Using Ground-Penetrating Radar to Map the Historic Pottersville Kiln, Edgefield, South Carolina

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ABSTRACT

Ground-penetrating radar (GPR) was used to map the Pottersville kiln in the Edgefield District of South Carolina. The results of the survey were used to determine the layout and dimensions of the kiln, which were unexpectedly large: 105 feet (32 m) long by 12 feet (3.7 m) wide. Results were also used to locate a previously unknown structure with a possible connection to the kiln's firebox. The survey required a half day in the field with quick results, suggesting that GPR is an efficient method for answering research questions about site architecture and targeting field work at kiln sites.

Introduction

In summer 2011 the University of Illinois field school began excavating a stoneware pottery kiln at Pottersville (30ED011, also known as Landrumsville) in the Edgefield District of South Carolina. Field school instructors located the kiln site using LiDAR surveys, topography, surface artifacts, and historical maps and accounts (Calfas et al. 2011). Archaeologists were surprised by the dimensions and layout of the kiln architecture because the kiln appeared to be 105 feet (32 m) long, which is far larger than the 20–30 feet (6–9 m) thought to be common for alkaline-glazed stoneware kilns (Calfas 2011). The field school organizers then contacted New South Associates, Inc., who suggested using ground-penetrating radar (GPR) to map the kiln and determine its length and configuration without requiring large excavation units to pinpoint the chimney and, thus, the complete kiln dimensions. Kiln excavations can be very time-consuming, and this case study is presented as an example of how GPR can significantly reduce the time and effort needed to interpret kiln sites.

Ground-penetrating radar is a geophysical technique used to identify dielectric permittivity contrasts within subsurface soils and sediments. These contrasts are often the result of cultural activities. In this case, the presence of a structure and the high-heat firing of pottery at Pottersville created a stark contrast to the natural soils. GPR data collection can be accomplished quickly and without ground disturbance and is therefore frequently used to target archaeological excavations or answer research questions without costly excavation. At Pottersville, GPR data were used to map kiln architecture between open excavation units to determine the location and configuration of the chimney (Figure 1). The GPR results also allowed for the identification of the remains of another pottery-related structure adjacent to the kiln. The results suggested a possible connection between the kiln and this structure, indicating the structure was possibly a greenware drying building heated with residual kiln heat diverted through an underground channel. Interpretations made from GPR maps and profiles were effective tools for identifying the internal kiln architecture and buildings associated with ceramic production at Pottersville. This technique could be used to study historic ceramic production in detail without expensive, time-consuming excavations traditionally needed to locate and delineate historic kilns. In cases where excavation is wanted or needed, GPR results can help to target work, reducing both field and laboratory time, while still answering research questions.

Ground-penetrating radar is just one method in a suite of near-surface geophysical methods commonly employed by archaeologists. Magnetometry, electrical resistance, and electromagnetic conductivity are all also commonly used in archaeological applications (Clark 1996; Gaffney and Gater 2003; Conyers 2004; Johnson 2006; Aspinall et al. 2009). The usefulness of all of these methods varies depending on the situation, and they can often be used together to obtain more complete results. In this case, GPR was employed because it offered a three-dimensional view of architecture at a level of detail not possible with any of the other methods and because the kiln's location was already known. For future study of kilns, however, magnetometry would be an excellent tool for locating kilns as data collection and interpretation are

Figure 1. View of GPR grid and kiln site; the chimney and firebox are located at the crest of the mound (view to south). (Photo by Chris Espenshade, 2011.)

much faster than GPR, and the high firing temperatures used in kilns leaves a strong and recognizable magnetic signature. Because of these conditions, however, magnetic results would likely lack resolution, and architectural details would likely not be visible.

The Edgefield District and Survey Background

The Old Edgefield District in South Carolina (Figure 2) was the location of innovations in the development of alkaline glazed stoneware in the early 1800s (Baldwin 1993). The potters Abner and John Landrum of Landrumsville (later Pottersville) led the development of alkaline-glazed pottery technology and set up one of the first large scale commercial production facilities for stoneware jars. As a result, the district became the center of ceramic production and distributed stoneware around the country. These potteries relied on the skills, experience, and labor of a large enslaved African population, famously including the potter and poet "Dave," to mass-produce alkaline-glazed ceramic containers for food storage and production (Baldwin 1993; Todd 2008).

Early archival and archaeological research conducted at Pottersville suggested that the Pottersville kiln was a typical groundhog kiln measuring about 20–30 feet (6–9 m) long by 10–12 feet (3–3.7 m) wide (Calfas 2011). When work began at Pottersville, excavations quickly revealed a much larger and more complex, seemingly industrial-sized kiln that measured approximately 105 feet (32 m) long by 12 feet (3.7 m) wide. This kiln may also be in an Asian style, using a hill slope (Calfas 2011). When the kiln size and shape did not meet expectations based on the historical literature, GPR was brought in to outline the dimensions and assist in placement of unit excavations.

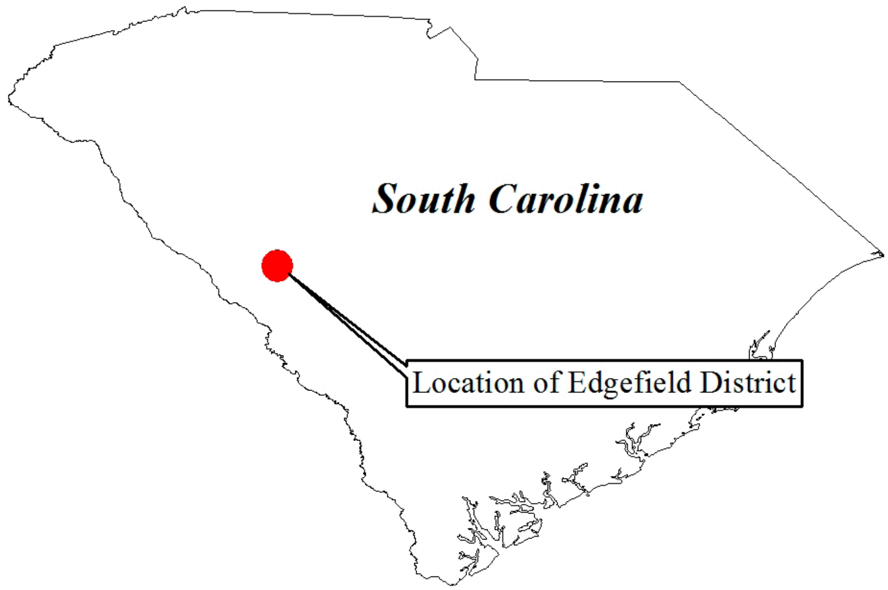

Figure 2. The Edgefield District's location in South Carolina. (Map by author, 2013.)

Ground-Penetrating Radar Methods

Ground-penetrating radar is used to map contrasts within the subsurface. Contrast can be created through cultural activities or natural stratigraphic breaks and geology. To measure these contrasts, electromagnetic radar waves are transmitted into the ground from an antenna; changes in subsurface conditions reflect the waves, and the reflections bounce back to the receiving antenna (Conyers and Goodman 1997; Conyers 2004). The strength of the reflections and their elapsed two-way travel time are recorded. Reflection strength across a large area is used to determine differences in subsurface conditions (some of which may be culturally created). Elapsed two-way travel time is used as a proxy for depth and can be converted to distance through estimated velocity calculations in postprocessing.

To collect GPR data for archaeology, a rectilinear grid is established over the site or desired collection area. In the case of Pottersville, an existing site grid was used. The GPR system used at Pottersville consisted of a computer (GSSI SIR 3000) attached to an antenna (with a frequency of 400 MHz) and survey wheel. Data were collected in transects, with 50 pulses of electromagnetic energy being transmitted and received for each meter. Together all of the pulses formed a profile. Multiple parallel transects, spaced 50 cm apart, formed the grid.

Data processing began with downloading data from the collection computer as a series of profiles. These profiles were imported into RADAN, a software package designed to process these profiles into a cohesive data set (Geophysical Survey Systems, Inc. 2011). In the software, each profile was aligned within the grid, and the space between each profile was interpolated to form a three-dimensional block of data. Basic filters and processing steps were applied as well, including setting time zero (setting the first radar reflection within the computer) and removing background noise (common air radio waves and ringing within the antenna). Velocity calculations were made using hyperbola fitting in order to convert travel time to depth (Conyers and Lucius 1996). The soil at the site was predominately a well-drained sandy loam. The average velocity was estimated at about 10 cm/nanosecond with an relative dielectric permittivity (RDP) of eight. At this point, the three-dimensional block of data was "sliced" to create plan view maps at arbitrary depths. At Pottersville, a series of 20-cm slices were made (Figure 3).

The plan-view slice maps and the profiles were used in conjunction to make interpretations about the site's architecture. Possible features were identified using both the plan and profile views. Although contrasts can be created by both geological and cultural differences in subsurface conditions, human made anomalies are apparent as they

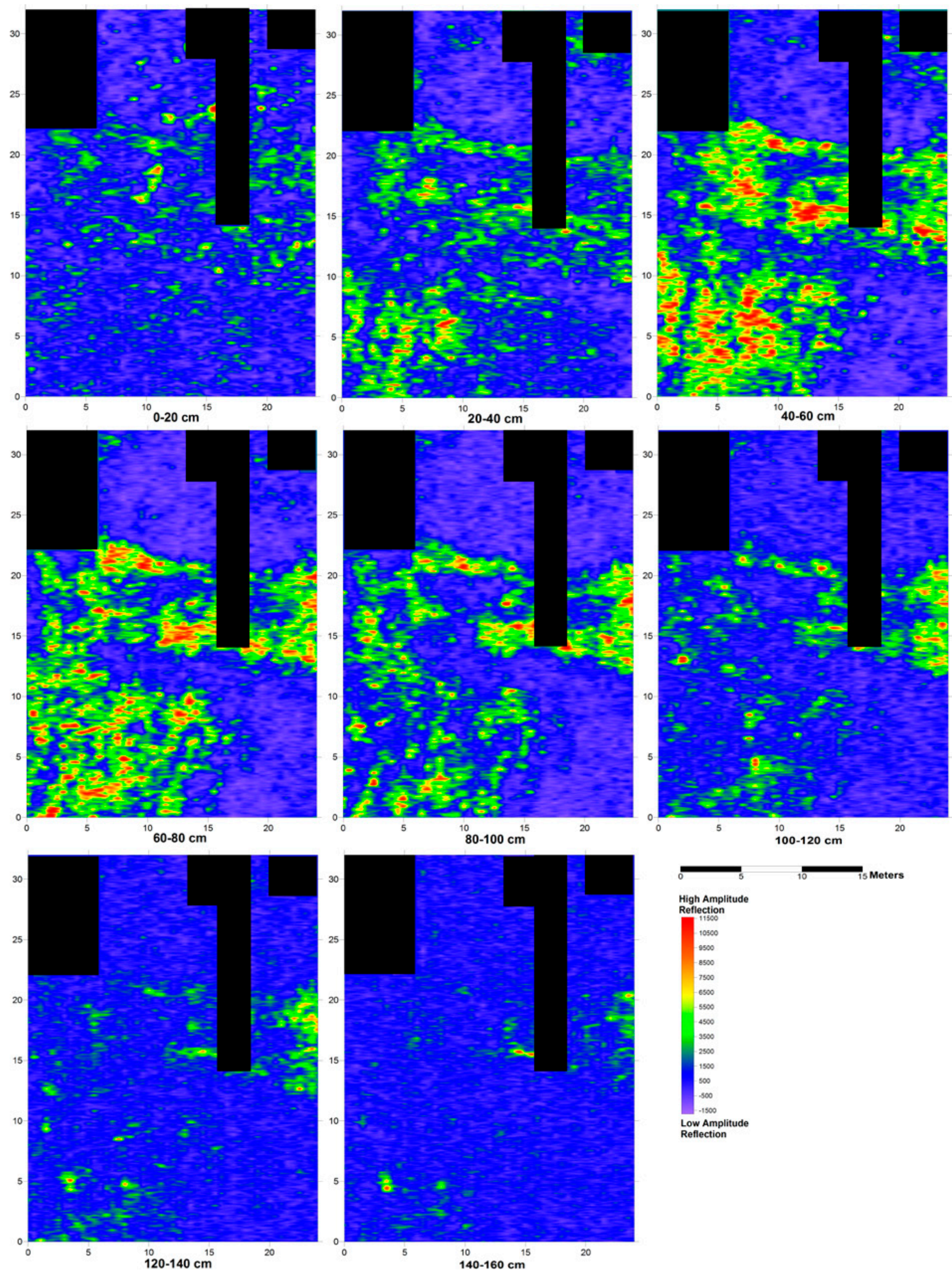

Figure 3. The three-dimensional GPR data were divided into 20 cm slices prior to interpretation. (Graphic by author, 2013.)

form geometric, architectural patterns in plan view, and have segmented sections of high amplitude (high contrast) floor features (Conyers 2012). The slice maps and profiles were annotated with interpretations to make final maps of hypothesized site features.

The author collected the GPR data at Pottersville in the summer of 2011 with one assistant. Data were collected in one rectilinear grid around the open excavation units; the 24- × 36-m grid was established to cover the suspected chimney portion of the kiln mound itself as well as some of the surrounding field, where possible, around open units, back dirt, and materials removed from the kiln. Field data collection took less than four hours.

Results and Interpretations

Slice maps from the GPR survey were used to identify a variety of kiln features and associated architecture, including internal kiln architecture and another building (Figure 4). The kiln and the building also appeared to be connected

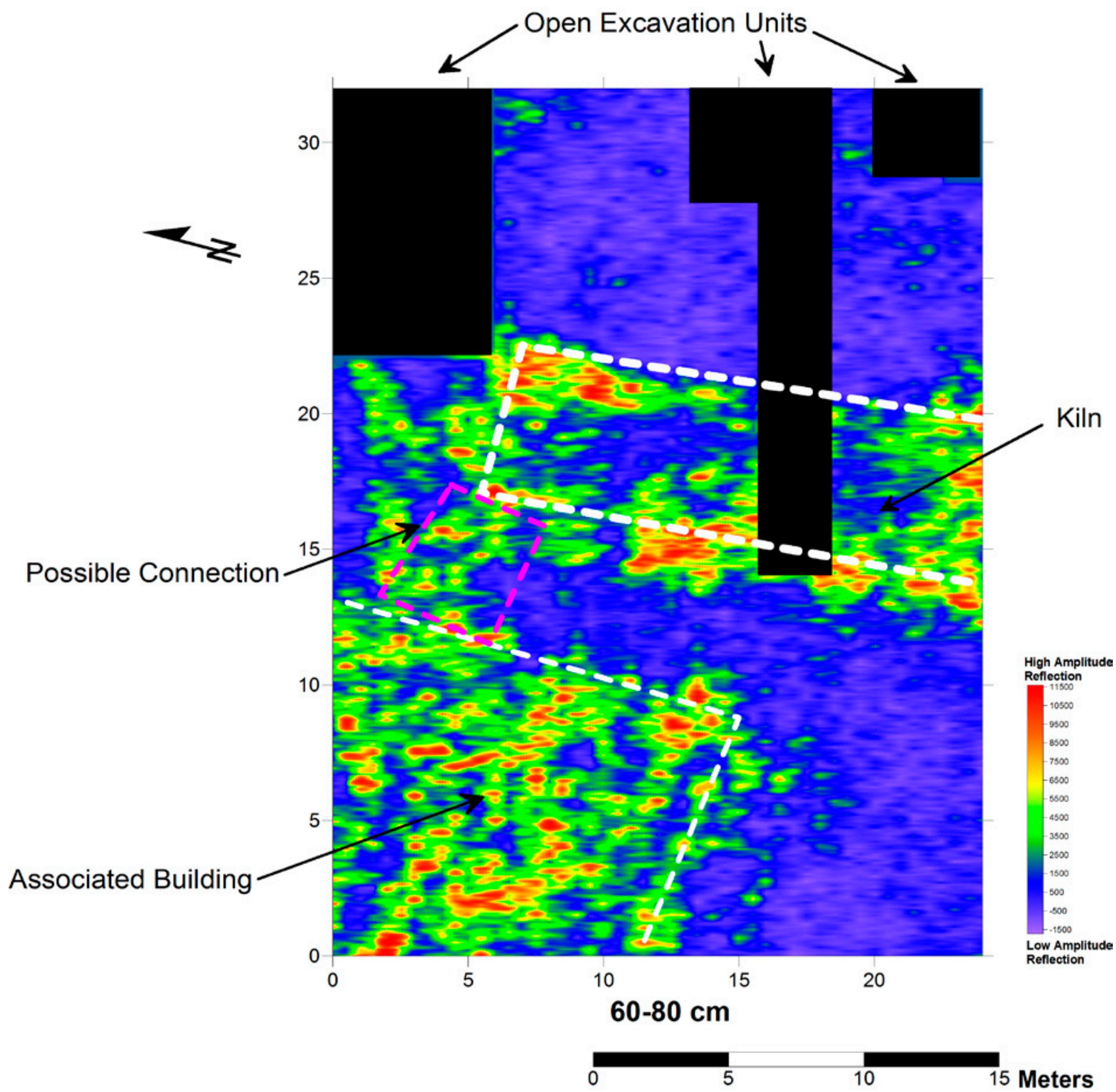

Figure 4. Two major structures were identified in the GPR results, the kiln and another structure; there may also be a connection between the two structures. (Graphic by author, 2013.)

in some way. Although the location of the kiln was already known and it was being excavated during the GPR survey, its horizontal extent and the location and configuration of the chimney were identified with the GPR results. The associated building was previously unknown.

The identified kiln architecture included side walls, a chimney foundation and fire box, the kiln floor, and collapsed ceiling rubble (Figure 5). The kiln itself was constructed of brick and measured 105 feet (32 m) long by 12 feet (3.7 m) wide. It is unusually long for a kiln in this area, indicating it was designed for mass production of stoneware (Calfas 2012). The outlines of the chimney base were still visible in the radar slice maps, as well as the brick rubble from the chimney's collapse. There was also evidence of dense areas of kiln roof collapse within the main chamber.

Associated with the kiln, directly to its side, the remains of a probable structure were identified. This structure measured at least 29 × 29 feet (12 × 12 mm), although it was likely larger because the GPR survey only covered a corner of it. It consisted of building debris on top of a floor or prepared construction surface (Figure 6). The floor was not completely intact and it was difficult to isolate. Nevertheless, the building debris or collapsed building materials on top of it were easily identifiable. The structure appeared to be connected to the kiln through some sort of underground linear connector. There were also indications of foundation remains still present along the edges, and some sort of small subfloor surface, the purpose of which is unknown. Due to limitations of time and resources, these possible interpretations could not be tested, but, as a highly productive kiln there were likely many structures surrounding it. Targeted excavations based upon these GPR interpretations would help to confirm this hypothesis and test others about kiln outbuildings.

This structure may have been used for greenware drying, using the heat of the cooling kiln (via tunnels attached to the firebox) to quickly dry greenware being prepared for the next firing. Sun drying of stoneware before firing was time consuming, risky due to unpredictable weather, and challenging in the winter. These problems were mitigated and managed through the use of drying buildings, of which this may be an example. Drying buildings either used unattached drying ovens, unlinked to the kiln (Zug 1986:166; Laub 1992:89; Sweezy 1994:119), or ductwork drawing heat from the kiln. Oral histories indicate that some potteries, particularly large ones, used drying buildings to control the drying process (Burrison 1983:209, 221). One such drying shed in northern Paulding County, Georgia,, described in *Brothers in Clay,* was "a log drying shed with a trench dug in the earthen floor where a fire could be kindled in the winters to keep the damp greenware from freezing" (Burrison 1983:209). Sweezy (1994) illustrated a similar drying shed that drew heat through an underground duct from the kiln at the Wilson pottery in Gillsville, Georgia (Figure 7). It is possible that in this case the drying shed, located about 16 feet (5 m) away from the firebox itself, would have been connected directly to save fuel and share the heat.

Once a kiln firing is complete, the kiln has to cool slowly for several days before the pottery can be handled (a process called annealing). If the kiln cools too quickly or unevenly the fired vessels may crack. To assist in that even cooling, the connection to the drying shed would allow heat to be drawn out of the otherwise sealed chimney, thus cooling the kiln in a controlled manner and using the heat to dry the next batch of greenware. At a kiln the size of Pottersville, with its large-scale production, it would have been necessary to dry greenware efficiently and rapidly but also evenly cool the kiln. This is one explanation for the apparent connection between the Pottersville chimney and the structure, but there may be another explanation. It is possible that the linear connection is only building rubble, and the function of the associated building cannot be identified. Hand excavations would be necessary to further address the possible linkage between the kiln and building.

Conclusions

The results of the GPR survey support the hypothesis that the Pottersville kiln was part of a significant, industrial-scale ceramic production facility. Using GPR, a series of structural elements were identified and preliminary interpretations about architecture were made. The kiln was outlined, and the firebox and chimney foundations were mapped, leading to the discovery of an entirely new structure and a possible connection between the structure and kiln. It is likely that if a larger GPR survey were undertaken in the fields surrounding the kiln, additional structures and cultural features would be identified.

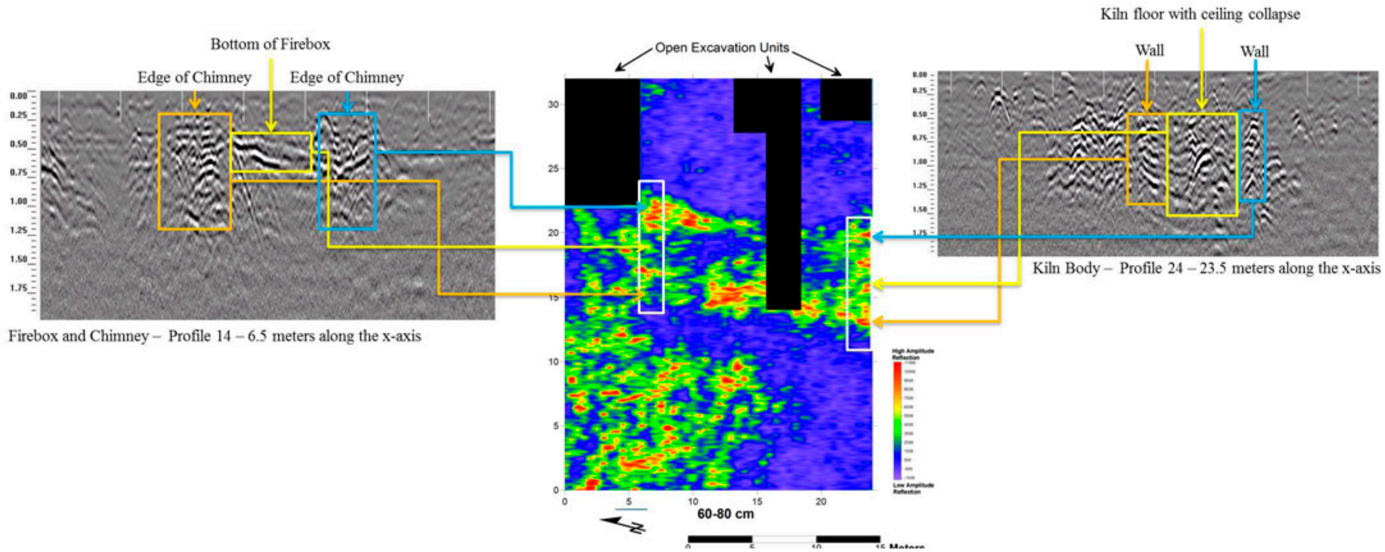

Figure 5. Kiln architecture identified in GPR results. (Graphic by author, 2013.)

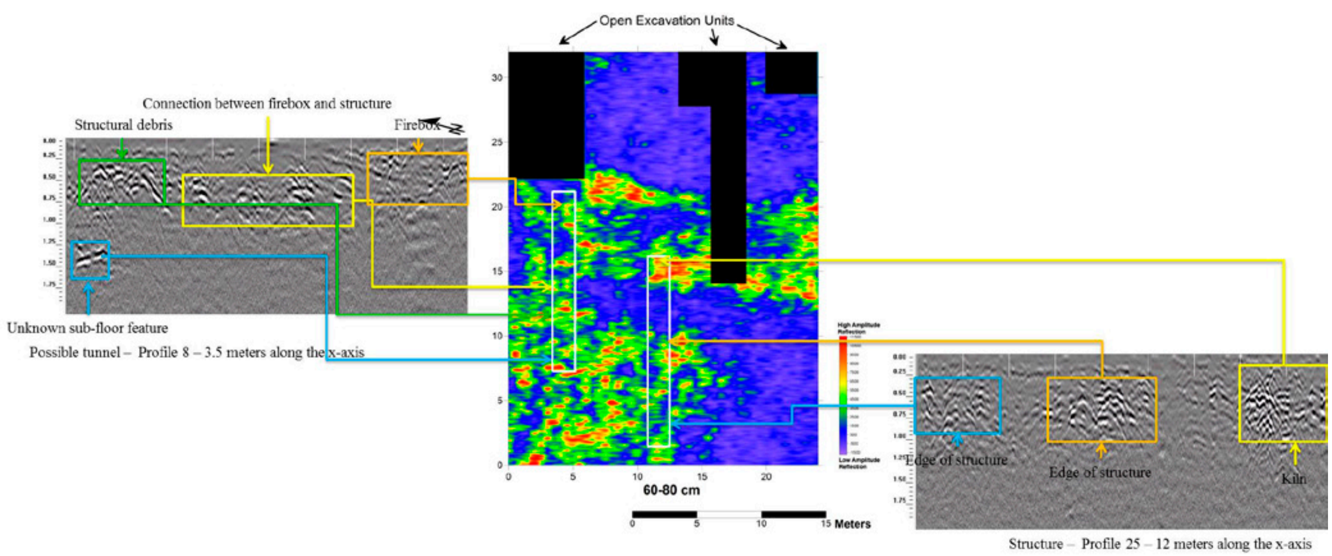

Figure 6. Structural architecture identified in GPR results. (Graphic by author, 2013.)

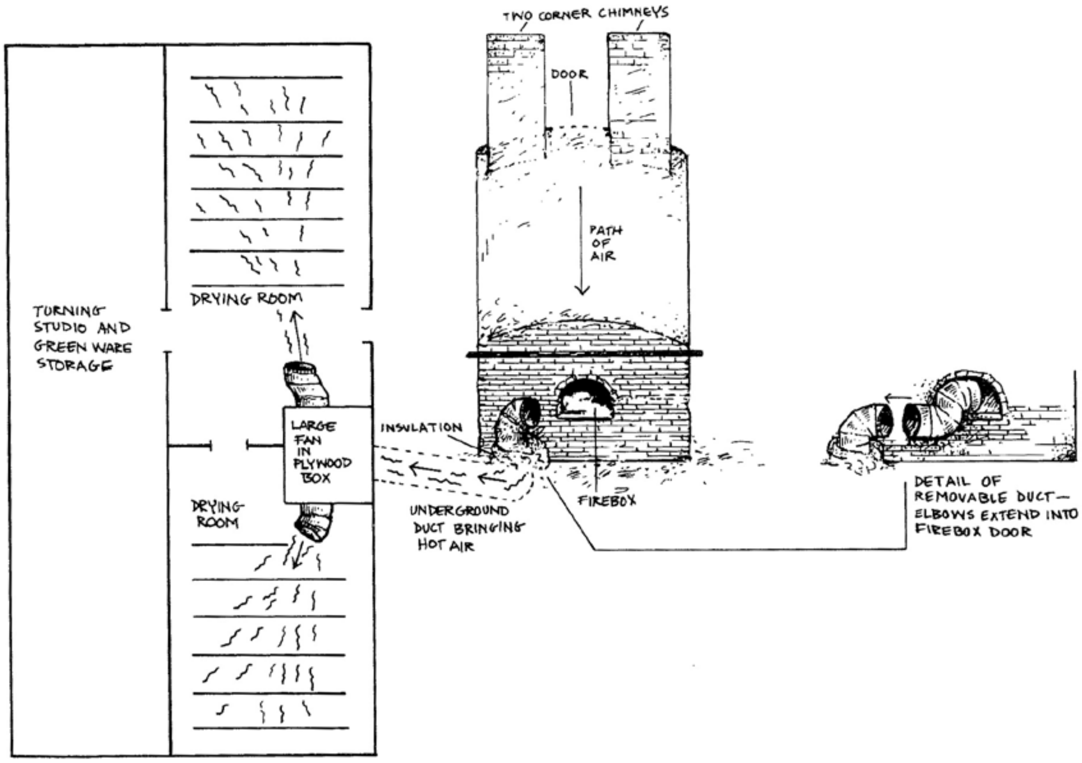

Figure 7. Example of duct connection between kiln and drying shed (Reprinted from Sweezy (1984:158), with permission of Smithsonian Institution.)

Most importantly, this data set was obtained through approximately 2–4 hours of field work with two people. Preliminary processing and interpretations were done the very same day, and final maps were made with less than a day's work, thus providing effectively 100% coverage of the surveyed area in eight hours of work. The immediate results, the non-invasive nature of investigation, and efficient data collection meant that questions about architecture and the direction of excavations could be determined while the crews were in the field. As early as the next day, GPR results were ready to be used.

Historical kilns and potteries are particularly suited to this type of geophysical investigation because the extensive and intensive architectural elements have a high contrast to the existing subsurface soils and sediments. The resulting kiln maps provide an outline of the structure's size, orientation, and even depth. This type of survey could readily be conducted on other historic kilns and could help to eliminate costly time spent "searching" for the kiln boundaries and outbuildings, allowing excavators to target more specific areas of the kiln to answer their research questions. For projects focused on regional variability in kiln types and sizes, GPR can provide valuable data quickly and non-invasively. With many kiln sites existing on private land, GPR is a good method when the landowner does not want excavations to occur. The GPR survey itself can also be used to answer questions about kiln layout and use of space within a production facility.

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Editor's Disclosure

Technical Briefs editor Chris Espenshade worked with Sarah Lowry on the project in question and co-authored an SHA paper with Ms. Lowry on this subject. This statement is provided in the interest of full disclosure.

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