



SUBSURFACE VIEWS

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Missing 150-year-old time capsule potentially found with CONQUEST®100

Dr. Jarrod Burks from Ohio Valley Archaeology, Inc based in Columbus, Ohio, began offering geophysical services for archaeological applications in 2001 and subsequently implemented ground penetrating radar (GPR) surveys in the mid-2000s, with clients ranging from private contractors, historical societies, academics, and the U.S. Government. With such a wide array of customers, Dr. Burks has had his fair share of unique applications for GPR and we are happy to share one of those.

Having done traditional archeological surveys in the past for the Jackson County Historical Society, Dr. Burks was approached by them to locate a time capsule that they knew was buried in one of the cornerstones of the Jackson County courthouse located in Jackson, Ohio. The cornerstone was laid in 1867, and since then locals had forgotten which corner the time capsule was in. As this project required a nondestructive and efficient means of imaging the insides of the cornerstones, Dr. Burks considered the use of GPR as a tool to attempt to locate this missing artifact.

A cornerstone is a ceremonial masonry stone set in a conspicuous side of a building and is often located above the actual foundation in a visible and prominent area, commonly

the northeast corner of a structure. Cornerstones are also known to contain a cavity in which, historically, time capsules could be placed. Time capsules contain various artifacts relevant to the time period they are buried and are a historic repository of information that help preserve and collect items and messages as a thoughtful way of communicating with people in the future.

An issue Dr. Burks faced was that this project would require a high frequency GPR system which at the time he did not possess. He therefore approached his existing GPR manufacturer, Sensors & Software Inc to get a CONQUEST® 100 system that operates at a center frequency of 1000 MHz.

Despite having never used a CONQUEST® system before, Dr. Burks completed the whole project in about 1.5 hours. He said that the system was easy to use and as he got more practice with it, the survey went increasingly faster as he got more efficient in setting up the grid and scanning on the side of the building.

The investigation consisted of a grid scan of the three accessible building corners (SE, SW and NW) with the high

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resolution CONQUEST® 100 GPR system (Figure 1). Each corner was scanned by combining two 24 x 24 inch grids into a 48 x 24 grid to cover 8 square feet (Figure 2). For two cornerstones (NW and SW) he surveyed both visible sides, but was able to only cover one side of remaining cornerstone (SE). Unfortunately, no potential target was detected at the first two corners on the south side of the building, which were the easiest to access. At the harder-to-access northwest corner, he detected a GPR anomaly that he attributed to either being an object or cavity within the sandstone cornerstone (Figures 3 and 4). After processing the grid scans into depth slices, in real time, right on the CONQUEST®100, the dimensions of the anomaly closely matched the dimensions of the time capsule from 1867 (Figures 3 and 4). Post-processing was done to produce a 3D volume render of the object (Figure 5).



Figure 1: Google Earth image of the Jackson County Courthouse survey site showing the 3 cornerstones, marked in yellow (SE, SW, NW) that were surveyed with the CONQUEST®100 System. The NW Corner where the time capsule might be is marked using a red star.



Figure 2: Dr. Burks, using the CONQUEST® 100 System to survey a 48 x 24-inch grid on the SW corner of the Jackson County Courthouse.

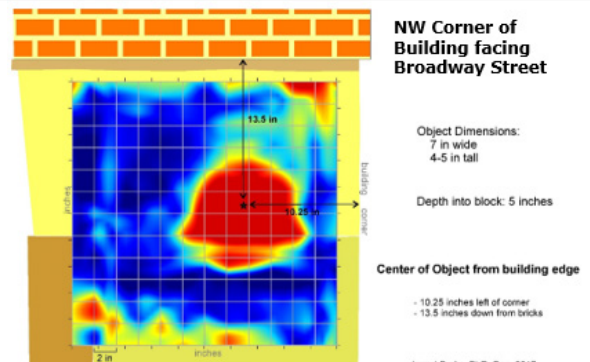
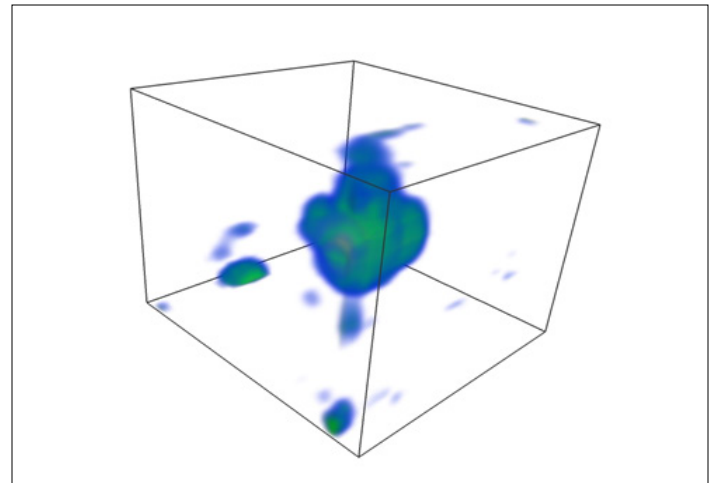
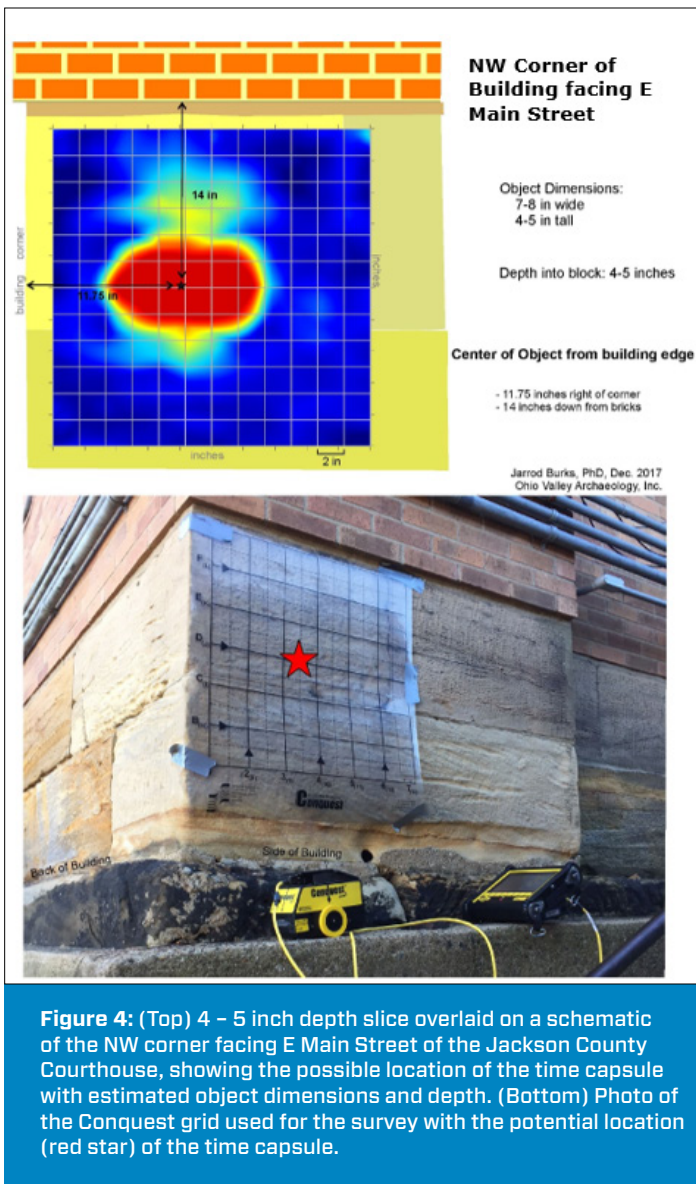


Figure 3: (Top) 5 - 6 inch depth slice overlaid on a schematic of the NW Corner facing Broadway Street of the Jackson County Courthouse, showing the possible location of the time capsule with estimated object dimensions and depth. (Bottom) Photo of the northwest cornerstone showing the potential location (red star) of the time capsule.



So far, this 150 year old artifact has yet to be brought to light; the County has chosen not to try and extract the time capsule from the cornerstone as it is still a standing structure in use and they do not want to damage the original foundation of this historic building. A physical mark was left on the side of the building where the object is likely located.

Overall Dr. Burks had a very pleasant experience with the CONQUEST® GPR system and shared the following with us: "We detected something that could certainly be the time capsule. I am looking forward to the day when they can test the cornerstone to determine if in fact a time capsule is present."

Stay tuned as we will share an update to this story once we hear the good news.

Story Courtesy of Dr. Jarrod Burks

Welcome to SensoftU, the future of online GPR training

For over 30 years, Sensors & Software has been a pioneer in the field of GPR equipment and its applications. We share what we have learned about GPR over the decades through the immense technical resources on our website - newsletters, case studies, webinars, etc., and via our training courses, which we have provided to the public since the 1990s. Innovative GPR equipment and training go hand-in-hand, as we educate users to make them more effective, successful GPR operators.

To that end, we are proud to announce the launch of SensoftU (www.sensoftu.com), an interactive online learning platform, which takes our GPR training courses to a new level. This is not just watching videos or static presentations. SensoftU features true interactive courses where the user is engaged, learning, interacting, and answering questions along the way.

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Welcome to SensoftU



**The future of
Online GPR
Training**



Interactive Courses

professionally developed courses to keep you engaged and learning



Webinars

software and application-focused webinars provide high level of detail



Progress at your pace

stop and continue where you left off at your convenience



Certificate of completion

print a certificate upon completion and passing the test

The first course we have available is the Nulca-accredited, Utility Locating with GPR. This course mimics our current one-day live course. Users learn about GPR theory, factors affecting GPR signals, use of Line Scan and Grid Scan and data interpretation. Throughout the course, there are questions to reinforce learning and retention of key concepts. To see some of the interactive content, click on one of the links below:

1. Changing Filter settings: <https://www.sensoft.ca/promo/training/FilterSlide/story.html>
2. Options for viewing depth slices: <https://www.sensoft.ca/promo/training/SliceViewbuttoninteractions/story.html>

At the end of the course, there is a quiz. Upon passing the quiz, the user can print a certificate of completion right on the spot. As we develop this platform, new content will be added regularly to address the many applications of GPR. To register for a course visit www.sensoftU.com. Free courses can be accessed after registering. To access paid courses, use the access code provided by the Sensors & Software training team or pay for the course through PayPal.

Even before the COVID-19 pandemic, we knew the importance of providing online education. Now, even more so, online learning is certainly the way of the future as companies and users can realize many benefits:

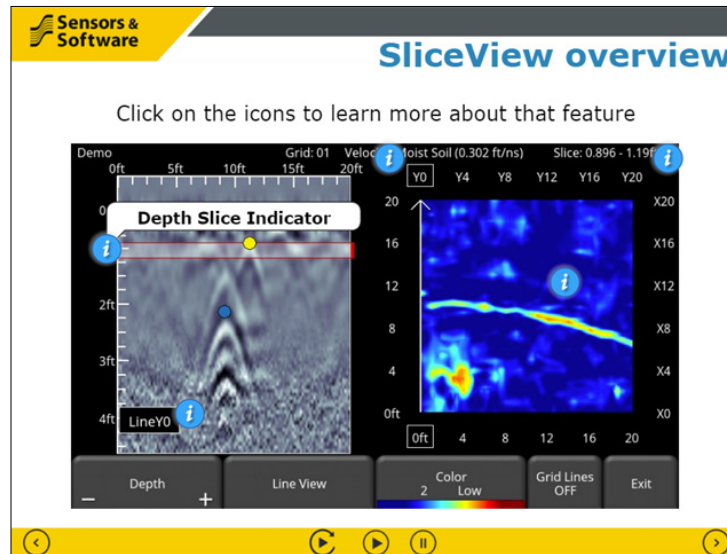
- **Cost effective:** Reduce travel costs to attend in-person training and minimize downtime while travelling to a live course.
- **On-demand:** Easily register & start training online anytime, allowing you to train employees on short notice, and have existing employees attend refresher courses.
- **Convenience:** Train anywhere, anytime, on any device.
- **Flexibility:** Learn at your own pace. Replay sections you want to review. Resume course from where you left off.

Online learning allows Sensors & Software to better support our customers and dealers worldwide, where travel can sometimes be cost-prohibitive. In addition, as many academic institutions move towards online learning, this platform can supplement their course curriculum by allowing students to learn about GPR in a one-stop shop.

While we are sure this is exciting news for you, it is important to note that SensoftU is not replacing any of our existing training offerings, but rather augmenting them so you have more options for learning. These courses include:

- [Live 1-day and 3-day courses](#)
- [Live and Pre-recorded webinars](#)
- [Product training videos](#)
- [Custom one-on-one web training](#)

Whether you are training new employees, providing a refresher course for existing employees or taking a course to meet continuing education requirements, SensoftU is ready and waiting. Visit www.sensoftU.com to start learning! [Contact us](#) for more information or to discuss company/group packages.



TIPS for Dips

When interpreting GPR data where understanding geologic structure is the goal, quantifying the slope (normally referred to as 'dip') of interfaces is often desired. Raw GPR cross-sections are not 'true' representations of subsurface geometry; simplistic dip estimates will yield erroneous values for dips if the GPR wave behaviour is not considered in the calculation. The following is a very high-level summary based on simplified assumptions; this topic can get much more complex.

GPR data are normally displayed in cross-section images with a horizontal position axis and a vertical time axis (Figure 1). Time (t) is often converted to Depth (z) by knowing the wave velocity (v) in the equation:

$$z = \frac{vt}{2}$$

where, t is the two-way travel time of the GPR wave in the subsurface.

A raw GPR cross-section display is a quick and convenient way to estimate target depths but should not be construed as a 'true' picture of the subsurface.

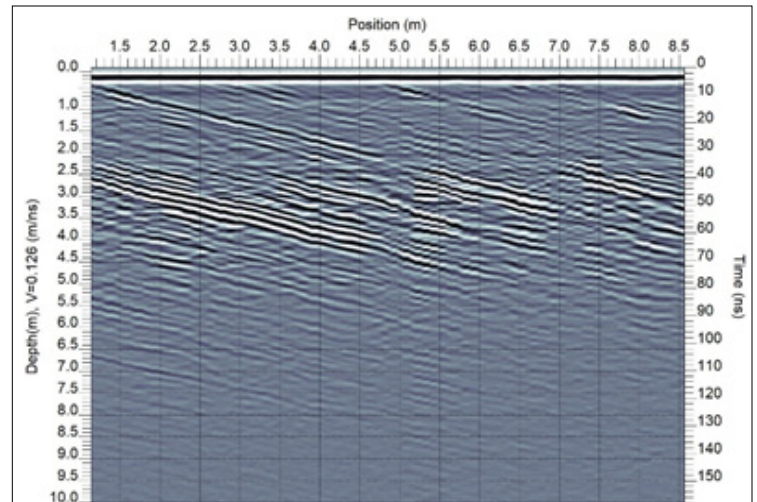


Figure 1: Example GPR cross-section with dipping interfaces. The vertical time axis (on the right side of the image) has been converted to a depth axis (on the left side of the image) using a GPR signal velocity of 0.126 m/ns

The normal expression for a dip or slope calculation is the change in depth, Δz , versus horizontal distance, Δx , along the profile, and expressed as:

$$\tan \theta = \text{Slope} = \frac{\Delta z}{\Delta x}$$

$$\theta = \tan^{-1} \left(\frac{\Delta z}{\Delta x} \right)$$

The slope is most often expressed as a dip angle, θ , which is the angle the interface meets the ground surface (Figure 2a). If the depths on a GPR cross-section and this expression are used to calculate the slope angle, the value will be incorrect. The reason is that the depths shown on the simple GPR cross-section are not the same as the signal ray paths in the subsurface.

These basic concepts are outlined below in Figure 2. Figure 2a illustrates the GPR signal ray paths. The GPR transmitter and receiver are often assumed to be coincident, which is a very good approximation for most reflection surveys. The GPR signals travel in straight paths to the interface and reflect back to the GPR system. Two ray paths are shown for a GPR at positions A and B on the surface; the GPR signals reflect from the sloping interface at points A' and B'. The lengths of the ray paths A-A' and B-B' are L_1 and L_2 .

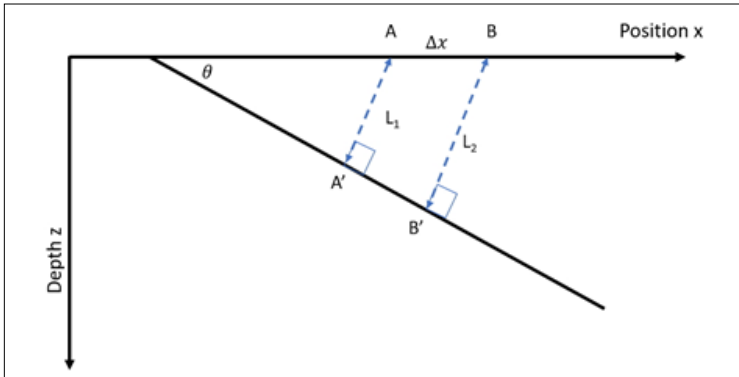


Figure 2a: A dipping or sloping interface showing the correct GPR ray paths, L_1 and L_2 .

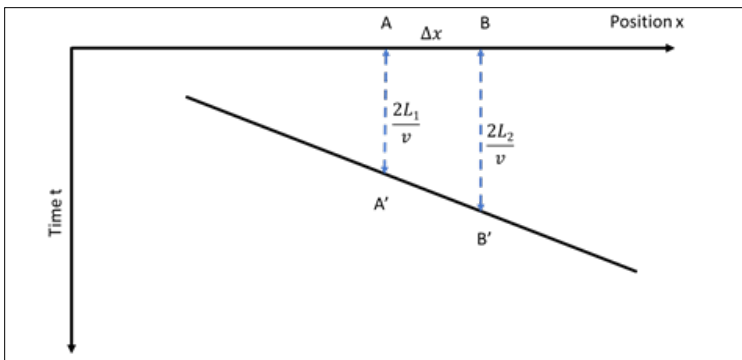


Figure 2b: A GPR cross-section displays data with target responses plotted directly below the system location, not the real reflection point shown in Figure 2a.

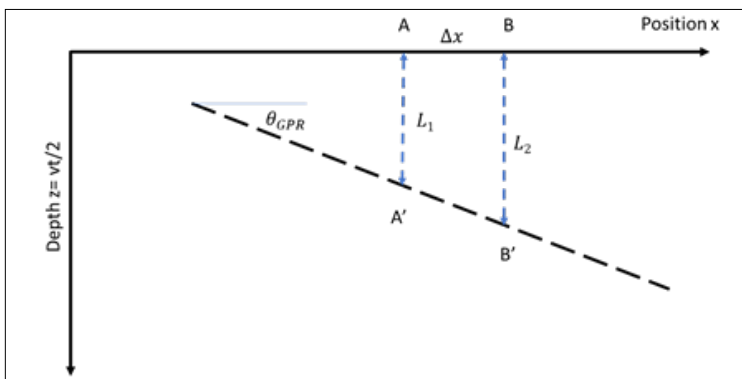


Figure 2c: The standard GPR data display with target responses plotted directly below the system location. Note that time is converted to depths L_1 and L_2 by a simple conversion.

The standard GPR cross-section displays the reflected signal directly below the GPR position on the surface (Figure 2b). In fact, the signals travel a slanted or non-vertical path to the target reflection point on the sloping surface. In a GPR cross section, the response for path A-A' appears at time $2L_1/v$ and for B-B' at time $2L_2/v$, where v is the GPR signal velocity in the prospected medium.

The dotted black line in Figure 2c shows the imaged reflection horizon. With the use of a simple time-to-depth conversion, Figure 2c does not change the GPR image geometry.

In a GPR cross-section, the sloping interface has the dip (slope), θ_{GPR} , which is related to the true interface dip, θ , as follows

$$\tan \theta_{GPR} = \text{Slope} = \frac{\Delta z}{\Delta x} = \frac{(L_2 - L_1)}{\Delta x} = \sin \theta$$

The true dip can be easily computed as:

$$\theta = \sin^{-1} (\tan \theta_{GPR})$$

$$\theta = \sin^{-1} \left(\frac{\Delta z}{\Delta x} \right)$$

For example, using the GPR data in Figure 1:

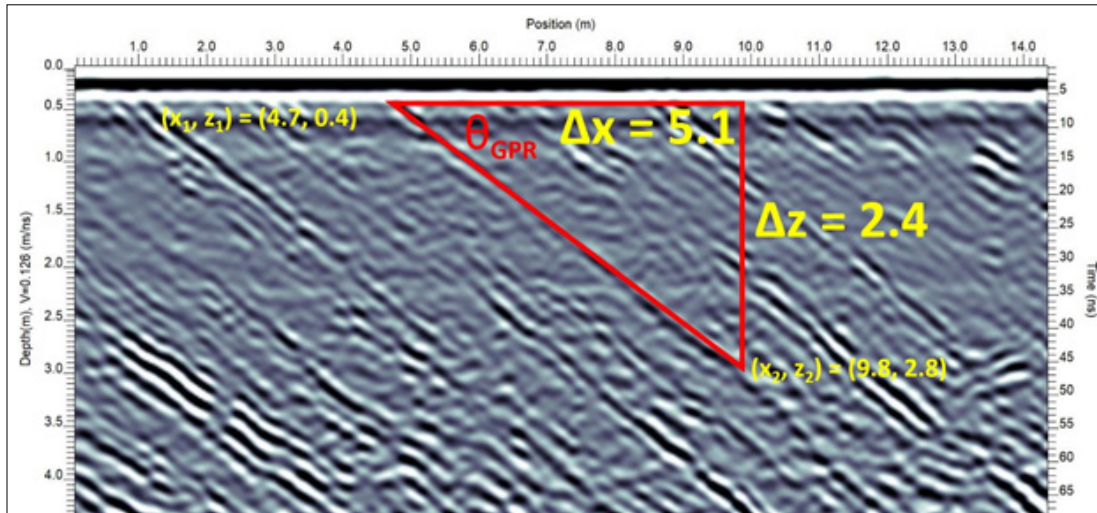


Figure 3: Example of calculating the true dip from the slope on a GPR cross-section.

$$\theta = \sin^{-1} \left(\frac{2.4}{5.1} \right)$$

$$\theta = 28 \text{ degrees}$$

Two important things to note are:

1. In a simple cross-section, GPR dip, θ_{GPR} , will always be smaller than the true dip.
2. The GPR image dip can only range between 0 and ± 45 degrees, whereas the real slope can range between 0 and ± 90 degrees.

Alternatively, advanced users could apply migration processing to convert the GPR section back into a true geometry cross-section. As migration moves observed 'responses' back to their 'true' location, measuring dip on a migrated section should give the correct dip. Hence migration is another way to address the true dip estimate.

This discussion is a very simple view of these concepts. In reality, the world is three dimensional and there's no certainty that the GPR cross section is aligned with the steepest slope (this would be revealed by a GPR cross-section collected perpendicular to the strike of the structure). If a full assessment of geometry is required, it will be essential to acquire GPR data in two orthogonal directions. This ensures that the orientation of strike can be ascertained and brought into the analysis. Those details are beyond the scope of this article.

Sand dune data in Figures 1 and 3 courtesy of Todd Thompson, Indiana Geological Survey.

Upcoming Courses

Subsurface Utility Locating with GPR course (NULCA-accredited)

[September 14](#), 2020, Mississauga, ON, Canada

[November 2](#), 2020, Mississauga, ON, Canada

Concrete Scanning with GPR course

[September 15](#), 2020, Mississauga, ON, Canada

[November 3](#), 2020, Mississauga, ON, Canada

Upcoming Events

[TAC Transportation Association of Canada](#) - Online, Sept 21 to October 8, 2020

[SEG Houston](#) - October 11-16, 2020, Houston, TX, US

[\(GSA\) Geological Society of America](#) - Online, October 26-30, 2020

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