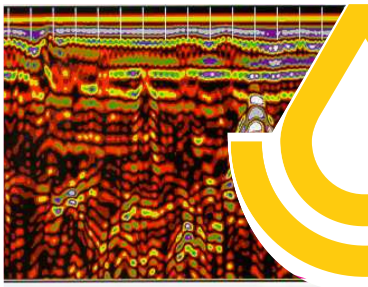
USDA United States Department of Agriculture

What is Ground Penetrating Radar?



Ground-penetrating radar (GPR) is a non-invasive geophysical method that uses the reflection of electromagnetic energy to produce images of subsurface interfaces and features. It provides a continuous real-time profile of sub-surface features in soil and geologic deposits.

The acronym radar is an abbreviation for radio detection and ranging. GPR is a time scaled system which measures the time that it takes pulses of electromagnetic energy to travel from an antenna to an interface (e.g., soil horizon, bedrock, and buried feature) and back.

How does GPR work?

A GPR system is made up of two main components: a control unit and antenna. The radar transmits high frequency, short duration pulses of energy into the ground from a coupled antenna. Transient electromagnetic waves are reflected, refracted, and diffracted in the subsurface by changes in electrical conductivity and dielectric properties. Travel times of those waves are analyzed to give depths, geometry, and material type information. The energy returning to the antenna is processed within the control unit and displayed on the receiver.

A favorable feature of GPR is its ability to noninvasively produce high-resolution images of the subsurface, and detect points or areas that have different reflection patterns than neighboring areas. An area or point having a contrasting spatial reflection pattern is often referred to as an anomaly because of its uncertainty and/or non-uniqueness. An anomaly often indicates there is something different in the subsurface. In an archaeological context, an anomaly may indicate an area of disturbance or an artifact buried in the soil.

However, even under favorable site conditions (i.e. dry, coarse-textured soils) the detection of an anomaly is never assured with GPR. The detection of an anomaly is affected by 1) the electromagnetic gradient existing between the feature and the soil; 2) the size, depth, and shape of the buried feature; and 3) the presence of scattering bodies within the soil.

The amount of energy that is reflected back to a GPR antenna is dependent on the contrast in dielectric permittivity that exists across subsurface boundaries or interfaces. Dielectric permittivity quantifies how easily a material becomes polarized in the presence of an electric field. The greater and more abrupt the contrast between an anomaly (e.g., buried archaeological feature) and the surrounding soil, the greater the amount of energy reflected back to the antenna, and the more intense and conspicuous the reflected signal.

Soil Suitability Maps

A common concern of GPR service providers is whether or not GPR will be able to achieve the desired depth of penetration in the soils of an assignment area. In many soils, high rates of signal attenuation severely restrict penetration depths and limit the suitability of GPR for a large number of applications. Knowledge of the probable penetration depth and relative suitability of soils can help service providers assess the appropriateness of using GPR and the likelihood of achieving acceptable results. Soil attribute data contained in the Digital State Soil Geographic (STATSGO2) and the Soil Survey Geographic (SSURGO) databases have been used to develop thematic maps showing, at different scales and levels of resolution, the relative suitability of soils for many GPR applications.

See tinyurl.com/2x5cbsky for more information.

The New Jersey map can be found here: tinyurl.com/ycm22f5b

GPR Soil Suitability Maps

GPR soil suitability maps have been prepared for the United States and Puerto Rico by the USDA - Natural Resources Conservation Service. These maps are based on soil attribute data and offer service providers an indication of the relative suitability of soils to GPR. Within any broadly defined area, the actual performance of GPR will depend on the local soil properties, the type of application, and the characteristics of the subsurface target.

State GPR soil suitability maps provide a more detailed overview of the spatial distribution of soil properties that influence the depth of penetration and effectiveness of GPR. The spatial information contained on state GPR soil suitability maps can aid investigators who are unfamiliar with soils to assess the likely depth and relative effectiveness of GPR within project areas. However, as soil delineations are not homogenous and contain dissimilar inclusions, on-site investigations are needed to confirm the suitability of each soil polygon for different GPR applications.

Interpreting GPR and Soils Data for Burial Grounds

On radar records, abrupt, vertical breaks in the continuity of reflections from soil horizons or stratigraphic layers are considered unnatural and an indication of human disturbance. The digging of grave shafts causes the truncation of soil horizons and stratigraphic layers, which when backfilled become mixed and can contrast with the adjoining undisturbed soil materials. Because the detection of grave shafts with GPR requires the presence of contrasting soil horizons and layers, which do not always occur, the use of GPR is truly site-specific and highly dependent on the soils. GPR is often more effective in detecting recently interred rather than older remains because of more substantial contrasts in dielectric properties (Usti, 2013; Schultz, 2008). Grave shafts, coffins, and corpses can produce conspicuous reflections.

However, with the passage of time, buried corpses or wood coffins decompose and become less contrasting with the surrounding soil matrix, reducing the potential for detection with GPR (Bevan, 1991; Vaughan, 1986). Bevan (1991) and Conyers (2006) noted that compared with a buried corpse or wooden coffin, grave shafts are often the most noticeable feature observed on radar records of older graves.

Interpreting GPR and Soils Data for Historic Artifacts

Historical archaeological sites are ideal locations for GPR surveys. The features are often numerous and fairly large, and they usually exhibit contrast with surrounding soil material (Peter Leach, GSSI).

Before geophysical methods arrived, shovel test were used to excavate sites. However, not only is this a laborious and time consuming process, but there is a high chance artifacts will be missed. (Ken Corcoran, GSSI).

The strength of GPR and other geophysical methods is the ability to collect landscape-scale data to assess overall feature associations, establish vertical and horizontal patterning, and to reconstruct the layout of the site (Peter Leach, GSSI). This information is essential when conservation practices are planned in potentially sensitive areas.

This technology can also be used in combination with electromagnetic induction (EMI). When used together, it's possible to generate a recognizance survey to locate areas of interest and produce a more detailed GPR study, thus improving the efficiency of the data collection.

The GPR data can then be used to build detailed maps that indicate activities areas, individual buildings and even 3D modules which depict the dimensions and depths.

New Jersey

Natural Resources Conservation Service