

SUBSURFACE VIEWS

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FINDAR® Locates Buried Bodies

Background - The Forensic Osteology Research Station (FOREST) is part of the Forensic Anthropology Program within the Anthropology and Sociology Department at Western Carolina University. The facility, the second oldest in the United States, was first established in 2005 and is used for education of medicolegal professionals, implementation of various research projects in forensic anthropology and also as a service to provide consultation, training and outreach to the law enforcement and medicolegal communities.

Prior to the establishment of these facilities, animals such as pigs and rabbits were used as proxies for humans but recently researchers have demonstrated that non-human models like pigs do not follow the same decomposition patterns as humans. At this facility, donated human bodies have been buried at different depths over a period of time and are therefore at different stages of decomposition.

Sensors & Software was invited to survey the site with ground penetrating radar (GPR). We brought our FINDAR® system to gather data and provide students in the Forensic Anthropology Program some practical experience with GPR in the field.

Survey Area - The survey area was 30.2 x 30.2 m, on a 15-18 degree slope and encircled by a very tall fence. There were four areas with bodies that were selected to be surveyed (Figure 1).

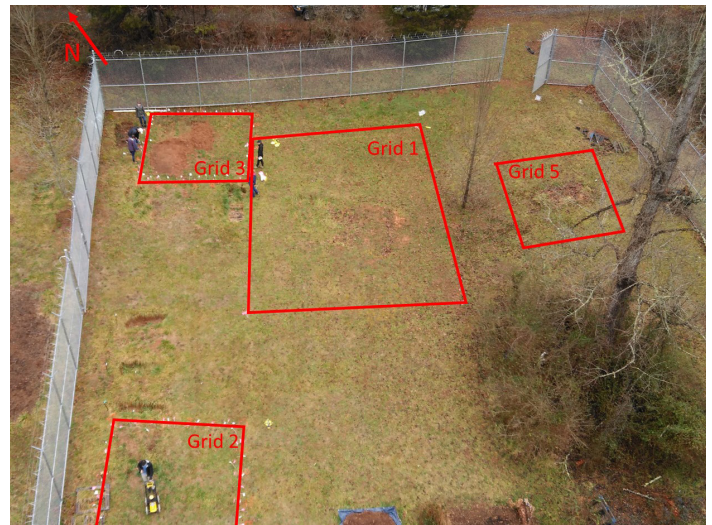


Figure 1: Top down view of the surveyed site, showing the four grid collection areas. Note that Grid 4 was also collected but was not included on this figure as it was replaced by Grid 5 which was collected over the same area.

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The grid locations were limited by trees, and up to one foot drops where the ground above the buried bodies had either sunk or the burials were only covered with wooden pallets. Instead of doing one large grid, the area was broken into 4 sub-areas covered by one grid 10 x 13 meters in size and three smaller grids (one 5 x 6 m, and two 6 x 6 m). The rationale was to focus the survey on areas where there were known bodies, to avoid obstacles like depressed graves, trees and wooden crates and to have complete grids in case we had to stop the survey due to inclement weather. The fourth grid is referred to as Grid 5, as Grid 4 was collected over the same area but was incomplete.

Data collection - FINDAR® is a great teaching tool when introducing people to GPR; with an intuitive interface that guides you through grid setup.

Grids were laid out using tape measures and marked using paint at 1 m intervals and alternating colored flags at 0.25 m intervals (Figure 2).



Figure 2: Grid 3 setup and data collection with exposed areas of recently disturbed soil.

Results - GPR data obtained from the FINDAR® proved valuable in pinpointing the location of the buried bodies. A depth slice of Grid 2 shows a body buried in February 2017 at approximately 40 cm, which was verified by using a ground probe (Figure 4).

For Grid 3, over two known burials from 2017 and 2019 (Figure 2), a depth slice at 40 cm only shows one anomaly (Figure 3). This was attributed to heavy clay soil on top of the second body, resulting in strong GPR signal attenuation (Figure 2).

3D Preview, a feature in EKKO_Project, allows an anomaly observed in the depth slice of Grid 3 to be seen alongside the two perpendicular cross-section lines, providing a better interpretation (Figure 3).

In Grid 5, FINDAR® was also successful in locating the position and depth of the body buried in September 2016 (Figure 4).

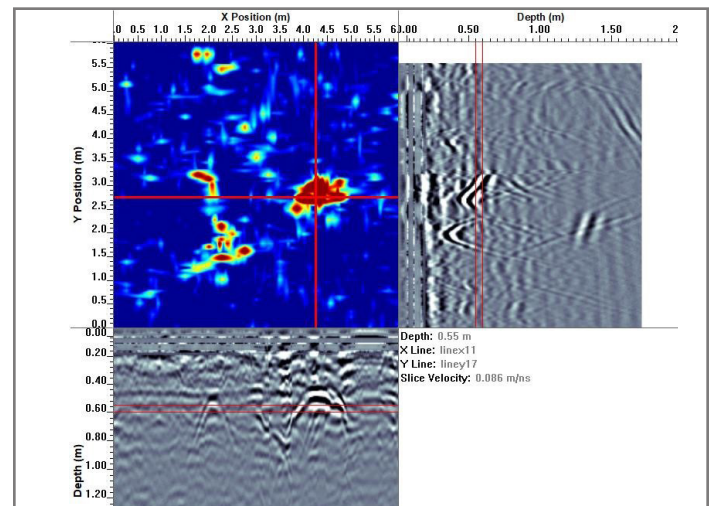


Figure 3: 3D Preview image of two perpendicular lines running across the first buried body in Grid 3.

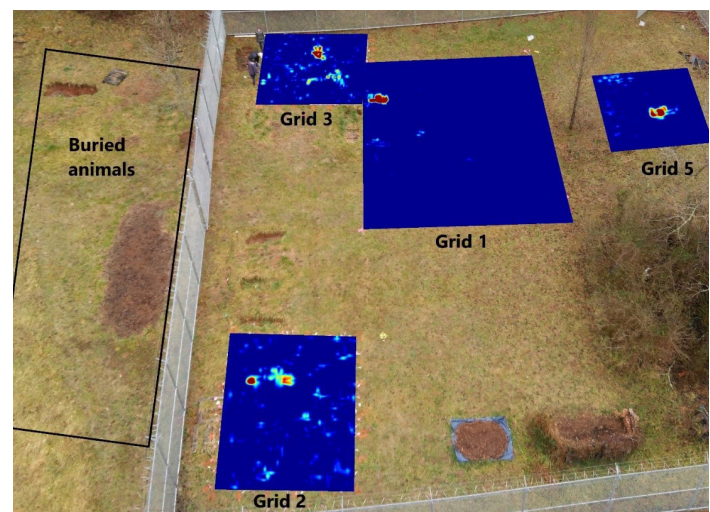


Figure 4: Plan view of all the collected grids overlaid with the depth slices showing the areas of interest identified with GPR. Note that animals are buried outside of the enclosure and are used as part of forensic anthropology modules by the students.

Conclusion - FINDAR® successfully showed that GPR is a great tool to provide the location and depth of donated bodies that were buried over the years at a human decomposition facility. The results obtained also demonstrate how adding GPR subsurface imaging technology as part of a forensic anthropology curriculum could benefit students.

Aknowledgements - We would like to thank Dr. Katie Zejdlik and Western Carolina University for allowing us access to the FOREST facility as well as the students for coming out to assist us with the survey despite the inclement weather.

Animal tunnels - a challenging target in near-surface imaging

Ground penetrating radar (GPR) is often used to image the shallow subsurface and investigate subsurface infrastructure. Frequently overlooked shallow structures are the tunnels and burrows that are excavated by burrowing animals. While potentially only centimetre-scale in diameter, a single, interconnected tunnel network may extend over several hundred metres and therefore, it contributes to the pore-space, influences subsurface hydrology and/or may destabilize embankments and other earthworks.

GPR is known to provide the highest image resolution of subsurface structures in a relatively short amount of survey time. Due to their potentially complex structure and small size, animal tunnels are an especially challenging target for all available geophysical methods. In contrast to other methods e.g., excavations of the tunnel network, a GPR survey leaves the animals and the subsurface completely undisturbed. Therefore, conducting GPR surveys allows imaging the extent and - when applied in a repeated manner - the temporal development of the tunnel network without exposing the animals and the subsurface to unnecessary disturbance.

To demonstrate the suitability of GPR for imaging and monitoring such small-scale features, we conducted a GPR survey on a field with clearly visible mole activity in Tubney, Oxfordshire, UK (Figure 1). Mole tunnel systems are often extensive, and the tunnels are small in diameter (approx. 0.05 m), making mole tunnel systems ideal for testing the applicability of GPR for imaging and monitoring the geometry of such features. To test these GPR capabilities, we conducted two surveys, one year apart, using a pulseEKKO PRO[®] system using a set of transducers with a 1000 MHz centre frequency. In previous surveys we found that a high precision positioning system is essential for such an application. Therefore, we used a self-tracking total station (Figure 1), which tracks the GPR antennas and transmits real time coordinates to the GPR acquisition system. With this setup, both 3D GPR data sets were acquired with an inline trace spacing of approximately 1 cm and a line spacing of approximately 5 cm.



Figure 1: Data acquisition at the field site using a pulseEKKO[®] PRO system in combination with a self-tracking total station (tripod at the left site of the image).

We applied advanced GPR processing to the recorded data; this included background removal, bandpass filtering, amplitude correction, data gridding to a regular surveying grid with 2 cm node spacing, and a Kirchhoff based migration scheme. The result of this processing scheme is a densely spaced 3D GPR volume, showing subsurface structures down to a depth of approximately 1 metre. When interpreting the migrated GPR profiles (e.g., Figure 2), we found a rather uniform sedimentary background with few visible geological structures. However, in the uppermost 5 ns of the profile (which is ~0.2 m) we observed small-scale features with high amplitudes that interrupt the otherwise continuous GPR image.

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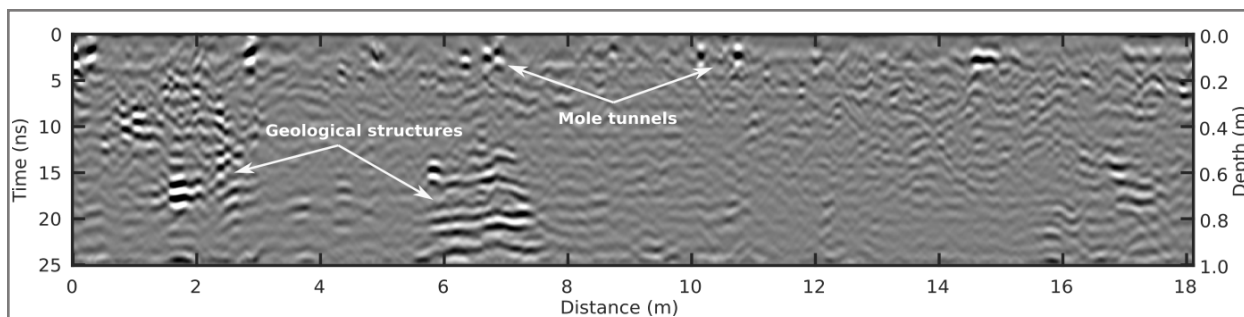


Figure 2: Example GPR profile extracted from a 3D GPR volume showing structures down to a depth of -1 m. Based on ground truth data, we interpret structures in the upper 5 ns (approx. 0.2m) of the profile as mole tunnels.

To calibrate our observations, we excavated a soil pit (Figure 3). This excavation revealed a mole tunnel network at a depth between ~0.05 m and ~0.25 m, which we mapped by measuring selected tunnel positions and junctions (plotted as red dots in Figure 4). We continued excavating up to ~0.70 m depth and, as also indicated in the GPR results, found no deeper tunnels. When looking at a time slice (Figure 4), a horizontal map through the GPR volume, we identify a complex network of high amplitude anomalies, which correspond well to the ground truth information from our excavation.



Figure 3: Picture showing the observed mole tunnel network on an excavated site to ground truth the GPR results.

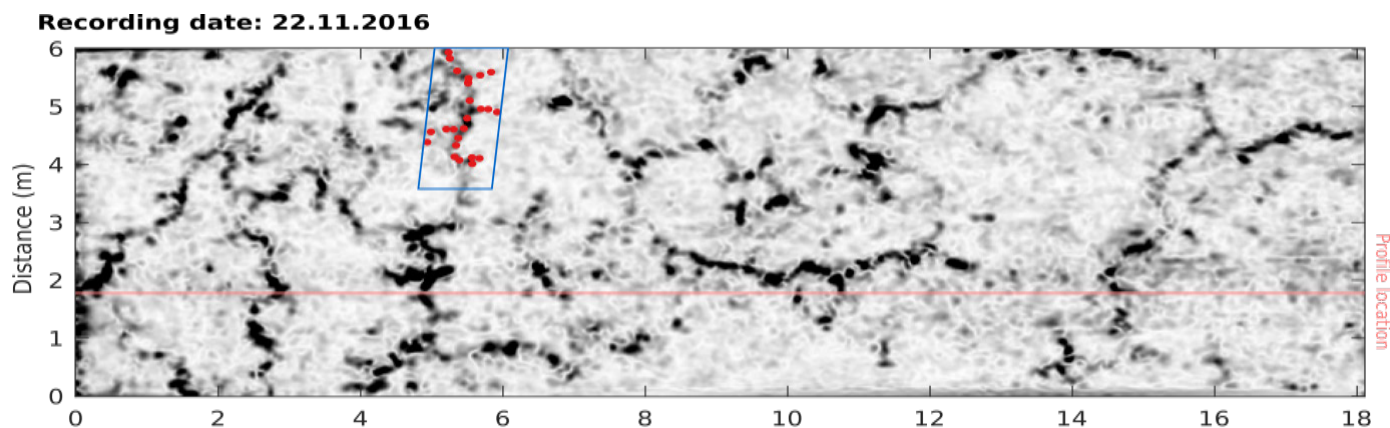


Figure 4: Horizontal slice through the 3D GPR volumes showing the mean envelope at a depth of 0.08 m to 0.16 m. Dark values indicate high reflection amplitudes that can be interpreted as mole tunnels with respect to our ground truth information.

With this case study we demonstrated the applicability of GPR for imaging small and complex animal tunnels within the shallow subsurface. We believe our imaging and monitoring approach including the highly precise acquisition and repeatable GPR data collection will make it possible to examine and monitor animal activities that are difficult to study using other methods.

More information, including the monitoring results and data acquisition and processing strategies, is available in the published article. Contact Sensors & Software for the reference.

Story courtesy of Niklas Allroggen, Jens Tronicke (Universität Potsdam), Adam Booth (University of Leeds), Sandra E. Baker, Stephen Ellwood (University of Oxford)

TIPS: Where am I? You are Here!

The latest release of the LMX200® software introduced the new SplitView feature which shows a real-time MapView beside your data cross-section when using an external GPS. It displays your current position as a blue dot in real-time as you are collecting data. This has garnered a lot of excitement from our customers. But why is this helpful?

1. Return to a location – during a utility survey you may locate an object on the GPR data and place an interpretation on it (pink dot in Figure 1). Now, say you want to return to that location. Simply look at the MapView screen (Figure 1) and navigate as your current position (blue dot) moves toward the interpretation you marked earlier.

2. Predicting where a target might be – most utility locators snake back and forth with the LMX200® and mark out targets as they cross them. By placing interpretations on the screen, you can see the linearity of buried targets. But what if an object doesn't show up where it's expected to be? You can keep on surveying and see if the target shows up on the next pass. Knowing that it is linear, you can extrapolate where the target is, even if it doesn't show up on the screen. A missed target is usually caused by changing ground conditions that attenuated the GPR signal at one location. The five pink dots in Figure 2 indicate the linearity of a target that is not clearly seen in the last crossing of the target.

3. Random walk coverage – a powerful feature in our EKKO_Project™ software is the ability to take lines of geo-referenced GPR data and create depth slices. Rather than laying out a rectilinear grid, the user simply walks back and forth collecting data over a given area (analogous to cutting the grass). The quality of the resulting depth slices depends on the accuracy of the GPS, as well as how closely spaced your lines are. Using the MapView feature in real-time, you can see if you are drifting away from your previous lines (Figure 3). Alternatively, if there is a noticeably large gap in your data, you can return to that area and collect additional data before generating your depth slices.

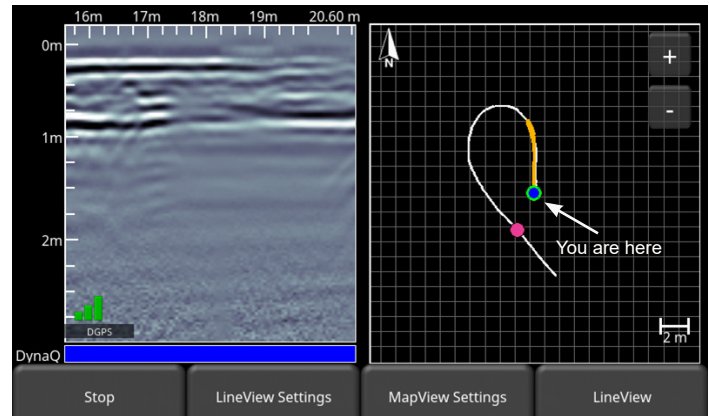


Figure 1: Blue dot is where the LMX200® is located. This makes it easy to return to the location of a target indicated by the pink interpretation dot.

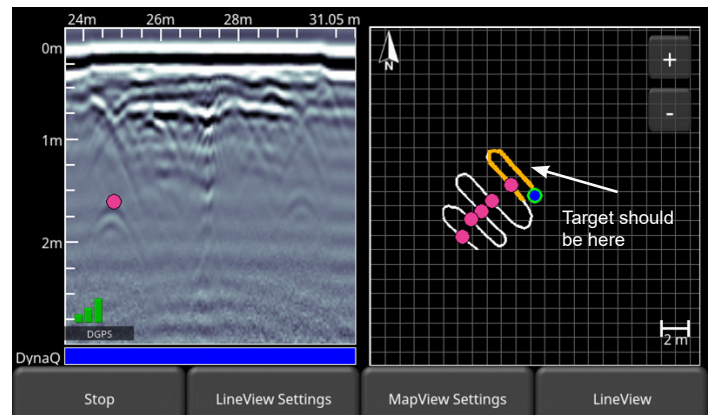


Figure 2: With multiple linear interpretations, you can predict where the next target will be (even if it is weak or not visible).

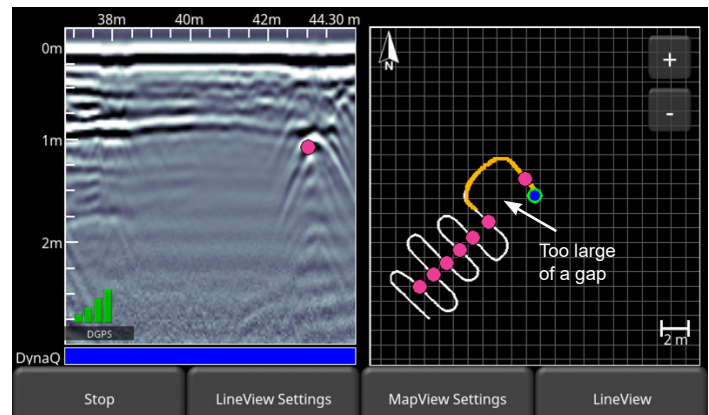


Figure 3: The GPS path shows where there are large gaps in the GPR data.

Knowing your real-time position during an LMX200® survey using the new position indicator in MapView has many benefits, including easier and improved target interpretations in the area, quickly identifying areas where more data is required for better depth slice generation and rapidly relocating previously marked targets. This powerful update is free for all LMX200® customers and can be downloaded from our website.

Upcoming Courses

[European 3-Day GPR course](#) - October 9-11, 2019, Höhr-Grenzhausen, Germany

This hands-on course covers a wide range of GPR equipment from the premier pulseEKKO® to the Innovative Noggin® systems.



Subsurface Utility Locating with GPR course (NULCA-accredited)

[September 9](#), 2019, Mississauga, ON, Canada

[September 17](#), 2019, Bay Area, Northern California, USA

[November 4](#), 2019, Mississauga, ON, Canada

Concrete Scanning with GPR course

[September 10](#), 2019, Mississauga, ON, Canada

[November 5](#), 2019, Mississauga, ON, Canada

[Free Webinar - EKKO Project LineView module for plotting GPR lines](#) - August 14, 2019

Upcoming Events

[\(EAA\) 25th Annual Meeting of the European Association of Archaeologists](#) - September 4-7, 2019, Bern, Switzerland

[\(NSG\) Near Surface Geoscience](#) - September 8-12, 2019, The Hague, The Netherlands

[\(GSA\) Geological Society of America](#) - September 22-25, 2019, Phoenix, AZ, USA

[\(No-Dig\) 37th International No-Dig](#) - September 30 - October 2, 2019, Florence, Italy

[\(ICUEE\) International Construction and Utility Equipment Expo](#) - October 1-3, 2019, Louisville, KY, USA

[\(IRF\) Global R2T Conference & Exhibition](#) - November 19-22, 2019, Las Vegas, NV, USA

[The Buildings Show](#) - December 4-6, 2019, Toronto, ON, Canada

[\(AGU\) American Geophysical Union](#) December 9-13, 2019, San Francisco, CA, USA

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