Locating Buried Canine Remains Using Ground Penetrating Radar

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Abstract

Ground penetrating radar (GPR) is a valuable geophysical tool to assist in the search for buried targets, including clandestine graves. Its use in forensic investigations has been limited due to a misconception of its capabilities and a lack of understanding of the limitations associated with its use. This case report details the application of GPR for locating buried canine remains at the request of the Ontario Provincial Police (OPP) in Canada. The canine was a police dog killed in the line of duty in 1975. His remains had been buried in a casket with concrete poured over the top prior to burial, however the exact location of the burial site was unknown. A Sensors and Software Smart Cart 500 MHz GPR system was used to locate the grave site on the front lawn of the OPP North Bay Detachment. The GPR data was collected in an X-Y grid format and analysed using Sensors and Software Ekko Mapper 4. This program allows the plots to be viewed from a bird’s eye view as depth slices rather than cross sections of the soil. Identification of the grave site allowed for the canine’s remains to be exhumed, cremated, and subsequently relocated to the OPP Museum in Orillia.

Résumé

Le radar par pénétration du sol (RPS) est un outil géophysique utile pour aider dans la recherche de cibles enterrées, incluant les tombes clandestines. Son utilité dans les enquêtes judiciaires a été restreinte dû à une idée fausse de ses capacités et à une méconnaissance deslimitations associées à son usage. Ce rapport de cas décrit l’application du RPS pour localiser des restes canins enterrés à la demande de la Police Provinciale de l’Ontario (PPO) au Canada. Le chien était un chien policier tué dans l’exercice de ses fonctions en 1975. Ses restes avaient été enterrés dans un cercueil sur lequel on avait fait couler du béton avant l’enterrement. Cependant, l’endroit exact de l’enterrement était inconnu. Un système RPS “Sensors and Software Smart Cart 500” a servi à la localisation de la tombe sous la pelouse retrouvée devant le détachement de North Bay de la PPO. Les données du RPS ont été collectées dans un format de grille X-Y et analysées en utilisant le logiciel “Sensors and Software Ekko Mapper 4”. Ce logiciel permet la visualisation du terrain en vue plongeante de couches en profondeur plutôt qu’en coupes transversales du sol. La localisation de la tombe a permis le déterrement, l’incinération et la relocalisation subséquente des restes canins au musée de la PPO à Orillia.

Introduction

Locating victim remains is integral to forensic investigations involving missing persons, homicide, or mass disasters, both natural and man-made. The search for human remains may encompass a large area of land and can be further hindered if the body has been buried in a clandestine grave in an attempt to conceal evidence of a crime. Numerous techniques have been proposed to assist with searching for, and locating, clandestine sites including remote sensing (1-3), scent-detection canines (2-5), soil and vegetation disturbances (2, 3, 6) metal probing (7), and geophysical surveys (8-13). Geophysical surveys can include the use of ground penetrating radar (GPR), magnetometry, and electrical resistivity to locate buried targets. However GPR is typically the most commonly employed geophysical instrument in forensic investigations involving clandestine graves (8,12).

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GPR involves the transmission into the ground and reflection of electromagnetic (EM) waves (usually 25-100 MHz) to detect variations in the earth’s properties. These variations are detected as changes in the background readings and are often termed anomalies or targets (14). The GPR system employs a source antenna to transmit a pulse of EM waves and a receiving antenna to detect the reflected waves. The antenna is moved along a line at regularly spaced intervals to construct an image which represents a vertical slice of the subsurface features. Once the incoming EM waves are detected, they are converted to a digital format and displayed on the screen in real-time (14). Post-acquisition data processing can also be conducted to enhance anomaly or target images. Based on the grid format, the size and depth of the anomaly can be estimated (8,15).

The choice of antenna is a compromise between vertical resolution and depth penetration. Low frequency antennae (15-50 MHZ) provide deep penetration such as in glaciers, but vertical resolution in the received signal will be poor. In contrast, higher frequency antennae (500-1000 MHz) provide better resolution but will only penetrate centimetres to metres in depth (14). In forensic investigations, the most commonly employed antenna for terrestrial searches is the 500 MHz as it provides a good compromise between vertical resolution and depth penetration (16,17). However, when searching beneath or behind concrete for buried targets, the 1000 MHz antenna is generally recommended.

In the past, GPR has been poorly used in forensic investigations due to misconceptions about its capabilities and a lack of understanding of the limitations associated with this technique. The success of a GPR survey is dependent on several factors including the conditions of the survey site, the composition of the soil, and the length of time since deposition of the target. The experience of the investigator with GPR is crucial in evaluating the burial situation and formulating an effective search. Field sites that are heavily overgrown and not properly cleared may increase the amount of artefacts detected due to poor antenna contact (8,9,18). A preliminary site survey to remove excess vegetation, metal objects or surface stones will reduce the production of interfering noise and improve the overall GPR output.

A site survey should also be used to determine the characteristics of the soil within the site. Assessment of site conditions is important since the dielectric permittivity of soil, and thus the GPR profile, is affected by the moisture, clay and salt content within the soil. Soils that are saturated, have a high clay content, or high salt concentrations, cause high attenuation of the EM wave resulting in poor feature resolution (8-11,16,18,19).

The time since deposition can also affect the success of a GPR survey (8,9). As decomposition progresses the remains release a range of decomposition by-products into the surrounding soil. The variance in the dielectric permittivity due to the remains themselves or surrounding decomposition by-products can be detected by GPR (9). Over time, the remains may reach skeletonization and although the bones may still cause subsurface disturbances, skeletonized remains can be more difficult to locate than those that still retain flesh (9,19). With extended deposition intervals, the electrical properties of the soil disturbances will normalize with the surrounding soil and will no longer be distinguishable by GPR (9).

Importantly, GPR searches should be carried out by trained individuals who have a good understanding of the data collection and data interpretation process. Many unsuccessful searches commonly cited in forensic investigations could be attributed to the misinterpretation of the data by personnel with minimal experience in locating buried “forensic” targets (8). Ideally, GPR searches should be conducted in collaboration between trained individuals with forensic experience and police personnel trained in search and rescue techniques. The combination of their experience and expertise will ensure a higher likelihood of success, especially when locating victim remains.
The Ontario Provincial Police USAR (Urban Search and Rescue) CBRNE (Chemical, Biological, Radiological, Nuclear, Explosives) Response Team (U.C.R.T) currently utilizes two GPR systems to assist with requests for locating buried targets. OPP USAR members have been extensively trained in the use of GPR systems in forensic investigations. GPR has been used in Ontario to locate victim remains under concrete, clandestine graves, and buried explosives, weapons, and drugs. Although not a forensic investigation, the case report detailed herein demonstrates the value of using GPR to locate buried remains.

Case Summary

On October 26, 2011 the Ontario Provincial Police (OPP) North Bay Detachment requested the assistance of the OPP UCRT to locate the grave site of a canine known as Cloud II. Cloud II was an OPP scent tracking police dog used for locating fugitives and missing people during the period 1971-1975. In 1975, Cloud II was killed while tracking a suspect with his handler in Skead, Ontario. He was the first OPP police dog to die in the line of duty in Canada.

Cloud II was buried in a plywood casket, and approximately one foot of concrete was poured on top of the casket before the grave was backfilled. He was buried on the front lawn of the North Bay OPP detachment, approximately 15m from the flagpole. At the time of burial, an asphalt driveway led from the main road towards the front entrance of the detachment which is where the flagpole was located. In subsequent years, renovations to the facility were conducted when a new highway replaced the road. The renovations included relocating the entrance of the building, removing the asphalt driveway and replacing with lawn, and relocating the flagpole. At the time of the request (2011), the exact location of Cloud II’s grave site was unknown. The OPP requested a Ground Penetrating Radar (GPR) search to be conducted of the front lawn in order to locate the grave site as the building was soon to be vacated by the Force and they wished to relocate the remains of Cloud II.

Methodology

A Sensors and Software Smart Cart 500 MHz GPR system was used to conduct the search of the front lawn. A preliminary line search was first conducted to narrow down the search location. GPR data was then collected in an X-Y grid format with a length of 6 metres and a width of 6 metres over the suspected deposition site. The line spacing was set at 25 centimetres and the depth penetration was set at 3 meters. The soil was noted to be predominantly sandy.

Data was collected and analysed using Sensors and Software Ekko Mapper 4. This program allows the plots to be viewed from a bird’s eye view rather than cross sections of the soil. Any disturbance in the ground is displayed as changes in colour. Dark blue colourization indicates no disturbances while lighter blue, yellow or red illustrates disturbances in the ground with increasing signal strength. Depth slices of 5 cm were analysed to locate disturbances in the subsurface.

Results and Discussion

All images are representative of the GPR data collected and are shown as depth slices at 5 cm intervals. Based on journal requirements, images are shown in grayscale with the area of interest outlined by a black border. Several anomalies were identified within the grid and were visible as yellow or red disturbances in the coloured images or darker areas in the grayscale images. A large anomaly was first observed at a depth of ~25 cm (Figure 1) although the shape and size of the anomaly did not appear to be consistent with a grave site. Subsequent depth slices demonstrated the loss of this anomaly within 20 cm confirming that it was not the suspected grave site.
A similar anomaly was also identified in depth slices from 65 through to 85 cm (Figure 2). Upon later excavation, both disturbances were found to be buried asphalt from the original driveway leading to the building entrance. Police confirmed that the driveway had been removed and buried when the new highway was installed. The length (~ 4 - 5 m) and shallow depth (~ 20 cm) of the anomalies in Figures 1 and 2 correlated with the long, flat pieces of asphalt identified.

A third anomaly was first identified as a small disturbance in the depth slice at 60 cm and can be seen directly below the anomaly in Figure 2 between X coordinates 1.7 - 3.7 m and Y coordinates.
0.5 - 1.5 m. As the depth slices increased, the anomaly became bigger and continued to be observed up to a depth of 150 cm. Figure 3 demonstrates the anomaly at a depth of 95 cm. The length, width and depth of this anomaly appeared to better correlate with the information provided by the OPP that the grave site included a casket and concrete. Although the burial had occurred more than 35 years prior to the search, it was believed that the concrete would have aided in the preservation of the plywood casket to some extent. Subsequent excavation of this anomaly confirmed the location as the grave site of Cloud II, and the casket demonstrated minimal degradation (Figure 4).

Figure 3: Depth slice of grid at 95-100cm with anomaly outlined in black

Figure 4: Casket encased in concrete demonstrating minimal degradation
Exhumation of Cloud II’s remains revealed excellent preservation after 36 years burial. His fur was completely intact with minimal slippage. His soft tissue had predominantly formed adipocere, resulting in good preservation of his body mass. The only region of the body which demonstrated extensive decomposition was the skull. His working collar was also in good condition and able to be removed for subsequent cleaning and preservation. Following exhumation, his remains were transferred to a pet crematorium for cremation. Cloud II’s remains are now on display in a special stone urn at the OPP Museum, General Headquarters in Orillia, along with a photo and plaque to remember his legacy.

The excellent preservation of the casket, coupled with the cooler temperatures experienced in a deep burial in North Bay, likely explain the preservation of Cloud II’s remains. The casket acts as a barrier between the soil environment and body, preventing access to the remains by soil microorganisms (20). The body was also wrapped in a sleeping bag with a plastic bag placed over the top prior to burial in the casket. These wrappings would have aided in trapping moisture within the remains, thus promoting adipocere formation before decomposition could proceed utilizing enteric bacteria (20). The decomposition of the skull may have been a result of the fatal gunshot wound to the back of his head. Information was not available as to whether or not the burial occurred immediately following death. If a delay occurred between death and burial, it is possible that decomposition may have been initiated around the wound, likely assisted by enzymatic, microbial and entomological activity. However, evidence of entomological activity was not investigated at the time of exhumation.

The successful use of GPR in a forensic investigation relies on many optimal factors being present. In this case, the site contained optimal search conditions, as the soil was predominantly sandy and well-drained and the front lawn of the detachment was relatively flat and covered in short grass. There were no large trees (and therefore no tree roots) on site and no large rocks detected subsurface to interfere with the EM waves. This environment is not always typical of a forensic scenario whereby a clandestine grave may be located in a dense forest with many trees and subsurface disturbances. However, this site is typical of a backyard which may contain a buried anomaly and the OPP UCRT team have conducted several GPR searches in urban environments not dissimilar to this site.

The inclusion of a casket, coupled with the concrete poured over the casket, also played a significant role in the successful use of GPR to locate the grave site. Typical “forensic” burials would be considerably shallower and would not include a coffin or casket around the body. As the post-burial interval increases and decomposition proceeds, it may become more difficult to detect skeletal remains as the contrast between the remains and surrounding soil decreases (16). In this case, the remains were well preserved. However, this limitation should be considered along with the intelligence available about the potential grave site when requesting a GPR search.

While this case report is not forensic in nature, GPR has been successfully used by OPP UCRT to locate clandestine grave sites in forensic investigations demonstrating the value of this technique for different burial conditions. These cases are still open and will be published in the future once the cases have concluded.

**Conclusion**

GPR is a valuable tool for conducting non-invasive searches of potential buried targets without disturbing the ground or possible buried evidence. Its value lies in its ability to highlight smaller areas of potential interest within a larger grid search area or to clear a suspected area. Regardless of whether locating a target site or clearing an area, investigators can use the GPR results to focus their resources more appropriately.
The success of GPR in locating a clandestine grave will, however, be dependent on the site and grave characteristics including soil type, state of decomposition and post-burial interval, antenna utilized, and experience of the operator. These factors should be considered when requesting the use of GPR to locate buried remains in a forensic context. GPR is just one of the numerous tools that can be deployed in search and recovery investigations to locate victim remains in clandestine graves.

References


