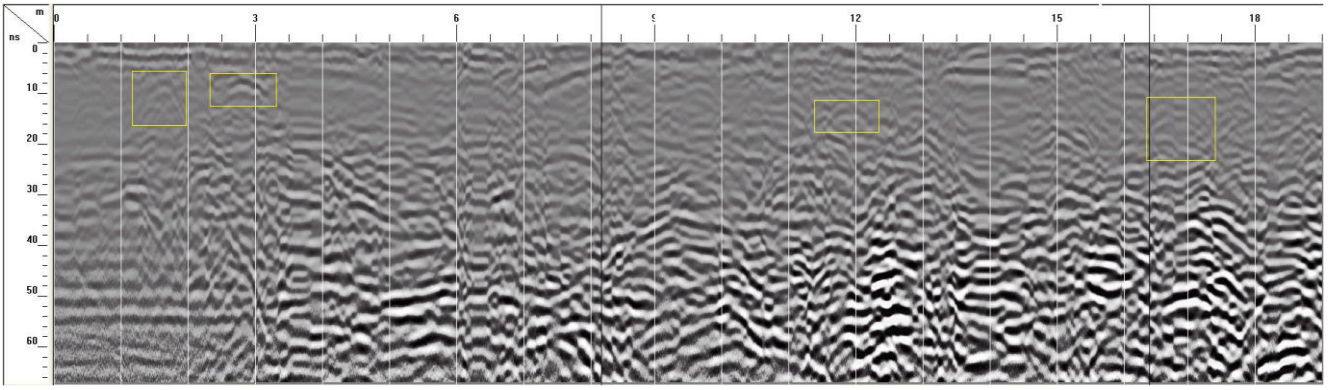

Figure 6: Transect acquired at Jefferson St. Cemetery with four possible burials highlighted by yellow boxes.

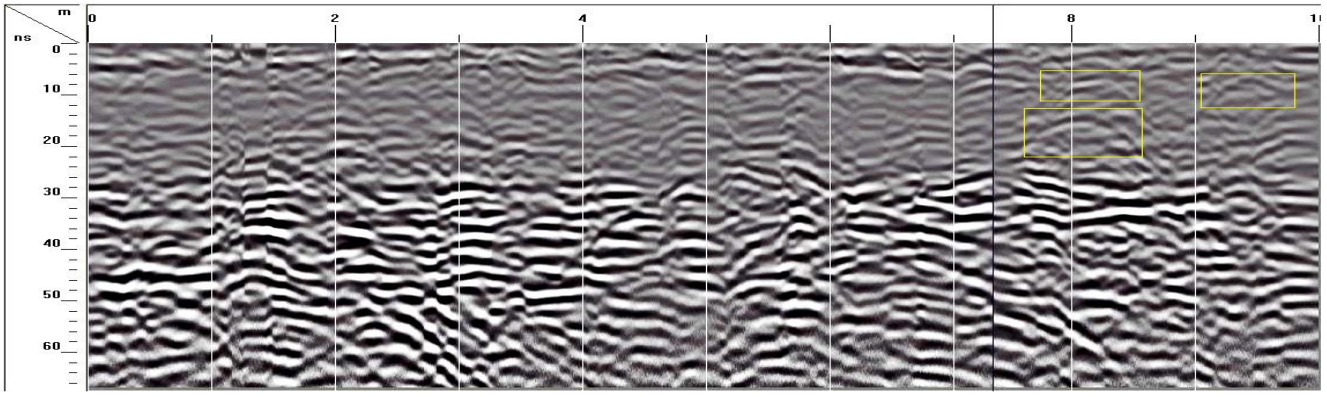

Figure 7: Transect acquired at Jefferson St. Cemetery with three possible burials highlighted by yellow boxes.

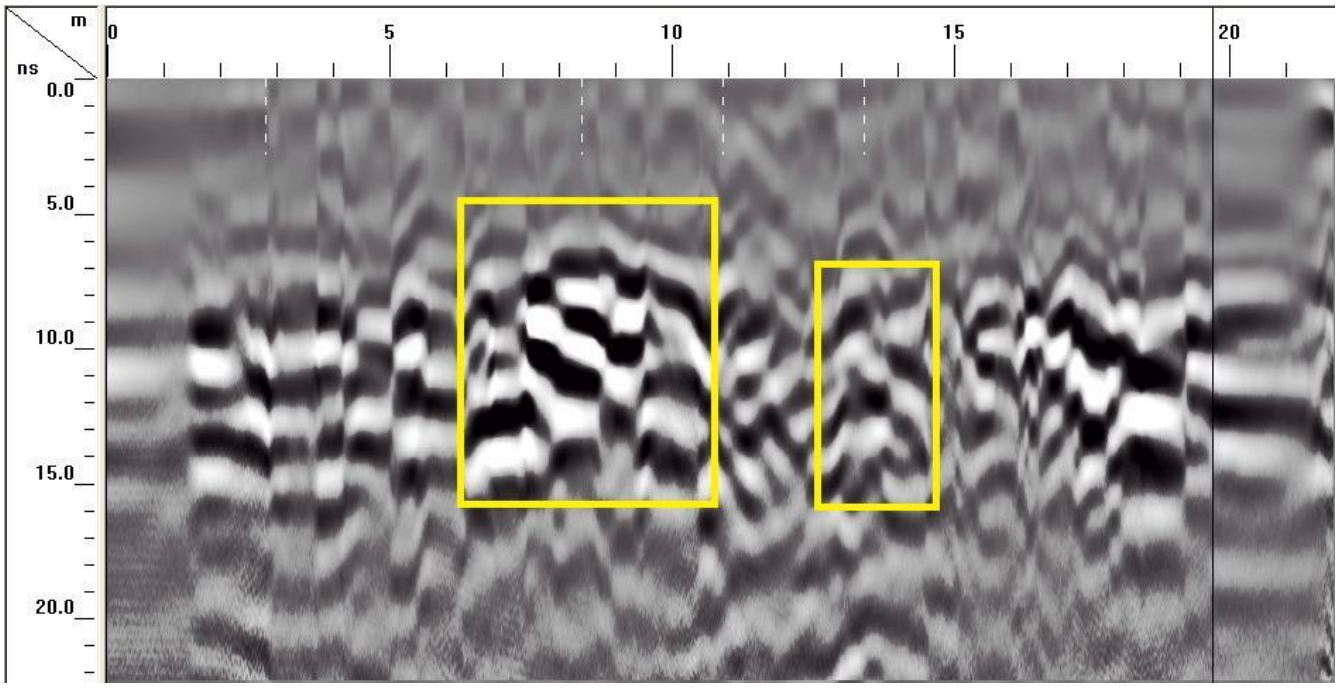

Figure 8: Transect acquired at Lockport Cemetery showing two reflections under the headstones located on site.

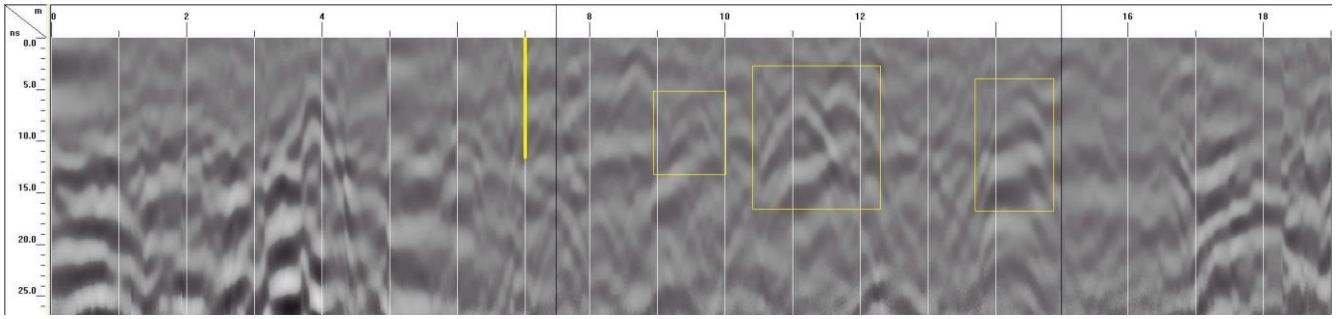

Figure 9: Transect acquired at Lockport Cemetery with three possible burials highlighted by yellow boxes. The yellow line represents the edge of the cemetery.