United States Department of Agriculture

Natural Resources Conservation Service

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Subject: Archaeology—Geophysical Assistance

Date: 5 April 2000

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Background:
The Battle of Oriskany occurred on August 6, 1777. Sir John Johnson and Joseph Brant leading a small number of Loyalist rangers and Mohawk and Seneca warriors ambushed General Nicholas Herkimer and about 800 militiamen and 60 Oneida warriors marching to the relief of the besieged Fort Stanwix. The ambush occurred about 10 miles east of Fort Stanwix in a boggy ravine that was crossed by the Military Highway. In the ensuing battle over 500 militiamen were killed or wounded. After a four-hour conflict, the Loyalist and their Iroquois allies withdrew. Discouraged, Loyalist and Iroquois allies under General St. Leger later ended their siege of Fort Stanwix and returned to Canada. Later that month, many of the dead were hastily buried in mass graves by General Benedict Arnold's relief force.

Approaching the 225 anniversary of the Battle of Oriskany, plans have been made for a new visitor and interpretive center. The Oriskany Battlefield is a State Historic Park and has been designated as a National Historic Landmark. Some have expressed interest in making Oriskany Battlefield a National Park.

The locations of the boggy ravine, Battle Creek, and the actual site of the battle has been approximated from oral and written records but remains tentative. In the intervening 223 years, the land has been extensively cleared, farmed and developed. Homes and new roads occupy some of the landscape on which the battle occurred. The purpose of this investigation was to use geophysical techniques to locate the old Military Highway, the mass graves, and any other feature relating to the site's history. The location of the old Military Highway and the mass graves would help to confirm the site of the actual engagement.

Participating Agencies:
New York State Office of Parks, Recreation and Historic Preservation
USDA-Natural Resources Conservation Service

Participants:
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Jim Doolittle, Research Soil Scientist, USDA-NRCS, Radnor, PA
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Activities:
All field activities were completed during the period of 29 to 30 March 2000.

Geophysical Survey
Oriskany Battlefield
Oriskany, New York

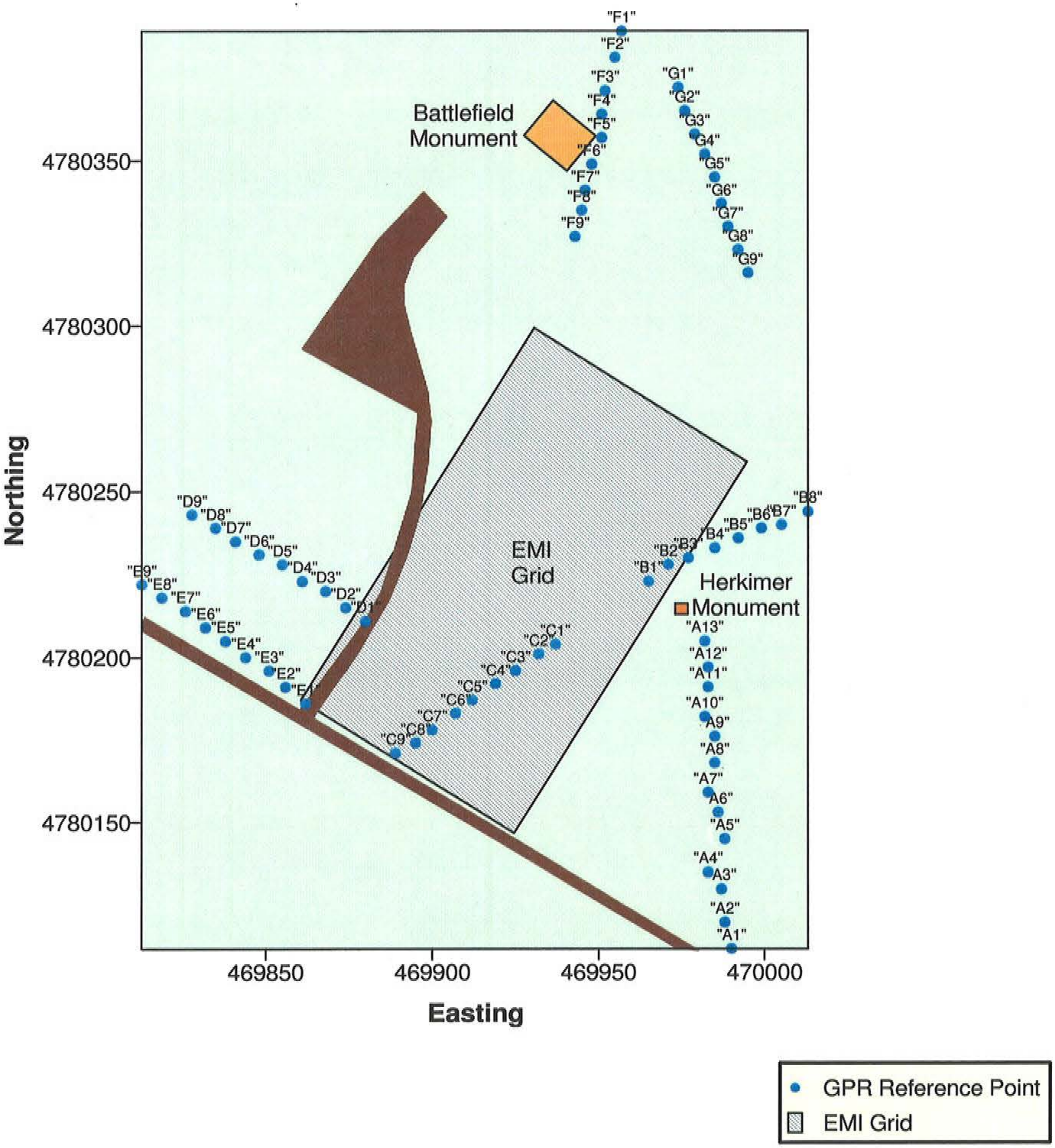

Figure 1

Equipment:
The radar unit is the Subsurface Interface Radar (SIR) System-2, manufactured by Geophysical Survey Systems, Inc.[1] Morey (1974), Doolittle (1987), and Daniels (1996) have discussed the use and operation of GPR. The SIR System-2 consists of a digital control unit (DC-2) with keypad, VGA video screen, and connector panel. A 12-volt battery powered the system. This unit is backpack portable and, with an antenna, requires two people to operate. A 400 mHz antenna was used in this study. Scanning times were 30 or 40 nanoseconds (ns); the scanning rate was 32 scan/second. Radar data were stored on disc and printed in the field on a model T-104 printer.

A GEM300 sensor, manufactured by Geophysical Survey Systems, Inc., was used in this study.[1] Geophysical Survey Systems, Inc, (1998) has described the principles of operation for the GEM300 sensor. The GEM300 sensor is configured to simultaneously measure up to 16 frequencies between 330 and 20,000 Hz with a fixed intercoil spacing of 1.6 m. Multiple frequencies are encoded in a pseudo-random binary sequence and transmitted in a step-frequency mode. The sensor records both inphase and quadrature measurements. Output is the mutual coupling ratio in parts per million or apparent conductivity (mS/m).

The coordinates of major field features were obtained with the Rockwell Precision Lightweight GPS receiver.[1] The Universal Transverse Mercator (UTM) coordinate system was used.

Study Site:
The study areas were located within the park and in areas of Chadakoin silt loam, 3 to 8 percent slopes, and Kendaia silt loam, 0 to 3 percent slopes. The deep and very deep, well drained Chadakoin soils formed in till. The Chadakoin soil is a member of the coarse-loamy, mixed, superactive, mesic Typic Dystrudepts family. The very deep ,somewhat poorly drained Kendaia formed in calcareous till. The Kendaia soil is a member of the fine-loamy, mixed, active, nonacid, mesic Aeric Epiaquepts family.

Field Procedures:
Seven traverse lines were established across the site (see Figure 1). Lines A, B, and C were oriented to traverse areas suspected to have been crossed over by the old Military Highway. Along each traverse line, survey flags were inserted in the ground at intervals of about 20 feet. The 400 mHz antenna was pulled along each traverse line. The GPR provides a continuous profile of the subsurface. As the radar antenna was pulled passed each flag, the operator impressed a vertical mark on the radar record. The vertical marks identified the reference points (flagged positions). The reference points provide a horizontal scale and identify relative locations along each traverse line.

A 400 by 250 foot grid was established across a portion of the park (see Figure 1). Measurements were taken with the GEM300 sensor held at hip-height in the vertical dipole orientation. The sensor was operated in the continuous modes with observations taken at 1 s intervals. Inphase, quadrature phase, and conductivity data were recorded with the GEM-300 sensor at three different frequencies (9810, 11730, and 14630 Hz).

Calibration of GPR:
Ground-penetrating radar is a time scaled system. This system measures the time that it takes electromagnetic energy to travel from the antenna to an interface (e.g., soil horizon, stratigraphic layer, buried artifact) and back. To convert the travel time into a depth scale, either the velocity of pulse propagation or the depth to a reflector must be known. The relationships among depth (d), two-way pulse travel time (t), and velocity of propagation (v) are described in the following equation (Morey, 1974):

$$v = 2d/t \qquad [1]$$

The velocity of propagation is principally affected by the dielectric permittivity (e) of the profiled material(s) according to the equation:

$$e = (c/v)^2 \qquad [2]$$

Where c is the velocity of propagation in a vacuum (0.3 m/nanosecond). Velocity is expressed in meters per nanosecond (ns). A nanosecond is one billionth of a second. The amount and physical state of water (temperature dependent) have the greatest effect on the dielectric constant of a material.

[1] Manufacturer's names are provided for specific information; use does not constitute endorsement.

A metallic reflector was buried at a depth of 15 inches in an area of Chadakoin soil. Based on the depth to this reflector (0.38 m) and equation [1], the velocity of propagation was estimated to be about 0.0895m/ns through the upper part of the soil profile. Using equation [2], the dielectric permittivity was 11.2. Using equation [1], a propagation velocity of 0.0895 m/ns, and scanning times of 30 and 40 ns, maximum depths of observation were estimated to be about 1.34 or 1.79 m, respectively.

Results:

GPR:

The GPR worked well at this site providing suitable observation depths and resolution of subsurface features. Several subsurface "point anomalies" were identified on the radar profiles. While the radar detect subsurface features, it does not identify the features. These features could represent rock fragments, tree roots, animal borrows, or artifacts of unknown identity and age.

No mass grave was identified on the radar profiles. However, to evaluate the suitability of GPR for this task, a radar traverse was conducted in an neighboring cemetery that dates back to colonial times. Figure 2 is a portion of the radar profile from the cemetery. Along the left-hand border of the radar profile is a depth scale. The depth scale is based on the estimated velocity of propagation, a scanning time of 40 ns, and equation [1]. The depth scale is expressed in meters.

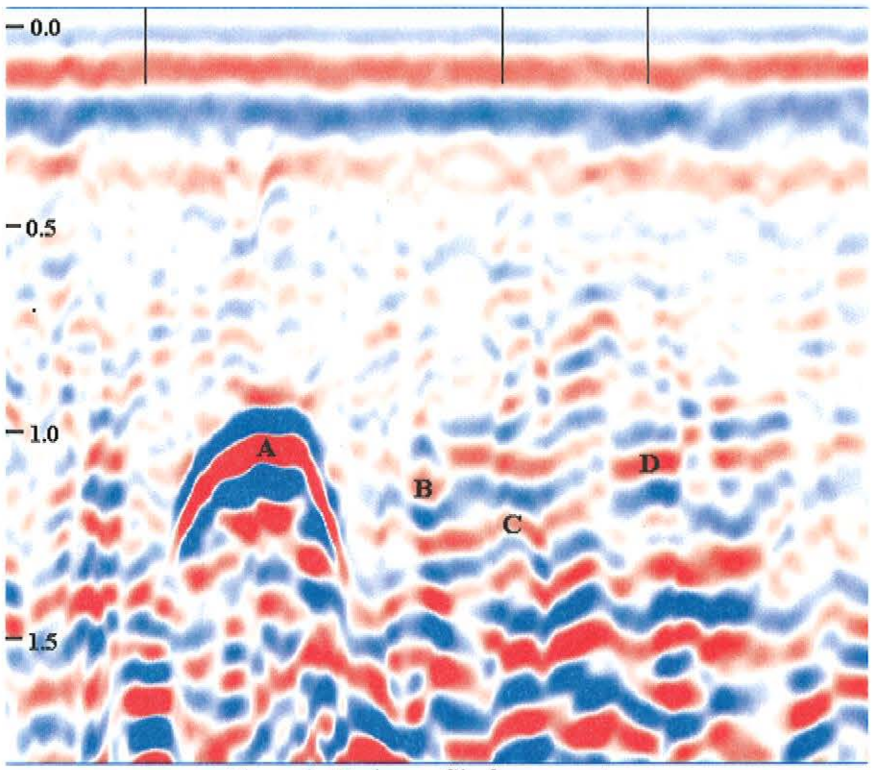

Figure 2. Radar profile from cemetery.

Three marked gravesites were traverse with the antenna. In Figure 2, the locations of the headstones for these graves have been identified with short vertical lines at the top of the radar profile. One headstone dates to the early 1900's (left-most vertical line); the other two headstones date to the early 1800's. As evident in Figure 2, only the former burial is readily apparent. The strong reflection at "A" is believed to have been produced by a coffin. Not uncommon, the burial is slightly offset from the center of the headstone. For the earlier burials, the imagery is more obscured and interpretations are not as straightforward. Three higher amplitude reflections (B, C, and D) have been identified in Figure 2. These short, truncated reflections could represent the burial. However, without knowledge of the actual gravesite, these features may have been overlooked or interpreted differently.

Bevan (1991) noted that it is more likely that GPR will detect the disturbed soil within a grave shaft, a partially or totally intact coffin, or the chemically altered soil materials that directly surrounds a burial rather than the bones themselves. Killam (1990) believes that most bones are too small and not directly detectable with GPR. This author observed that the disruption of soil horizons makes most graves and some cultural features detectable. However, in soils that lack contrasting horizons or geologic strata, the detection of a grave shaft is improbable. In addition, with the passage of time, natural soil-forming processes erase the signs of disturbances. While the detection of a mass grave dating back to the Battle of Oriskany with GPR is possible, the likelihood is considered highly fortuitous.

The Military Highway was not discerned on any radar profile. As a test, radar profiles were collected over one of the park's footpaths and over an abandoned road. The road dates back to the first half of the last century (1900's). The radar traverses were conducted orthogonal to the centerlines of both the footpath and the abandoned road. Radar traverses across the footpath and the abandoned road are shown in Figures 3 and 4, respectively. In each figure, short vertical lines at the top of the radar profile delimit the boundaries of the footpath or road. In Figure 3, the compacted surface layer of the modern footpath produces strong and easily identifiable reflections. However, the abandoned road is obscure on the radar profile shown in Figure 4. Based on these results, it is doubtful that the old Military Highway, if still undisturbed by two hundred and twenty-two years of human activities, would be identifiable on radar profiles. If the portion of the old Military Highway spanning the ravine was corduroy, it may produce a unique and identifiable reflection.

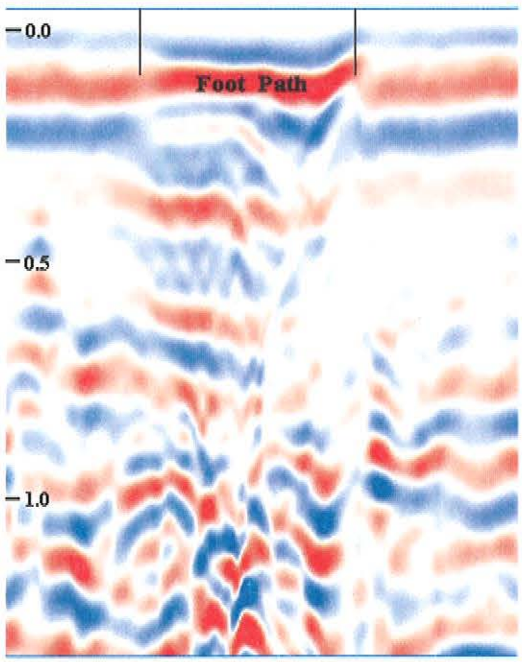

Figure 3. Radar profile of a modern foot path.

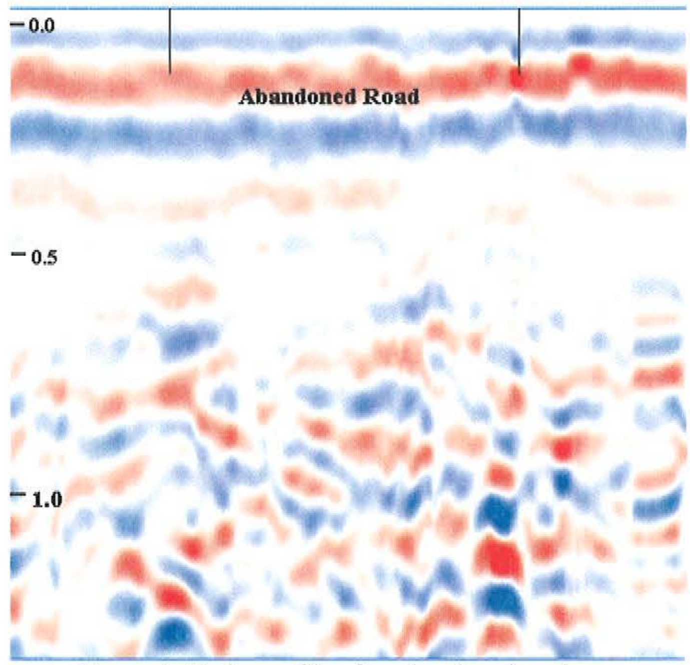

Figure 4. Radar profile of an abandoned road.

Along the north and west sides of a depression located to the northwest of the park entrance, radar profiles revealed the presence of two shallow stonewalls or rock lines. These features are aligned at approximately a right angle to one another. These features are most likely not related to the battle, but to land use during the ensuing two hundred and twenty-three years.

<u>EMI</u>

Electromagnetic induction (EMI) is a noninvasive geophysical tool that can be used for detailed site investigations. Advantages of EMI are its portability, speed of operation, flexible observation depths, and moderate resolution of subsurface features. Results from an EMI survey are interpretable in the field. This geophysical method can, in a relatively short time, provide the large number of observations that are needed to comprehensively cover sites. Maps prepared from correctly interpreted EMI data provide the basis for assessing site conditions, planning further investigations, and locating exploratory test pits.

Electromagnetic induction measures vertical and lateral variations in magnetic and/or electrical fields associated with induced subsurface currents. Data is expressed as inphase, quadrature phase, or apparent conductivity. The inphase and quadrature phase responses represent the ratio of the secondary magnetic field at receiver coil to the primary magnetic field at receiver coil. Inphase refers to the part of the signal that is in phase (has zero phase shift) with the primary or reference signal. The inphase signal is sensitive to buried metallic objects and has been referred to as the "metal detection" mode. The magnitude of the inphase signal is proportional to the cube of a buried metallic object's surface area and is inversely proportional to its depth raised to the sixth power (Greenhouse et al., 1998). Quadrature phase refers to the part of the signal that is 90 degrees out of phase with the primary signal. The quadrature phase response is linearly related to the ground conductivity. Some highly conductive targets with small cross-sections, such as pipes, may show up better in the quadrature phase because of the channelization of current. With the GEM300 sensor, inphase and quadrature phase data are expressed in parts per million (ppm).

GEM300 Sensor
14610 Hz

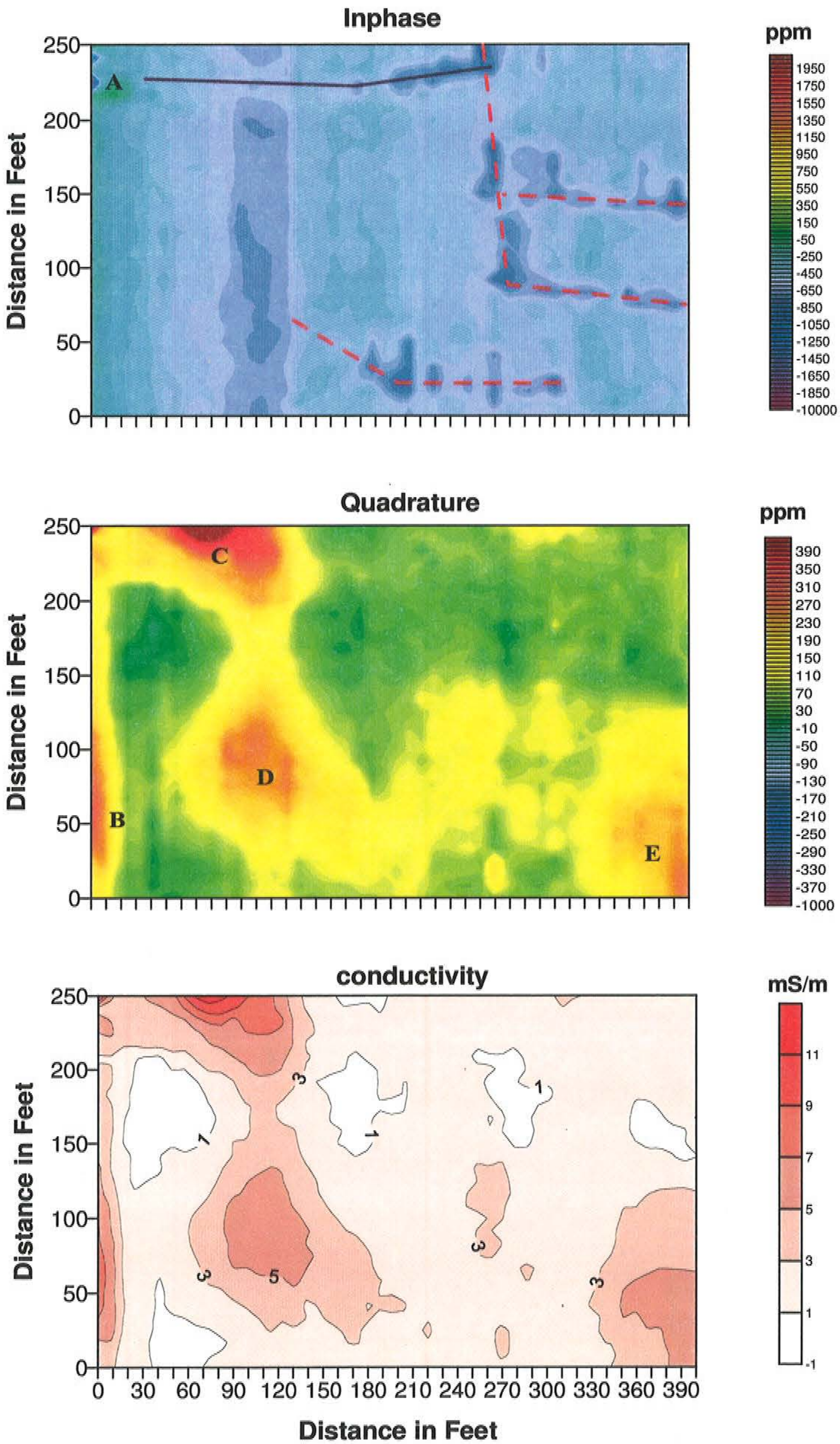

Figure 5

Traditionally, EMI data are expressed as apparent conductivity. The GEM300 sensor automatically converts quadrature phase data into apparent conductivity data. Values of apparent conductivity are expressed in milliSiemens per meter (mS/m). Apparent conductivity is a weighted, average measurement for a column of earthen materials to a specific depth (Greenhouse and Slaine, 1983). Variations in apparent conductivity are caused by changes in the electrical conductivity of earthen materials. The electrical conductivity of soils is influenced by the volumetric water content, type and concentration of ions in solution, temperature and phase of the soil water, and amount and type of clays in the soil matrix (McNeill, 1980). The apparent conductivity of soils increases with increases in soluble salts, water, and clay contents (Kachanoski et al., 1988; Rhoades et al., 1976).

Values of apparent conductivity are seldom diagnostic in themselves, but lateral and vertical variations in these measurements can be used to infer changes in soils and soil properties and the locations of buried artifacts. Interpretations are based on the identification of spatial patterns within data sets. To assist interpretations, computer simulations are normally used.

Data collected with the GEM300 sensor at different frequency were similar. Data collected at a frequency of 14610 Hz are shown in Figure 5. Inphase, quadrature phase, and apparent conductivity data are shown in the upper, middle, and lower plots, respectively. These image maps use different colors to represent the data. Colors are associated with percentage values (in relation to the minimum and maximum values).

In the plot of the inphase response (upper plot), the two conspicuous point anomalies apparent in the upper left-hand corner of the survey area (see "A" in Figure 5) represent the metal gates at the park's entrance. Linear streaks or features are evident in the inphase data. In the upper plot of Figure 5, linear features that are believed to represent buried drainage tiles have been identified with a segmented red line. A linear feature associated with the parks road has been identified with a continuous brown line. In the upper plot of Figure 5, prominent streaks, orientated in an east-west direction (up and down pattern) may represent the effects of cultivation or land management.

Quadrature and apparent conductivity data are, as should be expected, similar. Lower values are associated with higher-lying better-drained sites. Higher values are associated with interference from the fence that borders the state highway (see "B" in Figure 5) or lower-lying more poorly drained depression (see "C' and "D") or lower-lying slope positions (see "E"). No other conspicuous point anomalies are apparent in the data.

Conclusions:

Archaeologists have used geophysical techniques to facilitate excavation strategies, decrease field time and costs, and locate buried artifacts and archaeological features. However, even with favorable site conditions the detection of a buried cultural feature with geophysical techniques cannot be guaranteed. The detection of buried cultural features is affected by the electromagnetic gradient existing between a cultural feature and the soil, the size, shape, and orientation of the buried cultural feature, and the presence of scattering bodies within the soil (Vickers et al., 1976). In the search for buried cultural features with geophysical techniques, success is never guaranteed. Even under ideal site and soil conditions, buried cultural features will be missed. The usefulness of geophysical techniques for site assessment purposes depends on the amount of uncertainty or omission that is acceptable.

Ground-penetrating radar provided continuous, highly resolved images of the subsurface. However, no clear indications of mass graves or the old Military Highway were evident on the radar profiles. Features relating to the actual engagement are indistinguishable from those that are related to ensuing events and land use. In areas of till derived, forested soils, artifacts are difficult to distinguish from rock fragments, tree roots, and animal burrows. These scattering bodies produce undesired subsurface reflections that complicate radar imagery and may mask the presence of buried cultural features.

While the detection of a mass grave dating back to the Battle of Oriskany with GPR is possible, the likelihood is considered highly improbable. Based on the results of this investigation, it is doubtful that the old Military Highway, if still undisturbed by two hundred and twenty-three years of human activities, would be identifiable on radar profiles. However, if the portion of the old Military Highway that crossed the ravine was corduroy, it may still provide a unique and identifiable reflection.

Electromagnetic induction provided spatial patterns that were associated with recent land management and use or variations in soils and soil properties.

Interpretations are considered preliminary estimates of site conditions. The results of geophysical site investigations do not substitute for direct observations, but rather reduce their number, direct their placement, and supplement their interpretations. All interpretations made in this report should be verified by ground-truth observations.

It was my pleasure to be of assistance to you, your staff, and the New York State Office of Parks, Recreation and Historic Preservation.

With kind regards,

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