PRESERVATION IN PRACTICE:

GROUND-PENETRATING RADAR

Topics covered in this brief:

DATA PREPARATION
DATA COLLECTION
DATA PROCESSING
VISUALIZING DATA

National Center for Preservation Technology and Training
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Ground-penetrating radar (GPR) is perhaps the most recognizable geophysical survey technique used in archeology. The radar signal, an electromagnetic pulse, is directed into the ground. Subsurface objects and sediment layers with contrasts in physical and chemical properties will cause reflections that are sent back to a receiver. The two-way travel time and the assumed speed of the energy of the reflected signal(s) are used to calculate the depth of targets and layers.

GPR can be a powerful tool in favorable conditions, such as sandy soils, that best allow for the transmission of the pulse. GPR is unique in its ability to detect small objects and identify the depth of those objects. The disadvantage of GPR is that it is limited in less-than-ideal conditions. The high electrical conductivity of certain fine-grained sediments (such as clays and silts) limits depth penetration and overall performance, whereas rocky or mixed sediments may scatter the radar signal.

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PREPARATION

Preparation for a GPR survey involves documenting and being aware of a series of important variables.

- The following should be documented for each survey: Grid layout, grid size, transect spacing, survey direction, line sequence, drift value, and bias value. The center frequency of the antenna, and for stepped frequency modulated systems, the range of frequencies is needed. The operator should also record the date(s) of the survey, personnel involved, and weather conditions.
- Drift Value refers to the variable, often minor, changes to the time it takes for a pulse projected into the ground to the return to the instrument. Surface conditions, soil conditions, or temperature can slightly alter reflection times and result in "drift" that must be calculated for during survey.
- Bias Value refers to a variety of complicating factors introduced to the testing process by the surrounding soils. Directional dependencies such as electromagnetic scatterings, the differential ability of the soils to hold an electrical charge, and magnetic susceptibility can result in bias in the results that can obscure features or structures.
- Surveyors desire GPR results to be associated with a vertical scale. To acquire vertical measurements, it is important that time delay for the recording of the first reflection, the time sampling resolution, and the maximum time span of the recording are noted. This will allow an assessment of whether the device is investigating deep or shallow ground and what size of features may be detectable.

DATA COLLECTION

Data collection is best conducted using regularly spaced transects, staking your grid, and close monitoring and flagging of anomalies.

- Survey involves walking with the instrument along closely spaced parallel transects, taking readings at regular intervals using an integrated distance-encoding wheel.
- In most cases, the survey area is staked into a series of square or rectangular survey grids. The corners of the grids are reference points, and the operator uses tapes or marked ropes as a guide when collecting data.
- During survey, subsurface objects and stratigraphy (layering) will cause reflections that are picked up by the receiver. The travel time of the reflected signal, and the assumed velocity of the energy, are used to indicate the depth.

Dan Elliot operating the "Stream C" compact array ground penetrating radar system.

PROCESSING

Processing your data is critical for identification of subsurface features and objects.

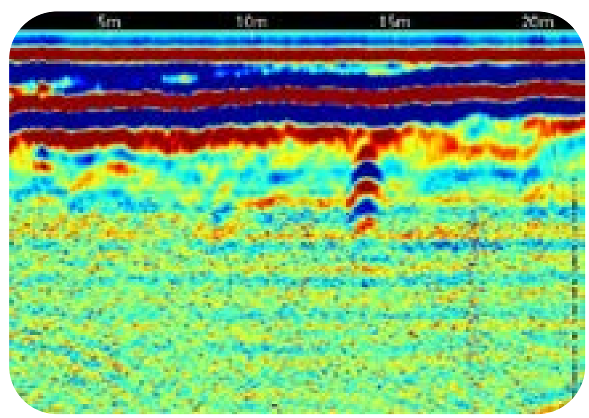
- Record the time delay for the first reflection, the time sampling resolution, and the maximum time span of the recording.
- Data processing and imaging convert numeric data into interpretable maps. This involves the removal of outliers and noise, and interpolation of data points.
- Statistical filters enhance features of interest (based on size, strength, orientation, or other criteria), or suppress obscuring modern or natural phenomena.
- Typical software-based post-processing methods include accurate positioning of the direct wave, removal of horizontal noise bands, bandpass filtering, and migration.

Davette Gadison (left) and Dr. Cynthia Ebinger (right) both affiliated with Tulane University conducting a GPR survey at the Natchez Fort site (16CT18) in central Louisiana.

VISUALIZING

Visualization of processed data allows you to see in profile and plan view the area you surveyed.

- Processed data will render images as contour maps or color-ramped amplitude maps. When geophysical data are rendered graphically, the interpreter can recognize cultural and natural patterns and visualize the geometry of objects and layers causing the detected anomalies.
- Data may be plotted as profiles, as plan view maps isolating specific depths, or as 3-dimensional (3D) models.
- In the case of historic masonry structures, GPR with a high frequency antenna can be used to detect cracks and decay patterns in the masonry.



An example of a high-frequency GPR readout from a survey transect at 5m intervals.

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